INSTITUT D´ADMINISTRATION DES ENTREPRISES

DOCTORATE in BUSINESS ADMINISTRATION

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The Impact of Supply Chain Risks and Supply Chain Strategies on Operational Performance and Supply Chain Robustness: An Empirical Analysis from Sufficiency and Necessary Condition perspectives

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“There is no end to education. It is not that you read a book, pass an examination, and finish with education. The whole of life, from the moment you are born to the moment you die, is a process of learning” Jiddu Krishnamurti

Contents

Abstract

This dissertation was developed in the Supply Chain Management research area, which is still a very new area compared to other disciplines in the social sciences and whose importance and criticality for any country in the word have become more apparent in the face of Corona Virus outbreak.

Our study was structured around the following main pillars: first evaluating and identifying the influence of Supply Chain Risks and specific Contingencies on the Operational Performance of Manufacturing companies in Brazil. Secondly, from significance and necessary condition analysis perspectives, we evaluated and distinguished the relative influence of a different set of Supply Chain Strategies upon Operational Performance and Supply Chain Robustness.

The thesis is organized in five distinct chapters as follows: Chapter 1 (Introduction); Chapter 2 (Article 1); Chapter 3 (Article 2); Chapter 4 (Article 3); and Chapter 5 (Conclusion). Using data collected from 165 Supply Chain Professionals allocated in different industries in Brazil, the present work follows quantitative research and applied four methods as such: Partial Least Structural Equation Modeling (PLS-SEM), Importance Performance Map Analysis (IPMA), Multi-Group Analysis (MGA) and Necessary Condition Analysis (NCA) to support our investigation.

In Chapter 1, we presented an introduction to the research based on the following elements: Study Background and Research Gaps, Research Problems, Aims, Objectives, Research Questions, Significance of the Study, Limitations, and Thesis Structure. The Chapter 2 was dedicated to evaluating the influence of overall Supply Chain Risks on the Operational Performance of industries in Brazil; identifying which sources of risks have a relatively higher negative impact on the Operational Performance; identify the influence of contingencies like Supply Chain Complexity, Firm Size, and Strategies for Competitive Advantage on the relationship between Supply Chain Risks and Operational Performance. Among other findings, the study presents for science and practical fields a relative hierarchy in terms of frequency and the negative impact of 04 distinct dimensions and 13 different sources of risk.

Chapter 3 focused on evaluating the influence of Supply Chain Risk Management and Supply Chain Agility on Operational Performance; and distinguishing the influence of such Supply Chain Strategies ty in terms of its average positive impact and predictive relevance of Operational Performance.

In Chapter 4, our conceptual model was further improved by introducing three dimensions of Supply Chain Integration (Supplier, Internal e Customer) and the second dimension of Performance (Supply Chain Robustness). In this chapter, we pursued the following main objective: to evaluate the influence of Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration on Operational Performance, and Supply Chain Robustness from both a significant and necessity logic perspectives.

The value and originality of this research are anchored on reducing specific scientific gaps identified in the literature (evidence, methodological, empirical, theoretical populational) By applying the necessary condition analysis, in complement to the PLS-SEM, to evaluate the relationship proposed on our conceptual model, we executed an unprecedented exploration of the impact of different strategies on organizational performance. The analysis utilizing the necessity logic view enabled our investigation to shift attention from 'average trends' among variables to the logic of 'the required level.", enabling us to identify the conditions that, when absent, will imply the absence of the outcome or, when present, will enable the presence of the outcome.

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CHAPTER 1

Thesis Introduction

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1. INTRODUCTION

1.1 - Opening Section

This doctoral dissertation will be developed in the field of Supply Chain Management that had a market size of $15.85 billion in 2019 with a forecast to grow approximately 11.2% per year up to 2027 (Wire, 2020).

Consultants originally introduced supply Chain Management (SCM) in the early 1980s (Cooper, Lambert, & Pagh, 1997). Since then, SCM has been used to managing the flows of products and information among companies. Various definitions of a supply chain have been offered in the past several years as the concept has gained popularity. In this thesis, we use the following definition of Supply Chain Management: "the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole". (Christopher, 2005, p.5)

Among the array of organizations that belong to a Supply Chain System, the analysis of the present investigation will be the manufacturing plant and its relationship among internal functions, customers, and suppliers. The business context to be research is the Brazilian Business environment.

The decision to perform our investigation at the industry level derives from different aspects. The first one consists of the impact that industries have on any country's economy. To illustrate, according to the official data produced by the National Confederation of Industries, Manufacturing companies' results represent 20.4% of Brazil's Gross Domestic Product in 2020 (CNI, 2021). Globally, Brazilian industries are among the top twenty industries with a Gross Domestic Product list at the top ten highest, up to 2019 with a shortfall to 12th position in 2020 (World Bank, 2021).

Second a reason from a broad perspective stems from the undeniable relevant role of manufacturer in the context of Supply Chain Management, from where goods are produced and subsequently distributed and commercialized through a chain of different organizations (e.g., Suppliers, Logistics Providers, Retailers)

In this context, understanding the functioning of the supply chain in which the industries operate is of paramount importance, mainly because we live in an era where different variables can positively or negatively impact performance. As highlighted by Ganiyu, Yu, Xu and Providence (2020, p.1491), "interruptions are increasingly frequent in the Supply Chain Management environment due to the tremendous expansion of business globally".

There are different examples of harmful consequences from disruptive events that exemplify the statement above. For instance, the performance of companies in general. Ericsson was undermined with a loss of $400 million in sales due to a semiconductor Supplier production interruption in 2000 (Chopra, S. and Sodhi, 2014), and Land Rover laid off 1,400 workers due to key suppliers insolvencies in 2001 (Tang, 2006c), just name a few.

Supply chain disruptions stem from numerous sources. In this research, we will focus on the following sources of supply chain risk: Supply-side risks, Demand-side risks, Regulatory, legal, and bureaucratic risks, Infrastructure risks, Catastrophic risks, suggested by Wagner & Bode (2008).

Motivated by the negative consequences usually attributed to different sources of Supply Chain Risks, based on contingency theory (Lawrence & Lorsch, 1967), this thesis's first aim consists of evaluating and identifying the influence of Supply Chain Risks and Contingencies on the Operational Performance of Manufacturing companies in Brazil, as presented in Chapter 2

The contingency theory will support our investigation. In its essence, this vital theory of the social sciences tells us that the variation in the performance of organizations is due to the influence of environmental factors, which can be understood as natural or operational risks, and of organizational characteristics (Lawrence & Lorsch, 1967; Sousa & Voss, 2008; Wagner & Bode, 2008b).

From contingency theory lenses, this research will promote data collection concerning the frequency of occurrence of different risks and investigate its relationship with negative consequences on performance. We also consider factors such as complexity drivers, company size, and market positioning strategy to understand how such contingencies may change the influence of risks on Operational Performance.

In addition to the empirical assessment of the influence of risks and a set of contingencies in the performance of industries, it is essential to investigate what capabilities need to be developed by industries to operate in a risky and complex environment (Um & Han, 2020). In this line, Dynamic Capability Theory emerges as a theoretical frame to support our investigation. According to this theory, organizations need to have processes and activities that allow them to sense the presence of uncertainties and risks, seize such information and, if necessary, react quickly in the market by adapting or transforming its operations (Teece, Pisano, & Amy, 1997).

Motivated by such a call, organizations have deployed different strategies to cope with threats and challenges, focusing on achieving superior performance. Among other possibilities, we observed that risk management, agility, and integration had received attention from professionals and scholars.

Different studies explored the relationship of the strategies above with Operational Performance. For instance, Nazempour, Yang, & Waheed, (2018) and Um (2017) examined the role of Supply Chain Agility, whereas Munir et al. (2020), Hu, Shou, Kang, & Park (2020), Shou, Hu, et al. (2018) and (Chaudhuri, Boer, & Taran, 2018) evaluated the impact of Risks Management and (Frohlich & Westbrook, 2001); (Huo & Wang, 2014) and Huo Jajja and (Munir et al., 2020) assessed the influence of Supply Chain Integration, just to name a few.

From such a view, this study's second aims consist of empirically evaluating and distinguishing the influence of a different set of Supply Chain Strategies, understood as dynamic capabilities, on performance, as presented in chapters 3 and 4 of this thesis.

This chapter presents an introduction to the research based on the following elements: Study Background and Research Gaps, Research Problems, Aims, Objectives, and Research Questions, Significance of the Study, Limitations, and Thesis Structure.

1.2 - Study Background and Research Gaps

Before presenting the research background, it is essential to emphasize that the present investigation is built upon existing research gaps identified in the literature. According to Miles (2017) taxonomy's, there are seven types of research gaps (see figure 1) defined based on the arguments exposed in table 1.

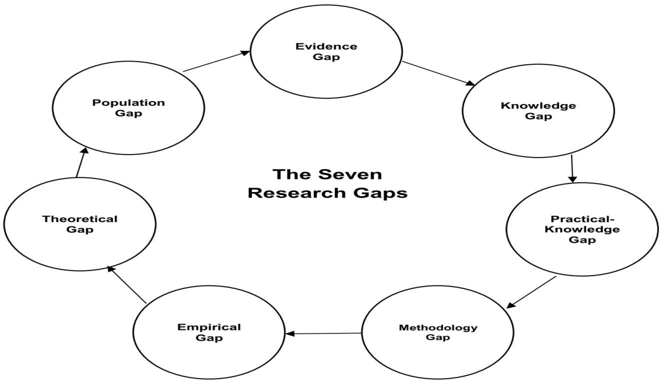

Figure 1 - Types of Research Gap Taxonomy extracted from (Miles, 2017).

