Pontifícia Universidade Católica
do Rio de Janeiro

Brenda de Farias Oliveira Cardoso

Disaster impacts on supply chains and countermeasures strategies

Tese de Doutorado

Thesis presented to the Programa de Pós-graduação em Engenharia de Produção of PUC-Rio in partial fulfillment of the requirements for the degree of Doutor em Engenharia de Produção.

Advisor: Prof. Adriana Leiras

Co-advisor: Prof. Tharcisio Cotta Fontainha

Rio de Janeiro
April 2024

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Bibliographic data

Cardoso, Brenda de Farias Oliveira

Disaster impacts on supply chains and countermeasures strategies / Brenda de Farias Oliveira Cardoso ; advisor: Adriana Leiras ; co-advisor: Tharcisio Cotta Fontainha. – 2024.
130 f. ; 30 cm

Tese (doutorado)–Pontifícia Universidade Católica do Rio de Janeiro, Departamento de Engenharia Industrial, 2024.
Inclui bibliografia

1. Engenharia Industrial – Teses. 2. Desastre. 3. Cadeia de suprimentos. 4. Revisão sistemática da literatura. 5. Modelagem de equações estruturais. I. Leiras, Adriana. II. Fontainha, Tharcisio Cotta. III. Pontifícia Universidade Católica do Rio de Janeiro. Departamento de Engenharia Industrial. IV. Título.

CDD: 658.5

Acknowledgements

To God and the Blessed Virgin, for allowing all of this to happen. Throughout my life. They have always been the greatest teachers.

I would especially like to thank my mother, Rita de Cássia Farias, who was the biggest supporter of my studies and my biggest motivation to get here. To her, who, besides being a mother, is my greatest example of courage and determination. I would also like to thank my sister, Bruna de Farias, for her unconditional support during these years and for making me believe that she could do it. They made me recognize strengths I didn't even know existed.

To my husband, Nilton Junior Viana, I thank you for your affection, love, patience and, above all, understanding. On countless occasions, he was the one who gave me the courage to continue following. My eternal gratitude for understanding all my moments, difficulties, absences and stresses. Your tireless support was definitive in many moments during these years.

To my entire family: father, grandparents, uncles, cousins and relatives, I thank you immensely for your continued encouragement.

I am incredibly fortunate to have friends like Gabriella, Ana Paula, Paula, Lorena, Evelyze, Jamile, Letícia, and Paloma, who have always showered me with love and support, even from a distance. For over 20 years, they have been an integral part of my life's most cherished moments. I am also grateful to friends like Luiza, Fabíola, Maria Angélica, and Andrei, who have

lightened my journey, sharing my anxieties and celebrating my achievements.

I want to thank, in a very special way, Professor Adriana Leiras for accepting the guidance of this work, in addition to her support, availability, patience and, above all, encouragement during all these years since her master's degree. I am also grateful for the opportunities provided during this period: publications, research projects, extension projects, guidance, and participation in national and international conferences.

I would also like to thank my co-supervisor, Tharcisio Fontainha, for the affection and friendship we have established over the years and whose participation was essential for carrying out this work, always guiding me along the best path. To him, who, in addition to being a co-supervisor, became a friend for whom I have total admiration.

I extend my heartfelt thanks to PUC-Rio and HANDs Laboratory for their invaluable assistance. I am also deeply grateful to the professors who have significantly contributed to the completion of this and other works during my postgraduate studies: Marcio Thomé, Vitor Martins, Hugo Yoshizaki, Irineu Brito, Paulo Gonçalves, and Patrícia Cardoso. I am particularly indebted to Professor Mariana Carneiro, whose unwavering support since my graduation has been instrumental in my pursuit of higher education.

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Abstract

Cardoso, Brenda de Farias Oliveira; Leiras, Adriana (advisor); Fontainha, Tharcisio Cotta (coadvisor). **Disaster impacts on supply chains and countermeasures strategies.** Rio de Janeiro, 2024. 130p. Tese de Doutorado – Departamento de Engenharia Industrial, Pontifícia Universidade Católica do Rio de Janeiro.

The impact of disasters causes disruptions in the flow within supply chains (SCs) and negatively affects operations' performance. Therefore, companies need to implement effective proactive and reactive strategies to minimise the impacts caused by these events. This thesis aims to contribute to developing prepared and responsive SCs to deal with disaster impacts. The research adopts the systematic literature review and survey methods. In the review phase, it is possible to highlight the descriptive analyses of publications through a bibliometric analysis, as well as content analysis of the documents. The main results of this phase are the elaboration of a taxonomy, a research agenda, and a framework. The taxonomy, specifically, presents the main disaster impacts on SCs (e.g., price instability) and the respective countermeasure strategies that were categorised into reactive (e.g., virtual markets) and proactive (e.g., digitalisation). The results of the literature review are insights for the development of the survey. Using structural equation modelling on survey data from Brazilian professionals, the model assesses whether the impacts of disasters negatively affect SC performance and also the role of digitalisation and localisation in minimizing the impacts of disasters. In general, the research results indicate that there is a negative impact of disasters on the SCs and that digitalisation and localisation have a moderating effect on the relationship between the main constructs. The evaluation of other proactive strategies and the development of mathematical models to evaluate the topic are suggested as future research.

Keywords

Disaster, supply chain, systematic literature review, structural equation modelling

Resumo

Cardoso, Brenda de Farias Oliveira; Leiras, Adriana (advisor); Fontainha, Tharcisio Cotta (coadvisor). **Impacto de desastres em cadeia de suprimentos e estratégias de contramedida.** Rio de Janeiro, 2024. 130p. Tese de Doutorado – Departamento de Engenharia Industrial, Pontifícia Universidade Católica do Rio de Janeiro.

Os impactos de desastres causam perturbações no fluxo das cadeias de suprimentos (CS) e afetam negativamente o desempenho das operações. Portanto, as empresas precisam implementar estratégias proativas e reativas eficazes para minimizar esses impactos. Esta tese visa contribuir para o desenvolvimento de CS preparadas e responsivas para lidar com os impactos dos desastres. A pesquisa adota os métodos de revisão sistemática da literatura e *survey*. Na fase de revisão, é possível destacar as análises descritivas através de uma análise bibliométrica, bem como a análise de conteúdo dos documentos. Os principais resultados são a elaboração de uma taxonomia, uma agenda de pesquisa e um *framework*. A taxonomia, especificamente, apresenta os principais impactos de desastre (ex.: instabilidade de preços) e as estratégias de contramedidas categorizadas em reativas (ex.: mercados virtuais) e proativas (ex.: digitalização). Os resultados da revisão são *insights* para o *survey.* Utilizando modelagem de equações estruturais com profissionais brasileiros, o modelo avalia se impactos de desastres afetam negativamente o desempenho de CSs e também o papel da digitalização e localização na minimização desses impactos. Em geral, os resultados indicam que há impacto negativo de desastres nas CS e que digitalização e localização têm efeito moderador na relação entre os principais construtos. Em pesquisas futuras, sugere-se a avaliação de outras estratégias proativas e também o desenvolvimento de modelos matemáticos para avaliar o tema.

Palavras-chave

Desastre, cadeia de suprimentos, revisão sistemática da literatura, modelagem de equações estruturais

Summary

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1 Introduction

Disaster is defined as a serious disruption of the functioning of a society, which involves human, material, economic or environmental impacts, and exceeds the capacity of the affected society to cope using its own resources (UNISDR, 2009). Climate-related disasters (e.g., floods, droughts, earthquakes, hurricanes) and human-made disasters (e.g., wars, conflicts, and refugee crises) impact communities and nations around the world (Leiras et al., 2014). In 2022, 387 disasters were recorded worldwide, with 30,704 lives lost, 185 million people affected, and economic damage of approximately US$ 223 billion. The total number of disasters in 2022 is higher than the average for 2002 to 2021 (EM-DAT, 2023).

Disasters are frequent causes of supply chain (SC) disruptions (Ivanov and Dolgui, 2021; Kazancoglu et al., 2022). SC disruptions impact the normal flow of materials in SCs (Chakraborty et al., 2020). SCs are sensitive to these disruptions, which have a strong impact on their performance (Laguir et al., 2022).

SC operational performance is related to effectiveness (high level of service) and efficiency (low costs) during the execution of SC processes (Ivanov et al., 2013). In an organization, operational performance is comprised of products delivered on time, product quality, capacity utilization, and low rate of waste in processes and inventories, all of which are difficult to control under uncertainty (Laguir et al., 2022).

In this context, SC management seeks to improve performance through the effective use of resources and capabilities, thus creating a coordinated SC (Maestrini et al., 2017). Thus, companies clearly need to focus on internal and external capabilities in order to more easily circumvent disruptions (Laguir et al., 2022). In this context, different organisational theories are inserted, such as the theory of dynamic capabilities view (DCV) and the theory of organizational changes (ORC).

DCV theory is related to the company's ability to integrate, build and reconfigure internal and external competencies to deal with rapidly changing environments (Teece et al., 1997). ORC theory, in turn, concerns the organisation's readiness for change, which refers to the shared resolution among organization members (Weiner, 2009). Therefore, regarding the disaster context, DCV and ORC theories are relevant to examine how companies can coordinate their capabilities and plan changes to ensure the continuity of SCs and maintain operational performance (Ruel and El Baz, 2023).

The occurrence of disasters highlights that preparedness elements need to be considered in SC management, including coordinating inter-organisational business practices to ensure SC readiness, responsiveness, and performance (Khurana et al., 2021). Therefore, companies must develop capacity to deal with disaster impacts (Laguir et al., 2022).

Still, the companies need to have a high level of readiness and rapid response and recovery capacity (Chowdhury et al., 2013). Therefore, companies must develop solutions to address the problems that occur in SC structures (Kazancoglu et al., 2022) through the implementation of effective strategies to minimise disaster consequences (Boyacı-Gündüz et al., 2021), such as proactive and reactive strategies.

Proactive strategies are implemented to avoid future disruptions (Coopmans et al., 2021; Darmawan, 2024). Proactive strategies are predefined plans to respond quickly to a disaster (Ali et al., 2021). One can cite, for example, technology-driven proactive strategies that depend on the development of technical infrastructures, such as digital connectivity through high connectivity between SC links and processes (Belhadi et al., 2021). Localisation, that is, when supply and processing are located in the same region to meet local demand and reduce the globalization of the SC is also a proactive strategy (Belhadi et al., 2021).

On the other hand, reactive strategies are focused on mitigating immediate disruptions caused by the disasters (Coopmans et al., 2021; Darmawan, 2024). Reactive strategies are changes implemented after a disaster to maintain performance under varying circumstances (Coopmans et al., 2021). Examples of reactive strategies involve the development of

virtual marketplaces for delivering the products and services, and collaboration between companies to meet shared objectives of recovery and support each other to mitigate disruption impact (Coopmans et al., 2021).

Proactive and reactive strategies are in the SC risk management contrext. The increased risk of disruptions represents a trend and challenge that will affect SC design and planning in the coming years (Darmawan, 2024). Therefore, SC risk management has received increasing attention in SC research (Chakraborty et al., 2020; Munim et al., 2022; Fan et al., 2023), and disruption mitigation strategies have attracted increasing attention from decision-makers (Fan et al., 2024).

Although research related to the topic has grown, there is still a lack of research that considers the identification of proactive and reactive strategies to deal with SC interruptions (Boyacı-Gündüz et al., 2021; Darmawan, 2024). It is important to highlight that these strategies are essential for SCs to cope with disruption risks (Fan et al., 2023) and achieve the expected performance (Laguir et al., 2022). In this context, this thesis seeks to shed light on the following research question: *How can SCs prepare to deal with disaster impacts considering proactive and reactive response strategies?*

1.1 Research topics and objectives

Considering the relevance of the topic, the main objective of this research is to contribute to the development of prepared and responsive SCs to deal with disaster impacts. In this sense, this research considers paper-based thesis approach. The paper-based thesis encompasses a set of academic papers developed through the doctoral period (Kubota et al., 2021). The research question and objective motivated the three papers in this thesis.

Firstly, the research considers a systematic literature review (SLR) to identify the state of the art concerning the topic. In this stage, two papers are developed (**Paper 1** and **Paper 2**). Subsequently, an empirical study contributes to identifying the role of proactive strategies to reduce the impacts of disasters on SCs performance. The empirical study is developed through a survey with Brazilian SC professionals (**Paper 3**).

Paper 1 is published in the Brazilian Journal of Operations & Production Management (Cardoso et al., 2022). Paper 2 is published in the International Journal of Logistics Research and Applications (Cardoso et al., 2023). Paper 3 will be submitted after the thesis defence.

Although not directly linked to the thesis, we have still published a paper with greater detail on the impact of the COVID-19 pandemic on food SC (Cardoso et al., 2021). This study brings insights for academics and professionals on the impacts of disasters on food SC and appropriate policies to mitigate them. The main results present a taxonomy, a framework (causal loop diagram) and a research agenda.

Table 1 illustrates the thesis structure, considering the primary and secondary objectives, research questions, and methodology adopted in each paper.

Table 1 – Thesis summary

Main research question	How can SCs prepare to deal with disaster impacts considering proactive and reactive response strategies?		
Main objective	Contribute to the development of prepared and responsive SCs to deal with disaster impacts		
Secondary Research questions	What are the characteristics of publications about the disasters' impact in SC and countermeasures strategies?	1. What are the major disasters' impacts on SCs and the countermeasure strategies? 2. How can we synthesise the impact assessment of SCs, considering the impacts and countermeasure strategies?	1. Do disasters' impacts negatively affect SC? 2. Do digitalisation and localisation mitigate the disasters impacts on SC performance?
Secondary Objectives	Present an overview of the main characteristics of publications on the topic	Identify and theoretically relate the major adverse disaster impacts on SCs and the countermeasure strategies to mitigate the negative effects on SC performance	Analyse the effect of digitalisation and localisation on the relationship between disruption impacts and SC performance in Brazil
Methodology	SLR (descriptive analysis)	SLR (content analysis)	Survey and Structural equation modelling
Deliverable	Bibliometric Analysis	Taxonomy; Framework Research agenda	Hypothesis testing
#	**PAPER 1**	**PAPER 2**	**PAPER 3**

1.2 Contribution originality, relevance, non-triviality, and limitations

The research has academic and practical contributions. The first part of the research (Papers 1 and 2) considers a SLR to identify the state of the art concerning the topic. Then, an empirical study (Paper 3) support to understand the opinion of professionals who work in practice on the relationship between the analysed constructs.

Specifically, the SLR (Papers 1 and 2) contributes to understanding the topic on academic literature. Paper 1 presents descriptive results through a bibliometric analysis, as well as initial results regarding disaster impacts and countermeasure strategies. Paper 2 deepens the literature content analysis and identifies the main impacts of disasters on the SC and the respective countermeasure strategies.

The empirical study (Paper 3) addresses the role of proactive strategies (i.e., digitalisation and localisation) in the relationship between disaster impacts and SC performance. The survey considers the opinion of Brazilian practitioners (e.g., SC managers, SC directors, and SC supervisors) to obtain adequate answers. The analysis of the results considers the structural equation modelling (SEM). Research using SEM in the area of disaster operations management is still scarce (Cardoso and Silva, 2022).

Thus, this research offers a logical sequence of methodological procedures so that there is a connection between the objectives, considering the following phases, as indicated by Kubota et al. (2021):

- Literature review (bibliometric/descriptive analysis)
- Literature review (content analysis and conceptual framework development)
- Empirical research (exploratory stage)
- Empirical investigation (confirmatory stage)

In this way, the multi-methodological approach contributes to the non-triviality of the research. In this approach, the same research problem can be studied using different methods and perspectives to verify and validate research results and conclusions. Moreover, Choi et al. (2016) argue that a multi-methodological approach contributes to developing scientifically sound, rigorous and relevant studies.

Considering the typologies proposed by Creswell (2021) for mixed methods, this research is characterized as a sequential exploratory design. In sequential exploratory design, results from the qualitative component can be used to develop insights for the subsequent quantitative component. Qualitative data is analysed, in part, with the intention of creating conceptual domains or dimensions that can be considered for the quantitative phase (Creswell, 2021).

The literature related to the topic points out that it is necessary to understand the impacts of disasters (Belhadi et al., 2021) as well as strategies that minimize the adverse effects of disasters in SCs (Boyacı-Gündüz et al., 2021). Furthermore, the literature also suggests the development of new models or structures related to disasters in SCs to improve decision-making in companies (Magableh, 2021). In this case, the results found in the literature brings some insights for the elaboration of the subsequent quantitative study.

Based on this evidence, the originality and non-triviality of the thesis are observed through the contribution to the theory and practice. The research is worked on an in-depth analysis of the relationship between impacts and strategies, delivering taxonomies and conceptual models (Papers 1 and 2). Also, we developed a structural model empirically validated (Paper 3). With the empirical data collected, analyses are performed, covering gaps in the literature and quantitatively investigating the relationships between the constructs.

Regarding the research limitations, the theoretical model developed in the SLR (Paper 2) is based on papers retrieved from Scopus and Web of Science databases. In this sense, not considering grey literature (e.g., reports and sites) may imply publication bias regarding initiatives in the early stages of development or alternative publishing channels (Thomé et al.,

2016). Also, the theoretical model developed in the SLR (Paper 2) is general and does not specify the type of disaster (climate-related or human-made).

Still, the model proposed in the empirical study (Paper 3) considers a limited number of proactive strategies (i.e., digitalisation and localisation). Still in this context, it is also noteworthy that all the constructs used in the model have scales or items already validated in the literature and, therefore, no new scales were created and validated.

1.3 Thesis structure

This thesis is structured in seven chapters. The first chapter provides the introduction to the research topic, research questions, objectives, originality, relevance, research non-triviality and limitations. Chapter 2 comprises the research methodology. The following chapters exhibit the papers that compose this thesis. Therefore, Chapter 3 presents the SLR, specifically, the bibliometric analysis (Paper 1), Chapter 4 is the SLR that addresses content analysis (Paper 2), and Chapter 5 discusses the empirical study (Paper 3). Chapter 6 provides the discussion and main thesis contributions. Finally, Chapter 7 provides the final considerations and suggestions for future research.

2
Research methods

This chapter presents the multi-methodological procedures used in the research. Multi-methodological Operations Management (OM) research is an approach in which at least two distinct OM research methods (e.g., analytical modelling, quantitative empirical, survey, and case studies) are employed to meet the research goals (Choi et al., 2016). To achieve the research objectives and answer the research questions, we used a SLR and survey.

In this thesis, we consider the following stages, according to Kubota et al. (2021):

(i) Literature review: bibliometric/descriptive analysis (**Paper 1**);

(ii) Literature review: content analysis and conceptual framework development (**Paper 2**);

(iii) Empirical research – exploratory stage (**Paper 3**);

(iv) Empirical investigation – confirmatory stage (**Paper 3**).

It is worth mentioning the need to present a logical sequence in the methodology and procedure applied in the research. Therefore, it is necessary to connect and align the methodological procedures applied in each of the papers (Kubota et al., 2021). We used a SLR (Phase 1 and Phase 2) and a survey with data analysis through SEM (Phase 3 and Phase 4) to achieve the objectives and answer the research questions.

Figure 1 presents the summary of the research methods, chapters and deliverables of the studies.

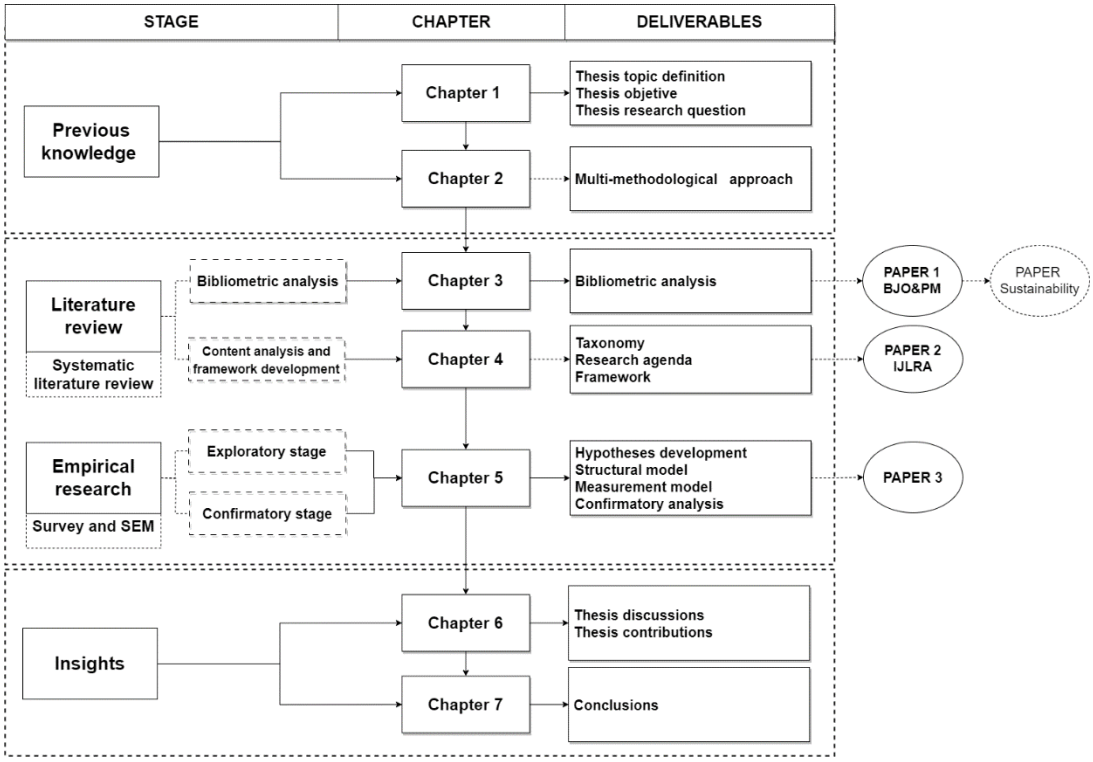

Figure 1 – Research methods, chapters and deliverables

2.1 Systematic Literature Review

SLR is a research method used in several areas of research that, among others, has the objective of reviewing, updating, criticizing and improving knowledge on a specific topic (Torraco, 2016). SLR identifies the strengths and weaknesses of a given subject, as well as existing gaps and contradictions (Torraco, 2016).