Research Gap Type	Definition
Evidence Gap (Contradictory Evidence Gap)	Results from studies allow for conclusions in their own right, but are *contradictory* when examined from a more abstract point of view [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Knowledge Gap (Knowledge Void Gap)	Desired research findings do not exist [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Practical-Knowledge Gap (Action-Knowledge Conflict Gap)	Professional behavior or practices deviate from research findings or are not covered by research [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017]. .
Methodological Gap (Method and Research Design Gap)	A variation of research methods is necessary to generate new insights or to avoid distorted findings [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Empirical Gap (Evaluation Void Gap)	Research findings or propositions need to be evaluated or empirically verified [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Theoretical Gap (Theory Application Void Gap)	Theory should be applied to certain research issues to generate new insights. There is lack of theory thus a gap exists [Müller-Bloch & Kranz, 2014]. [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Population Gap	Research regarding the population that is not adequately represented or under-researched in the evidence base or prior research (e.g., gender, race/ethnicity, age and etic). [Robinson, et al, 2011].

Source: Robinson, Saldanhea, & McKoy (2011); Müller-Bloch & Kranz, (2015); Miles, (2017).

Table 1 - Type of Research Gaps Taxonomy extracted from (Miles, 2017)

The contextualization and motivation of the research presented below will refer to the gaps above taking into consideration the available literature in the Supply Chain Management field.

Supply Chain Risk and Contingency Theory

There are several definitions for the term risk: the probability of incurring a loss Knight (1921); uncertainty about outcomes Sitkin & Pablo (1992); and unanticipated or adverse variation on performance Miller (1992) are some examples. Risk is also associated with positive opportunity Purdy (2010). In this research, we apply the notion of risk in regards to its negative consequences following the proposition of scholars like Rao & Goldsby (2009); Wagner & Bode (2008), and Hendricks & Singhal (2003),

Among different definitions, Supply Chain Risks derive from two main dimensions: disruption risk and operational risks. The former refers to significant disruptions caused by natural and man-made disasters such as earthquakes, floods, hurricanes, terrorist attacks, etc., or economic crises such as currency evaluation or strikes. In contrast, the latter involves uncertainties in customer demand, supply, and cost (Tang, 2006).

Macdonald, Zobel, Melnyk, & Griffis (2018) point out that Supply Chain Risk is an important research topic that has received growing attention from researchers in the field of Supply Chain Management. Nevertheless, despite the growing number of articles, the definition, sources, and consequences of Supply Chain Risks are not yet very precise and clear (Cao, Bryceson, & Hine, 2020; Heckmann, Comes, & Nickel, 2015; Jüttner, 2005; Tran, Dobrovnik, & Kummer, 2018; Wagner & Bode, 2006a; li Zhao, Huo, Sun, & Zhao, 2013)

According to Macdonald, Zobel, Melnyk, & Griffis (2018, p.1), "researchers are currently restricted in their ability to build supply chain risk theory due to the difficulty of collecting the necessary data.". The present study aims to reduce such a theoretical gap.

In the literature, different studies related risks and disruptions as a consequence of the presence of complexities sources, as pointed out by S. Piya, Khadem, & Kindi (2020), Bode & Wagner (2015), Chopra, S., and Sodhi (2014). In parallel, different studies characterized the presence of supply chain complexity as a factor that negatively impacts operational performance (Akın Ateş, Suurmond, Luzzini, & Krause, 2021)

Naturally, this phenomenon has caught the attention of scholars. The investigations of El Hiri, En-Nadi, & Chafi, (2018); Jajja, Chatha, & Farooq, (2018); Truong Quang & Hara, (2018); and Zhao, Huo, Sun & Zhao, (2013) are examples of scientific efforts towards understanding the impact of Supply Chain Risks and Operational Performance but with conflicting findings concerning the nature and significance of such a relationship. Such a condition characterize an evidence gap in the literature.

Addition to the lack of evidence concerning the negative consequences that risks and disruption may generate on the companies' ability to outperform their rivals in the last years, it is also important to note that the number of empirical studies is still limited. Based on our literature review, to best of our knowledge, we found 06 (six) empirical studies which have explored empirically the consequences of Supply Chain Risks on Organizational Performance.

Due to the nature of the phenomenon of interest, contingency theory will be applied to support our model conceptualization and scientific investigation. Within the Contingency Theory scope, researchers explore the relationship between contextual variables (derived from the internal and external environment), organizational characteristics, and organizational performance (Wagner & Bode, 2008a). Contributions to the theory under discussion are achieved by evaluating the influence of the contingent effects of certain variables (Roscoe, Skipworth, Aktas, & Habib, 2020)

Based on Contingency Theory tenets, we assume the view that internal and external contextual environmental variables (in the form of Overall Supply Chain Risk) and Organizational/Interorganizational Characteristics (e.g., Supply Chain Complexity, firm size, and strategy form competitive advantage) may influence negatively System Performance (understood here as Operational Performance).

The investigation of the phenomenon proposed above is aligned, for instance, with Kilubi & Haasis (2016). They suggested that researchers and managers should better understand the different sources of Supply Chain Risks to deploy a coherent approach to risk management.

After a brief literature review about the investigation of the phenomenon above in the Brazilian business environment, we identified only 04 studies performed by Ceryno, Scavarda, & Klingebiel (2015), Troche-escobar, Lepikson, Gaud, & Freires (2018), (Lima et al., 2019), Rosales, Oprime, Royer, & Batalha (2020) concerning such a subject.

Considering the arguments exposed above, it is possible to visualize that currently there is limited number of empirical researches available in the literature, characterizing an empirical gap. Furthermore, the almost absence of investigation taking into consideration in emerging economies like Brazil, illustrate a population types of scientific gap, according to Miles's (2017) taxonomy.

<u>Dynamic Capabilities</u>

In addition to understanding how Supply Chain Risks impact Operational Performance, another critical research area in the field of Supply Chain Management consists of understanding which strategies may counteract the negative impact generated by different sources of risks.

Globalization and the turbulent market dynamism create new uncertainties and risks and amplify the existing ones, representing a constant threat to the flow of products and consequently to the economies (Gurtu & Johny, 2021). Thus, appropriate capabilities become crucial to organizations achieve competitive advantage (Teece et al., 1997; Um & Han, 2020).

According to Dynamic Capabilities Theory, organizations should promote actions to sense and seize opportunities and threats and transform their processes and operations to cope with an increasingly volatile and turbulent environment (Teece, Pisano, & Amy, 1997).

Then, in the current market conditions, it is keen to understand which supply chain capabilities companies should implement and prioritize to strive in today's business environment. Nevertheless, limited research concerning how dynamic capabilities impact firm performance in the supply chain management field is available (Kareem & Kummitha, 2020).

In the present research, we conceptualized Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration as strategies under the theoretical view of dynamic capabilities. We assume that organizations require the deployment of such Supply Chain Strategies to sense and seize opportunities and threats and transform their processes and operations to improve their Organizational Effectiveness (understood here in terms of Operational Performance and Supply Chain Robustness). In the following paragraphs, we briefly present the theoretical support for such a proposition, further detailed in the following chapters.

<u>Supply Chain Agility</u>

Wieland & Marcus Wallenburg (2012) and Li et al. (2019) contend that Supply Chain Agility is a required capability of a firm to reconfigure supply chain resources and respond to changes promptly. Consequently, it became a critical element that can affect a firm's competitiveness at the strategic level (Tse, Y.K., Zhang, M., Akhtar, P. and MacBryde, 2016).

Supply Chain Agility is still considered an evolving concept in the literature, and empirical research about the topic is in its early stages. For that reason, different researchers have argued for further investigation about this strategy (Ahmed, Najmi, Mustafa, & Khan, 2019; Chiang, Kocabasoglu-Hillmer, & Suresh, 2012; Eckstein, Goellner, Blome, & Henke, 2015)

Recently, Al Humdan et al.'. (2020) systematic literature review reveals that the research about the relationship between Supply Chain Agility and Performance is limited in the number of studies. We also observed limited empirical research and a lack of research in European and emerging economies from such a review. Such conditions, from our perspective, are elements that characterize the existence of empirical, population, and theoretical types of gaps, according to Miles's (2017) taxonomy.

<u>Supply Chain Risks Management</u>

Um & Han (2020) characterize Supply Chain Risk Management as a dynamic capability that, together with an appropriate risk mitigation strategy, is critical in the highly uncertain global supply chain environment. Then, the second potential dynamic capability under investigation is Supply Chain Risks Management.

The research about Supply Chain Risk Management has received considerable attention by scholars due to the recent series of crises and catastrophes and the fact that modem supply chains seem to be more vulnerable than ever (Huo, Qi, Wang, & Zhao, 2014) (Colicchia & Strozzi, 2012) (Trkman & McCormack, 2009) (Wagner & Bode, 2008a).

Supply Chain Risk Management activities involve identifying, assessing, controlling, and monitoring possible risks (Hallikas, Karvonen, Pulkkinen, Virolainen, & Tuominen, 2004; Kern et al., 2012; Wieland & Wallenburg, 2012). Different researchers suggest that firms can improve performance through the implementation of such routines (Kilubi & Haasis, 2016; I. Manuj & Mentzer, 2008; Thun, Drüke, & Hoenig, 2011, Chaudhuri et al., 2018)

Based on this premises, scholars have attempted to understand better the relationship between Supply Chain Risk Management and essential aspects of business performance (Chaudhuri et al., 2018; Kauppi, Longoni, Caniato, & Kuula, 2016; Wiengarten, Humphreys, Gimenez, & McIvor, 2016a)).

Nevertheless, despite the academic efforts performed, there is limited empirical research on Supply Chain Risk Management and Operational Performance. We also observe the absence of this type of investigation using data solely from Brazilian Industries. To the best of our knowledge, only two studies performed by Shou et al. (2018) and (Kauppi et al., 2016), considered Brazilian industries data as well as from other countries.

Moreover, as emphasized (Kilubi & Haasis, 2016), based on a systematic literature review including 60 academic journals, only partial evidence is provided by a few studies about the positive relationship between risk management and performance in the field of Supply Chain Management.

The limited number of empirical researches among Supply Chain Risk Management and Operational Performance, as well as the absence of this type of investigation using data solely from Brazilian Industries, characterize, respectively, the existence of empirical, population, and theoretical types of gaps, according to Miles's (2017) taxonomy.

<u>Supply Chain Integration</u>

In addition to agility and risk management, we also conceptualize Supply Chain Integration as another set of dynamic capabilities that may positively influence performance and recovery from disruptions (Duong & Chong, 2020).

The definition of Supply Chain Integration adopted in this study is the one offered by (Flynn, Huo, & Zhao, 2010a) that explains such concept as “the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra-and inter-organization processes.” According to the authors' views, supply chain integration involves three dimensions: supplier (upstream), customer (downstream), and internal integration.

Based on the available research in academia, multiple studies advocate the proposition that Supply Chain Integration generates higher Operational Performance (Feng et al., 2017; Frohlich & Westbrook, 2001; Huo & Wang, 2014; Jajja, Chatha, & Farooq, 2018b; Vanpoucke et al., 2014; Vickery et al., 2013).

Conversely, the investigations of Wiengarten, Pagell, Ahmed, & Gimenez (2014); Danese & Romano (2011); Lu et al., 2018) Danese, Romano, & Romano,(2013); Boon-itt & Wong,(2011); Koufteros, Vonderembse, & Jayaram,(2005); Sezen (2008); Devaraj et al. (2007)); Parente, Baack, & Hahn (2011) and Huo et al., (2014) and Schoenherr & Swink (2012) either found negative, insignificant or mixed results.

The differences in the results obtained may derive from the fact that despite many benefits, “integrated supply chains bring with them the risk of amplified and propagated disruptions along the supply chain if not managed properly.” Furthermore, integration may produce adverse effects due to the higher inter mutual interactions among the parties, resulting in more exposure to risks (Munir et al., 2020, p.15; Terjesen, Patel, & Sanders, 2012).

Another relevant remark concerning Supply Chain Integration scientific efforts is the lack of empirical studies in some regions of the world, including Brazil, where we have identified only studies of de Mattos & Laurindo (2016) and Parente Baack & Hahn (2011a). As a result, there is an urgent need to perform empirical studies about integration in such an unexplored region (Kamal & Irani, 2014).

In sum, based on Miles (2017) types of research gaps taxonomy, the conditions above may characterize three different research gaps. The first one, is the evidence gap due to the conflict findings concerning the nature of the impact of integration on performance. The second is named population gap due to the concentration of research considering industries mainly located in the US, Europe, and Asia. The third is an Empirical gap since there are minimal empirical studies in Brazil about this subject.

Operational Performance and Supply Chain Robustness

In terms of performance outcome, as discussed previously, this research focused on exploring two dimensions of Organizational Effectiveness (Operational Performance and Supply Chain Robustness). Operational Performance was chosen to be evaluated in our study instead of Supply Chain Performance. Our decision follows the proposed view of Lu et al. (2018, p. 5), which suggest that “supply chain performance, it is somewhat beyond defined ‘unit of analysis, which is the manufacturer; also the conceptual scope of ‘supply chain performance’ can be ambiguous and blurry.

Nevertheless, it does not mean that Supply Chain Performance is being disregarded since Operational Performance plays a vital role in supply chain performance and has gained attention from the research community (Devaraj et al., 2007; Lu et al., 2018b; Saryatmo & Sukhotu, 2021).

Organizations can evaluate the relative superiority of one company upon its rival based on the difference between the operational performance.(Cristea & Cristea, 2021). In this sense, the competitive market environment imposed to the industries the need to achieve superior Operational Performance since its critical nowadays to survive and thrive. (Shou, Li, Park, & Kang, 2018).

The term operational performance represents “the level in which one company’s operations can reach goals of being right, fast, on time, productive and able to change” (Zhang et al., 2017, p. 4). Latifah, Wijayanti, & Utami (2021, p.67) contend that operational performance is associated with the “effectiveness resource use by a company such as capital, raw materials, and others.” In this study, the following critical dimensions of Operational Performance, proposed by Huo et al. (2014), are being considered as such: Overall product quality; Customer service level; Pre-sale customer service; Product Support; Responsiveness to the customer; Delivery Speed; Delivery Dependability; Volume flexibility; Product Mix flexibility; and New product Flexibility

In terms of the current status of the scientific research about the potential factors that may influence Operational Performance in the Brazilian Industries environment, we identified only a few studies available in chapter 2. Still, none of them explored the influence of Supply Chain Risks |(inhibitors) and the set of Dynamic Capabilities (enablers) of relatively higher Operational Performance levels.

We propose that organizations should outrival competitors Operational Performance and have a robust system. As Wieland & Wallenburg (2012) stressed, industries must also develop capabilities to ensure continuity to operation if internal or external disruptions occur.

In this context, Supply Chain Robustness figures into our conceptual framework as the second dimension to be investigated in parallel to operational performance as an endogenous. Such a topic is an object of emerging interest and importance in academia and manufacturing (Monostori, 2018). Moreover, as suggested by Zhuo, Ji, & Yin (2021), the literature about the relationships between Supply Chain Integration, Supply Chain Agility, and Supply Chain Robustness remains limited, denoting empirical, population, and theoretical gaps concerning how such Supply Chain Strategies impact Supply Chain Robustness.

1.3 - Research Problems, Aims, Objectives, and Research Questions

Two main research problems emerged as central issues. The first one consists of understanding the impacts of Supply Chain Risks and different contingencies on Operational Performance. In contrast, the second concerns gaining knowledge about how Dynamic Capabilities (in the form of Supply Chain Strategies) impacts industries to outrivals competitors and keep performance in case of disruptions. As briefly discussed, such problems are anchored at different research gaps, based on Miles' (2017) taxonomy, considering the brief background provided above.

Our research journey will follow the three articles format. Then, in chapter 2, this study will aim to evaluate and identify the influence of Supply Chain Risks and contingencies on the Operational Performance of Manufacturing companies in Brazil.

From such research aim, we established the following Research Objectives:

Objective 1 – To evaluate the influence of overall Supply Chain Risks on the Operational Performance of Manufacturing companies in Brazil.

Objective 2 - To identify which sources of risks have a relatively higher negative impact on the Operational Performance of Manufacturing companies in Brazil

Objective 3 – to identify contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage influence the relationship between Supply Chain Risks and operational performance

From the objectives stated above, the following research questions (RQ) emerge:

RQ1: How does Overall Supply Chain Risks influence Operational Performance?

RQ2: What sources of risks have a relatively higher negative impact on Operational Performance?

RQ3: What are the contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage that influence the relationship between Supply Chain Risks and operational performance?

In Chapter 3, this study will aim to evaluate and distinguish the influence of a different set of dynamic capabilities (Supply Chain Management Strategies) on Operational Performance. From such research aim, we established the following Research Objectives:

Objective 4 –to evaluate the influence of Supply Chain Risk Management and Supply Chain Agility on Operational Performance of Manufacturing companies in Brazil

Objective 5 – to distinguish the influence of Supply Chain Risks Management and Supply Chain Agility in terms of its relevance and performance to increase Operational Performance of Manufacturing companies in Brazil.

From the objectives stated above, the following research questions emerge:

RQ4: How do Supply Chain Risk Management and Supply Chain Agility influence the Operational Performance of Manufacturing companies in Brazil?

RQ5: Which Supply Chain Strategy has relatively higher relevance and performance to increase the Operational Performance of Manufacturing companies in Brazil?

In Chapter 4 of this thesis, this study will aim to evaluate and distinguish the influence of a different set of dynamic capabilities (Supply Chain Management Strategies) on Operational Performance and Supply Chain Robustness, considering both sufficiency logic and necessity logic view. From such research aim, we established the following Research Objectives:

Objective 6 –to evaluate the influence of Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration on Operational Performance, and Supply Chain Robustness of Manufacturing companies in Brazil

Objective 7 – to evaluate if Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration are necessary conditions to Operational Performance and Supply Chain Robustness in the context of Manufacturing companies in Brazil

Objective 8 - to evaluate if Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration are necessary and significant conditions to Operational Performance and Supply Chain Robustness in the context of Manufacturing companies in Brazil

From the objectives stated above, the following research questions emerge:

RQ6: How do Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration influence Operational Performance and Supply Chain Robustness in the Manufacturing companies in Brazil

RQ7: Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary conditions, to a certain degree, to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

RQ8: Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary, to a certain degree, and significant condition to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

1.4 - Significance of the Study

According to White (2011), the value and originality of research derive from different aspects, as such: offering new or supplementary knowledge; solving a problem; bringing established beliefs into question; articulating a problem that others should take seriously but which, until that time, has gone unrecognized are elements that constitute the value of a study.

Originality, in turn, as per White (2011), also relies on specific aspects like: the method or its application is unique; a new synthesis of existing material is provided; the execution of the investigation occurs under a unique set of circumstances; the findings are unique; another researcher's original insight is extended; an original contribution is made to an ongoing debate, and an established interpretation is challenged.

The significance of this study is anchored in terms of value and originality in some of the aspects suggested above, as follows:

<u>Offering new or supplementary knowledge (value):</u>

- Based on Contingency theory, this thesis will contribute to the body of knowledge on Supply Chain Management, offering new, supplementary knowledge through a comprehensive empirical analysis and evidence concerning the impact of Supply Chain Risks Operational Performance as well as the relative influence of specific contingencies.