The SLR developed in this research adapts the steps proposed by Thomé et al. (2016). The steps to carry out the search are described below: (i) planning and problem formulation, (ii) literature search, (iii) data gathering, (iv) quality evaluation, (v) data analysis and synthesis, (vi) interpretation, and (vii) presenting the results. The search steps are detailed in each Paper.

Generally, considering the scope of the thesis, in **Paper 1**, we adopted SLR to develop a bibliometric analysis, offering an overview of the main characteristics and trends of publications. The bibliometric analysis provides a quantitative way of dealing with the literature on a particular topic and provides an overview of the research patterns (Zupic and Cater, 2015). Regarding **Paper 2**, we consider the content analysis of the documents. The content analysis consists of techniques

related to the systematic interpretation of texts and can be performed qualitatively or quantitatively. The content analysis allows for identifying and categorising the essential points for interpreting the results (Seuring and Gold, 2012).

The literature search considers two databases: Scopus and Web of Science (WoS), due to the capacity for complementarity between journals indexed in the two databases (Thomé et al., 2016; Mongeon and Paul-Hus, 2016).

In **Paper 1,** the data analysis was done by using the Bibliometrix tool (Aria and Cuccurullo, 2017). The results consist of data related to publication characteristics and specificities such as the evolution of publications per year, trend topics, journals, authors, papers more cited, keywords co-occurrence, disasters, SC type, and preliminary identification of disaster impacts and countermeasure strategies.

In **Paper 2,** data analysis is organised using a conceptual matrix (vom Brocke et al. 2009; Thomé et al. 2016). A conceptual matrix is developed using auxiliary spreadsheets. It organises the data into rows and columns to identify the essential elements for analysing the results (i.e., impacts, proactive and reactive strategies, models or frameworks, and SC topics). The results present a taxonomy (Appendix A and Appendix B) featuring inductive analysis based on a complete reading of the documents selected through the SLR; the research agenda based on identifying research gaps that open up new opportunities for future studies; and a framework to summarise explanations and predictions and support propositions.

Further details of the adopted method and results can be found in Chapters 3 and 4.

2.2 Survey

The survey method aims to contribute to knowledge in a particular area of interest, collecting data and information about individuals and narrowing the distance between theory and practice (Miguel et al., 2012). Considering the scope of this thesis, the application of the method is adapted based on the stages of Forza (2002): theory-relationship, design, pre-test, data collection and data analysis. The survey method is applied in **Paper 3**.

In the theory-relationship stage, the constructs are based on Paper 2. The measures used in the model were adapted from instruments validated in the existing literature on the subject. We use four constructs: disaster impacts, digitalisation, localisation and SC performance.

The questionnaire (Appendix C) is developed in the design stage, considering the literature on the impacts of disasters on SCs. The questionnaire is divided into two blocks: descriptive information and model items. Descriptive information relates to the sector, position within the company, scope of the company, and years of experience. Questions about model items are based on items previously established in the literature for the constructs. Appendix D presents the constructs, items, and respective references.

In the pre-test stage**,** two academics and four SC managers evaluated and tested the instrument to ensure that all measurement items were understandable. Then, the proposed improvements were applied, and the instrument was e-mailed to the SC practitioners with a letter presenting the study's objective.

Data collection took place virtually through the Survey Monkey platform. The sample is composed of SC professionals from Brazil. In data analysis, we used SEM. SEM allows researchers to simultaneously model and estimate complex relationships between multiple dependent and independent variables. Constructs are considered unobservable and measured by multiple indicators. When estimating relationships, SEM considers the measurement error in the observed variables (Hair et al., 2021).

We used structural equation modelling (SEM) using the partial least squares (PLS-SEM), in the Smart-PLS version 4.1.0.0 software. The PLS algorithm is relevant to evaluate models with multiple construct interactions (Sarstedt et al., 2020). Also, PLS-SEM offers a flexible approach to investigate models with constructs about which there is relatively insufficient theoretical knowledge or at an exploratory stage (Jabbour et al., 2021; El Baz and Ruel, 2012). We analysed the model considering convergent validity, internal consistency, discriminant validity, moderation analysis, and hypothesis testing (Hair et al., 2021).

Further details of the method and results can be found in Chapter 5.

3
Disasters' impact on supply chains and countermeasure strategies: an overview of the academic literature' nature

This chapter presents Paper 1 (Cardoso et al., 2022), which was published in the Brazilian Journal of Operations & Production Management (BJO&PM). BJO&PM copyrights show that the first authors can use the paper in their thesis (Appendix D).

This paper presents a bibliometric analysis of the topic in question. This bibliometric analysis allows us to identify the characteristics of the academic literature, which involves analysis of the evolution of publications per year, largest sources of publication, trending topics, authors who publish the most, and map keywords. It is also possible to identify previous results related to the most analysed type of disasters, as well as the initial identification of disaster impacts and countermeasure strategies on the supply chains. It is worth noting that this paper does not consider grey literature, as the scope is to analyse academic literature, that is, documents indexed in academic journals.

3.1 Introduction

Supply Chain (SC) disruptions are caused by unplanned events that interrupt the normal flow of materials and information within an SC (Craighead et al., 2007; Bier et al., 2020). Such disruptions can be caused by disasters or fluctuations in the regular operations of the supply chain (Bier et al., 2020; Singh et al., 2020). For instance, in 2020, 389 disasters affected 98.4 million people worldwide and cost US$ 171.3 billion (CRED, 2021).

During disasters, SCs face impacts such as instability in production and inventory (Lim and Tam, 2018), transportation disruption (Davies et al., 2017), supply and demand fluctuation (Pratama et al., 2021), damage to premises,

equipment, and vehicles (Asgary, 2012), and coordination problems (Cardoso, 2021; de Oliveira et al., 2020). Being prepared for such disruptions is challenging; however, it is possible to mitigate the eventualities through contingency plans and effective strategies to increase SC responsiveness (Abe and Ye, 2013; Boyacı-Gündüz et al., 2021; Cordeiro et al., 2021a).

These SC strategies involve activities that are fundamental to the normal flow of the operation, such as strategic purchases (Lamenza et al., 2019), social media and digital platforms (Cordeiro et al., 2021b; Eckhardt et al., 2022), information sharing (Ding et al., 2021), and collaboration with stakeholders (Cundell et al., 2020).

Considering that disasters represent a relevant impact on SCs and societies (Singh et al., 2020), this paper aims to investigate the academic literature's nature on the disasters' impacts on SC and countermeasure strategies. Thus, the research adopted a Systematic Literature Review (SLR) to develop a bibliometric analysis, offering an overview of the main characteristics and trends of publications. The bibliometric analysis provides a quantitative way of dealing with the literature on a particular topic. In addition, some bibliometric analysis tools provide an overview of the research patterns (Zupic and Cater, 2015).

The paper is organized as follows. After this introductory section, Section 2 presents the research methodology used in this study. Next, Section 3 shows the results obtained through the bibliometric analysis. Finally, Section 4 presents the conclusions, limitations, and future research directions.

3.2 Methodology

The SLR is a research method used to review, update, criticize and improve knowledge on a specific topic, identifying the strengths and weaknesses of a given subject, as well as existing gaps and contradictions (Torraco, 2016).

This research applies the eight steps for an SLR proposed by (Thomé et al., 2016), which are described as follows:

1. Planning and formulating the problem: The SLR intends to answer the research question: What are the characteristics of publications on the disasters' impact on SC and SC strategies?

2. Searching the literature: the research considers the bibliographic search in the Scopus and Web of Science (WoS) databases to reduce the source bias (Thomé et al., 2016). The search considers three keywords' groups (Figure 2) to search titles, abstracts, and keywords. Group 1 focuses on the SC. Group 2 brings SC impacts and related strategies, policies, and practices. The W/5 and NEAR/5 are proximity operators used to specify the maximum number of words that separate terms. In this case, the words from groups 1 and group 2 must be joined in a set of 5 words. Group 3 encompasses disasters terminologies based on (IFRC, 2021) and (CRED, 2009).

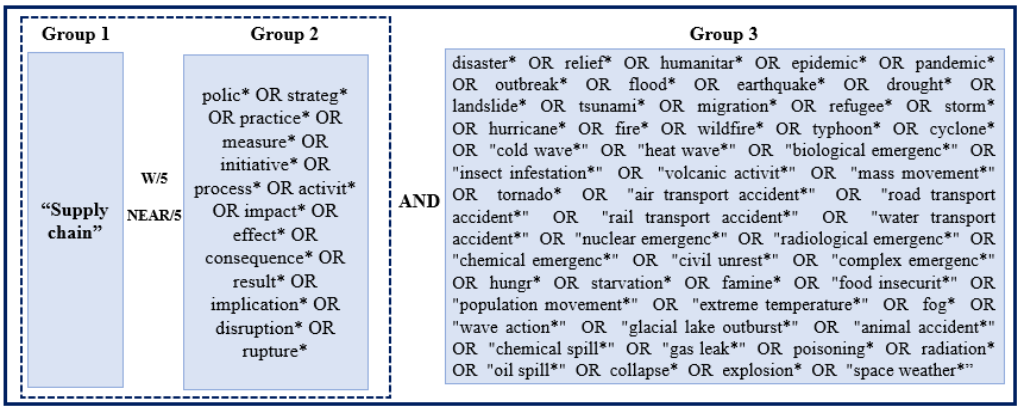

Figure 2 – SLR Keywords.

The search returned 2,516 documents on July 6, 2021. After that, we adopted a filter to remove duplicated abstracts in the two databases and documents in languages other than English. Then, the abstracts were analysed according to the following inclusion and exclusion criteria. Figure 3 summarizes the SLR.

- Inclusion criteria: papers discussing the disaster's impacts on SCs; papers presenting countermeasure strategies for SCs disruptions caused by disasters.
- Exclusion criteria:
  - Abstracts reading: research outside the context of disasters; research that does not identify disaster impacts on the SCs; research that does not identify strategies to minimize these impacts.
  - Full-text reading: disruptions in the SCs not caused by a disaster (e.g., lack

of raw materials); does not identify disaster impacts in the SCs (e.g., environmental impacts); mathematical models (e.g., facility location, profit maximization); methodologies to support logistical activities.

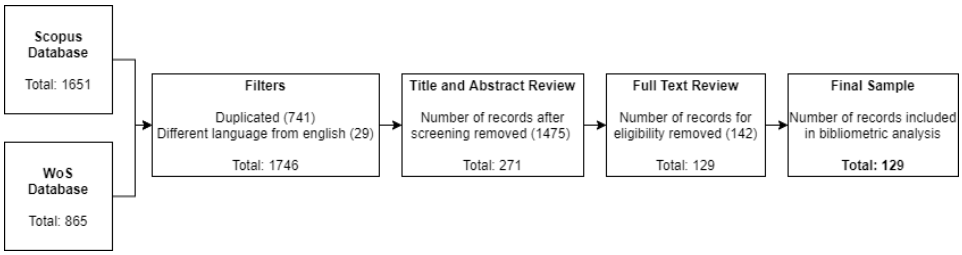

Figure 3 – Searching the literature

3. Data gathering: the research identifies and compiles data related to publication characteristics and specificities such as the evolution of publications per year, trend topics, journals, authors, papers more cited, keywords co-occurrence, disasters, SC type, and preliminary identification of disasters' impacts and countermeasure strategies;

4. Quality evaluation: the research provides a detailed description of the SLR to ensure quality evaluation. Moreover, two researchers are responsible for reviewing the selected documents, and they obtained an acceptable agreement index of 94,9% (Krippendorff, 2018).

5. Analysis and synthesis: the research perform a bibliometric analysis using the Bibliometrix package of the "R" software, VOSviewer software, and descriptive analysis of the findings.

6. Interpretation of the results: the paper discusses the consequences of the findings for the topic of disasters' impact on SC and SC strategies;

7. Presentation of the results: the research describes the results within this paper;

8. Updating the review: the research suggests the update of the SLR as future research.

3.3 Results and Discussions

The analysis of the document type reveals that 75% of them are articles, 8% are conference papers, and 7% are reviews. The other documents are divided into notes, proceedings papers, short surveys, and other publications. Figure 4 presents the evolution of the number of publications per year.

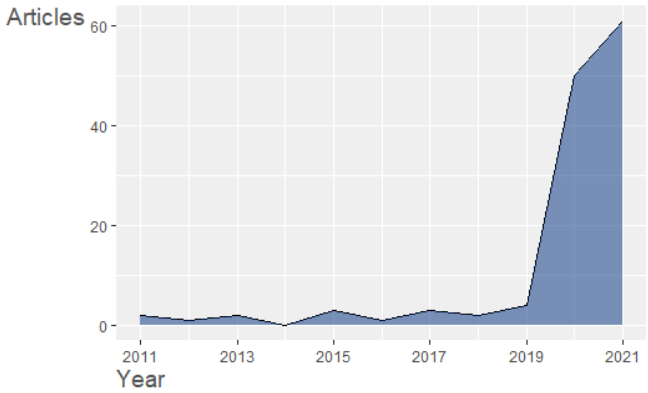

Figure 4 – Publications per year

Source: Designed from Bibliometrix (2021)

The high number of publications in 2021 (61 documents) can be explained by the COVID-19 pandemic - a biological disaster - which is supported by an analysis of trend topics in Figure 5.

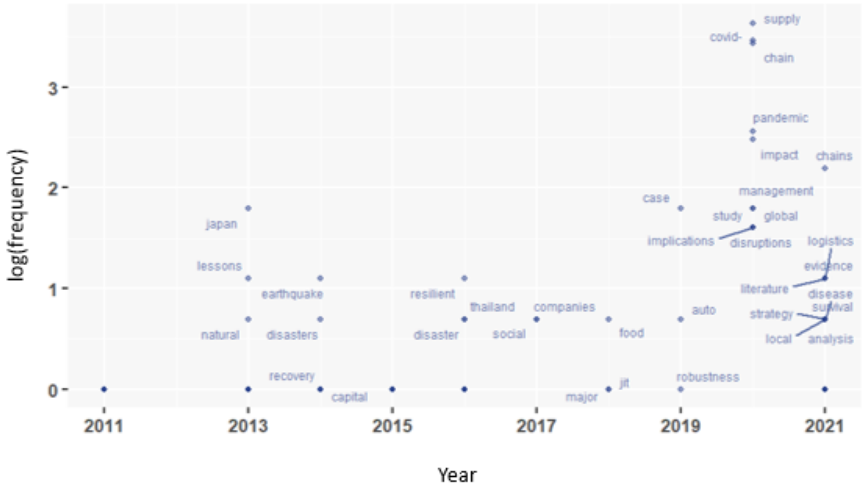

Figure 5 – Trend topics

Source: Designed from Bibliometrix (2021)

Figure 5 reveals that publications are addressing terms like “covid” and “pandemic” increased since 2020. The COVID-19 pandemic has severely impacted all SC and sectors (Singh et al., 2020), including the food SC (Bassett et al., 2021; Mahajan and Tomar, 2021; Rukasha et al., 2021), personal protective equipment (Aljadeed et al., 2021; Scala and Lindsay, 2021), medical and pharmaceutical items (Cundell et al., 2020, Miller, 2011; Bookwalter, 2021), construction sector (Assaad and El-adaway, 2021), manufacturing sector (Garlick et al., 2020; Okorie et al., 2020), automobile sector (Hsieh et al., 2016; Iwase, 2011).

In addition to the impacts on SC activities, the COVID-19 pandemic also highlighted significant social challenges, for example, food insecurity. Food demand and, consequently, food security are strongly affected due to mobility restrictions, and reduced purchasing power strongly affects vulnerable population groups (Siche, 2020).

Regarding publication sources, Table 2 indicates that the Agricultural Systems journal stands out with 4 publications. In addition to the analysis of specific journals, the topic has been addressed by journals from different areas, for example, social sciences and disaster risk reduction. These findings reinforce that the theme is multidisciplinary, considering different research perspectives.

Table 2 – Publication sources

Journal	Documents
Agricultural Systems	4
International Journal of Production Economics	3
International Journal of Disaster Risk Reduction	3
Sustainability	3
Food Control	3
Animals	2
Applied Economic Perspectives and Policy	2
Canadian Journal of Agricultural Economics	2
China Agricultural Economic Review	2
Cogent Social Sciences	2
Others	103

Concerning the authors' profile, Figure 6 shows the authors who most publish on the topic. Few authors have more than one publication, providing evidence of the low continuity of research on the theme in the area. Nevertheless, there is a continuity of publications by some authors. Also, Table 3 shows the documents with the highest number of citations in total and per year.

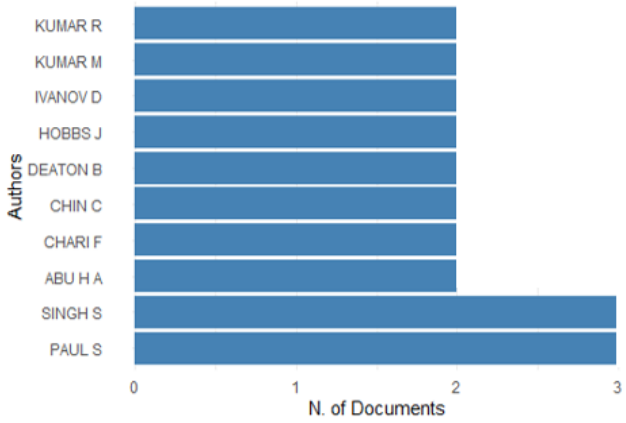

Figure 6 – Most published authors.

Source: Designed from Bibliometrix (2021)

Table 3 – Citations per author

Authors	Total	Average per year
Hobbs (2020)	166	83.0
Park et al. (2013)	119	13.2
Haraguchi and Lall (2015)	94	13.4
Siche (2020)	66	33.0
Singh et al. (2020)	59	59.0
Asgary et al. (2012)	51	5.1
Ivanov and Dolgui (2021)	43	43.0
Sharma et al. (2020)	39	19.5

About the most cited documents, Hobbs (2020) addresses the implications of COVID-19 in the food SC, involving demand-side and supply-side shocks, as well as long-term changes brought about by the pandemic. Park et al. (2013) discusses the response of manufacturing companies to disasters (earthquake, tsunami, and nuclear disaster) in Japan. The authors address the process of restoring SCs disruptions and present lessons in terms of disaster planning and responses. Haraguchi and Lall (2015) assess the impact of floods on the global

economy and propose measures related to risk in the SC.

Figure 7 presents the occurrence of the keywords related to the disasters' impacts on SC (e.g., SC disruption, panic buying, food waste, drug shortages; prices; shocks; consumer behavior) and SC strategies (e.g., agility; risk management). Besides, terms explicitly related to the food SC (e.g., food security, food system). Impacts on food SCs involve labour scarcity, price increases, and production interruptions. Also, food supply disruptions decrease the food security of the vulnerable communities (Chodur *et al*., 2018).

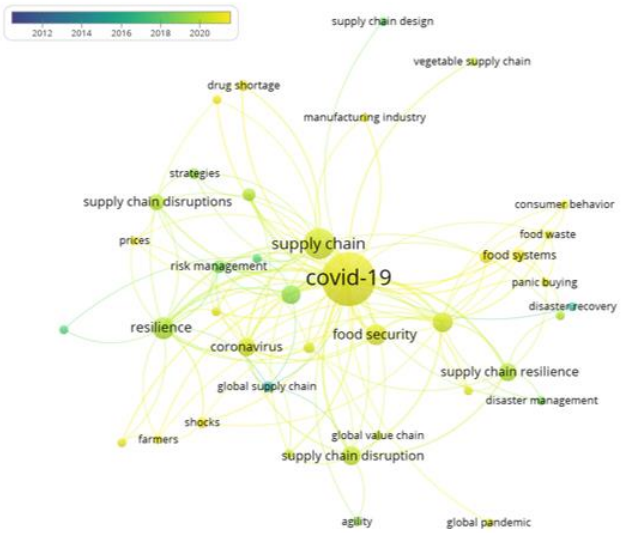

Figure 7 – Keywords map

Source: Designed from Bibliometrix (2021)

Figure 7 also highlights the temporal analysis of keywords. It is noted that before 2019 the keywords were more general in terms of the supply chain, impacts, and strategies (e.g., global value chains, disaster recovery, supply chain design, risk management, disaster management, supply chain resilience). From 2019 onwards, the keywords are related to the COVID-19 pandemic. It is noteworthy that 107 (83%) documents address the COVID-19 pandemic. The pandemic caused an unprecedented global disruption, where most companies were unprepared (Ali et al., 2021).

Figure 8 presents the disaster type covered by the documents per year. The values in parentheses represent the number of documents that deal with the disaster in a specific year (e.g., in 2013, only one document covers floods). The sum of documents is greater than 100%, as some documents address more than

one type of disaster (e.g., Gunessee et al., 2018 – that address earthquake-tsunami and flood).

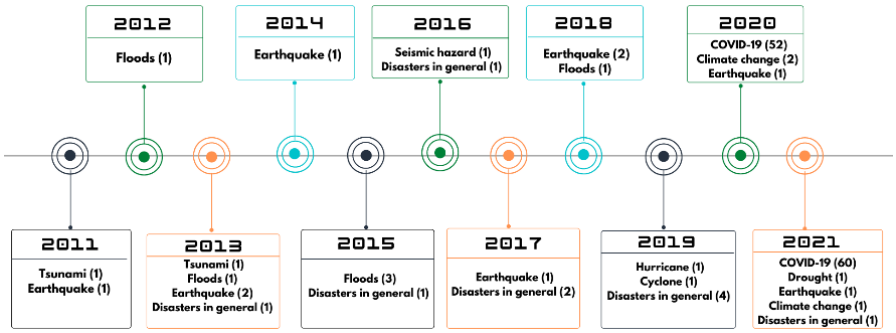

Figure 8 – Disaster type

Source: Authors (2021)

Figure 8 illustrates the frequency of occurrence of studies related to specific disasters. It is interesting to note that some disasters frequently appear in the timeline, for example, earthquakes. Earthquakes cause enormous short-term damage, negatively impacting production assets, public infrastructure, business development (Abe and Ye, 2013), roads, railways, bridges, air transport, navigation (Davies et al., 2017), electricity, and water supply (Ding et al., 2021). Some mitigation strategies highlighted are a collaboration between the public and private sectors (Abe and Ye, 2013), resilient design, interdependency planning, mutual assistance agreements (Davies et al., 2017), greater operational efficiency, cash flows optimized, and information sharing (Ding et al., 2021).