- It is one of the first empirical investigations about Supply Chain Risks that will explore its different dimensions sources in detail to understand their impact on influencing operational performance and its relative behavior against each other in terms of performance (level of occurrence) and importance (level of influence).

- - this thesis will also expand the knowledge and provides an original contribution to the ongoing debate concerning Dynamic Capabilities Theory by developing and testing a conceptual model that comprises a range of Supply Chain Strategies (Supply Chain Risks, Supply Chain Risks Management, Supply Chain Agility, Internal Integration, Supplier Integration, and Customer Integration) upon Operational Performance and Supply Chain Robustness.

<u>Execution of the investigation under a unique set of circumstances (originality)</u>

This study will be executed under a unique set of circumstances, in the context of Brazilian Industries, that have not been explored to date based on the best of our knowledge.

<u>Bringing an established belief into question (value)/ the method or its application is unique, and the findings are unique (originality)</u>

This study will apply contemporary and different perspectives to explore causal problems in Social Science based on Necessary Condition Analysis (NCA). The use of NCA will allow us to evaluate our proposed conceptual model from a necessity logic view to identifying the critical predictors that when absent, the desired outcome is constrained, in our case, to a certain degree. In other words, the analysis utilizing the necessity logic view will enable our investigation to shift the attention from 'average trends' among variables to the logic of 'the required level.'

Historically dynamic capabilities have been reported as necessary but with no appropriate quantitative method to support such calls. Tho (2018, p. 323) stresses out that the question of “what level of each capability serving as a necessary condition for a wanted level of performance has been largely ignored in the literature.”. To this date, to the best of our knowledge, only the research mentioned in this paragraph adopted NCA to investigate the effect of Dynamic Capabilities on Performance. Based on that, our work seeks to reduce such a gap, which can be classified as a methodological gap according to Miles (2017) taxonomy.

Furthermore, It is important to highlight that, to this date, there is a limited number of studies that have applied the NCA methodological approach in the field of Supply Chain Management. The research of Stek Schiele (2021) and van der Valk, Sumo, Dul, & Schroeder (2016), to the best of our knowledge, are the only two studies that had applied it at the time that this work was written.

1.5 - Limitations

It is essential to acknowledge that this research also has particular limitations: the study considers only the Brazilian industries segment; the study does not cover service industries; our sample comprises 52% small and medium industries and 48% of larger firms based on sales volume parameters and the unit of analysis is the manufacturing plant.

According to the author's views, these limitations are acceptable. We chose Brazilian industries due to the distinguishing characteristics of other environments where the studies about dynamic capabilities in Supply Chains have been executed. The limited number of scientific researches dedicated to this environment is another motivating factor. The manufacturing plant was selected as the unit of analysis in this research. Thus, due to this reason, no service industries were considered. Finally, the sample profile of mix size companies does not conflict with the general purpose of this study.

Furthermore, since we adopt a quantitative instead of qualitative research approach, as suggested by Almeida, Gaya, Queirós, (2017) there is classical limitation usually related to such type of research as such: lower flexibility and exploratory analysis, the immediate scope of the study in time, reliability of data depends on the quality of answers and the survey' structure, and the researcher point of view is external

1.6 - Structural Outline

The present thesis is organized into five different chapters. In chapter one, a broad introduction of the proposed investigation is developed. The following chapters (two, three, and four) are dedicated to a specific article. Finally, in chapter five, the conclusion is presented. Figure 2 details the overall structure of the present thesis.

Chapter 1
Introduction

Chapter 2
The Impact of Supply Chain Risks on Operational Performance, the contingent role of supply chain complexity, firm size and competitive strategy
Methodology: Structural Equation Modeling
Data Source: 165 practioners.
Research Objectives: 1, 2 and 3

Chapter 3
The Impact of Supply Chain Risks, Supply Chain Risk Management and Supply Chain Agility on Operational Performance: A empirical analysis

Methodology: Structural Equation Modeling
Data Source: 165 practioners.
Research Objectives: 4 and 5

Chapter 4
The Impact of Supply Chain Risks, Supply Chain Risk Management and Supply Chain Agility and Supply Chain Integration on Operational Performance and Supply Chain Robustness: A empirical analysis from significance and necessary condition perspectives.

Methodology: Structural Equation Modeling/Necessary Condition Analysis.
Data Source: 165 practioners.
Research Objectives: 1, 2 and 3

Chapter 5
Conclusion

Figure 2 - Thesis Structure

The present work follows a quantitative research approach with a nonexperimental correlational form of research. It applies correlational statistics to describe and measure the degree of association between two or more variables (Creswell, 2014).

Due to the nature of the phenomenon under investigation, we chose the survey research design to obtain the data. This type of method relies on the application of questionnaires to collect data about the people or organizations systematically. (Bhattacherjee, 2012).

Using the data collected, the research questions 1-6 proposed above will be analyzed employing Structural Equation Modeling (SEM). SEM is a multivariate statistical technique with elements from Structural Theory, Measurement Theory (Sarstedt, Ringle, & Hair, 2017)

Regarding research question 7, the application of PLS-SEM alone would not be suitable to evaluate it. PLS-SEM is adequate only to measure the average net effect and significance of the relationships. In this question, we suggest exploring if the Dynamic Capabilities are necessary conditions for Operational Performance and Supply Chain Robustness to manifest.

The proposition and exploration of question 7 derive from an observation that most research in Social Science, which included Supply Management field, relies on exploring the nature of relationships from a significance, average net effect, approach (Dul, 2016).

According to Dul, Hak, Goertz, & Voss (2010, p.1173), “Necessary condition hypotheses are important types of hypotheses that are common in many fields including Operations Management.” Based on the literature, historically, scholars have reported different variables as “necessary conditions” but with no appropriate quantitative methodological approach to support such calls (Dul, Hak, Goertz, & Voss, 2010).

Then, in research question 7, we investigate the necessity logic perspective in complement of significance perspective. The answer to such a question demands applying a different research method named Necessary Condition Analysis (NCA). NCA is an emerging methodological prism recently proposed by Dul (2016) based on the necessity of logical reasoning.

The necessity logic means that a certain level of X (the condition) is necessary for a certain level of Y (the outcome). Unlike regression-based models where researchers include variables to improve the model predictive capacity through average tendencies, NCA shifts our attention from ‘average trends’ to the required level's logic.

Finally, to answer research question 8, PLS-SEM and NCA will be applied in a combined manner. As proposed by Richter, Schubring, Hauff, Ringle, & Sarstedt (2020, p. 2243), “PLS-SEM and NCA enable researchers to identify the must-have factors required for an outcome in accordance with the necessity logic. At the same time, this approach shows the should-have factors following the additive sufficiency logic. Combining both logics enables researchers to support their theoretical considerations and offers new avenues to test theoretical alternatives for established models”.

2 - THESIS RESULTS - SUMMARY

The following results were obtained based on the application of PLS-SEM:

2.1 - Chapter 2 - Article 1 Results

H1: Overall Supply Chain Risks negatively impacts Operational Performance	Supported

Table 2 – Article 1 - PLS SEM Results

Groups	MICOMM (Compositional Invariance)	MGA
Number of Customers (DCP1)	Supported (partial invariance was established).	No differences
Customer Heterogeneity (DCP2)	Supported (partial invariance was established).	No differences
Life Cycle (DCP-3)	Supported (partial invariance was established).	**There are differences among groups**
Demand Variability (DCP-4	Supported (partial invariance was established).	No differences
Number of Active Parts (MCP-1)	Supported (partial invariance was established).	No differences
Number of Distinct Products (MCP-2)	Supported (partial invariance was established).	**There are differences among groups**
Number of Suppliers (UPC-1)	Supported (partial invariance was established).	No differences
Longer supplier lead time (UPC-2 e (UPC-3)	Supported (partial invariance was established).	**There are differences among groups**
Supplier Delivery unreliability (UCP-4)	Not Supported	Not feasible
Globalization of Supply Chain Base (UCP-5)	Supported (partial invariance was established).	No differences
Firm Size (Employees)	Supported (partial invariance was established).	No differences
Firm Size (Sales Volume)	Supported (partial invariance was established).	No differences

Type of Strategy for Competitive Advantages	Supported (partial invariance was established).	No differences

Table 3 – Article 1 - Multigroup Analysis Results

Risk Dimensions	Performances Results	Importance Results
Demand Risks	27.88	**- 0.06**
Supplier Risks	20.03	**- 0.21**
Regulatory Risks	19.34	**- 0.08**
Infrastructural Risks	9.84	**- 0.22**
Average	19,27	**-0,14**

Table 4 – Article 1 - Importance Performance Analysis Results (Construct Level) - Article 1

Risk Sources	Performance Results	Importance Results
SCRD1 - Unanticipated or very volatile demand	31.01	- 0.03
SCRS5 - Capacity fluctuations or shortages on the supply markets	25.66	- 0.04
SCRD2 - Insufficient or distorted information from your customer about orders or demand quantities	24.55	-0.03
SCRS2 - Supplier quality problems	21.11	-0.04
SCRS1 - Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity)	20.71	-0.04
SCRR1 - Changes in the political environment due to the introduction of new laws, stipulations, etc.	19.6	-0.04
SCRR2 - Administrative barriers for the setup or operation of supply chains (e.g., authorizations).	19.09	-0.04
SCRS4 - Poor logistics performance of logistics service providers	17.47	-0.05
SCRS3 - Sudden demise of a supplier (e.g., due to bankruptcy)	14.44	-0.04
SCRI3 - Loss of own production capacity due to technical reasons (e.g., machine deterioration).	13.33	-0.05
SCRI1 - Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents).	10.51	-0.06
SCRI2 - Perturbation or breakdown of internal IT infrastructure (e.g., caused by computer viruses, software bugs).	8.08	-0.05