One can cite other documents that address earthquake impacts on SCs, as well as mitigation policies that are also handled by other studies (Miller et al., 2011; Park et al., 2013; Olcott et al., 2014; Gunessee et al., 2018; Lim and Tam, 2018; Hendricks et al., 2020). The high number of documents dealing with earthquakes occurs because natural disasters are highly unpredictable events, and the impacts on the SC can be significant if companies do not have sufficient resilience (Gunessee et al., 2018).

Also, Figure 7 shows that in the years 2020 and 2021, there is a significant number of documents that address COVID-19. The COVID-19 pandemic has had negative implications for commercial businesses, including restaurants, aviation, logistics, and industries. Furthermore, the pandemic negatively impacted the

employment and income of many families, global world stocks, items prices, and economic growth (Al-Mansour and Al-Ajmi, 2020). To minimize impacts on the SCs, contingency plans need to be developed. Also, it is necessary, for example, to monitor marketing and sales activities, maintain accounting and financial registers, maintain stock levels to a minimum (Al-Mansour and Al-Ajmi, 2020). Pratama et al. (2021) highlight the impacts of the COVID-19 pandemic on global SCs: operation disruption, supply and demand disruption, cash flow problem, changes in consumer behaviour, and risk of uncertainty. Mitigation strategies include financial management, digital transformation, network relationship, government policy, orientation, and information.

Figure 9 presents the SCs types most covered by the documents. The food SC is the most mentioned among the documents, which reinforces the high importance of the food SC has for developing economies (Swinnen and Vos, 2021), and the survival and health of societies (Boyacı-Gündüz et al., 2021).

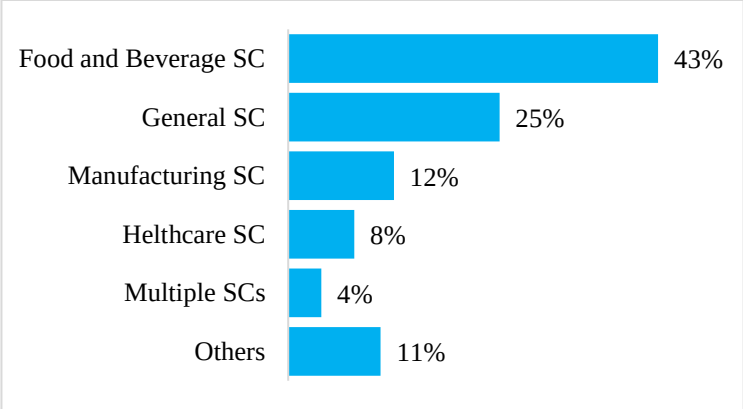

Figure 9 – SC type

Source: Authors (2021)

The COVID-19 pandemic, for example, highlighted the vulnerability of food systems in response to disasters. Some impacts are highlighted: interruptions in international trade due to movement restrictions, labour shortages, reduced productivity, the decline in production, interruptions in distribution channels, and the supply of capital inputs and services (Van Hoyweghen et al., 2021). Besides the internal impacts on the SC, the COVID-19 pandemic also represents a threat to global food security due to income loss and reduced capacity to access food

(Swinnen and Vos, 2021). Strategies that represent food SC resilience involve structure, government facilitation, and the ability of food companies to adapt to shock and changing market conditions (Swinnen and Vos, 2021).

Due to natural disasters and political risks, the manufacturing SC suffers large-scale disruptions (Okorie et al., 2020) During the COVID-19 pandemic, the negative impacts highlighted the risks of interruptions in the manufacturing SC such as time constraints, supply and demand fluctuation, complexity in repurposing product and infrastructure, human resources constraints. Business continuity strategies involve, for example, building organisational flexibility, digital technology, and benchmarking (Okorie et al., 2020).

In the healthcare SC, disasters, including pandemics, can disrupt the supply of medical and pharmaceutical products (Cundell et al., 2020). With increased global demand and disruption to transport, the COVID-19 pandemic has resulted in a shortage of drugs needed to treat illnesses, in addition to a shortage of personal protective equipment such as masks and gowns (Cundell et al., 2020). Among the strategies to minimize the impact of interruptions in the healthcare SC, we can highlight strengthening existing supplier relations, seeking alternative suppliers, and enhancing collaboration with suppliers (Cundell et al., 2020).

The automotive industry is an elaborate network that involves moving vehicles and parts from suppliers, manufacturers, wholesalers, distributors, and retailers to end customers (Hsieh et al., 2016). Lim and Tam (2018) assess the impacts of the Malaysian Kumamoto earthquake on auto industry inventories. The authors emphasize consequences such as production stoppages, inventory problems, market supply deficit, chain reaction with other suppliers, and planning issues. The strategies to minimize these impacts are strengthening the supplier-customer relationship, improving risk assessment during supplier selection, and using multiple sourcing (Lim and Tam, 2018).

The multiple SC category involves documents that address more than one type of supply chain, for example, electronic, automobile, and food SCs (Liu et al., 2020); medical, food, and manufacturing SCs (Marquez et al., 2021). Other SCs include specific SCs, for example, the construction sector (Assaad and El-adaway, 2021), vaccines (Snowdon et al., 2021), airline industries (Belhadi et al.,

2021), engineering sector (Khalfan and Ismail, 2020), tourism sector (Ngin et al., 2020), toilet paper (Paul and Chowdhury, 2020). It is essential to mention that in some documents (25%), there is no specification of the SC type; they address the SC in general.

In general, interruptions in the normal flow of activities, the high negative impact, and losses resulting from the occurrence of disasters can threaten the financial state of companies (Marszewska, 2016). The effects of disasters on operations highlight the interdependent nature of the global SC and the importance of disaster risk reduction (Abe and Ye, 2013).

SC risk management had never seemed more important than today when global SCs were heavily affected by the COVID-19 pandemic (Yang et al., 2021). Although companies with a global SC have advantages such as cost reduction, a greater variety of supplies, and access to international customers, they also face more significant uncertainties and risks and are prone to SC disruptions (Ding et al., 2016).

To reduce the impacts of disasters on SCs, operational, tactical, and strategic strategies are needed (Kim and Bui, 2019). Operational strategies must be implemented in the disaster response phase and involve, for example, effective communications, damage assessment. Tactical strategies include investing in maintenance, hardening and upgrading infrastructure, and emergency supplies. Finally, strategic strategies involve investing in pre-disaster stages (mitigation, adaptation, and planning) and building relationships with diverse stakeholders to support recovery.

3.4 Conclusion

This paper brings a bibliometric analysis of the academic literature discussing the disasters' impact on SCs and SC strategies. Based on the SLR procedures, we analyse trends in the 129 documents obtained from the Scopus and Web of Science databases, according to bibliometric aspects regarding the year, trend topics, journals, authors, papers more cited, keywords co-occurrence, disasters, SC type, and preliminary identification of disasters' impacts and countermeasure strategies.

The results reveal that disasters' impact on SCs and countermeasure strategies has been debated for some time. As of 2019, the number of publications on the subject has increased. We notice that the topic is covered by different journals and authors, making the theme dispersed in the academic field. The analysis of trend topics shows a high number of publications covering the COVID-19 pandemic. The COVID-19 pandemic is the most recent global disaster and severely affects SCs in different sectors.

Concerning the disaster type addressed by the documents, the documents that deal with natural disasters (e.g., floods, earthquakes, tsunami, and pandemics) stand out since, generally, natural disasters are unpredictable events and the impacts on the SCs can be significant for companies. Still, there is a need to assess the impacts of man-made disasters (e.g., terrorist attacks, wars, fires) to assess differences and similarities between impacts and policies considering the type of disaster.

Regarding the type of chain analysed, most documents (43%) address the food SC. This pattern shows the importance of the food chain for the economy of countries and the need to ensure the availability of food to meet demand during crises and disasters. Other SCs are also covered, such as healthcare SC, manufacturing SC, automobile SC.

Also, the bibliometric analysis allows the preliminary analysis of the documents which provides some disaster impacts on SCs: SC disruption, ripple effect, panic buying, supplies shortages, SC instability (price, inventory, supply, demand, human resources), changes in consumer behaviour, mobility restrictions, income reduction and unemployment, infrastructure constraints, transport and distribution disruption (e.g., roads and railways), services unavailability (e.g., electricity and water), production and operation disruption, business and economic decline, cash flow problems, and productivity reduction. Besides, the documents present disaster' countermeasure SC strategies: agility; risk management, a collaboration between SC links, alternative suppliers, resilient design, interdependency planning, operational efficiency, organisational flexibility, cash flows optimized, information sharing, financial management, digital transformation, government policies, orientation and information, inventory management, and benchmarking.

The findings indicate the remarkable increase of research focusing on the disasters' impact on SC and SC strategies. The results constitute a first analysis on the subject, considering that it presents descriptive characteristics of the studies, which can influence the development of more detailed and specific studies. We suggest future research incorporate existing studies in other databases. Future research may address the impact of human-made disasters on SCs. Also, future studies can analyse impacts and strategies in category format (e.g., demand-side, supply-side, infrastructure). Finally, future researchers can use tools to analyse the relations between multiple variables (impacts and strategies).

4
Looking back and forward to disaster readiness of supply chains: a systematic literature review

This chapter presents Paper 2 (Cardoso et al., 2023), which was published in the International Journal of Logistics Research and Applications (IJLRA). Taylor & Francis Group copyrights show that the first authors can use the paper in their thesis (Appendix D).

This paper presents the results of a systematic literature review to identify the impacts of disasters on supply chains and countermeasure strategies from a content analysis of the documents. The main results of this paper are a taxonomy of the impacts of disasters, classified into five categories, and the countermeasure strategies, divided into proactive and reactive strategies. Also, we propose a research agenda with the main gaps found in the literature. Finally, a conceptual framework synthesises the results found. It is worth noting that this paper does not consider grey literature, as the scope is to analyse academic literature, that is, documents indexed in academic journals.

4.1 Introduction

Supply chain (SC) disruptions are increasingly frequent owing to the growing complexity and uncertainty of global SCs (Corsini et al., 2022; Chakraborty et al., 2020; Singh et al., 2020). Specifically, SC disruptions are unplanned events that interrupt the normal flow of goods and materials (Giri and Sarker, 2017), consequently impacting organisations' operational, financial, and strategic performance (Craighead et al., 2007; Macdonald et al., 2018). Disruptions in SCs are often caused by disasters (Ivanov and Dolgui, 2021; Kazancoglu et al., 2022).

Disasters are severe disturbances due to dangerous events that cause losses and damage, affecting the functioning of a community at any scale, and

can be distinguished by the onset speed; specifically, they consist of slow-onset disasters (e.g., droughts and pandemics) and sudden-onset disasters (e.g., earthquakes and floods) (UNISDR, 2009). Different disasters have affected SCs and have significantly impacted companies (Rejeb, 2020). Many SC disruptions result from disasters (Wilson et al., 2007). For example, the 2016 earthquake in Japan resulted in low profitability for companies owing to labour shortage (Park et al., 2013); the 2017 cyclone in Australia disrupted roads, railway systems, and bridges, causing transport interruption (Lenzen et al., 2019); and the COVID-19 pandemic made it challenging to supply the necessary inputs for production such as fertilisers, machinery, and workers (Sid et al., 2021; Cardoso et al., 2021). Considering the growing concern in recent years regarding business continuity in the face of disasters, the activities of SCs amid disruptions have received attention from practitioners and academics to enrich and improve SC readiness (Ali et al., 2021; Raj and Srinivas, 2019; Chakraborty et al., 2020; Kaur and Singh, 2020; Ivanov and Dolgui, 2021).

SC readiness approaches include SC resilience (Farrell et al., 2020; Van Hoyweghen et al., 2021), SC robustness (Khurana et al., 2021; El Baz and Ruel, 2021), SC stability (Boyacı-Gündüz et al., 2021; Al-Mansour and Al-Akmi, 2020), SC viability (Chari and Ngcamu, 2019; Ivanov and Dolgui, 2021), SC responsiveness (Kazancoglu et al., 2022), SC flexibility (Ivanov and Dolgui, 2021; Kazancoglu et al., 2022), SC agility (Liu et al., 2020; Kazancoglu et al., 2022), SC survivability (Baral et al., 2021; Sharma et al., 2022), and SC visibility (Mubarik et al., 2021). The occurrence of disasters has highlighted that these elements need to be considered in SC management, including coordinating inter-organisational business practices to ensure SC readiness and responsiveness (Khurana et al., 2021).

In this context, SC performance during disruptions depends on the management and implementation of appropriate practices (Gao et al., 2019b; Ali et al., 2021). Therefore, companies must develop solutions to address the problems that occur in SC structures (Kazancoglu et al., 2022). Then, contingency planning and implementation of effective strategies must be ensured to minimise disaster consequences (Olivares-Aguila e ElMaraghy, 2020; Boyacı-Gündüz et al., 2021). Such strategies consist of proactive and reactive actions

that are designed to respond to disasters. Proactive strategies are implemented before a disaster strikes to prevent and mitigate adverse effects (Belhadi et al., 2021; Coopmans et al., 2021), whereas reactive strategies are executed during or after a disaster occurs to adjust operations (Belhadi et al., 2021; Coopmans et al., 2021; Corsini et al., 2022).

To establish readiness to face disruptions, SC managers need to understand the extent of impacts, formulate proactive or reactive strategies, and reconfigure resources to strengthen capabilities and adapt to the ensuing effects (Cardoso et al., 2021; Norwood and Peel, 2021; Belhadi et al., 2021). It is worth mentioning that an interruption's impact often causes a ripple effect on SCs (Priore et al., 2019; Kek et al., 2022; Sawik, 2022; Scarpin et al., 2022). Thus, there is a need to understand how SCs can prepare and maintain disaster-response plans (Queiroz et al., 2020). Nonetheless, determining effective response strategies for each type of impact and aligning the activities of all SC links remain difficult (Salimi et al., 2020; Belhadi et al., 2021). Furthermore, considering these gaps, this study aims to simultaneously identify and relate the major impacts of disasters on SCs and countermeasure strategies to mitigate the negative effects on SCs.

Therefore, we seek to shed light on the following research questions:

1. What are the major disasters' impacts on SCs and the countermeasure strategies?
2. How can we synthesise the impact assessment of SCs, considering the impacts and countermeasure strategies?

This study involves an exhaustive compilation of data and information through a systematic literature review (SLR) of scientific documents. We deliver a taxonomy, framework, and research agenda, which are some of the fundamental SLR deliverables defined by Torraco (2016). The theoretical basis of this research is established around the theories that support a SLR (Seuring et al., 2020; Durach et al., 2021): the dynamic capabilities view (DCV) and organisational readiness for change (ORC).

DCV theory describes and captures an organisation's ability to acquire, integrate, and recombine resources to better adapt to changes in the external

environment (Teece et al., 1997). ORC theory contributes to defining the determinants and outcomes of readiness for organisational change, which leads to increased performance (Weiner, 2009). In this study, proactive and reactive strategies are perceived as dynamic capabilities and readiness determinants that allow companies to better manage SC disruptions and maintain high performance. Thus, the DCV and ORC constitute the theoretical anchors for this study. The use of theories corroborates previous studies (Denicolai et al., 2021; El Baz and Ruel, 2021; Ruel and El Baz, 2021; Laguir et al., 2022) that also present potential solutions for companies to prepare themselves to deal with disaster impacts on SCs (e.g., SC risk management practices).

This study makes both theoretical and practical contributions to the literature. From a theoretical perspective, this study contributes to the literature in a number of ways. First, the study expands the literature on the impact of disasters on SCs and associated countermeasure strategies. Second, the study provides a framework for synthesising the different findings across the literature with insights based on the literature on how to improve SC readiness and responsiveness. Third, the study identifies research gaps and proposes future avenues for innovative research. From a practical perspective, the study also offers valuable insights to organisations and practitioners. The main findings of this study can support organisations in reformulating their strategies to deal with disaster situations and survive in the long term. Our findings will encourage organisations to implement strategies to minimise and manage disaster impacts and, consequently, support the implementation of resolution processes during disasters.

The remainder of the paper is organised as follows: Section 2 addresses the research methodology. Section 3 presents the literature analysis and taxonomy. Section 4 presents the research gaps and opportunities. Section 5 presents the framework and summarises the findings. Section 6 presents a discussion and theoretical and practical implications. Finally, Section 7 concludes the paper.

4.2 Materials and Methods

Effective literature reviews create a solid foundation for advancing knowledge (Webster and Watson, 2002). This study employs the SLR method through an eight-step process, as detailed by Thomé et al. (2016): (i) planning and problem formulation, (ii) literature search, (iii) data gathering, (iv) quality evaluation, (v) data analysis and synthesis, (vi) interpretation, (vii) presenting the results, and (viii) review updating.

The research problem formulation has research questions presented in the introduction of a paper. The SLR intends to answer research questions about the difficulty of simultaneously identifying disaster impacts on SCs and countermeasure strategies.

The second step encompasses a bibliographic search in both the Scopus and Web of Science (WoS) databases, as these databases cover a significant number of indexed journals (Thomé et al., 2016). The search considers three groups of keywords defined by a combination that covers the topic broadly enough to avoid any artificial limitation of the documents obtained while providing limits to exclude undesirable results (Cooper, 2020). The first group includes impact and policy terminologies. The second group addresses the SC research focus. W/5 and NEAR/5 are proximity operators used to specify the maximum number of words that separate terms. In this case, the words from Groups 1 and 2 must be combined into a set of five words. The third keyword group encompasses disaster terminologies (see IFRC, 2021 and CRED, 2009). Figure 10 shows the set of keywords.

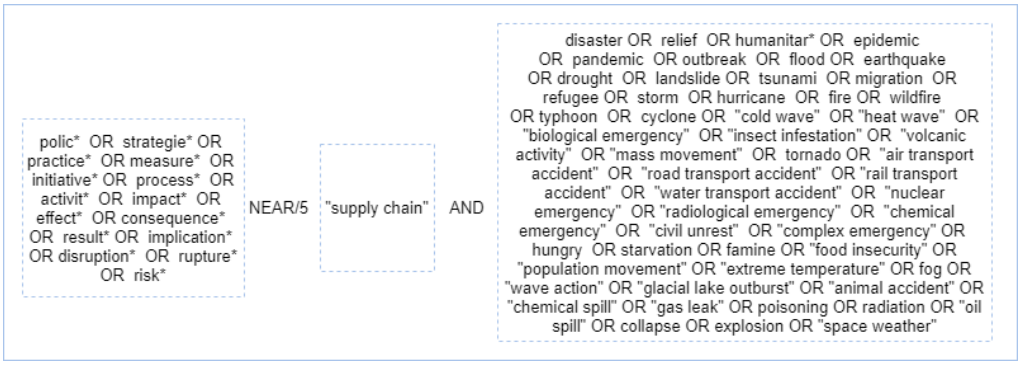

Figure 10 – Set of keywords

In February 2022, the SLR returns 3,273 documents without initial exclusions and without a time limitation. In addition, no filter related to document type is applied to obtain all documents related to the topic, except books. The documents are analysed using the review protocol (Figure 11) according to the inclusion and exclusion criteria adapted by Ivanov and Dolgui (2021).

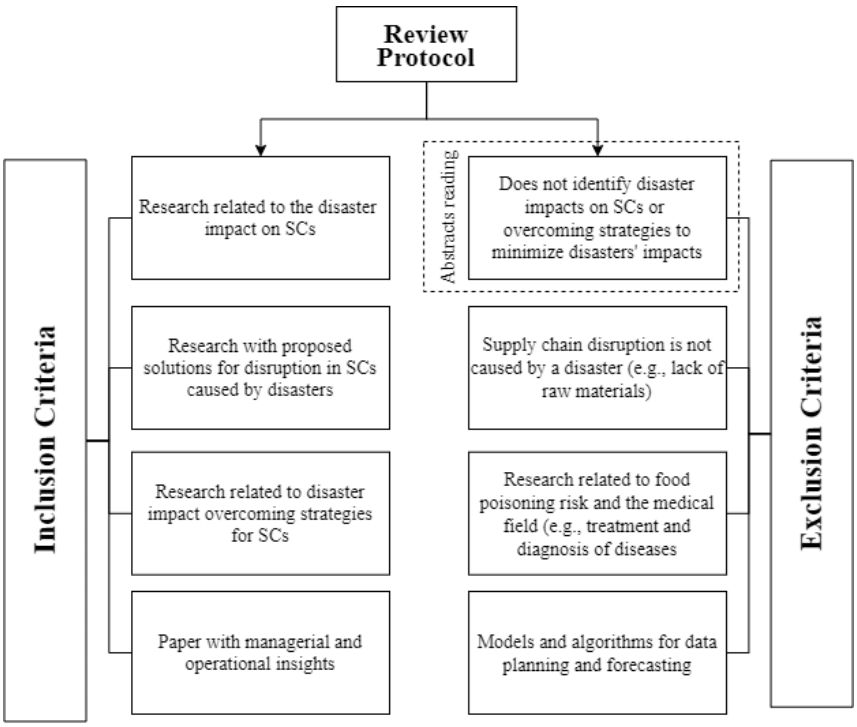

Figure 11 – Review protocol (inclusion and exclusion criteria)

Figure 12 summarises the steps involved using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram (Moher et al., 2009). These steps are used for the selection of documents later analysed in this study.

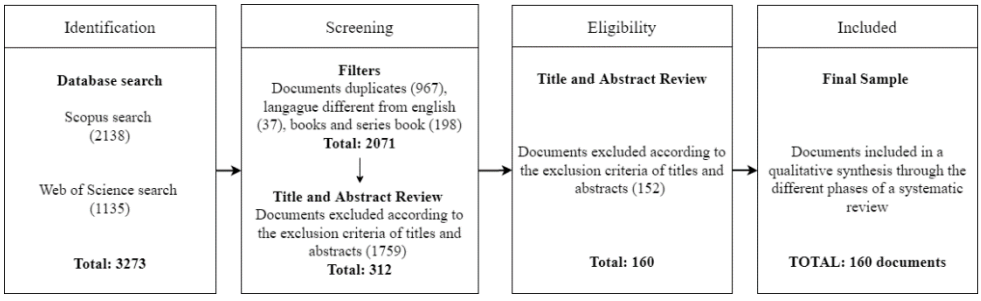

Figure 12 – PRISMA (summary of the literature search)

The third stage – data gathering – is organised using a conceptual matrix (vom Brocke et al., 2009; Thomé et al., 2016). A conceptual matrix is developed using auxiliary spreadsheets. It organises the data into rows and columns to identify the essential elements for analysing the results (i.e. impacts, proactive and reactive strategies, models or frameworks, and SC topics). This stage considers bibliometric analysis (year, journal, methodology) and content analysis, which contribute to the development of a taxonomy. Therefore, the papers are carefully read to extract relevant information.

The fourth step – quality evaluation – considers the use of peer-reviewed documents as a form to guarantee the inclusion of only qualified discussions in the current study. Seuring and Gold (2012) explain that peer-reviewed documents represent an important mode of communication and can be considered units of analysis. Two reviewers were responsible for analysing the titles and abstracts of the selected documents. Process reliability was checked, ensuring an acceptable agreement index for the review, according to Krippendorff (2018), with 95% for reading abstracts and 88% for reading the full text.

The fifth step – data analysis and synthesis – is described in the next section according to the three different deliverables suggested by Torraco (2016) when developing an SLR: a taxonomy, framework, and research agenda. For a taxonomy, a concept matrix subdivides documents according to specific topics, which allows organising, discussing, and synthesising previous research (vom Brocke et al., 2009). We propose a taxonomy featuring inductive analysis based on a complete reading of the documents selected through the SLR. Inductive analysis is defined as the analysis of the material itself from an iterative construction process with tests, analyses, and constant data comparisons (Seuring and Gold, 2012).

The concept matrix classifies the documents according to the following unity analysis:

- Disasters impacts: unplanned events that disrupt the normal flow of SCs (Macdonald et al., 2018). Impact categories are based on a complete reading of the documents (Seuring and Gold, 2012);

- Strategies: proactive or reactive disaster response actions (Belhadi et al., 2021; Coopmans et al., 2021). Proactive strategies are predefined plans to respond quickly to a disaster (Ali et al., 2021), whereas reactive strategies are changes implemented after a disaster to maintain performance under varying circumstances (Coopmans et al., 2021). The proactive and reactive strategy categories are based on a complete reading of the documents (Seuring and Gold, 2012).

The research agenda provides a basis for advancing and updating knowledge (vom Broke et al., 2009). Our research agenda is based on identifying research gaps that open up new opportunities for future studies. The research agenda encompasses topics that are accompanied by theoretical justifications for their formulation. Finally, we propose a framework to summarise explanations and predictions and realise supporting propositions (Webster and Watson, 2002). Our framework presents taxonomy findings, including impact and strategy categories. In addition, the framework highlights the research agenda and relates it to other research findings.

The seventh step – interpretation – is the basis for understanding the findings, with arguments describing, discussing, and explaining the entire research object (Thome et al., 2016). Interpretation assesses appropriate strategies for each impact and strategy to support SC management during a disaster. The interpretation of the study involves a series of insights into the literature and professionals, as it contributes to the preparation of SCs during a disaster. The results are presented in this study. Updating of the SLR, the eighth step, is proposed for future research.

4.3 Disaster impacts and countermeasure strategies for SCs

The analysis reveals that a significant number of publications were published in 2020 and 2021 (Figure 13).

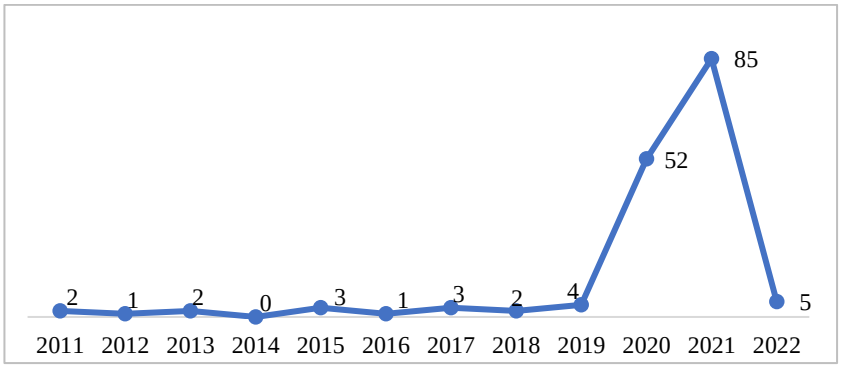

Figure 13 – Publications per year

The high number of publications in 2020 and 2021 (137 documents) can be attributed to the COVID-19 pandemic – a biological disaster. The COVID-19 pandemic has significantly impacted SC components in different sectors (Hobbs et al., 2021; Cardoso et al., 2021; Vanany et al., 2021).

Regarding publication sources, Table 4 indicates that Sustainability and the International Conference on Industrial Engineering and Operations Management stand out with five publications. In addition to the analysis of specific journals, the topic has been addressed by journals from different areas, such as the social sciences, technology disaster risk reduction, transport, and economy. These findings reinforce the idea that the theme is multidisciplinary and considers different research perspectives.

Table 4 – Publications sources

Source	Total
Sustainability (Switzerland)	5
Proceedings Of the International Conference on Industrial Engineering and Operations Management	5
Agricultural Systems	4
Operations Management Research	4
International Journal of Disaster Risk Reduction	3
Food Control	3
International Journal of Production Economics	3
Brazilian Journal of Operations and Production Management	3
Animals	2
Trends In Food Science and Technology	2
Environmental Science and Pollution Research	2
World Development	2
Foods	2

China Agricultural Economic Review	2
Cogent Social Sciences	2
Canadian Journal of Agricultural Economics	2
Food Security	2
Ieee Access	2
Journal of Integrative Agriculture	2
International Journal of Operations and Production Management	2
Frontiers in Veterinary Science	2
Applied Economic Perspectives and Policy	2
Logforum	2
Iop Conference Series: Earth and Environmental Science	2
Ieee Engineering Management Review	2
International Journal of Production Research	2
Agricultural Economics (United Kingdom)	2
Journal of Transport and Supply Chain Management	2
Others	90

Concerning methodology, the reviewed studies address different research methods, making the research topic comprehensive in qualitative and quantitative research. We highlight the different research methods of the reviewed studies: survey (20%), case study (17%), literature review (12%), statistical analysis (5%), mathematical modelling (3%), multicriteria analysis (3%), simulation (2%), and undefined (43%).

The case study method is employed for different purposes, considering semi-structured interviews with SC links such as restaurant and hotel managers (e.g., Ngin et al., 2020), the public health sector (e.g., Scala and Lindsay, 2021), and actors in the agri-food sector (e.g., Coopmans et al., 2021). The literature review method has been applied to assess disaster impacts and gaps in food SCs (e.g., Abu Hatab et al., 2021a; Cardoso et al., 2021), identify valuable insights for small businesses (e.g., Pratama et al., 2021), evaluate SC resilience (e.g., Umar et al., 2017), and map the application of operational research methods in SC studies (Ivanov and Dolgui, 2021).

Some studies use statistical analysis methods such as multiple regression (e.g., Anser et al., 2021), cluster analysis (e.g., Farias and Araújo, 2020), and correlation analysis (e.g., Perera et al., 2021). In addition, mathematical modelling is used in some cases to model policies adopted during SC disruptions

(e.g., Gao et al., 2019a), model economic losses during disasters (e.g., Lenzen et al., 2019), and model demand on products (e.g., Paul and Chowdhury, 2020).

Further, simulation is applied in some documents to simulate impacts on global agricultural markets (e.g., Elleby et al., 2020) and operational policies of the supply network (e.g., Lozano-Diez et al., 2020). Other studies use multi-criteria analysis such as DEMATEL to establish causal relationships between critical SC factors (Chowdhury et al., 2021), AHP methods to identify resilience factors (e.g., Khurana et al., 2021), and the AHP-DEMATEL approach to analyse the factors that affected SC networks (e.g., Das et al., 2021).

Almost half of the studies are based on descriptive and exploratory analyses of the impact of disasters on SCs in several countries such as China (e.g. Cao et al., 2020), Turkey (e.g. Abiral and Atalan-Helicke, 2020), Japan (e.g. Marszewska, 2016), Canada (e.g. Beaulieu et al., 2022), and Latvia (e.g. Pilvere et al., 2021), and in different sectors such as food (e.g. Attwood and Hajat et al., 2020; Coluccia et al., 2021), healthcare (e.g. Faiva et al., 2021; Miller, 2011), and services (e.g. Chtioui et al., 2020). Finally, some studies combine different research methods, such as survey and case study (Munim et al., 2022), literature review, and statistical analysis (Perera et al., 2021).

4.3.1 Disaster impacts analysis

During the complete reading of the documents, we identified the different SCs analysed in the literature. Table 5 presents the impact categories and total number of documents that cited any impact related to a specific category. It is worth mentioning that some authors cited more than one impact. The complete list of associated categories and impacts is detailed in Appendices A (slow-onset disasters) and B (sudden-onset disasters).

The specific study of these impacts lead to five main categories:

- Resource constraints: refers to the scarcity of resources that is essential for the development of activities, such as workforce scarcity (Garlick et al., 2020) and infrastructure interruptions (Notteboom et al., 2021);
- SC instabilities: refer to frequent SC fluctuations and oscillations that generate future uncertainties and impact decision making, such as price instability (Taqi et al., 2020) and inventory instability (Ding et al., 2020);

- Outflow disruptions: refer to disturbances of the normal flow of the SC affecting both the upstream and downstream parts of the process, such as export and import restrictions (Salimi et al., 2020);
- Financial constraints: refer to the difficulties in controlling and planning financial activities, such as an increase in operating costs (Zhou et al., 2021).
- Consumption patterns: disasters generate rapid and dynamic changes in consumption habits and patterns, as consumers need to deal with new priorities, such as job losses (Fan et al., 2021).

Table 5 – Disaster impacts on SCs

Starting mode/ SC Impacts	**Sudden onset**		**Slow onset**	
	No. documents	**%**	**No. documents**	**%**
SC instabilities	16	10%	126	79%
Outflow disruptions	15	9%	107	67%
Resources constraints	15	9%	93	58%
Financial constraints	3	2%	52	33%
Consumption patterns	3	2%	54	34%

Table 5 shows a significant number of studies addressing the impact of SC instability. For sudden-onset disasters, the impact of instability in inventories stands out. When a sudden-onset disaster occurs (e.g., the 2016 Japan earthquake), companies with higher levels of inventory turns have greater operational efficiency and flexibility to avoid losses (Ding et al., 2021). Supply, demand, and price instability impact slow-onset disasters (e.g., pandemics). During the COVID-19 pandemic, for example, there was a panic buying behaviour, which impacted the supply of products (Hobbs et al., 2021) and constant variation in the price of products (Vanany et al., 2021).

Table 5 also highlights the impacts related to interrupting the SC's normal flow. For sudden-onset disasters, transport interruptions due mainly to road obstructions stand out. In the 2017 cyclone that occurred in Australia, roads, rail systems, and bridges were damaged or destroyed, along with other systems

(Lenzen et al., 2019). For slow-onset disasters, production disruption is a significant impact. Drought, for example, affects agriculture, resulting in reduced yields, crop failure, and production deficits (Mishra et al., 2021).

Resource constraints also have a significant effect on both sudden-onset and slow-onset disasters. In sudden-onset disasters, infrastructure restrictions can be cited. For example, during the 2013 flood in Germany, damage to public infrastructure, equipment, residences, and commercial buildings was estimated at €6.4 billion (Schulte et al., 2015). For slow-onset disasters, supply and workforce constraints are highlighted. During the COVID-19 pandemic, there had been difficulties in supplying inputs (e.g., fertilisers, machinery, and workers) for production (Sid et al., 2021) and a lack of labour owing to people infected by the virus (Cardoso et al., 2021).

The financial constraint category represents the loss of revenue and profit impact for both slow-onset and sudden-onset disasters. In sudden-onset disasters (e.g., the 2011 earthquake and tsunami in Japan), the low level of plant operation results in low profitability (Park et al., 2013). In slow-onset disasters, companies risk losing profits and revenue (Ferreira et al., 2021). Finally, in the consumption patterns category, the impact of job and income loss for slow and sudden onset disasters stands out (Lenzen et al., 2019; Bashir et al., 2021).

4.3.2 Countermeasure strategies analysis

We also identify countermeasure strategies. The complete list of associated categories and strategies is detailed in Appendix A (slow-onset disaster) and Appendix B (sudden-onset disaster).

The analysis of strategies in terms of proactivity and responsiveness also led to the definition of five groups of proactive strategies:

- Preventive SC collaboration: SC companies should operate closely together to meet the shared objectives of predicting and preventing potential threats, such as strengthening link relationships (Sid et al., 2021);
- Preventive resource maintenance: resources system and lifeline before disruption should be maintained, such as investing in warehousing facilities (Mahajan and Tomar, 2021);

- Digitalisation or automation: digital technologies such as the Internet of things, blockchain technology, and digital twins are proving to have great potential to enhance SC resilience through high connectivity, accuracy, and transparency (Belhadi et al., 2021), such as smart packaging technology (Chitrakar et al., 2021);
- Local SC: Sourcing and processing are localised within the same region to meet local demand and reduce SC globalisation challenges, such as national inventories (Aday and Aday, 2020) and local suppliers (Macmahon et al., 2015);
- Human capability: refers to the capabilities of humans concerning the analysis of enormous amounts of information, monitoring, and controlling critical SC points, such as human resource capacity (Okorie et al., 2020);

The five groups of responsiveness strategies are as follows:

- Responsive SC collaboration: SC companies should operate closely together to meet the shared objectives of recovery and assist each other to mitigate disruption impact, such as public–private partnerships (Abe and Ye, 2014);
- Responsive resource maintenance: the resources system and lifeline during disruption should be maintained, such as remote work (Garlick et al., 2020);
- Virtual marketplace: refers to the development of a digital marketplace for delivering products and services, such as online market implementation (Ratnasignam et al., 2020);
- Information system: SC information systems use big data analytic (BDA) capabilities to collect, process, and extract meaningful insights from real-time data across the overall SC to support suitable and timely decision making (Belhadi et al., 2021), such as delivery systems (Fan et al., 2021);
- Business continuity plans: business continuity planning is of the utmost importance to create processes and systems of prevention and recovery to deal with potential SC disruption, such as the relaxation of laws and regulations (Ino and Watanabe, 2021).

It is worth noting the similarity between the categories of proactive and reactive strategies. We can observe a certain correspondence between preventive and responsive SC collaboration because the two strategies are related to implementing more collaborative management between SC links. There is also a certain similarity between preventive and responsive resource maintenance, as the two strategy categories refer to the proper management of existing resources. We can also note the similarity between the local SC (proactive) and virtual marketplace (reactive), as both deal with perspectives of SC coverage. Digitalisation in the proactive group and the information system in the reactive group are related to information technologies. Finally, we can mention the proactive strategy of human capability and the reactive strategy of business continuity plans, which correspond to the competencies needed for disaster response, focusing on human resources (proactive) and organisational capacities (reactive).

Table 6 presents the sudden-onset disasters' impacts on SCs, and the countermeasure strategies presented in the documents. The number of documents in Tables 5 and 6 differ because some documents highlight only the impacts on SCs, whereas others present the impacts and countermeasure strategies.

Table 6 – Impacts and strategies (sudden-onset disaster)

Sudden-onset disaster		**SC Impacts**					
Countermeasure strategies		**Resources constraints**	**SC instability**	**Outflow disruption**	**Financial constraints**	**Consumption patterns**	**TOTAL**
Proactive Strategies	SC collaboration	2	4	5	3	-	**14**
	Resources maintenance	1	-	-	-	-	**1**
	Digitalisation/automation	1	3	1	1	-	**6**
	Local SC	3	1	1		-	**5**
	Human capabilities	-	-	-	-	-	**0**
TOTAL		**7**	**8**	**7**	**4**	**0**	**26**
Reactive Strategies	SC collaboration	1	2	3	-	-	**6**
	Resources maintenance	1	-	-	-	-	**1**
	Information system	-	-	-	-	-	**0**
	Virtual marketplaces	-		1	-	-	**1**
	Business continuity plans	1	3	4	-	-	**8**
TOTAL		**3**	**5**	**8**	**0**	**0**	**16**

Table 6 reveals that, although proactive and reactive strategies are highlighted in the documents, most proactive strategies can still be observed. This finding is justified by the fact that sudden-onset disasters (e.g., earthquakes) cause production interruptions, damage to facilities, and loss of inventory, as well as locality-wide consequences, including electricity and water cuts, road blockages, infrastructure collapse, and cancellation of services (Ding et al., 2021). Therefore, proactive strategies support companies and SCs in preparing for disasters.

The most appropriate proactive strategies are local SC, preventive collaboration, digitalisation, and automation. Local SC is recommended when the impact is a resource constraint. Some organisations depend on materials in highly globalised SCs, and disasters affect the availability of these materials (Zhu et al., 2020). SC collaboration is essential for managing SCs impacts and creating confidence and flexibility in responding to unexpected changes (Oh et al., 2020; Hobbs, 2020). SC digitalisation or automation is crucial in the interaction and commercialisation of SC actors (Aday and Aday, 2020).

Considering the reactivity in implementing strategies, SC collaboration and business continuity plans stand out. In the context of a disaster, there is a need for collaborative management approaches for adequate temporary solutions (Schleper et al., 2021). Business continuity planning is essential to deal with possible SC interruptions and is linked to quick strategies that ensure the organisation's survival (Belhadi et al., 2021; Magableh, 2021).

Table 7 presents the impact of slow-onset disasters on SCs and the countermeasure strategies presented in the documents. The number of documents in Tables 5 and 7 differ as some documents highlight only the impacts on SCs, whereas others present the impacts and countermeasure strategies.

Table 7 – Impacts and strategies (slow-onset disaster)

Slow-onset disaster		**SC Impacts**					
Countermeasure strategies		**Resources constraints**	**SC instability**	**Outflow disruption**	**Financial constraints**	**Consumption patterns**	**TOTAL**
Proactive Strategies	SC collaboration	16	32	30	6	2	**86**
	Resources maintenance	4	2	6	6	-	**18**
	Digitalisation/automation	25	42	17	4	1	**89**
	Local SC	25	7	11	1	-	**44**
	Human capabilities	3	1	0	1	-	**5**

	TOTAL	**73**	**84**	**64**	**18**	**3**	**242**
Reactive Strategies	SC collaboration	12	32	21	9	-	**74**
	Resources maintenance	12	15	-	3	2	**32**
	Information system	5	7	6	2	1	**21**
	Virtual marketplaces	3	4	9	6	-	**22**
	Business continuity plans	24	32	20	19	7	**102**
	TOTAL	**56**	**90**	**56**	**39**	**10**	**251**

Table 7 shows that most documents suggest reactive strategies for slow-onset disasters. The justification, in this case, is related to the long-term duration of the disaster. In the COVID-19 pandemic, for example, companies had to adjust and, sometimes, reinvent their operations, processes, and product lines (Islam, 2021). In this case, in a way, companies had time to adapt to the new reality in the face of the disaster and implement reactive strategies according to what was imposed by the moment. However, planning strategies in advance is still important to reduce negative impacts on SCs (Das et al., 2021).

Overall, the proactive strategies that stand out are preventive SC collaboration, digitalisation, and automation. Preventive collaboration created through strong relationships supports the building of a responsive SC (Hobbs, 2020). Digitalisation or automation plays an essential role in the operation of SCs owing to its high connectivity, accuracy, and transparency (Sharma et al., 2020; Belhadi et al., 2021).

Local SC, preventive resource maintenance strategies, and human capabilities are also indicated for the disaster's impact on SCs. Local SCs are highly recommended to improve SC preparedness for disasters (Xu et al., 2020; Tellioglu, 2021) because they are less vulnerable to global disturbances (Pujawan and Bah, 2021). Still, to ensure SC responsiveness, organisations must be concerned with configuring and strengthening their resources, considering the need to deal with rapid changes caused by disasters (Gunessee et al., 2018). The human capacity strategy refers to a team's ability to analyse, monitor, and control information from critical points in the SC (Belhadi et al., 2021).

We highlight business continuity plans and responsive collaboration concerning SC reactivity in the context of slow-onset disasters. Business continuity plans involve, for example, government aid such that the population continues to purchase products that are most in need (Deaton and Deaton, 2020). There is also a need to create a collaborative network between SC

departments and links to form a more impact-resistant SC (Navavongsathian et al., 2020).

Still, the maintenance of resources, virtual markets, and information systems are reactive strategies indicated. Resource maintenance involves managing physical assets (e.g., warehouses) and affecting product availability (Mahajan and Tomar, 2021). Virtual markets highlight the need to transform current SCs formats to resist various impacts (Zhu et al., 2020). Information systems, through databases and integrated platforms, contribute to the preparation of SCs during adverse events (Haraguchi and Lall, 2015; Oh et al., 2020).

It is important to emphasise that some results in Tables 3 and 4 have a low association or no association (-), as discussed in the literature. However, these relationships are fundamental in practice and represent an opportunity for further discussion.

4.4 Research Agenda

There remains plenty of opportunities for substantial contributions to developing and testing new theories and models that involve elements for controlling the impact of the disaster on SCs. Based on the main gaps identified by an SLR, we propose some research topics that may be potential future studies. They are grouped into the following topics: (i) local SC analysis, (ii) cascade effect, (iii) short-term and long-term impacts, (iv) readiness elements, and (v) empirical studies.

First, there is a need for studies that analyse the implementation of local SCs. Some studies indicate that local SCs have an advantage over long SCs in times of crisis (Abiral and Atalan-Helicke, 2020). Local SCs reduce dependence on global SCs. Consequently, the risk of disruption can be contained as there is no spread of a risk incident from one region to another (Belhadi et al., 2021). Interestingly, local SCs have an advantage in times of crisis (Abiral and Atalan-Helicke, 2020).

Second, research on the ripple effects of disasters on SCs is also recommended. The ripple effect refers to organisational structures and their

impacts on processes, products, information, cash flow, and other elements (Priore et al., 2019; Kek et al., 2022; Sawik, 2022; Scarpin et al., 2022***).*** In the disaster context, research on the ripple effect has been promising (Ivanov and Dolgui, 2021). Analyses of the ripple effect involve an understanding of the impacts related to each SC link. Therefore, it is possible to identify specific strategies, including proactivity and reactivity. Moreover, we examine how the implementation of these strategies in one SC link influences the implementation of strategies in a subsequent SC link.