SCRI4 - Perturbation or breakdown of external IT infrastructure.	8.08	-0.06
Average	17,97	0,04

Table 5 - Article 1 - Importance Performance Analysis (Indicator Level) Results

2.2 - Chapter 3 - Article 2 Results

H1: Overall Supply Chain Risks negatively impacts Operational Performance	Supported
H2: Supply Chain Risks Management positively impacts Operational Performance -	Supported
H3: Supply Chain Agility positively impacts Operational Performance - Chapter 3	Supported
H4: Supply Chain Risks Management positively moderates the relationship Supply Chain Agility and Operational Performance.	Supported

Table 6 - Article 2 - PLS SEM Results

Constructs	**Performances Results**	**Importance**
Supply Chain Risk Management	76.14	0.28
Supply Chain Agility	70.67	0.13
Supply Chain Risks	17.50	- 0,39

Table 7 - Article 2 - Importance Performance Analysis Results (Construct Level)

	Performance Results	Importance Results
SCRM 1 - Systematic identification of sources for such disruptions.	74.24	0.07
SCRM2 - Assessment of both own risks and risks of important suppliers and customers	76.46	0.07
SCRM4 - Continuous monitoring of developments that might promote such disruptions.	74.75	0.07
SCRM3 - Assigned persons responsible for the management of such risks.	79.90	0.06
AGL2 - Adapt level of customer service.	76.36	0.05
AGL3 - Adapt delivery reliability.	68.38	0.03
AGL4 - Adapt responsiveness to changing market needs.	68.28	0.03
AGL 1 - Adapt manufacturing lead times.	65.35	0.02
Average	72,96	0,05

Table 8 - Article 2 - Importance Performance Analysis Results (Indicator Level)

2.3 - Chapter 4 - Article 3 Results

H1: Overall Supply Chain Risks negatively impacts Operational Performance	Supported
H2: Supply Chain Risks Management positively impacts Operational Performance -	Supported
H3: Supply Chain Agility positively impacts Operational Performance - Chapter 3	Supported
H4: Supply Chain Risks Management positively moderates the relationship Supply Chain Agility and Operational Performance.	Supported
H5: Supplier Integration positively impacts Operational Performance	Not Supported
H6: Internal Integration positively impacts Operational Performance	Not Supported
H7: Customer Integration positively impacts Operational Performance	Not Supported
H8: Supply Chain Risks Management mediates the relationship among Supplier Integration and Operational Performance	Not Supported
H9: Supply Chain Risks Management mediates the relationship among Internal Integration and Operational Performance	Supported
H10: Supply Chain Risks Management mediates the relationship among Customer Integration and Operational Performance	Supported
H11: Supplier Integration positively impacts Robustness	Supported
H12: Internal Integration positively impacts Robustness	Not Supported
H13: Customer Integration positively impacts Robustness	Not Supported
H14: Supply Chain Risk Management positively impacts Supply Chain Robustness.	Supported
H15: Supply Chain Agility positively impacts Supply Chain Robustness.	Supported
H16: Supply Chain Risks Management positively moderates the relationship Supply Chain Agility and Robustness.	Supported

Table 9 - Article 3 - PLS SEM Results

	Operational Performance	Supply Chain Robustness
Necessary Conditions	1. Supply Chain Risk Management 2. Supply Chain Agility	1. Supply Chain Agility 2. Supply Chain Risk Management 3. Customer Integration 4. Internal Integration

Table 10 - Necessary Conditions Analysis Results

	Operational Performance	Supply Chain Robustness
Significant determinant and necessary condition	Supply Chain Risk Management and Supply Chain Agility	Supply Chain Agility Supply Chain Risk Management
Significant determinant but no necessary condition	XXXXXXX	Supplier Integration
Nonsignificant determinant but a necessary condition	XXXXXXX	Customer Integration Internal Integration
Nonsignificant determinant/ no necessary condition	Internal, Customer, and Supplier	

Table 11 - Combined PLS-SEM and Necessary Condition Analysis Results

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CHAPTER 2

Article 1

The Impact of Supply Chain Risks on Operational Performance, the contingent role of supply chain complexity, firm size and competitive strategy

2.1 INTRODUCTION

Supply Chain Risk has expanded its presence due to movements like globalization, sustainability, customization, outsourcing, innovation, just to name a few (Serdarasan, 2013b). Competitive conditions make risks omnipresent and unavoidable in modern business (Tran et al., 2018). At the same time, different crises and catastrophes have exposed supply chains to disruptions (Wieland & Wallenburg, 2012).

Businesses have become more complex, and corporate exposure to risks has increased as companies continue to integrate globally concerning customers and suppliers. (George A Zsidisin, Panelli, & Upton, 2000.) Such exposure to risk may produce severe consequences to companies' market value.

Hendricks & Singhal (2003) indicates that firms do not quickly recover from the harmful effects of disruptions. The authors examined the relationship between stock price and supply chain disruption and found that firms' average abnormal stock returns that experienced disruptions are nearly -40%.

Thus, in the current competing environment, organizational, operational performance tends to be influenced by the level of risk exposure derived from internal and external environment factors (Y. Fan, Stevenson, Fan, & Stevenson, 2018; Wagner & Bode, 2008a). As a result, different scholars have dedicated several scientific investigations to understand further the impact of risks on performance (El Hiri, En-Nadi, & Chafi, 2018; Jajja et al., 2018a; Truong Quang & Hara, 2018; li Zhao et al., 2013).

The characteristics of the problem under discussion find unity with the Contingency Theory of Management. This theory contends the premise that an organization's system performance is contingent on the fit between contextual variables and the company's strategies, structures, and processes (Lawrence & Lorsch, 1967). Thus, we consider that such a theoretical lens may support the proposed investigation.

According to (Bae, 2011) even though the use of contingency theory was expanded to logistics since the 80s, "in supply chain management, little work utilizing contingency theory has been published." (Buttermann, Germain, & Iyer, 2008, p.955),

Here we propose to apply the contingency theory to support the view that internal and external contextual environmental and structural elements, in the form of Overall Supply Chain Risk, may negatively influence System Performance (understood here as Operational Performance). The investigation of such issue is aligned with (Kilubi & Haasis, 2016) who suggest that researchers and managers should strive to build a better understanding about the different sources of Supply Chain Risks in order to deploy a coherent approach to risk management.

In the present research we seek to contribute to this objective by taking into consideration the influence of several different risk sources upon operational performance dimensions in the specific context of Brazilian Business Environment.

Furthermore, we also propose to explore if such negative impact happens in a more or not significant proportion in the presence of different contingencies like Supply Chain Complexity, Firm Size, and Type of Strategy for competitive advantage.

S. Piya, Khadem, & Kindi (2020), Bode & Wagner (2015) (Chopra, S. and Sodhi, 2014) highlight that disruptions to the Supply Chain steam from the presence of complexity, whereas Bozarth, Warsing, Flynn, & Flynn (2009) associate complexity with performance deterioration. Following these views, our investigation suggests that different Supply Chain Complexity drivers may play a contingent role in the relationship between Supply Chain Risks and Operational Performance.

The influence of organization characteristics like firm size and strategy for competitive advantage as potential contingents' factors are classical contingent factors explored in the literature (Donaldson, 2001). Regarding such variables, our aim consists of understanding if there are differences in the influence of Overall Supply Chain Risks upon Operational Performance by comparing small versus medium and large industries and companies with cost leadership versus differentiation strategy to the market.

As mentioned previously, the context of the present study is the Brazilian business environment. We chose the Brazilian business environment due to its distinguished characteristics like different supply and demand constraints, various regulatory and bureaucratic systems concerning other businesses environments where the relationship between Supply Chain Risk and operational performance has been explored.

Sweeney, Grant, & Mangan (2015) emphasized the importance of perspective and context in the field of Supply Chain Management research. At the same time (Wagner & Bode, 2008a) encouraged the execution of investigations in developing countries to explore the infrastructural, political, and cultural issues that may affect Supply Chains considering their global nature.

Thus, based on the lenses of the theoretical perspective discussed above, this study will aim to evaluate and identify the influence of Supply Chain Risks and contingencies on the Operational Performance of Manufacturing companies in Brazil.

From such research aim, we established the following Research Objectives:

Objective 1 – To evaluate the influence of overall Supply Chain Risks on the Operational Performance of Manufacturing companies in Brazil.

Objective 2 - To identify which sources of risks have a relatively higher negative impact on the Operational Performance of Manufacturing companies in Brazil

Objective 3 – to identify contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage influence the relationship between Supply Chain Risks and operational performance

From the objectives stated above, the following research questions (RQ) emerge:

> **RQ1:**How does Overall Supply Chain Risks influence Operational Performance?
>
> **RQ2:**What sources of risks have a relatively higher negative impact on Operational Performance?
>
> **RQ3:**What are the contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage that influence the relationship between Supply Chain Risks and operational performance?

Concerning the value and originality of this research, we address that the current effort is one of the first studies that empirically investigated the impact of different sources of Supply Chain Risks upon Operational Performance in the Brazilian business environment in such a broad perspective. Then, it is worth emphasizing that a unique structural model will be built and tested using data solely collected from manufacturing industries in several Brazilian states.

2.2 LITERATURE REVIEW

2.2.1- Contingency Theory

"A theory is a set of systematically interrelated constructs and propositions intended to explain and predict a phenomenon or behavior of interest, within certain boundary conditions and assumptions" (Bhattacherjee, 2012, p.10). In Social Sciences, there are numerous theories, being the contingency theory one of the most prominent.

In this research, we develop the empirical investigation based on Contingency Theory tenets. The basic premise of this theory is that higher performances are associated with companies that create a more beneficial fit with their environment. (Wright, Kroll, Parnell, 2000).

Our effort will join existing studies that seek to validate such a theory empirically. It is noteworthy that few studies in the supply chain area considered the contingency theory as a basis for understanding Supply Chain Management Systems (Buttermann, Germain, & Iyer, 2008).

The Contingency Theory is anchored in the paradigm that the effectiveness of organizations results from the interaction of environmental factors with their own characteristics, also called contingencies. In abstract terms, in such a theory, the effect of one variable on another depends on a third variable (Donaldson, 2001).

In the light of this theory, there are three primary system variables: environment/contextual variable, Organizational and Interorganizational Characteristics (Contingencies), and Performance variables (Luthans & Stewart, 1977; Sousa & Voss, 2008). The Theory claims that organizations, as systems, are influenced by relevant environmental and resource constraints (Luthans & Stewart, 1977). From such a view, researchers have been explored the relationship between the variables above. (Wagner & Bode, 2008a).

Contributions to the Contingency Theory are achieved by evaluating the influence of the contingent effects of certain variables (Roscoe et al., 2020). As Sousa & Voss (2008) proposed, researchers seek to identify the contingencies that best explain the variance in performance when applying contingency,

There are three different analytical approaches proposed by Contingency Theory as a basis for understanding the relationships' nature: selection, interaction, and system approach. (Romero-Silva, Santos, & Hurtado, 2018; Sousa & Voss, 2008). The selection view does not consider performance and focuses its analysis on the relationship among contextual factors along with specific organizational. The interaction approach considers performance as a result of fit in between practices and contextual factors. Finally, the system view assumes a firm's overall performance relying on an array of contextual variables and procedures that interact with one another and not in isolation.

Among the analytical approaches above, in this study, the interaction approach will be applied. In our particular case, the contingency theory supports the view that internal and external environmental and structural elements, in the form of Overall Supply Chain Risk, negatively influence System Performance (understood here as Operational Performance).

Furthermore, we investigate the role of some specific contingencies. First, we assume that different Supply Chain Complexity drivers may act as Organizational and Interorganizational Characteristics, which play a contingent role in the relationship between Supply Chain Risks and Operational Performance. As pointed out by S. Piya, Khadem, & Kindi (2020), Bode & Wagner (2015), Chopra, S., and Sodhi (2014) , uncertainties and disruptions to the Supply Chain are caused as a result of the presence of complexities sources.

A company's size is classical contingency, as suggested by Donaldson (2001). Following such a call, this variable will also be explored as a potential contingency in complement to Supply Chain Complexity. In this study, such a variable will be operationalized in terms of firms size (number of employees and sales volume). Thus, we seek to understand differences between small versus medium and large industries and companies regarding the influence of Overall Supply Chain Risks upon Operational Performance.

Finally, the strategy for competitive advantage (cost leadership and differentiation) will also be assessed as a potential contingent factor. As Donaldson (2001) emphasizes, strategy is a vital aspect to be considered in the studies of contingency theory. By adopting such an analysis, we seek to understand whether the strategy for competitive advantage adopted by the company influences the effects of risks on performance.

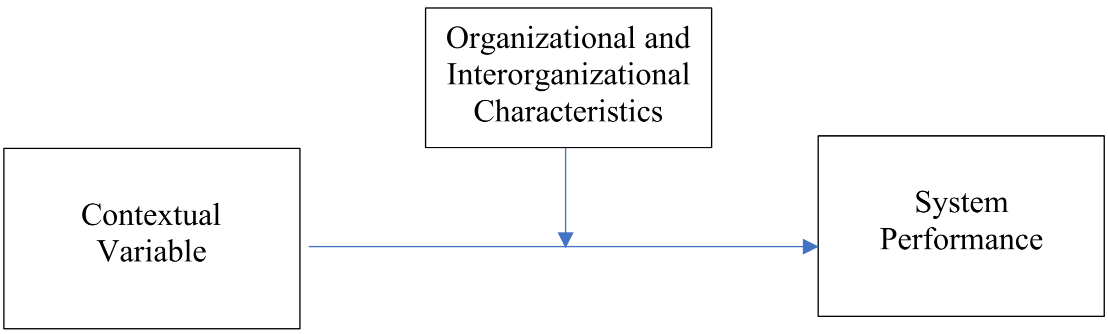

Figure II - 1 - Contingency Model (Adapted from Lawrence & Lorsch 1967))

Main Contextual variables (Internal and External Environment)	**Organizational and Interorganizational Characteristics (Contingencies)**	**Performance Variables**	**Research stance**
Overall Supply Chain Risks	Firm Size, Types of Strategy, Supply Chain Complexity drivers	Operational Performance	Development and test of hypotheses specifying the existence of differences concerning the impact of Risk on Performance across Firm Size, Types of Strategy, Supply Chain Complexity drivers

Table II - 1 - Contingent Model Variables

2.2.2 - Supply Chain Risks

This section will define supply chain risks and their different sources based on the scientific literature in supply chain management. From this review, we will present the operational definition that will be applied in this article. Based on the chosen operational definition, the supply chain risk construct dimensions will be selected from the literature to guide the empirical investigation about the impact on performance in the Brazilian business environment.

Based on the graphic below (figure 1) retrieved from the Scopus database, there is increasingly strong interest in supply chain risk at an academic level. In terms of scholarly production.

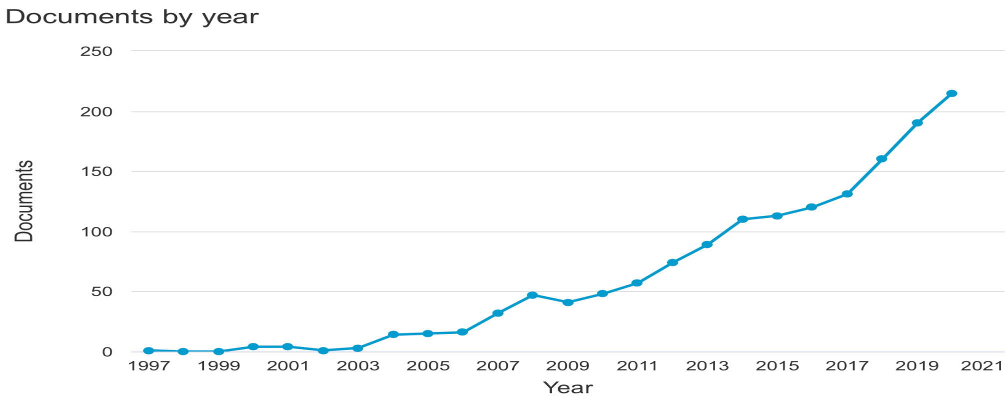

Figure II - 2 - SCR Published articles according to Scopus Database (December 2020)

Nevertheless, despite the growing number of articles, the definition, sources, and consequences of Supply Chain Risks on Supply Chain field is not yet very precise and clear (Cao et al., 2020; Heckmann et al., 2015; Jüttner, 2005; Tran et al., 2018; Wagner & Bode, 2006a; li Zhao et al., 2013).

The lack of unanimity concerning supply chain risks definition and sources conveyed by the authors above can be verified by analyzing the available literature; different authors have tried to define a perimeter from where risks may emerge. In the following paragraphs, our research illustrates such status.

Uta Jüttner, Peck, & Christopher (2003) suggested that supply chain risks dimensions derive from internal elements like processes and control, external aspects such as demand and supply, and environmental. The authors provide the following definition for the term Supply Chain Risk: “any risks for the information, material, and product flows from the original supplier to the delivery of the final product for the end-user.” (Uta Jüttner et al., 2003, p.7)

From Jüttner (2005) views, risk in the supply chain strives to disrupt information, materials, products, and money flows. The author defines Supply Chain Risk sources as “any variables which cannot be predicted with certainty and from which disruptions can emerge. (Jüttner, 2005, p.123)

(Chopra & Sodhi, 2004) expanded the categories of supply chain risks suggesting that it steams from disruption, delays, forecast, intellectual property, procurement, receivables, inventory, and capacity. From Jüttner (2005, page 122) perspective, supply chain risk sources are “any variables which cannot be predicted with certainty and from which disruptions can emerge.” The author categorized risk into the following classifications supply, demand, and environmental areas.

According to Tang (2006), there are two main dimensions: disruption risk and operational risks. The former refers to significant disruptions caused by natural and man-made disasters such as earthquakes, floods, hurricanes, terrorist attacks, etc., or economic crises such as currency evaluation or strikes. In contrast, the latter involves uncertainties in customer demand, supply, and cost.

Manuj and Mentzer (2008) contend that supply chain risks can be categorized as supply, operations, demand, security risks, macro risks, policy risks, Competitive Risks, Resource Risks and produce both quantitative and qualitative results. In such a view, for instance, overstocking, stock-outs, obsolescence, customer discounts, and inadequate availability of components and materials in the supply chain can be understood as quantitative. In contrast, qualitative risks may encompass a lack of accuracy, reliability, and precision of the components and materials in the supply chain.

Punniyamoorthy & Thamaraiselvan (2013) summarize various sources of risk covering all of these categories at three points: internal to the companies, external to companies, internal to the supply chain, and external to the supply chain. The authors highlight six basic risk constructs: risk of supply, demand risk, manufacturing risk, logistical risk, information risk, and environmental risk. The authors applied a systematic approach to develop and validate an instrument for assessing the overall risk of the supply chain.