Third, we suggest more research on the short- and long-term impact of disasters on SCs. Whether in the short- or long-term, disasters significantly affect normal business operations (Chen et al., 2021). Short-term effects involve, for example, the closure of borders and input scarcity, and long-term impacts include income loss and price instability. Therefore, considering a temporal analysis, research on the differences and similarities between impacts is necessary to identify potential strategies.

Future studies can also highlight the specificity of disaster impacts on readiness elements, for example, SC resilience (Farrell et al., 2020; Van Hoyweghen et al., 2021), SC robustness (Khurana et al., 2021; El Baz and Ruel, 2021), SC stability (Boyacı-Gündüz et al., 2021; Al-Mansour and Al-Akmi, 2020), SC viability (Chari and Ngcamu, 2019; Ivanov and Dolgui, 2021), SC responsiveness (Kazancoglu et al., 2022), SC flexibility (Ivanov and Dolgui, 2021; Kazancoglu et al., 2022), SC agility (Liu et al., 2020; Kazancoglu et al., 2022), SC survivability (Baral et al., 2021; Sharma et al., 2022), and SC visibility (Mubarik et al., 2021).

Future studies should focus on developing and testing new disaster-related models, structures, and components (Magableh, 2021). Empirical studies are essential to support decision-making in organisations during disasters. Thus, this study explores the theory of disaster impacts on SCs and countermeasure strategies, which provides a theoretical basis for the development of empirical studies (e.g., surveys and case studies).

4.5 Disaster impacts and countermeasure strategies framework

The analysis of the findings obtained in the literature related to the impacts of disasters and countermeasure strategies adopted by both proactive and reactive SCs led to the development of a generalised and integrated decision-making structure for the improvement of SCs (Figure 14). The framework presents the structure of the relationship between disaster impacts, strategies, and the research agenda.

The proposed framework considers the characteristics of other conceptual models identified in the literature. Our framework considers the main SC activities, such as production, processing, storage, distribution, and consumption, based on the SC components presented in the framework proposed by Hald and Coslugeanu (2021).

Our framework also answers the research questions proposed in this study by synthesising the findings identified in the literature to identify the major impacts of disasters on SCs and their main countermeasure strategies. Similarly, Weber (2021) proposed a framework to summarise the results and answer the research questions of his study.

In addition, our framework presents the impact of disasters on the SC and presents the studies of Magableh (2021) and Vanany et al. (2021). Further, we represent proactive and reactive disaster strategies in SCs, corroborating the results presented by Belhadi et al. (2021) and Vanany et al. (2021). Moreover, our framework offers potential research opportunities, considering the results of the research agenda, following the framework proposed by Ivanov and Dolgui (2021).

Although we consider other literature frameworks as a basis for our proposal, none of them address the results in a structured and detailed manner. We differentiate our analysis from existing contributions by systematising the literature search to identify the results and present them in a structured format. Our framework, therefore, provides a holistic view of research findings and advances proposed frameworks that uniquely address disaster impacts, countermeasure strategies, and research agendas (Coopmans et al., 2021; Magableh, 2021; Ivanov and Dolgui, 2021; Beaulieu et al., 2022).

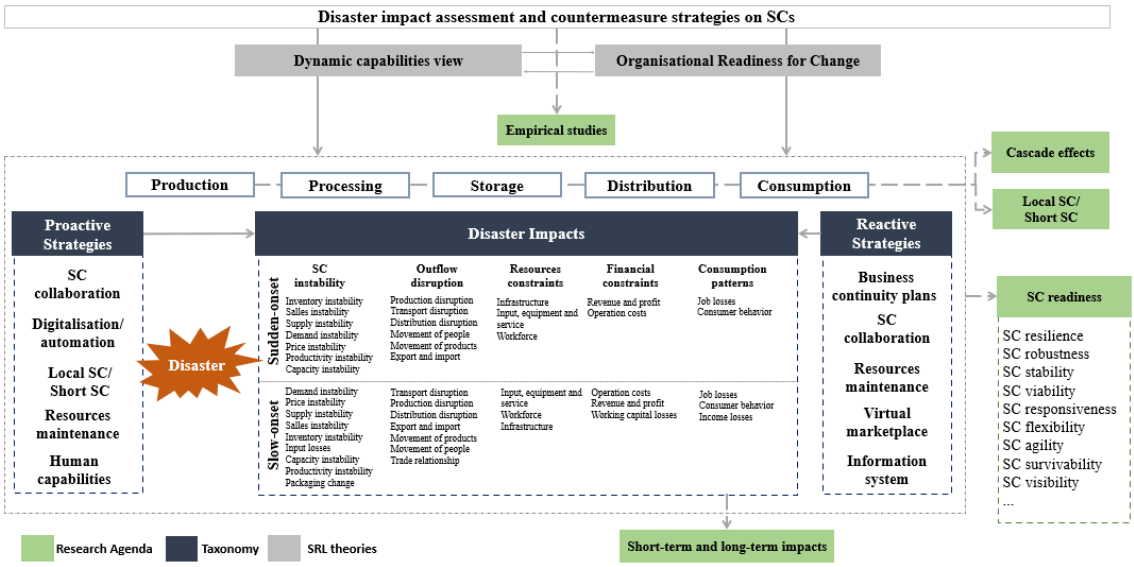

Figure 14 – Framework for organisational decision making

4.6 Implications from the study

4.6.1 Implications for the academic literature and researches

The instability and rapid changes caused by disasters have heavily affected SCs (Magableh, 2021). The uncertainty and subjectivity associated with a disaster's impacts on an SC create difficulties in determining effective response strategies and aligning all SC links' activities (Salimi et al., 2020; Belhadi et al., 2021). In this context, the effects of disruptions on organisations' performance depend on the system's ability to identify the impacts and implement ways to recover (Gao et al., 2019b). The literature analysis we developed leads to the systematisation of knowledge about disaster impacts on SCs and countermeasure strategies (proactive and reactive).

Our study holistically presents disaster impacts and countermeasure strategies (Section 4.3) instead of focusing on isolated results. The association of the SC impact with the respective strategy (Appendices A and B) assists in identifying an adequate approach to minimise the adverse effects of disasters on SCs.

Based on the presented results, our study demonstrates the potential to integrate DCV and ORC theories based on the proximity of their theoretical lenses and the compatibility between their assumptions (Ruel and El Baz, 2021; Okhuysen and Bonardi, 2011). Some documents selected in the literature review directed their research using these theories in the context of disasters (e.g., El Baz and Ruel, 2021; Ruel and El Baz, 2021; Chatterjee and Chaudhuri, 2021; Anser et al., 2021).

Our study's combination of DCV and ORC theories focuses on SC preparedness and readiness in disaster contexts. DCV theory is interconnected with the resource-based view (RBV), which describes how firms can build competitive advantages in an uncertain environment (Barney 1991). Dynamic capabilities, therefore, are capabilities that integrate, build, and reconfigure internal and external abilities to respond to a volatile environment (Teece et al., 1997). ORC theory defines the readiness determinants and results for change at the organisational level (Weiner, 2009). ORC theory shows that organisational readiness is based on the collective behaviour of organisational members committed to ongoing change (Weiner 2009).

Considering disaster SC preparedness, the DCV is a relevant theory for examining how companies can coordinate their capabilities to ensure survival in the marketplace. The ORC, in turn, refers to the shared resolution of organisational members to implement a change. Therefore, in this study, countermeasure strategies are perceived as dynamic capabilities that enable organisational-level change so that SCs can better manage disruptions caused by disasters and continue to deliver high-performing products and services to consumers in an uncertain market.

Based on this evidence, the contribution of this study is justified by the need to understand the impacts (Belhadi et al., 2021), identify strategies that minimise the adverse effects of disasters on SCs (Boyacı-Gündüz et al., 2021), and develop new models or structures related to disasters in SCs to build a tool to improve decision making in companies (Magableh, 2021).

4.6.2 Implications for the organisations and practitioners

The theoretical results of our study also reflect practical contributions for companies and collaborators involved in complex SCs. The extensive restrictions imposed by disasters and the consequent suspension of various activities (e.g., transport and retail) highlight that business strategies must be reconsidered and reassessed (Al-Mansour and Al-Ajmi, 2020). Thus, this study's main findings can assist organisations in reformulating their strategies to deal with disaster situations and survive in the long term.

Our results encourage organisations to implement strategies to minimise and manage the impacts of disasters and, consequently, support the implementation of resolving processes during disasters. Still, our approach offers an opportunity to establish the links and relationships between components (disaster impacts and strategies), which can contribute to the development and implementation of SC readiness to face disasters, increase preparedness, and improve the response capacity of SC stakeholders.

Interestingly, companies involved in SCs need to think intelligently and be forward-looking to develop strategies, processes, and operations relevant to dealing with disasters and achieving resilience and sustainability in the long term (Islam, 2021). In this way, our study would allow organisations to prepare properly with the implementation of proactive strategies that consider contingency planning. Contingency planning involves predefined planning for precaution against any interruption outside an organisation's control, helping to reduce corporate vulnerabilities in SCs and mitigating economic losses (Das et al., 2021).

In addition, this study contributes to the literature with a list of reactive strategies that can be incorporated into organisational management during a disaster. It is worth mentioning that the strategies identified can be adapted to the context of the type of disaster and also consider the particularities of each organisation, given the resource and time constraints to obtain the benefits of these strategies (Ali et al., 2021).

4.7 Conclusions

Although there exists a vast literature on the subject, difficulties still exist in understanding how to prepare SCs to respond to a disaster with adequate and effective strategies for each impact (Queiroz et al., 2020; Salimi et al., 2020; Belhadi et al., 2021).

This research results from an exhaustive literature review of 160 papers on SC disruptions and their countermeasure strategies. The results identify disaster impacts on SCs and proposed countermeasure strategies to mitigate SC disruptions. Furthermore, this study presents a research agenda with the main opportunities for future research on the topic and a framework to summarise the results. This study provides findings that can serve as the basis for stakeholders of different SCs on how to act in disaster response planning.

Specifically, the literature review findings present the impacts of disasters and proactive and reactive strategies. Disaster impacts are categorised into resource constraints, SC instability, outflow disruption, financial constraints, and consumption patterns. Proactive strategies are classified into five categories: SC collaboration, resource maintenance, digitalisation or automation, local SC, and human capabilities. Reactive strategies are also classified into five categories: SC collaboration, resource maintenance, information systems, virtual marketplaces, and business continuity plans. Our results illustrate the association between strategies and impacts, indicating the most suitable strategy for each type of impact according to the literature.

Therefore, the research agenda demonstrates opportunities for future studies that focus on improving the preparedness of SCs to deal with disasters. SCs involve different stakeholders who need to be prepared to meet customer expectations, even in times of crisis, such as a disaster. Therefore, the research agenda encompasses specific points for developing organisational capacities in the context of disasters (e.g., SC readiness).

Finally, the study proposes a framework that integrates the research findings, including research theories, a taxonomy, and a research agenda, consolidating the findings to facilitate understanding by decision makers who are involved in complex SCs.

In this context, our study contributes to advancing academic knowledge through a holistic view of SCs in the context of disasters. It is worth emphasising that the number of disasters has increased in recent decades. The spread of a disaster interrupts the normal flow of an SC, and its operations must be adapted to the new reality. Thus, organisations need to reconfigure themselves through the dynamic capabilities of organisations and implement appropriate strategies (Al-Mansour and Al-Akmi, 2020; Anser et al., 2021). Our study presents relevant results for organisations that intend to enable a quick response to unpredictable events. Our list of strategies and their associated actions (Appendices A and B) provides support for transforming responsive SCs.

This study has some limitations. First, the framework cannot be generalised to all SCs, and the tool needs to be adapted to specific contexts, taking into account the SC type analysed. In addition, the study is affected by a lack of empirical validation and is still analysed only through a theoretical lens. Therefore, it is also suggested that future studies should expound upon our literature review by considering the different types of SCs (e.g. food, automobiles), and empirical studies should be developed to validate the findings we observed.

5
Exploring the effects of digitalisation and localisation in the relationship between disaster impacts and supply chain performance

This chapter presents Paper 3. This paper will be submitted to a journal after the thesis defence.

This paper investigates the moderating role of two proactive strategies (digitalisation and local SC) in the relationship between disaster impact and SC performance. The proactive strategies considered in this research are based on Paper 2, previously presented. It is necessary to emphasize that the choice of these strategies is justified by the existence of strategies in the form of constructs and their respective items already consolidated in the literature. Also, the choice can be justified by the importance of these proactive strategies in supply chains, and this becomes evident throughout the text.

5.1 Introduction

In recent decades, supply chains (SCs) have been under increasing pressure due to complex interactions and disruptions, which challenge the development of activities (Coopmans et al., 2021). Disruptions on SCs impact the efficiency of operations by affecting the quality, cost, processing, sourcing, and delivery of products and services (Laguir et al., 2022) and, consequently, the SC performance (Laguir et al., 2022; Cardoso et al., 2023).

These SC disruptions are often caused by disasters (Rejeb, 2020; Kaur and Singh, 2019; Cardoso et al., 2023). Disaster is defined as a serious disruption of the functioning of a society, which involves human, material, economic or environmental impacts, and exceeds the capacity of the affected society to cope using its own resources (UNISDR, 2009). Disasters can be climate-related (e.g., earthquakes, tsunamis, extreme weather conditions) or human-made (e.g., fires, terrorist attacks) (Lotfi and Saghiri, 2017; Das et al., 2021).

There are several examples of climate-related and their corresponding impacts on the SC links. In 2011, floods in Thailand limited production capacity, caused production losses and damaged infrastructure (Abe and Ye, 2013). In 2016, the earthquake in New Zealand caused interruptions in the transport network and the closure of production plants (Davies et al., 2017). In 2017, the hurricane in Puerto Rico impacted roads, bridges, ports and airports, transport and distribution of goods and services (Kim and Bui, 2019).

Also, recent examples of the human-made disaster have affected SCs. The recent war between Russia and Ukraine, which started in 2022, affected oil and food prices (Mbah and Wasum, 2022). The political crisis in Venezuela led to hyperinflation, restrictions on food distribution, and decreased availability and access to food (Doocy et al., 2019). The civil war in Syria created humanitarian logistics problems with refugees, and supply chain strategies changed as it was necessary to serve people in refugee camps (Katsaliaki et al., 2022).

Generally, the impact of disasters has a negative effect on the performance of SC since each disaster creates delayed deliveries, security problems, closed ports (Goçer, 2012; Dormadyd et al., 2021), instability in production and inventory (Lim and Tam, 2018), transportation disruption (Davies et al., 2017), supply and demand fluctuation (Pratama et al., 2021), and coordination problems (Schleper et al., 2021). Operational performance is comprised of products delivered on time, product quality, capacity utilization, and low rate of waste in processes and inventories, all of which are difficult to control under uncertainty (Laguir et al., 2022).

The increasing occurrence of disasters and their impacts (EM-DAT, 2023) demonstrates the need for proactive measures for possible disruptions in SCs (Cardoso et al., 2023). Therefore, disruptions and their impact on the SCs have been investigated extensively (Darmawan, 2024). Research shows that implementing proactive strategies is essential throughout the SC and across sectors (Kovacs and Sigala, 2021). It is necessary to plan strategies to prepare for disruptions and continue business (Sharma et al., 2022). In general, proactive strategies are implemented with the aim of reducing the impacts of future disruptions (Mostafa et al., 2024).

Still, in this context, research reveals that if no prior preparation is made, negative impacts on SC will prevail during a disaster (Chen et al., 2021).

Therefore, companies need robust SC planning to absorb disruptions caused by disasters (Kaur and Singh, 2019). Proactive strategies include digitalisation and localisation indicated to mitigate the disaster impacts on SCs (Belhadi et al., 2021; Cardoso et al., 2023).

Digitalisation driven by new technologies has attracted more attention and research from academia and industry (Hennelly et al., 2020; Zhao et al., 2023). Digitalisation encompasses using various advanced digital technologies to synchronise organisational interactions (Mishra et al., 2023). Therefore, digitalisation supports companies in dealing with risk effectively, avoiding disruption, and mitigating the ripple effects of impacts (Min, 2019; Melkonyan et al., 2020). Digitalisation can improve supply chain visibility, connectivity, innovation, real-time, transparency, and speed (Zhao et al., 2023), thus allowing better planning of resources during crises.

Localisation, in turn, implies a closer relationship between manufacturer and consumer (Maggio et al., 2016). Localisation becomes a vital strategy to prepare for a disaster since local suppliers and customers guarantee the execution of activities during crises (Cardoso et al., 2023). Based on small-scale local production, distributed manufacturing represents an alternative that can provide flexibility to currently established centralised supply chains and environmental and social benefits (Almena et al., 2019). Supply and processing in the same region decrease the risk of interruption within the area, as there is no spillover of a risk incident from one region to another (Belhadi et al., 2021).

There is, therefore, a trend among companies to decentralise and shift focus to local and regional distribution channels and also to consider digitalising supply chains (Zhu et al., 2020; Ding et al., 2021; Bassett et al., 2021; Cardoso et al., 2023). Whence, it is necessary to assess the role of strategies (digitalisation and localisation) in dealing with the impacts of disruptions caused by disasters. Thus, this paper seeks to shed light on the following research questions:

1. Do disasters' impacts negatively affect SC performance?

2. Do digitalisation and localisation mitigate the disasters' impacts on SC performance?

To answer these research questions, this paper considers the Brazilian perspective. Brazil is currently among the ten countries most affected by disasters

in recent years (EM-DAT, 2023). Notable disasters are recorded every year (e.g., drought, flood, landslides), and Brazil is one of the countries with the most deaths and economic damage caused by disasters (EM-DAT, 2023). Brazil's experience in dealing with multiple disaster events in recent years suggests the need for more scientific reasoning in disaster management, and the country still needs to work on implementing effective mitigation strategies (Alem et al., 2021).

Thus, this paper aims to analyse the effects of digitalisation and localisation on the relationship between disaster impacts and SC performance in Brazil. We analyse data collected from a survey with Brazilian SC professionals through structural equation modelling (SEM) to answer the research questions.

For the study's theoretical basis, the theories of dynamic capability view (DCV) and organisational readiness for change (ORC) are used, emphasising resources and capabilities to mitigate risks throughout SCs. DCV theory describes and captures an organisation’s ability to acquire, integrate, and recombine resources to better adapt to changes in the external environment (Teece et al., 1997). ORC theory contributes to defining the determinants and outcomes of readiness for organisational change, which leads to increased performance (Weiner, 2009).

This paper’s contributions are threefold. First, we expand the literature on SC management in the context of disasters. Key topics include understanding the impacts of disasters on SC performance. Thus, our research directs the projection of implementing efficient and flexible mechanisms with fast responses and methods of recovering from interruptions. Second, our proposal applies the survey method to obtain real data and analyses them through SEM to mutually justify the correlation of the proposed managerial insights with more accurate managerial results to mitigate the impacts of SC interruptions. Third, the results provide a necessary foundation since supply chains must be prepared to deal with disruptions caused by disasters (Xu et al., 2020; Cardoso et al., 2023).

The remainder of this paper is organised as follows. Section 2 addresses the theoretical foundation and conceptual background. Section 3 presents the hypotheses and the conceptual framework. Section 4 brings the methods and procedures, including construct measures, research design, and data analysis. Section 5 provides the main results. Section 6 discusses the theoretical and

practical implications. Finally, Section 7 summarises the concluding remarks, limitations, and future research avenues.

5.2 Theoretical foundation and conceptual background

SC research has advanced through understanding how different organisational theories explain changes in the SC such as DCV and ORC theories. The combination of these theories was possible due to the proximity of their theoretical lenses and the compatibility between their underlying assumptions (Okhuysen and Bonardi, 2011; Ruel and El Baz, 2023). Different authors apply these theories in the context of the SC performance during disasters (El Baz and Ruel, 2021; Dubey et al., 2022; Cardoso et al., 2023; Ruel and El Baz, 2023; Dubey et al., 2024).

5.2.1 Dynamic capabilities view (DCV)

The DCV theory is an extension of the Resource-Based View (RBV) theory (Al Humdan et al., 2023; Sturm et al., 2023) and focuses on exploring and developing unique firm-specific capabilities (Sturm et al., 2023). The view of dynamic capacity garnered significant attention from organisational scholars (Dubey et al., 2023).

DCV theory describes and captures an organisation’s ability to acquire, integrate, and recombine resources to better adapt to changes in the external environment (Teece et al., 1997). The external environment is related to the business ecosystem, comprising multiple stakeholders, which can impact the focal organisation, its customers and suppliers (Chowdhury et al., 2023).

Dynamic capabilities can be characterised as the ability to perceive and shape opportunities and threats, seize opportunities and remain competitive through the improvement, combination, protection and reconfiguration of the company's tangible and intangible assets (Teece, 2007). Organisations usually develop dynamic capabilities when exposed to highly competitive pressures and dynamic environments, integrating, building and reconfiguring internal and external competencies (Dubey et al., 2023). Still, dynamic capabilities perceive and shape opportunities, leading to a competitive advantage (Teece, 2007; Sturm et al., 2023).

Dynamic capabilities are also related to the firm's potential to systematically solve problems, formed by its propensity to perceive opportunities and threats, make timely and market-oriented decisions and change its resource base. Dynamic capabilities serve as the main means of responding to the challenges posed by the dynamics of the environment. They are characterised by rapid and flexible innovation and the management capacity to coordinate and redistribute skills to stay in the market effectively (Barreto, 2010).

Based on the concept of DCV, we argue that organisations need to develop processes and capabilities to mitigate the impacts of disasters in the SC since the DCV aims to develop readiness, response and recovery capacity in the specific changes and challenges of a dynamic environment (Teece et al., 1997; Chowdhury et al., 2023) and support to achieve a long-term competitive advantage (Chowdhury et al., 2023).

5.2.2. Organisational readiness for change (ORC)

ORC theory was first introduced by Weiner (2009) to define the determinants and outcomes of readiness for change at the organisational level. The concept of organisational readiness for change can be applied and adapted to different contexts, including operations research.