The literature review performed by (Ho, Zheng, Yildiz, & Talluri, 2015) about supply chain risks result in five categories of Supply Chain Risks as follows: macro, demand, manufacturing, supply, and infrastructural (information, transportation, and financial) factors. Ho et al. (2015, p.5) defines supply chain risks as ‘the likelihood and impact of unexpected macro and/or micro-level events or conditions that adversely influence any part of a supply chain leading to operational, tactical, or strategic level failures or irregularities’

Rudolf, Spinler, Rudolf, & Spinler (2018) explored critical risks in the supply chain of large-scale engineering and construction projects. Their study contributes to research defining a supply chain risk taxonomy into four main areas: environment, supply chain coordination and management, supplier and behavior, and cooperation.

Adeseun, Anosike, Garza Reyes, & Al-Talib (2018) classified supply chain risk according to the following categories: Disruptions, Delays, System, Forecast, Intellectual Property. Procurement, Receivables Inventory, and Capacity.

Ganeshan, Murugan, Rajan, & Hassan (2020) literature review about the supply chain risk suggest that such phenomenon is broadly identified and categorized according to functional aspects of the Supply Chain, and so it includes, for instance, strategic risks, operational risks, monetary risks, disasters, internal risks, external risks, etc

In addition, to understand the different risk types, it is also important to highlight that in the supply chain arena, the perspective of risks is mainly concerned with its negative consequences Wagner & Bode (2006). In this study, we will apply such a view..

Aligned with the negative perspective of risks in the Supply Chain arena, Uta Jüttner et al.(2003,p.7) emphasize that risk consequences usually impact “supply chain outcome variables like, e.g., costs or quality, i.,e. the different forms in which the variance becomes manifest.”

Thus, since there is no standard agreement around the operational definition of Supply Chain Risks in the literature, in the scope of this study, we chose the one offered by (Uta Jüttner et al., 2003, page 7). As per those authors, supply chain risks comprise ‘‘any risks for the information, material, and product flows from the original supplier to the delivery of the final product for the end-user’’.

From such a broad operational definition, the next step was to find the best dimensions (translated into constructs) to promote an empirical measure of Supply Chain Risks. As described so far, the literature provides different sources in supply chain management. Still, despite this amplitude, it is possible to identify that risks emerge from areas like demand, supply, environment, and disasters.

Then, for that, the purpose of this research, the measurement items developed by Wagner & Bode (2008), will be applied to assess the overall risk of the supply chain in which the Brazilian Industries are exposed. Those authors developed and empirically validated constructs for five different classes of supply chain risk sources: Supply-Side Risks, Demand Side Risks, Regulatory, Legal, and Bureaucratic Risks, Infrastructural Risks, Catastrophic Risks.

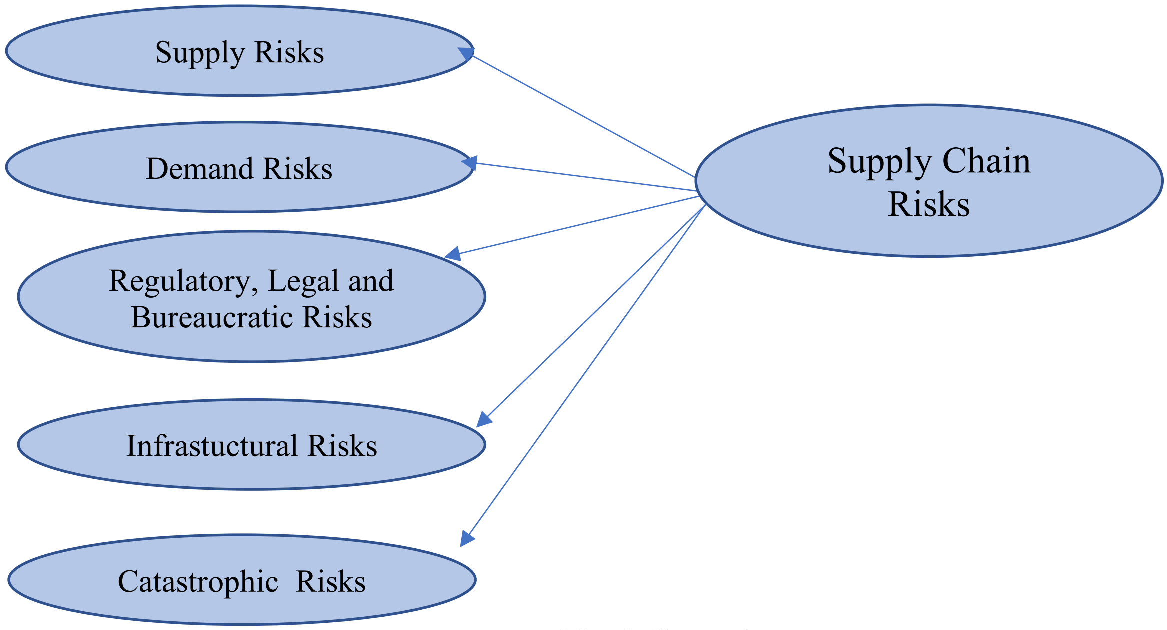

Figure II - 3 Supply Chain Risks

Endogenous Variable	Dimensions		Risks Sources
Overall Supply Chain Risk	Supply Side Risks	Risks stemming from events and actors in the upstream supply chain, for instance, the supply market conditions and the performance of suppliers	Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity) Supplier quality problems Sudden demise of a supplier (e.g., due to bankruptcy) Poor logistics performance of logistics service providers Capacity fluctuations or shortages on the supply markets
	Demand Side Risks	Risks deriving from the interaction (or lack thereof) with customers and volatility of the market	Unanticipated or very volatile demand; and Insufficient or distorted information from your

			customer about orders or demand quantities
	Regulatory, Legal, and Bureaucratic Risks	Risks caused by changes in the political environment as well as administrative barriers imposed by governmental authorities	Changes in the political environment due to the introduction of new laws, stipulations, etc. Administrative barriers for the setup or operation of supply chains (e.g., authorizations).
	Infrastructural Risks	Risks associated with IT, equipment, and facility malfunctions	Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents). Perturbation or breakdown of internal IT infrastructure (e.g., caused by computer viruses, software bugs). Loss of own production capacity due to technical reasons (e.g., machine deterioration). Perturbation or breakdown of external IT infrastructure.
	Catastrophic Risks	Risks that originate from terrorism, socio-political crises, natural disasters, and epidemics,	Political instability, war, civil unrest or other sociopolitical crises. Diseases or epidemics (e.g., SARS, Foot and Mouth Disease). Natural disasters (e.g., earthquake, flooding, extreme climate, tsunami). International terror attacks (e.g., 2005 London or 2004 Madrid terror attacks).

Table II - 2 - Supply Chain Risks adapted from Wagner & Bode, (2008)

Regarding the current status of presence and its consequence in the Brazilian industrial environment, figure 2 displays a modest number of publications about Supply Chain Risk or Supply Chain Risk Management produced considering the Brazilian business environment.

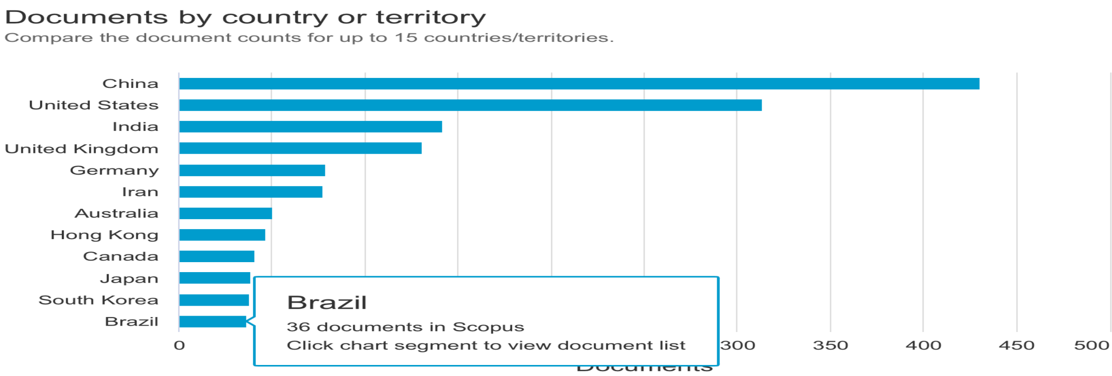

Figure II - 4 - Article by Country or Territory according to Scopus Database (December 2020)

After a brief review of the 36 articles, only 04 researches concern the assessment of Supply Chain Risks in the Brazilian business environment. Ceryno, Scavarda, & Klingebiel (2015) identified the main risks along the automotive supply chain by investigating their manifestation in three supply chains in Brazil and offers an initial risk profile for the Brazilian automotive industry. Troche-escobar, Lepikson, Gaud, & Freires (2018) assessed a set of risk factors identified in the literature concerning wind power supply chain projects. (Lima et al., 2019) investigate the influence of manufacture, customer, and supplier side on the operational performance of manufacturing. Finally, Rosales, Oprime, Royer, & Batalha (2020) identify the risks to agri-food supply chain slaughterhouses.

The limited number of empirical research and lack of research about Supply Chain Risks in emerging economies like Brazil, characterize, respectively, the existence of empirical and population types of gaps, according to Miles's (2017) taxonomy.

2.2.3 - Operational Performance

We chose the Operational Performance to be evaluated in our research instead of Supply Chain Performance. Our decision follows the proposed view of Lu et al. (2018, p. 5), which suggest that “supply chain performance, it is somewhat beyond defined ‘unit of analysis, which is the manufacturer; also the conceptual scope of ‘supply chain performance’ can be ambiguous and blurry.