The proposed conceptualisation of ORC theory proposes operational flexibility and maturity (Shahrasbi and Rouhani, 2021). In this way, ORC is essential for organisations, as it creates solid change management strategies, which are crucial for any company to survive and sustain in turbulent environments.

Preparing for organisational change is a multi-level notion, as organisations, units, departments and individuals have different levels of preparedness. Therefore, the effectiveness of the change depends on the readiness and shared commitment of all those involved in the operations and processes to implement a change (Budhiraja, 2019). Organisations that exhibit greater readiness for change do better when they initiate intentional initiatives to improve effectiveness through organisational-level reforms (Sreenivasan and Suresh, 2022).

ORC theory contributes to defining the determinants and outcomes of readiness for organisational change, which leads to increased performance

(Weiner, 2009). Therefore, ORC theory is relevant when studying the role of strategies in reducing the disaster impacts on SC.

5.3 Proposed Hypotheses and Conceptual Model

This section presents the formulation of the hypotheses. The hypotheses are based on the literature that establishes the relationships between the constructs.

5.3.1 Disaster impacts and SC performance

Today's supply chains are time-sensitive, and disruptions have a strong impact on their operational performance (Laguir et al., 2022). Disruptions may arise from climate-related and human-made disasters (Kim and Bui, 2019). Disruptions can happen at different SC links, from production to consumption (Abiral and Atalan-Helicke, 2020), which affects the normal flow and performance of the SC (Chin, 2020). SC performance refers to supply chain activities that extend to meet end customer needs, including product availability, on-time delivery, inventory and all production capacity required in the SC (Navavongsathian et al., 2020).

As mentioned earlier, some disasters significantly affected the SC. We can cite more examples in detail. In 2011, the earthquake in Japan had severe impacts on firm performance, resulting in shortages of critical components, low profitability and operational downtime, resulting in substantial adverse economic outcomes for firms, exemplified by the closure of their plants for several months and loss of their market share (Park et al., 2013). In 2011, prolonged flooding in Thailand caused negative impacts, such as employee productivity (Gunessee et al., 2018), significant losses in industrial production, and difficulties in obtaining parts from suppliers (Abe and Ye, 2013). In 2011, landslides that occurred in a mountainous region of Rio de Janeiro were considered one of the biggest climate tragedies to occur in Brazil (Da Costa et al., 2017). In 2013, floods in Germany caused significant impacts on the SC, such as a direct drop in demand, production losses, and labour losses (Schulte et al., 2015). In 2015, the mining tailings dam collapsed in Minas Gerais (Brazil), which caused impacts on production, agriculture, industry and services (Niquito et al., 2021). In 2016,

earthquakes caused production stoppage in Japan (Marszewska, 2016) and severe damage to distributed infrastructure, mainly transport networks, making it difficult to transport goods and people in New Zealand (Davies et al., 2017). In 2017, the hurricane season affected Puerto Rico and Hawaii with damaged roads, bridges, ports and airports, transportation, distribution of goods and services, and damage to the water and energy system (Kim and Bui, 2019). In 2017, a cyclone in Australia destroyed roads and communication systems (Lenzen et al., 2019). In 2019, during the COVID-19 pandemic, there were panic buying behaviours, which impacted the supply of products (Hobbs et al. 2021) and constant variation in the price of products (Vanany et al. 2021), difficulties in supplying inputs (e.g., fertilisers, machinery, and workers) for production (Sidet al., 2021), and a lack of labour (Cardoso et al., 2021).

In general, disasters have a severe impact in that they can be highly disruptive to the business functions of an enterprise, including its SC, and can have negative consequences (Gunessee et al., 2018). Disruptions of flows, materials and information affect SCs in different ways and consequently have negative impacts on SC performance (Ambulkar et al., 2015; Navavongsathian et al., 2020; Palouj et al., 2021; Macdonald et al., 2018; Magableh, 2021; Cardoso et al., 2023).

SC interruptions substantially influence all short-term performance of the SC. Furthermore, SC outages also negatively influence overall SC performance (Qin et al., 2021; Belhadi et al., 2021). Upstream outages that propagate downstream from SCs negatively affect the performance of individual companies and networks (Ivanov and Dolgui, 2021b).

Drawing on the arguments mentioned above, we propose the following hypothesis:

H1: Disaster impacts negatively affect SC performance

5.3.2 Effect of SC digitalisation between disaster impacts and SC performance

In SC management principles and models, SC disruption risk management through digitalisation has gained attention from the scientific community (Ivanov et al., 2019; Hennelly et al., 2020; Zhao et al., 2023). Unexpected crises (e.g., the COVID-19 pandemic, geopolitical conflicts, and wars) cause significant

impacts on commercial operations involved in assembly, production, logistics and consumption activities (Tsao et al., 2023). Thus, considering the advantages of digitalisation, scholars and practitioners have begun to understand how digitalisation strategy can support companies improve performance in crises, allowing them to recover from interruptions in their original performance levels quickly (Zhao et al., 2023).

Digitalisation is organisations' use and adoption of external digital technologies to improve their SC and operational performance (Hennelly et al., 2020). During the COVID-19 pandemic, for example, blockages and logistical disruptions brought the need for teleservice work, paperless operation and reconstruction of the SC structure, which accelerated the pace of digital SC construction and supported companies to deal quickly with the risk of disruption (Ardolino et al., 2022; Zhao et al., 2023).

Digitalisation in SCs assists managers in using available resources in the best and most optimised way to deal with risks proactively (Belhadi et al., 2021; Kumar et al., 2023; Cardoso et al., 2023). During the occurrence of a disaster, the role of digitalisation is fundamental for real-time risk assessment and monitoring (Kumar et al., 2023), increased cost-effectiveness (Zhato et al., 2023); implementation of communication and management systems (Colombari et al., 2023; Cardoso et al., 2023; Zhao et al., 2023); demand planning and forecasting (Hartley and Sawaya, 2019); process improvement (Hartley and Sawaya, 2019); data collection and integration (Hannelly et al., 2020; Colombari et al., 2023); and cooperation between the SC links (Tellioglu, 2021).

With the adoption of digitalisation in the SC, a company can deal with any turbulent environment (Chatterjee and Chaudhuri, 2021). The implementation of digitalisation is a fundamental practice for monitoring production and consumption to ensure the continuity of activities during disasters (Boyacı-Gündüz et al., 2021). In this context, using digital technologies is essential for companies to continue their activities effectively (Goçer, 2021), minimising the impacts of interruptions (Xu et al., 2020).

Overall, digitalisation is crucial to minimise the impacts of outages, as manufacturers have been able to redesign and reuse faster (Okorie et al., 2020). Digitalisation is an opportunity to address the downside of disruptions and boost growth opportunities (Herold et al., 2021). Thus, digitalisation is critical to

managing the SC during disruptions (Okorie et al., 2020; Xu et al., 2020; Belhadi et al., 2021; Cardoso et al., 2023; Colombari et al., 2023; Kumar et al., 2023).

Thus, we propose the following hypothesis:

H2a: Digitalisation moderates the relationship between disaster impacts and SC performance

5.3.3 Effect of localisation between disaster impacts and SC performance

In recent years, interest in localisation (or local networks) has increased (Brunori and Galli, 2016; Hendry et al., 2018; Jamwal and Phulia, 2020; Anderson et al., 2021; Cardoso et al., 2023). Part of this interest comes in light of concerns about disruptions in global SCs (Maggio et al., 2016; Hendry et al., 2018; Cardoso et al., 2023) and vulnerabilities inherent in overreliance on global SCs (Bassett et al., 2021).

Some authors highlight the importance of not completely retreating from globalisation, but it is necessary to balance offshoring with nearshoring to reduce supply chain risk (Remko, 2020; Zhu et al. al., 2020), as local SCs can be a solution to excessive dependence on foreign suppliers or dependence on governments from other countries (Belhadi et al., 2020; Handfield et al., 2020). Thus, companies may consider a combination of local and offsite sourcing to diversify risks while balancing overall costs (Tellioglu, 2021).

In the context of disruptions, local employment should be considered to avoid issues related to travel restrictions, and local market suppliers should be explored to overcome the disruption of overseas SCs (Khalfan and Ismail, 2020; Aday and Aday, 2020). Shortening SCs also has other benefits, such as reduced environmental impact, greater traceability and benefits for the local economy and the community (Brunori and Galli, 2016; Hendry et al., 2018; Aday and Aday, 2020).

With the restrictions imposed by disasters (e.g., border restrictions during the COVID-19 pandemic), the sourcing and procuring of products and services became difficult and limited, and companies turned to local companies and suppliers (Aday and Aday, 2020; Tellioglu, 2021). Although new methodologies have emerged, shorter SCs are more reliable for meeting demand due to less

susceptibility to interruptions (Abiral and Atalan-Helicke, 2020; Aday and Aday, 2020).

Companies can benefit from shorter chains as a preparedness measure to deal with the impacts of interruptions and ensure the continuity of the performance of their processes (Aljadeed et al., 2021). Localisation implies a closer relationship between manufacturer and consumer (Maggio et al., 2016; Albrecht and Smithers, 2018), providing flexibility in the SC and simplifying administration.

In this way, there is an incentive for local and regional processing operations, creating shorter SCs (Jamwal and Phulia, 2020; Anderson et al., 2021; Belhadi et al., 2021; Bassett et al., 2021; Cardoso et al., 2021; al., 2023).

Therefore, we propose the following hypothesis:

H2b: Localisation moderates the relationship between disaster impacts and SC performance.

Figure 15 presents the research model based on the hypotheses:

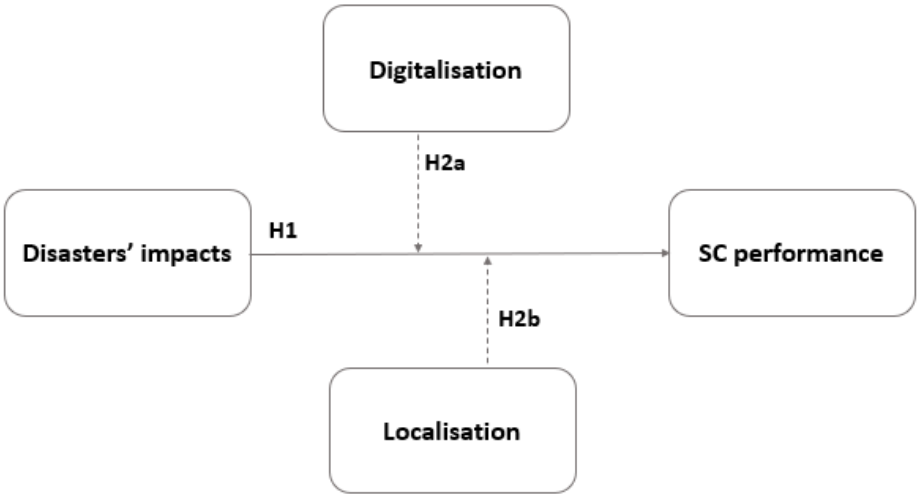

Figure 15 – Research model

It is worth to highlight the alignment of the proposed model with the DCV and ORC theories. The proposed model considers proactive strategies as dynamic capabilities to be implemented by companies to reduce the impacts of a disaster on the SCs. Implementing these strategies requires organizational readiness during periods of change, which is critical for companies facing uncertain conditions caused by disasters.

5.4 Methods and Procedures

This research uses the survey method. Survey aims to contribute to knowledge in a particular area of interest, using the collection of data and information about individuals or about the environment of which these individuals are part, narrowing the distance between theory and practice (Forza, 2002). The application of the method is adapted based on the steps of Forza (2002): i) link to the theoretical level, ii) design and pilot test, iii) data collection and data analysis.

5.4.1 Link to the theoretical level

First, we developed a structural model (Figure 15 presented in the previous section) with the aim of translating theory into practice. Next, we define the constructs, that is, the conceptual elements considered relevant from which the variables to be tested unfold.

We use four constructs: disaster impacts, digitalisation, localisation, and SC performance. Disaster impact measures were adapted from previous studies (Bode et al., 2011; El Baz and Ruel, 2021). The scale measures how SC disruptions reported by the respondents impacted their firm's overall efficiency of operations (IMP1), delivery reliability to customers (IMP2), costs/ price for items (IMP3), responsiveness to customer demands (IMP4), final product quality (IMP5), and sales (IMP6).

Regarding the digitalisation construct, the measures are adapted from other studies (Ying et al., 2023). Respondents were asked to indicate the extent to which they use digital technologies to collect data (DIG1), connect business processes (DIG2), promote information exchange (DIG3), build customer interface (DIG4), and connect SC partners supplies (DIG5).

The localisation is measured through items previously established in the literature (Boehe et al., 2007; Wang, 2018) related to partnerships with the local network regarding relationships with local customers (LOC1), relationships with local suppliers (LOC2), local institutes and universities (LOC3), and local industrial associations (LOC4).

Based on previous studies (Aslam et al., 2023; Reyna-Castillo et al., 2023), the items measure the SC performance due to service level (PER1), development of new business opportunities (PER2), reduced costs (PER3), delivery time (PER4), and high profitability (PER5).

The structural model is elaborated based on the literature on the topic. In previous studies, the constructs of disaster impacts (Bode et al., 2011; El Baz and Ruel, 2021), digitalisation (Liu and Chiu et al., 2021; Ying et al., 2023), localisation (Boehe et al., 2007; Wang, 2018), and SC performance (Aslam et al., 2023; Reyna-Castillo et al., 2023) were considered reflective. In reflective constructs, changes in the underlying construct are hypothesised to cause changes in the indicators.

5.4.2 Design and pilot test

The questionnaire (Table 8) was developed considering the literature on the impacts of disasters on SCs. The questionnaire is divided into two blocks: descriptive information and model items. Descriptive information relates to the industry sector, position within the company, scope of operation, and years of experience.

Questions about model items are based on items previously established in the literature for the constructs of disruption impacts (Bode et al., 2011; El Baz and Ruel, 2021), SC digitalisation (Ying et al., 2023), localisation (Boehe et al., 2007; Wang, 2018), and SC performance (Aslam et al., 2023; Reyna-Castillo et al., 2023). Appendix D summarises the constructs, items, and respective references in a table.

The items were evaluated using a 5-point Likert scale (1 = completely disagree; 2 = partially disagree; 3 = neither agree nor disagree; 4 = partially agree; 5 = completely agree). Two academics and four SC managers evaluated and tested the instrument to ensure that all measurement items were understandable. Then, the proposed improvements were applied to the research instrument so that it could be sent to respondents.

Furthermore, we conducted “a priori” power analyses using the G*Power tool to assess the adequacy of the sample size. We considered a statistical power

of 80% and a probabilistic error of 0.05. The "a priori" estimate G*Power indicated a sample size of 55 respondents.

Table 8 – Construct items

Construct	Code	Indicator
Disaster impacts (IMP)	*Do disruptions caused by disasters negatively affect the indicators?*	
	IMP1	Overall efficiency of operations
	IMP2	Delivery time (delivery reliability)
	IMP3	Acquisition costs/price
	IMP4	Responsiveness to customer demands (readiness)
	IMP5	Quality of final product
	IMP6	Sales
Digitalisation (DIG)	*To what extent do these statements apply to your supply chain?*	
	DIG1	We adopt digital technologies to collect data from different sources
	DIG2	We adopt digital technologies to connect business processes
	DIG3	We adopt digital technologies to promote the exchange of information
	DIG4	We adopt digital technologies to build the customer interface
	DIG5	We embrace digital technologies to connect supply chain partners
Localisation (LOC)	*To what extent do these statements apply to your supply chain?*	
	LOC1	We have solid relationship with local customers
	LOC2	We have extensive links with many local suppliers
	LOC3	We often meet with local research institutes and universities
	LOC4	We partner with local industry associations
SC performance (PER)	*To what extent do these statements apply to your supply chain?*	
	PER1	Our supply chain satisfies the customer and has high levels of service
	PER2	Our supply chain has frequent development of new business opportunities
	PER3	Our supply chain has reduced operating costs
	PER4	Our supply chain is punctual and accurate in the delivery time of services/products
	PER5	Our supply chain has high profitability

5.4.3 Data collection and data analysis

The data were collected through a survey administered in 2023 and 2024 to a random sample of SC practitioners in Brazil. The instrument link is emailed to databases with SC professionals. The questionnaire is administered virtually through the SurveyMonkey platform.

We received 136 responses from Brazilian professionals. The responses are extracted and exported to Microsoft Office Excel, where data processing is carried out. Non-responses and incomplete responses are excluded from the analysis. Finally, 62 complete responses are considered in the analysis. This value represents 45.58% of the total responses received and approximately 13% more than the value defined by G*Power (55 answers).

For data analysis, we used SEM using the partial least squares (PLS-SEM) in the Smart-PLS version 4.1.0.0 software. PSL-SEM is a causal predictive method for SEM that highlights prediction in the estimation of statistical models,

designed to provide causal explanations (Henseler et al., 2015). Still, PLS-SEM works efficiently with small sample sizes (Hair et al., 2021).

The PLS algorithm is relevant to evaluate models with multiple construct interactions. Also, PLS-SEM offers a flexible approach to investigate models with constructs about which there is relatively insufficient theoretical knowledge or at an exploratory stage (Jabbour et al., 2021; El Baz and Ruel, 2012). It is worth noting that other studies also use PLS-SEM for hypothesis testing in the context of disasters (e.g., Chowdhury and Quaddus, 2016; Gunessee et al., 2018; El Baz and Ruel, 2021; Duong et al., 2022; Ruel and El Baz, 2023).

Thus, using PLS-SEM is suitable for our research purposes and questions. We analysed the model considering the steps below:

1. Convergent validity (Average Variance Extracted) and internal consistency (Cronbach's Alpha and Composite Reliability);
2. Discriminant validity (cross-loadings analysis and Fornell and Larcker's criterion);
3. Moderation analysis (effect size $\boldsymbol{f}^2$);
4. Hypothesis testing (path coefficient and p-value through bootstrapping).

5.5 Results

This survey involved a sample of Brazilian SC professionals (sample = 62). Table 9 presents the descriptive results of the collected sample. The majority of respondents work in SCs with a national operating scope (48%) and manufacturing sector (35%). All respondents hold supply chain-related roles (e.g., purchasing, planning, management, logistics). Furthermore, a significant part of the sample has more than ten years of experience working in SCs (32%).

Table 9 – Descriptive results

Characteristics of respondents (sample = 62)	Total	Percentage
Sector		
Primary Sector (agriculture)	9	15%
Second Sector (manufacturing)	22	35%
Tertiary sector (services)	16	26%
Other	15	24%
Operation scope		
Local	5	8%
National	30	48%
Multinational	27	44%
Experience of SCs (in years)		

[1-5]	25	40%
[6-10]	17	27%
> 10	20	32%
Respondents' job titles		
SC analyst	20	32%
SC manager	10	16%
SC coordinator	6	10%
SC director	4	6%
Other	22	35%

Overall, Smart-PLS software provides an overall model quality score to validate the research model. This index is called standardised root mean square residual (SRMR), and a value below 0.08 is recommended for a good fit (Henseler et al., 2014). In this case, with SRMR = 0.07, it is possible to affirm that there is quality in the model. Furthermore, the normed fit index (NFI) was 0.931 (>0.90), indicating a good model fit (Hair et al., 2019).

5.5.1 Convergent validity and internal consistency

Figure 16 presents the measurement model. Validation through PLS-SEM aims to obtain the best fit of the model. The evaluation of the measurement model is performed through model parameters for convergent validity and internal consistency (step 1 – section 5.4.3), such as Average Variance Extracted (AVE), Composite Reliability (CR) and Cronbach's alpha (α).

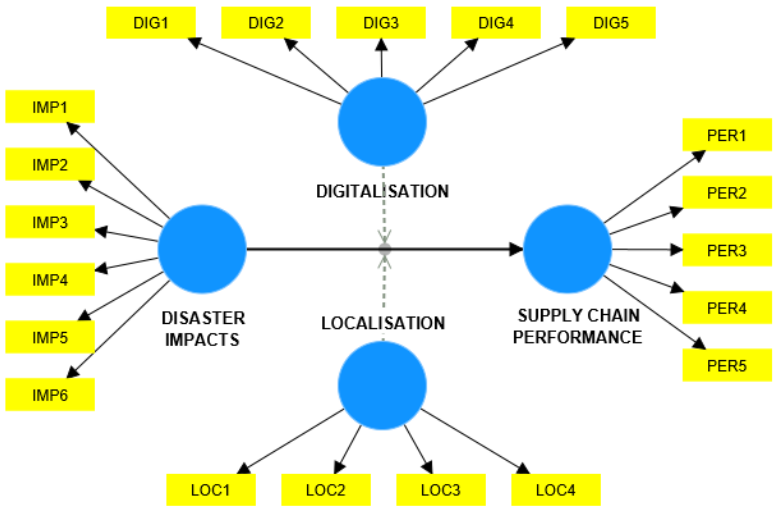

Figure 16 – Measurement model.

Source: SMART-PLS

Therefore, when the results are different from the literature, researchers must make changes to define this adjustment (Rampasso et al., 2019). Initially, an attempt was made to validate the model, which presented a problem in calculating the Average Variance Extracted (AVE) for the IMP and PER constructs. Thus, the parameters with the lowest factor loading were removed from the constructs, one at a time (IMP1 and PER4). This change increased the AVE of the constructs, showing that the other parameters were sufficient to explain the construct.

Table 10 illustrates the parameters. We established the reliability of the items, as in all constructs, the Composite Reliability and Cronbach's Alpha values were above the lower limit of 0.60 (Hair et al., 2021). Together with AVE values above 0.5, they present adequate reliability and consistency of the constructs included for analysis (Ringle et al., 2014; Hair et al., 2021).

Table 10 – Construct reliability and validity

	(α)	**CR**	**AVE**
Disaster impacts	0.794	0.894	0.530
Digitalisation	0.865	0.907	0.642
SC performance	0.670	0.797	0.510
Localisation	0.789	0.848	0.603

5.5.2 Discriminant validity

Discriminant validity (step 2 – section 5.4.3) is assessed through the analysis of factor correlations (cross-loadings) and Fornell and Larcker's criterion. Factor correlation analysis or cross-loading analysis consists of verifying the correct allocation of parameters in their respective constructs and certifying that the constructs are independent. Ringle et al. (2014) recommend cross-loading analysis to verify whether the factorial load of each parameter is greater in its construct than in other constructs. Table 11 presents the cross-loading analysis, indicating that the items are correctly allocated to their respective constructs.

Table 11 – Cross loading values

	DIG	IMP	LOC	PER
DIG1	**0.565**	-0.004	0.164	0.035
DIG2	**0.857**	0.070	0.314	0.188

DIG3	**0.837**	0.045	0.306	0.137
DIG4	**0.838**	0.078	0.319	0.220
DIG5	**0.867**	0.127	0.050	0.185
IMP2	0.207	**0.788**	0.078	0.337
IMP3	0.003	**0.867**	0.051	0.459
IMP4	0.061	**0.766**	0.060	0.234
IMP5	0.010	**0.523**	0.151	0.160
IMP6	0.062	**0.648**	0.263	0.087
PAR1	0.394	0.116	**0.901**	0.264
PAR2	0.420	0.102	**0.885**	0.196
PAR3	0.415	0.076	**0.831**	0.266
PAR4	0.288	0.007	**0.354**	-0.007
PER1	0.068	0.130	0.136	**0.463**
PER2	0.220	0.295	0.268	**0.800**
PER3	0.141	0.207	0.173	**0.612**
PER5	0.163	0.459	0.223	**0.900**

Fornell and Larcker's (1982) criterion requires that the square root of the AVE for each construct be more significant than its correlation with all other constructs. Since the diagonal values are greater than the correlations between the other values, there is discriminant validity. The results in Table 12 reveal that this criterion was met for all constructs. The diagonal elements (bold) are the square root of the variance shared between the constructs and their indicators (AVE).

Table 12 – Fornell and Larcker's criterion

	DIG	IMP	LOC	PER
DIG	**0.801**			
IMP	0.094	**0.728**		
LOC	0.467	0.112	**0.776**	
PER	0.216	0.420	0.284	**0.714**

5.5.3 Moderation effect

The moderating construct changes the strength or even the direction of a relationship between two constructs in a model (Hair et al., 2021). It is worth mentioning that the model can also involve multiple moderator constructs that can be analysed simultaneously (step 3 – section 5.4.3).

In the context of moderation, special attention should be paid to the effect size f^2 of the interaction effect (Hair et al., 2021). With regard to the interaction

effect, the effect size f^2 indicates how much the moderation contributes to the explanation of the endogenous construct. In general, f^2 values of 0.005, 0.01, and 0.025 should be considered as evidence for small, medium, and large effect sizes, respectively (Hair et al., 2021).

The value of $\boldsymbol{f^2}$ for the digitalisation (DIG) is $\boldsymbol{f^2 = 0.007}$ and for localisation (LOC) is $\boldsymbol{f^2 = 0.018}$, indicating that the effect of the variables is small and medium as moderating variables in the relationship between disaster impact and SC performance.

5.5.4 Hypotheses testing

To the hypotheses testing (step 4 – section 5.4.3), bootstrapping procedure was applied considering a sample of 10000. Bootstrapping is a resampling technique that extracts a large number of subsamples from the original data (with replacement) and estimates models for each subsample. It is used to determine standard errors of coefficients to assess their statistical significance without relying on distributional assumptions (Hair et al., 2021).

Through bootstrapping, it was possible to verify that, for at least 95% of the cases, the correlation and regression are valid since no values were below 1.96, according to Hair et al. (2021). In this case, for the model's main relationship between disaster impact and SC performance, we have $\boldsymbol{t\ value = 2.687}$.

Table 13 illustrate the results of bootstrapping (path coefficient and p-value) for hypotheses analysis.

Table 13 – Hypotheses analysis

ID	Hypothesis	*β*	*p-value*	Result
H1	IMP => PER	0.356	<0.05(*)	Supported
H2a	DIG --> (IMP => PER)	0.085	<0.05(*)	Supported
H2b	LOC --> (IMP => PER)	0.136	<0.05(*)	Supported

The results demonstrate that disaster impacts (IMP) negatively affect SC performance, since the path coefficient in question is β = 0.356, with respective significance level p < 0.05(*). The positive path coefficient (β) reinforces the hypotheses that was proposed. It is important to highlight that H1 (disaster

impacts negatively affect the SC) is proposed as a negative statement and the questions in the survey also follow this reasoning. In this case, the positive coefficient reinforces that yes, in the opinion of the respondents there is a negative impact of disasters on the SC performance.

Furthermore, the results indicate that digitalisation (DIG) as a moderator impacts the relationship between disaster impacts and SC performance (IMP→PER) in a positive way, since the path coefficient in question is β = 0.085 with a level of significance p < 0.05(*). Still, localisation (LOC) as a moderator impacts the relationship (IMP→PER) positively, since the path coefficient in question is β = 0.136 with a significance level of p < 0.05(*).

We also analysed the coefficient of determination ($\boldsymbol{R}^2$) of the endogenous constructs. R2 represents the variance explained in each of the endogenous constructs and is a measure of the explanatory power of the model also referred to as predictive power in the sample (Rigdon, 2012; Hair et al., 2021). R^2 values of 0.75, 0.50 and 0.25 can be considered substantial, moderate and weak, respectively (Hair et al., 2021). In this research, there is only one $\boldsymbol{R}^2$ since just one endogenous construct. In our model, the value of $\boldsymbol{R^2 = 0.307}$, which indicates a substantial value for the explanatory and predictive power in the sample considered.

5.6 Discussions and Implications

This study presents the role of proactive strategies as moderators, reinforcing the importance of the combination of DCV and ORC theories focusing on SC preparedness and readiness in disaster contexts (Ruel and El-Baz, 2021; Laguir et al., 2022; Cardoso et al., 2022; Dubey et al., 2024). The results provide valuable information about the relationship of disaster impacts on SC performance, as well as the role of proactive strategies in smoothing this relationship.

The validation carried out in this research provides a series of findings. According to the perception of professionals, “delivery time,” “acquisition costs/price”, “responsiveness to customer demands,” “quality of the final product,” and “sales” are sufficient to explain the disaster impacts. Furthermore, the items “high levels of service,” “development of new business opportunities,”

“reduced operating costs,” and “high profitability” are sufficient to explain SC performance.

Another relevant finding concerns the f^2 coefficients of proactive strategies in the relationship between disaster impact and SC performance. The construct with the greatest moderating effect is localisation ($f^2 = 0.018$). This result is interesting when compared with the literature since in the literature there has been an increase in interest in analysing the benefits of shorter chains in the context of disaster (Kazancoglu et al., 2023).

Shortening SCs involves regionalisation or minimising exposure to geographically separate economies beyond the region of origin, which allows the number and intensity of international links to be reduced; this can also reduce vulnerability to external shocks (Kazancoglu et al., 2023). The COVID-19, for example, gave new emphasis to the discussion about the risks and instability associated with globalisation. Some companies have considered relocating or at least rethinking the location of their business (Stefano et al., 2022), strategy that became known as reshoring. Reshoring is defined as the decision to relocate an industrial activity back to the country of origin. Decision makers claim that more localized production reduces uncertainty for consumers and companies and guarantees supply during crises (Barbieri et al., 2020).

Also, digitalisation showed a medium degree of moderation in the relationship between the main constructs ($f^2 = 0.007$). The importance of digitalisation is well articulated in the SC risk management literature (Chowdhury et al., 2023). Overall, the concept of SC digitalisation has emerged in recent years as a focal point for companies striving to adapt to the rapidly changing global market landscape, including disruptions where digitalisation of the SC has gained notable prominence, particularly in the post-COVID-19 pandemic (Salamah et al., 2024). Once more, the results collaborate with discussions from other studies.

In Brazil, the focus of this study, the results are considered fundamental since there is a need to implement proactive strategies in order to minimise the impacts of disasters. As mentioned previously, Brazil is in the ranking of countries most affected by disasters in terms of mortality, affected people and economic damage and losses (EM-DAT, 2023).

Still, in the Brazilian context, digitalisation in the SC is a challenge as it has several barriers, for example, supporting and maintaining systems and data

collection and storage (Trevisan et al., 2023). In this scenario, it is important to highlight that digitalisation can support organisations in improving their SC capabilities, allowing them to respond to changes in the market and other external factors (Dubey et al., 2024).

Regarding the importance of localisation strategy, it is possible to highlight the behaviour of several variables that illustrate how pressure on global SCs was reflected in Brazil in the context of the COVID-19 pandemic, for example. Reports from the Central Bank of Brazil (2022) reveal that variables such as transport prices, supplier delivery time and shortage of inputs stood out as the main impacts. Therefore, the localisation strategy becomes fundamental in the context of disasters since shortening the SC can provide flexibility to all stakeholders (Almena et al., 2019).

Generally, in Brazilian SCs, disaster mitigation and preparedness appear to require maximum attention. Therefore, managers of focal companies, together with other actors along the SC, need to plan appropriate intra- and inter-organisational SC practices to ensure the stable supply of products to consumer markets (Silva et al., 2018).

Based on the results, this paper has contributions to both theory and practice. From a theoretical perspective, the study contributes to the SC risk management literature by focusing on the planning and implementation of proactive strategies. The importance of these strategies stands out since the impact of a catastrophic event has repercussions on several levels of global SCs, including end customers and production and transportation activities (Fan et al. 2024).

Still, from a theoretical perspective, the results enrich the discussion based on ORC and DVC theories not only within a company, but for the entire SC. The study systematically reveals the association between disaster impacts on SCs and countermeasure strategies in disaster scenarios, which contributes to promoting the improvement of dynamic capabilities and readiness to ensure the functioning of supply chains. In this study, both DCV and ORC are relevant due to their emphasis on the resources and capabilities needed to mitigate disruptions along SCs.

From a practical perspective, the paper brings important empirical results that reveal to decision-makers the importance of proactive strategies to minimise

the impacts of disasters on SC performance. Our results encourage organisations to implement strategies to minimise and manage the impacts of disasters; that is, our study indicates that there is a need for organisations to prepare adequately by implementing proactive strategies in their contingency plans. It is also important to highlight the importance of the results for public policy makers to define initiatives to reduce the impacts of disasters in SCs.

5.7 Conclusions

The exponential interest in having strategies for managing risks in SCs was the motivation for developing this study. This paper provides an analysis of the relationship between disaster impacts and SC performance, ad also presents the role of digitalisation and localisation in mitigating these impacts.

Data collected from 62 professionals working in Brazil were analysed using structural equation modelling to investigate the relationships between the constructs in the proposed conceptual model. The results suggest that the impacts of disasters negatively affect SC performance in indicators such as levels of service, development of new business opportunities, operating costs, and profitability.

Also, the results indicate that strategies such as localisation and digitalisation moderate this impact between the main constructs. Considering digitalisation, the use of digital technologies to collect data, connect business processes, and promote the exchange of internal information with clients and suppliers brings benefits to reducing the impacts of disasters on the SCs. In relation to localisation, aspects such as having relationships with suppliers, clients, institutes, universities, and local associations also have the role of reducing the impacts of disasters on the SC.

Our study, therefore, provides an initial step for researchers and practitioners to understand that the implementation of proactive strategies can positively impact SC performance in the context of disruptions such as disasters, which will result in organisationally valued results, generating productivity and business performance among stakeholders in the SC ecosystem. The findings of this study provide a deeper understanding that proactive strategies play a moderating role in the relationship between disaster impacts and SC

performance and are useful for companies and policymakers who aim to maintain a SC prepared for any adverse event.

There are different avenues for future research addressing the limitations of the current study and further expanding the literature on the topic. Firstly, it is possible to carry out analyses considering the type of disaster (climate-related and man-made) and also specific SCs (e.g., automobile, food, healthcare). Furthermore, it is possible to expand the study by considering the role of other proactive strategies, such as preventive collaboration and human capabilities (Cardoso et al., 2023). In this sense, it is still possible to evaluate the role of specific technologies (e.g., artificial intelligence, big data analysis, cloud computing) in SC risk management (Chowdhury et al., 2023). Finally, the small sample size of our investigation may limit the generalisation of our results, since the model was tested in an emerging economy; therefore, it is suggested to expand the study to other countries to understand the similarities and differences between the results.

6
Thesis discussions and contributions

During the past few decades, SC management's primary focus has been increasing efficiency and minimising costs. This approach is suitable for stable operating environments (Kovacs and Sigala, 2021). SC disruptions caused by disasters are becoming more frequent, and the impacts are significant. Thus, it is necessary to consider high-impact disruptors in the SC (Kovacs and Sigala, 2021).

The occurrence of disasters causes unpredictability in information, which influences the SC instability. The COVID-19 pandemic (a biological disaster), for example, has recently significantly impacted SCs. SCs were massively disrupted at all stages, including procurement, operations, distribution and other services (Chowdhury et al., 2021). The COVID-19 pandemic caused substantial negative impacts on SCs, including fluctuations in supply and demand (Coopmans et al., 2021), price instability (Zhou et al., 2021), difficulties in acquiring materials (Kumaran et al. 2021 al., 2021), the shutdown of processing plants (Fan et al., 2021), transportation difficulties (Rejeb et al., 2021) and other impacts.

Although there exists a vast literature on the subject, difficulties still exist in understanding how to prepare SCs to respond to a disaster with adequate and effective strategies for each impact (Queiroz et al. 2020; Salimi et al. 2020; Belhadi et al. 2021). In this context, this thesis considered a central research question, the focus of analysis of this section: *How can SCs prepare to respond to the impacts of disruptions caused by disasters?* The research is divided into specific steps considering different research methods.

The first stage of the research considers the systematic literature review to holistically understand the state of the art related to the topic. In Paper 1, the findings indicate the remarkable increase of research focusing on the disasters' impact on SC and SC strategies. The results constitute a

first analysis of the subject, considering that it presents descriptive characteristics of the studies, which can influence the development of more detailed and specific studies.

Paper 2, in turn, simultaneously presents the main impacts and respective countermeasure strategies for the SC. The literature analysis we developed leads to the systematisation of knowledge about disaster impacts on SCs and countermeasure strategies (proactive and reactive). In this study, countermeasure strategies are perceived as dynamic capabilities that enable organisational-level change so that SCs can better manage disruptions caused by disasters and continue to deliver high-performing products and services to consumers in an uncertain market. Among the proactive strategies, the results indicate the SC digitalisation and localisation.

Paper 3 shows the moderating role of digitalisation and localisation strategies in the relationship between disaster impacts and SC performance. Paper 3 directs the projection of implementing efficient and flexible mechanisms with fast responses and methods of recovering from interruptions. Our proposal combines different methodologies, such as quantitative modelling and empirical studies, to mutually justify the correlation of the proposed managerial insights with more accurate managerial results to mitigate the impacts of interruptions on the SCs.

The logical sequence of studies to obtain more comprehensive results is worth noting. The first paper considers the descriptive analysis of the literature, thus being input for the development of Paper 2. Paper 2, in turn, is the continuation of the literature review, considering the content analysis of the literature. The primary countermeasure strategies identified in Paper 2 are inputs for developing Paper 3. Finally, Paper 3 presents an empirical study that considers the moderating role of two specific strategies (digitalisation and localisation).

To address these types of SC disruptions, organisations need to invest in building capabilities to reduce the damaging impacts of such disasters on SC performance (Dubey et al., 2023). Increasing market uncertainties and challenges force organisations to reassess their dynamic SC capabilities to react quickly to changes and adapt their structures as necessary (Dubey et

al., 2024). In this context, there are proactive strategies that can support reduce the impacts of interruptions such as disasters.

Digitalisation affects companies at an unprecedented speed of development and forces companies to enter a new era of digital construction (Miao et al., 2022). Organisations must assess their business needs and technical capabilities to leverage digital technologies and improve their SC capabilities and, consequently, organisational performance (Dubey et al., 2024). Digitalisation represents several advanced technologies to support and synchronize organisational interactions, making services more valuable, accessible and customer satisfaction (Mishra et al., 2023).

It is essential to understand that digitalisation in the SC can improve processes, with several benefits such as better connectivity, resource scalability and easy accessibility (Sharma et al., 2023). Digitalisation ensures automation and intelligence through information collection, monitoring, transmission, analysis, processing, decision-making and other work. Data from each energy production link can be shared, interacted, integrated and connected. Security and reliability are further ensured by providing optimal decisions through advanced analytics tools (Lin and Huang, 2023).

The localisation strategy, in turn, becomes fundamental in the context of disasters, as shortening the SC can provide flexibility to centralized SCs (Almena et al., 2019). Sourcing and processing in the same region reduce vulnerability to external shocks (Belhadi et al., 2021; Kazancoglu et al., 2023). Therefore, it is important to have alternative suppliers for products and raw materials (Kuizinaite et al., 2023).

Although globalisation provides benefits to companies, it is important to highlight the negative impacts, such as increased susceptibility to natural catastrophes, as multinational business environments are impacted by these disruptions that compromise the overall performance of the SC (Kazancoglu et al., 2023). To mitigate these risks, companies employ strategies such as local networks (Kazancoglu et al., 2023).

In addition to proactive strategies, it is also necessary to highlight that reactive strategies are essential to respond to disasters. Reactive strategies are implemented according to the needs that adverse events impose.

During the COVID-19 pandemic, for example, the SC was significantly affected, leading to decreased supply availability, unsatisfied demand, extended delivery times and high delays (Mostafa, 2024). The need for social distancing has implied, for example, remote working and improved delivery systems (Boyacı-Gündüz et al., 2021). In this case, adapting to the new reality is a necessity for organisations to continue processes and meet demand.

Overall, these strategies are planned and implemented in an attempt to maintain SC performance in the context of disasters. Maintaining high performance, a critical component of strategic objectives, is a major challenge for companies (Laguir et al., 2022). However, it is essential to highlight that the implementation of these strategies goes beyond the results found because they require long-term integrated structures, including the involvement of all SC links. Certainly, the results highlighted in this research and in the literature (e.g., Belhadi et al., 2021) highlight the fundamental contribution that strategies have to minimize the impacts of disasters.

From this perspective, the research findings corroborate the suggestions of DCV and ORC theories about the need to have dynamic capabilities (in this thesis translated as strategies) and consider the readiness to maintain performance in a turbulent and uncertain scenario. In fact, as the results indicate, disasters have a negative effect on supply chain performance and the implementation of proactive and reactive strategies are essential to reduce the impacts of disasters.

In this sense, our results encourage organisations to implement strategies to minimise and manage the impacts of disasters and, consequently, support the implementation of resolving processes during disasters. Companies involved in SCs need to think intelligently and be forward-looking to develop strategies, processes, and operations relevant to dealing with disasters and achieving resilience and sustainability in the long term (Islam, 2021). In this way, our study would allow organisations to prepare properly with the implementation of proactive strategies that consider disaster context.

7
Conclusions and future research directions

The development of the thesis presents sequential results that allow us to conclude that disasters have a significant impact on supply chains, as they interrupt the normal flow of operations (e.g., closure of manufacturing plants). However, implementing proactive strategies that prepare supply chains for potential crises is essential to reduce disaster impacts. Planning reactive strategies in order to adapt to the new reality that disasters impose is primary. It is also necessary to conclude that, for each type of impact, there are specific strategies that can help with business continuity even in times of disaster. Therefore, it is necessary to understand what the existing impacts are in order to plan appropriate strategies.

Considering the general objective of the thesis, specific objectives were defined, and different papers address each objective. First, Paper 1 maps the literature to understand the panorama and general characteristics of publications related to the topic. Then, Paper 2 brings a deep review of the literature to identify the main impacts of disasters and countermeasure strategies in SCs. Finally, Paper 3 validates of the results found in the literature through an empirical study applying survey methods and considering SEM in the data analysis.

The thesis comprises a logical sequence of papers developed based on opportunities in the academic literature. Paper 2, for example, encompasses research opportunities highlighted in Paper 1 as “analyse the relations between multiple variables (impacts and strategies). Paper 3 encompasses the research opportunity highlighted in Paper 2 “development of empirical studies (e.g., surveys and case studies)”.

The SLR developed in Paper 1 analyses 129 documents, and the results show that most literature documents address climate-related disasters (e.g., floods, earthquakes, tsunamis, and pandemics). Also, most papers analyse the food SCs. Other SCs, such as healthcare SC, manufacturing SC, and automobile SC are also covered. The bibliometric analysis allows the preliminary analysis of

the documents, which provides some disaster impacts on SCs and countermeasure strategies.

Paper 2 presents the content analysis of SLR. This research results from an exhaustive literature review of 160 papers on SC disruptions and their countermeasure strategies. Specifically, the literature review findings present the impacts of disasters and proactive and reactive strategies. Disaster impacts are categorised into resource constraints, SC instability, outflow disruption, financial constraints, and consumption patterns. Proactive strategies are classified into five categories: SC collaboration, resource maintenance, digitalisation or automation, local SC, and human capabilities. Reactive strategies are classified into five categories: SC collaboration, resource maintenance, information systems, virtual marketplaces, and business continuity plans. Therefore, the research agenda encompasses specific points for developing organisational capacities in the context of disasters. Finally, the study proposes a framework that integrates the research findings, including research theories, a taxonomy, and a research agenda.

Paper 3, in turn, presents the empirical study to understand the moderating role of digitalisation and localisation to minimise the impacts of disasters on the SC performance. Our research presents hypotheses built from the literature analysed from structural equation modelling. Based on the opinion of 62 SC professionals in Brazil, our model is validated. With the PLS-SEM algorithm, it is possible to test hypotheses to validate strategies to reduce the impacts of disasters in the SC.

The development of papers in a logical sequence brings results in light of the research question, "*How can SCs prepare to deal with disaster impacts considering proactive and reactive response strategies?*". Notably, we identified that there is a need to redesign the supply chain considering the occurrence of disasters. Preparedness of supply chains requires attention to existing and potential impacts and corresponding strategies to mitigate them.

Our results primarily address the SC preparedness to deal with disasters, as that if no prior preparation is done, adverse effects will prevail during a crisis such as a disaster (Chen et al., 2021). Preparing SCs is fundamental to dealing with and recovering from disasters (Dormady et al., 2021). Therefore, our results provide a foundation that is needed since SCs need to be prepared to deal with

disruptions caused by disasters. Paper 2 compiles strategies that can be proactively implemented to prepare SCs when a disaster occurs. Besides, Paper 3 highlights the fundamental role of strategies (i.e., digitalisation and localisation) in reducing disaster impacts.

This research has limitations, and future study directions are suggested. First, our framework (Paper 2) is general, with no specificity regarding the SC type. Thus, future studies can deepen research to understand similarities and differences between SCs (e.g., food, healthcare). Second, our study (Paper 3) adopts a cross-sectional design and mainly investigates the context of Brazilian companies. Therefore, future studies in other countries may provide data regarding similarities and differences with other contexts. Furthermore, the number of proactive strategies used in the model is limited. Testing more proactive strategies is necessary to improve the generality of the results presented in this research. Finally, even though the solution method proposed in this research (Paper 3) is useful for evaluating proactive actions, it is considered necessary to develop decision support models capable of quantitatively evaluating the effect of implementing proactive and reactive strategies in SCs (Darmawan, 2024).

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Appendix A – Taxonomy (Paper 2)

Slow-onset disaster analysis

Table A1 – Impacts and Countermeasure Strategies | Slow-onset disasters (resource constraint category)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Workforce shortages	SC automation and digitalisation	Disruptive innovation and technology	Business continuity plans	Administrative controls
		SC automation and digitalisation		Crisis management plan
	Human capabilities	HR capacity		Contingency plans
			Resources maintenance	Remote work
				Guidelines on seasonal workers and migrant workers
				Optimizing the familial or community workforce
				Temporary works
				HR management
Supply (input), equipment and services shortages	SC collaboration	Collaboration/coordination	SC collaboration	Public-private cooperation
	Local SC	Alternative supply sources	Information system	Warning systems
		Identify critical suppliers		Communicating information
		Local suppliers	Business continuity plans	Business continuity plans
		Purchasing policy		Administrative controls
	SC digitalisation/ automation	Communicating information technology		Free supply of essential goods
		Supply Chain Digitalisation		Government assistance
				Crisis Management Committee (ICMC)
			SC collaboration	Collaboration/coordination
			Resources maintenance	Reserves of inventory
Infrastructure constraints	SC digitalisation/ automation	SC Digitalisation	Business continuity plans	More funding
		Digital transformation		Relaxation of laws/regulations
	SC Collaboration	Risk management program		Flexible layout
		SC integration		Assistance government
	Resources maintenance	Improving infrastructure	SC Collaboration	Network relationship
		Capacity management	Virtual marketplace	Online market

Table A2 – Impacts and Countermeasure Strategies | Slow-onset disasters (SC instability category)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Salles instability	Local SC	Alternative channels	Virtual marketplaces	Marketing digital
	SC Collaboration	Collaboration	Business continuity plans	Salles management
		Customers retention		Government assistance
				Diversification of product lines
				Communicating information
			SC Collaboration	Collaboration
Inventory instability	Local SC	National inventories	SC Collaboration	Coordination/collaboration
	SC digitalisation/ automation	Digital solutions	Resources management	Redirect inventories
	SC Collaboration	Risk management plan		Inventory control policies
		Outsourcing of business operations		Stock management
		Coordination/collaboration		Sustainable procurement strategies
				Visibility on stock levels
			Information system	Information and communication availability
Capacity constraints	SC digitalisation/ automation	SC automation and digitalisation	SC collaboration	Collaboration
		Technology implantation	Business continuity plans	New operating procedures
	Resource maintenance	Quality tools		Short-term incentives
			Virtual marketplaces	Focus on online infrastructures
Supply instability	SC digitalisation/ automation	SC Digitalisation	SC Collaboration	Partnerships
		JIT dimensions		Collaboration
		Technology implantation	Business continuity plans	Business continuity plans
		Communication tools	Information system	Data availability
		Inventory management tools		Effective communication
		Demand planning (e.g., forecast)		
	SC Collaboration	Risk management program		
		Collaboration		
		Supplier diversification		
		Cooperative relationships		
	Local SC	Regionalizing supply chains		
		Strategic Facility Placement		

Demand instability	SC digitalisation/ automation	Digital Solutions	SC Collaboration	Collaboration/coordination
		Communication technologies	Resources management	Strategic inventory
		Demand planning (e.g., forecast)		*Diversifying Single-Product Categories*
		Collaborative demand forecasting		
	SC Collaboration	Integration		
Packaging change	SC digitalisation/ automation	Smart packaging technology	Business continuity plans	Business continuity plans
	Human capabilities	Enable operation teams		Adaptive strategies
			SC Collaboration	Collaboration/coordination
				Strengthen existing supplier relations
Prices instability	SC Collaboration	Alternative channels	SC Collaboration	Public-private cooperation
		Control/flex prices		Collaboration/coordination
		Risk management program	Business continuity plans	Government assistance
		Collaboration/coordination		Readiness
				Effective Communication
				Strong, focused country leadership
				Control/flex prices
	SC digitalisation/ automation	SC digitalisation		
		JIT dimensions		
Productivity instability	SC digitalisation/ automation	SC automation and digitalisation	Business continuity plans	Administrative controls
				More funding
				Financial aid packages (government)
Inputs losses (e.g., product expiry)	Resource maintenance	Ponytail and processing centers	SC Collaboration	Collaboration
	SC digitalisation/ automation	Communication technologies	Business continuity plans	Assistance government
	SC Collaboration	Collaboration		Relaxation of standards
			Resources management	Disposal management
				Resources management

Table A3 – Impacts and Countermeasure Strategies | Slow-onset disasters (outflow disruption)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Delivery/Distribution restrictions	Local SC	E-commerce	Virtual marketplaces	Delivery systems
		Distributor sourcing		E-delivery services; online platforms
	SC Collaboration	Guidelines/manuals	SC Collaboration	Alternative transportation
		SC risk management		Coordination/collaboration
		Coordination/collaboration	Business continuity plans	Crisis Management Committee
	Resource maintenance	Outsourcing		Flexibility
		Warehouse integration		Leadership
	SC digitalisation/ automation	Data analytics		Distribution planning and resource allocation
		Decision Support System (DSS)	Information system	Communication
Production disruption	Local SC	Local production	Business continuity plans	Government assistance
	Resource maintenance	Development of local infrastructure		Adequate controls
	SC digitalisation/ automation	Novel production systems (Technology)		Policies incentives
	SC Collaboration	Risk management program		Crisis Management Committee
		Coordination		Adapt production/products
			SC collaboration	Coordination/collaboration
			Information system	information sharing
Transport disruption	SC Collaboration	Coordination/collaboration	SC Collaboration	Coordination/collaboration
		Green channel		Partnership between links
		Risk management plan	Business continuity plans	Government assistance
		SC integration		Alternative transportation
	Local SC	Local system		Rapid policies for reduce bottlenecks
	Resource maintenance	Inter- and intra-island transport		Operational flexibility
		Warehousing facilities	Information system	Effective Communication
	SC digitalisation/ automation	Innovation and digital transformation	Virtual marketplace	E-commerce opportunities
		Decision Support System (DSS)		
Movement of goods restriction	Local SC	Local system	SC Collaboration	Collaboration/coordination
	SC digitalisation/ automation	Innovation and digital transformation	Business continuity plans	Facilitate barrier-free movements of good
	Resource maintenance	Guidelines/manuals		Keep trade open

	SC Collaboration	Collaboration/coordination		Government assistance
				Selling the products in the domestic market
Movement of people restriction	SC collaboration	Strengthening links relationships	Virtual marketplaces	New channels and processes
	Resource maintenance	Quality tools		
Trade relationships restrictions	SC digitalisation/ automation	Innovation and digital transformation	SC Collaboration	New supply chain partnership
	SC Collaboration	Collaboration/coordination		Collaboration/coordination
		Alliance formation	Information system	Effective stakeholder communication
Export and import restrictions	Local SC	Local system	Business continuity plans	Tax relief reduction
		Trade and market diversification	SC Collaboration	Reducing interdependencies
	Resource maintenance	Guidelines/manuals		Collaboration
	SC Collaboration	Cooperation of Upstream and Downstream		

Table A4 – Impacts and Countermeasure Strategies – Slow-onset disasters (financial constraint)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Working capital losses	Resource maintenance	Resources management	Business continuity plans	Government assistance
	SC digitalisation/ automation	SC automation		Flexibility of regulations
				Minimize trade promotion costs
		Digital Technologies	SC Collaboration	SC Collaboration
	Human capabilities	Team capabilities		Effective communication
	Local SC	Local SC	Information system	Information/communication
	SC Collaboration	Collaboration/coordination	Virtual marketplaces	Online market
				Focus on building online infrastructures
			Resources maintenance	Resources management
Revenue and profit losses	Resource maintenance	Risk management program	SC Collaboration	Collaboration
		Notice manuals	Business continuity plans	Costs reduction
	SC digitalisation/ automation	Communication technologies		Flexibility of regulations
	Human capabilities	Team capabilities		Cost reduction and elimination of non-essential assets

	Local SC	Local SC		Revenue streams
	SC Collaboration	Collaboration/coordination		Government assistance
			Information system	Communication technologies
			Virtual marketplaces	Online market
				Remote support centers
			Resources maintenance	Resources management
Operation costs instability	Resource maintenance	Supply chain risk management (SCRM)	SC Collaboration	Agility
		Quality tools		Collaboration/coordination
	SC Collaboration	Collaboration/coordination	Business continuity plans	Cost optimization
	SC digitalisation/ automation	SC automation		Flexibility of regulations
	Human capabilities	Team capabilities		Product rotation in trade
	Local SC	Local SC		Government assistance
			Virtual marketplace	Digital market
			Resource maintenance	Resources management
			Information system	Information/communication

Table A5 – Impacts and Countermeasure Strategies | Slow-onset disasters (consumption pattern)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Change in consumer behaviour	SC automation and digitalisation	Efficient information sharing mechanisms	Business continuity plans	Relaxation of competition laws
	SC Collaboration	Collaboration/coordination		Understand customer needs
			Information system	Provide detailed information
				Transparent dissemination of information
Income losses	SC Collaboration	Social protection	Business continuity plans	Government's subsidies
				Social protection
				Measures as social assistance and incentive
				Maximise consumption with minimum wastage
Job losses	SC Collaboration	Social protection	Business continuity plans	Government's subsidies
				Measures as social assistance and incentive

				Social protection
			Resources management	rethink and reorganize works
				Enabling remote working and learning
Change in consumer behaviour	SC automation and digitalisation	Efficient information sharing mechanisms	Business continuity plans	Relaxation of competition laws
	SC Collaboration	Collaboration/coordination		Understand customer needs
			Information system	Provide detailed information
				Transparent dissemination of information
Income losses	SC Collaboration	Social protection	Business continuity plans	Government's subsidies
				Social protection
				Measures as social assistance and incentive
				Maximise consumption with minimum wastage
Job losses	SC Collaboration	Social protection	Business continuity plans	Government's subsidies
				Measures as social assistance and incentive
				Social protection
			Resources management	rethink and reorganize works
				Enabling remote working and learning

Appendix B – Taxonomy (Paper 2)

Sudden-onset disaster analysis

Table B1. Impacts and Countermeasure Strategies | Sudden-onset disasters (resource constraint category)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Workforce shortages	SC automation and digitalisation	Disruptive innovation and technology	Business continuity plans	Contingency plans
		SC automation and digitalisation		
Supply (input), equipment and services shortages	SC collaboration	SC preparation and integration	SC collaboration	Public-private cooperation
	SC automation and digitalisation	Communicating information technology	Business continuity plans	Business continuity plans
		Supply Chain Digitalisation		Administrative control/ Leadership
	Local SC	Alternative supply sources		Government assistance
		Local suppliers	Resources management	Reserves of inventory
Infrastructure constraints	SC Collaboration	SC integration	Business continuity plans	More funding
			SC Collaboration	Alternate locations of production

Table B2. Impacts and Countermeasure Strategies | Sudden-onset disaster (SC instability category)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Salles instability	SC Collaboration	Customers retention		
Inventory instability	Local SC	Alternate suppliers		
	SC automation and digitalisation	Digital solutions		
Capacity constraints	Digital connectivity/SC automation	Technology implantation		
Supply instability	SC automation and digitalisation	Technology implantation	SC Collaboration	Collaboration
		Demand and supply planning (e.g., forecast)	Business continuity plans	Business continuity plans
	SC Collaboration	Collaboration		

Demand instability	SC automation and digitalisation	Digital Solutions		
		Demand and supply planning (e.g., forecast)		
Prices instability	SC Collaboration	SC preparation	SC Collaboration	Public-private cooperation
Productivity instability	SC links integration	Disaster risk management	Business continuity plans	More funding
				Financial aid packages (government)

Table B3. Impacts and Countermeasure Strategies | Sudden-onset disasters (outflow disruption category)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Delivery/Distribution restrictions	Local SC	Distributor sourcing	Virtual marketplaces	Expediting delivery
	SC Collaboration	Coordination/collaboration	SC Collaboration	Strengthen the supplier–customer relationship
				Coordination/collaboration
Production disruption			Business continuity plans	Adapt production/products
Transport disruption	SC Collaboration	Coordination/collaboration	SC Collaboration	Coordination/collaboration
		Availability of alternative routes	Business continuity plans	Effective Communication
		Warehousing facilities		Business continuity plan
	Local SC	SC integration		
	SC automation and digitalisation	Information flow platforms		
Movement of goods restriction			Business continuity plans	Facilitate barrier-free movements of good
Movement of people restriction				
Export and import restrictions				

Table B4. Impacts and Countermeasure Strategies | Sudden-onset disasters (financial constraint category)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Revenue and profit losses	SC Links integration	SC preparation		
		Risk management program		
	SC automation and digitalisation	Communication technologies		
Operation costs instability	SC Collaboration	Collaboration/coordination		

Table B5. Impacts and Countermeasure Strategies | Sudden-onset disasters (consumption patterns category)

Impact	Proactive Category	Strategies	Reactive Category	Strategies
Change in consumer behaviour				
Job losses				

Appendix C – Questionnaire (Paper 3)

- **Informed Consent**

This term aims to present the research in which you were invited to participate, as well as guarantee your authorisation to carry it out. The questionnaire aims to collect responses from professionals who work in activities linked to the supply chain (e.g., purchasing, logistics, distribution and others). Filling time: approximately 8 minutes.

Procedure: This questionnaire is part of doctoral research from the Department of Industrial Engineering (DEI) at the Pontifical Catholic University of Rio de Janeiro (PUC-Rio), developed in the HANDS (Humanitarian Assistance and Needs for Disasters) laboratory. **Objective:** The research aims to evaluate the behaviour of proactive strategies in mitigating the impacts of disasters in supply chains. **Risk or discomfort:** This study has minimal risks for its participants. However, if at any time you feel uncomfortable, you can request the closure of your records and withdraw from participating in the research. **Research confidentiality and security:** The results of this research may be published in journal articles and conferences. All information obtained will be used for scientific research, and under no circumstances will names appear in any publications. **Consent:** By completing this online questionnaire, you indicate that you are voluntarily participating in the research and agree to this consent form.

1) **Sector**

Primary Sector (agriculture)
Second Sector (manufacturing)
Tertiary sector (services)
Other

2) **Operation scope**

Local
National
Multinational

3) **Experience of SCs (in years)**

[1-5]
[6-10]
> 10

4) **Respondents' job titles**

The impacts of interruptions caused by disasters are increasingly frequent in supply chains. During disasters (e.g., COVID-19 pandemic, drought,

floods, landslides), supply chains face impacts such as instability in production and inventory, fluctuations in supply and demand, variability in production costs and others. To minimise these impacts, supply chains need to implement strategies to quickly respond to market changes.

In this context, we ask you to answer the following questions, considering the reality of the company or supply chain in which you operate. Likert scale (1 = completely disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = completely agree).

Do disruptions caused by disasters negatively affect the indicators?
Overall efficiency of operations
Delivery time (delivery reliability)
Acquisition costs/price
Responsiveness to customer demands (readiness)
Quality of final product
Sales

To what extent do these statements apply to your supply chain?
We adopt digital technologies to collect data from different sources
We adopt digital technologies to connect business processes
We adopt digital technologies to promote the exchange of information
We adopt digital technologies to build the customer interface
We embrace digital technologies to connect supply chain partners

We have solid relationship with local customers
We have extensive links with many local suppliers
We often meet with local research institutes and universities
We partner with local industry associations

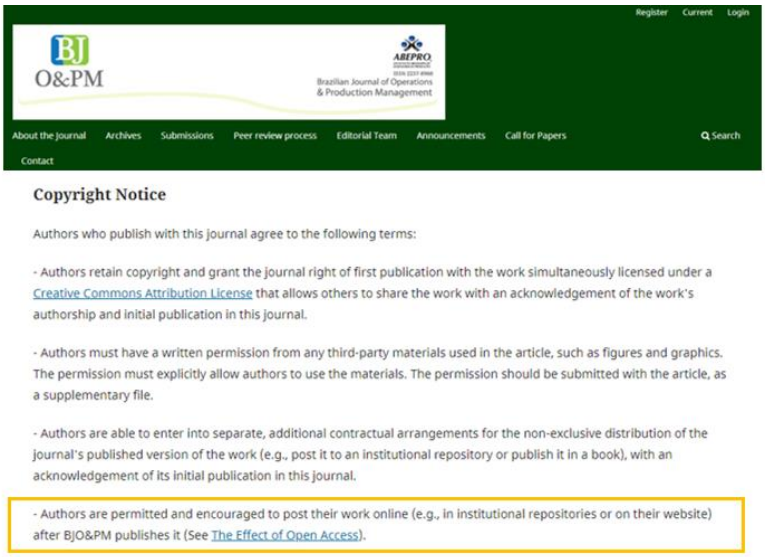
Our supply chain satisfies the customer and has high levels of service
Our supply chain has frequent development of new business opportunities
Our supply chain has reduced operating costs
Our supply chain is punctual and accurate in the delivery time of services/products
Our supply chain has high profitability

Appendix D – Constructs and items (Paper 3)

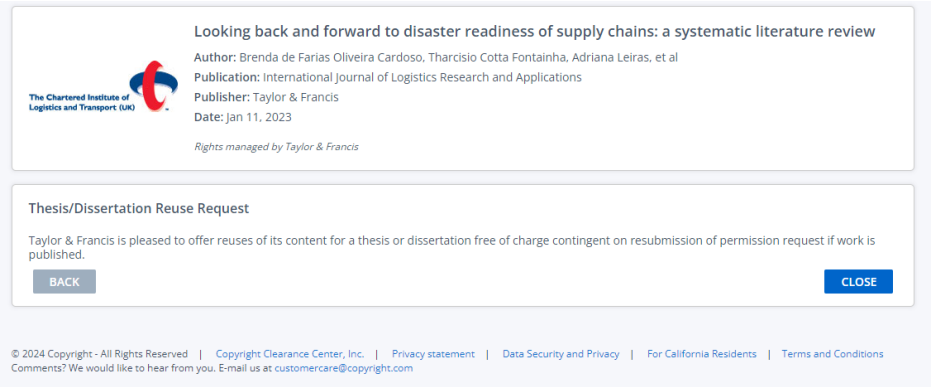
Construct	Refence	Code	Indicator
		Do disruptions caused by disasters negatively affect the indicators?	
Disaster impacts (IMP)	Bode et al. (2011); El Baz and Ruel (2021)	IMP1	Overall efficiency of operations
		IMP2	Delivery time (delivery reliability)
		IMP3	Acquisition costs/price
		IMP4	Responsiveness to customer demands (readiness)
		IMP5	Quality of final product
		IMP6	Sales
		To what extent do these statements apply to your supply chain?	
Digitalisation (DIG)	Ying et al. (2023)	DIG1	We adopt digital technologies to collect data from different sources
		DIG2	We adopt digital technologies to connect business processes
		DIG3	We adopt digital technologies to promote the exchange of information
		DIG4	We adopt digital technologies to build the customer interface
		DIG5	We embrace digital technologies to connect supply chain partners
		To what extent do these statements apply to your supply chain?	
Localisation (LOC)	Boehe et al., (2007)	LOC1	We have solid relationship with local customers
	Wang (2018)	LOC2	We have extensive links with many local suppliers
	Boehe et al., (2007)	LOC3	We often meet with local research institutes and universities
	Boehe et al., (2007)	LOC4	We partner with local industry associations
		To what extent do these statements apply to your supply chain?	
SC performance (PER)	Reyna-Castillo et al. (2023)	PER1	Our supply chain satisfies the customer and has high levels of service
	Aslam et al. (2023)	PER2	Our supply chain has frequent development of new business opportunities
	Reyna-Castillo et al. (2023)	PER3	Our supply chain has reduced operating costs
	Reyna-Castillo et al. (2023)	PER4	Our supply chain is punctual and accurate in the delivery time of services/products
	Aslam et al. (2023)	PER5	Our supply chain has high profitability

Appendix E – Copyright

Appendix E1 – Copyright BJO&PM



Appendix E2 – Copyright IJLRA



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Appendix F – Curriculum Vitae

BRENDA DE FARIAS OLIVEIRA CARDOSO

Professor at the Production Engineering department at the State University of Pará

EDUCATION

Pontifical Catholic University of Rio de Janeiro – PUC-Rio D.Sc. Production Engineering	**2019 – 2024**
Pontifical Catholic University of Rio de Janeiro – PUC-Rio M.Sc. Production Engineering	**2017 –2019**
University of State of Para – UEPA B.Sc. Production Engineering	**2012 –2016**

PROJECTS DURING THE DOCTORAL PERIOD

PNUD - Projeto de Cooperação Técnica Internacional BRA/12/017 - Plano Nacional de Proteção e Defesa Civil *(in Portuguese)*	**2023-CURRENT**
CNPq/MCTI/FNDCT 406666/2022-9 - Mapeando as interligações entre Mudanças Climáticas, Operações Humanitárias e Objetivos de Desenvolvimento Sustentável para fortalecimento da Agenda 2030 *(in Portuguese)*	**2022- CURRENT**
FAPERJ - Plataformas para integração de stakeholders em operações de preparação e resposta a desastres E-26/290052/2021 *(in Portuguese)*	**2021-CURRENT**
FAPERJ Segunda Chamada Emergencial de Projetos p/Combater os Efeitos da Covid-19 SEI-260003/002705/2020 - Tecnologias integradas para fortalecimento das cadeias de suprimento alimentar e de EPIs na pandemia de COVID-19 *(in Portuguese)*	**2020-CURRENT**
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