Nevertheless, it does not mean that Supply Chain Performance is being disregarded since Operational Performance plays a vital role in supply chain performance and has gained attention from the research community (Devaraj et al., 2007; Lu et al., 2018b; Saryatmo & Sukhotu, 2021).

Organizations can evaluate the relative superiority of one company upon its rival based on the difference between the operational performance.(Cristea & Cristea, 2021). In this sense, the competitive market environment imposed the industries the need to achieve superior Operational Performance since it is critical nowadays to survive and thrive. (Shou, Li, Park, & Kang, 2018).

The term operational performance represents “the level in which one company’s operations can reach goals of being right, fast, on time, productive and able to change” (Zhang et al., 2017, p. 4). Latifah, Wijayanti, & Utami (2021, p.67) contend that operational performance is associated with the “effectiveness resource use by a company such as capital, raw materials, and others.”

In the seminal work Skinner (1966), cited by (Ferdows & De Meyer, 1990), four central capabilities are essential to manufacturing industries' performance: cost efficiency, quality, dependability, and flexibility. In the literature, some authors do not consider the cost dimension as part of Operational Performance.

For instance, Harland (1997) suggests that each player within the Supply Chain has a different operational requirement to satisfy the end customer need. In this view, the manufacturers (the unit of analysis of this research) must fulfill the paramount quality, delivery, and service dimensions. Nikolchenko, Zenkevich, & Lebedeva (2018) also stress that the evaluation of Operational level performance is mainly based on nonfinancial indicators. Such construct is anchored at "the measurable aspects of the outcomes of an organization's processes" (Voss, Åhlström, & Blackmon, 1997, p. 1048).

Operational performance is a multi-dimensional construct (Shou, Hu, et al., 2018). Therefore, operational performance encompasses multiples dimensions. Examples of the main areas are the followings: order fulfilment, delivery as promised, delivery flexibility, flexibility to change output volume, flexibility to change product mix, forecasting accuracy, overall product quality, customer service level, responsiveness, operational efficiency, and flexibility are examples of Operational Performance dimensions (Acar, Zaim, Isik, & Calisir, 2017; Battesini, ten Caten, & Pacheco, 2021; Chae, Yang, Olson, & Sheu, 2014; Huo et al., 2014).

This study will apply the measurement items suggested by Huo et al. (2014) since it encompasses the main areas understood as critical dimensions of Operational Performance in terms of quality, service level, responsiveness, speed, dependability, flexibility, and new product flexibility. The respondents are supposed to indicate their industry performance level in comparison with their major competitors.

In terms of the current status of the scientific research about the potential factors that may influence operational performance in the Brazilian Industries environment, we identify the studies available in Appendix A. It is important to stress that none of them explored the influence of Supply Chain Risks as a possible inhibitor of superior Operational Performance levels.

2.2.4 – Supply Chain Complexity

Bozarth, Warsing, Flynn, & Flynn (2009) discuss that Supply Chain Complexity was first explored in the literature in work of Wilding (1998), in which the author proposed a Supply Chain Complexity triangle, composed of the following three vertices: deterministic chaos, parallel interactions, and amplification, as a frame to understand their origins of uncertainty in the scope of Supply Chain Management.

Even though Supply Chain Complexity is a relatively new subject in Supply Chain, such a topic has been under investigation for a long time in different disciplines (Bozarth et al., 2009; A. Piya, 2019). Simon (1962, p.468) defines System Complexity as follows: ''Roughly, by a complex system, I mean one made up of a large number of parts that interact in a non-simple way''. Senge (1990) distinguishes two types of complexity: detail and dynamic. The former refers to the number of variables of a given system, and the latter is related to the unpredictability of the interactions among the system parts and functions.

(S. Piya, Shamsuzzoha, & Khadem, 2019), contends that supply chain complexity depends on several evolving drivers due to globalization, customization, innovation, flexibility, sustainability, and uncertainties. Then, organizations must seek to identify the primary sources of complexity and their relationships to conduct complexity management in the Supply Chain. (Kavilal, Venkatesan, & Kumar, 2017)

Any supply chain property that increases the complexity within Supply Chains may be understood as a complexity driver (Serdarasan, 2013a). After reviewing the work of different authors, according to Bozarth et al. (2009), eleven drivers of supply chain complexity can be identified and classified based on the location of its presence within the scope of supply chains systems functioning environment (upstream, downstream and internal) as follows:

Upstream complexity drivers:	Type	Downstream complexity drivers:	Type	Internal manufacturing complexity drivers:	Type
Number of suppliers	Detail and dynamic	Number of customers	Detail	Number of distinct products	Detail
Long or unreliable supplier lead times	Detail and dynamic	Heterogeneity in customer needs	Detail and dynamic	Number of active parts	Detail
Supplier delivery unreliability	Dynamic	Shorter product life cycles	Detail and dynamic	One-of-a-kind/low volume batch production	Detail Dynamic
Globalization of the supply base	Dynamic	Demand variability	Dynamic	Manufacturing schedule instability	Dynamic

Table II - 3 - Complexity Drivers extract from (Bozarth et al., 2009)

S. Piya et al. (2019) also illustrated drivers of SC complexity. According to them, the complexity is associated with the following drivers: Product variety, Manufacturing process, Internal communication, and information sharing, Planning and Scheduling, Resource constraint, Organizational structure, Logistics an,d transportation, Marketing and sales Wilding, Product development, Customer need, Competitor action, Technological change, Product life cycle, Government regulations, laws, and legal issues, Organizational standards, Improper process synchronization, Forecasting error, Incompatible information technology, Number of suppliers, Supplier location, Number of customers, Company culture, Incompatible supply chain network

2.2.5 - Hypothesis Development

<u>H1: Overall Supply Chain Risks negatively impacts Operational Performance</u>

According to Macdonald, Zobel, Melnyk, & Griffis (2018, p.1), "researchers are currently restricted in their ability to build supply chain risk theory due to the difficulty of collecting the necessary data." The present study aims to reduce such a theoretical gap.

As emphasized previously, we anchored our theoretical framework using Contingency Theory. In our model operational performance of Brazilian Industries is assumed as one type of organizational effectiveness in which environmental contextual Supply Chain Risks may negatively influence Chain Risks.

Thus, the current academic efforts seek to empirically validate if Supply Chain risk negatively influences the Operational Performance of industries in the Brazilian business environment to enrich supply chain risk theory.

The investigation about the relationship between Supply Chain Risks and Performance follows the call of the scientific community. For instance, Sousa & Voss (2008) address the importance of focusing on operational performance since researchers have not explored operational performance in depth through the contingency theory lenses. Punniyamoorthy & Thamaraiselvan (2013) highlight that "understanding the supply chain risk sources that disrupt the performance and the severity of their impact on the supply chain can help an organization design efficient supply chain networks."

Based on our literature review (see appendix B), we find few studies to date focused on understanding how risk variables impact the companies' ability to outperform their rivals. In the following paragraphs, we will provide a quick view of its purposes and main findings.

Hiri et al. (2018) performed an analysis of the impact of Supply Chain Risks on the Supply Chain Performance of Moroccan companies; through applying a regression model, using data from 29 different industries, the authors found that supplier and demand risks negatively influence Operational Performance. In contrast, external and infrastructure risk showed a weaker effect upon performance.

Truong Quang & Hara (2018) analyzed the impact of different sources risks on the Supply Chain Performance of the Vietnam construction sector. The authors found that there is a negative impact between Supply Chain Risks and Supply Chain Performance. Furthermore, the study suggests that the negative influence of Risks on Performance is more significant due to the power of a "push" effect. According to the authors, since numerous risks co-occur, such conditions created a "push" effect is characterized by the influence of one type of risk on another.

Yeboah & Yuansheng (2017) executed an investigation at the agri-food supply chain in Ghana. The authors found that demand, supply, weather, logistics/infrastructure, financial risk sources negatively impact the performance. Conversely, different sources of risks emerging from biological/ environmental, management/operational, policy/regulations, and political-related issues insignificantly affect Ghana's agri-food supply chain. According to the results obtained, half of the overall agri-food chain performance is explained by the different risks explored.

Chen, Sohal, & Prajogo (2013) evaluated the relationship between risk and supply chain performance in the Australian manufacturing environment. The study results demonstrate that demand risk and process risk significantly impact supply chain performance, but there is no significant relationship in supply risk.

Punniyamoorthy & Thamaraiselvan's (2013) study provides a reliable and accurate instrument to assess the supply chain risk of similar comparable industries regarding its impact on Supply Chain Performance. Their investigation performed with heavy Industries in India found that Demand risk has the most adverse effect on the supply chain, followed by manufacturing side risk and supply-side risk. In contrast, Logistics, information, and environment were rated lower

Wagner & Bode, (2008) empirical work in Germany demonstrated that supply and demand-side risks have a significant negative impact on supply chain performance. Nevertheless, they failed to support the other risk dimensions (Legal and Bureaucratic Risks, Infrastructural Risks, Catastrophic Risks) upon industry's performance in Germany. Such a situation motivates the authors to call for further research on different business environments.

The objective here was not to perform a profound overview of all literature in the field but to show the current empirical research on the relationship between supply chain risks and performance. According to the set of reviewed articles listed above, we have not found to the date any similar model that explored the proposed collection of relationships herewith under investigation, taking exclusively into consideration the Brazilian environment.

Therefore, based on the lack of empirical research in the Brazilian industry environment demonstrated above, the present study finds its relevance in building scientific knowledge and business understanding.

As discussed previously, we will conduct this research utilizing the measurement items developed by Wagner & Bode (2008) to respond to the following research questions:

- How does Overall Supply Chain Risks influence Operational Performance?; and
- What sources of risks have a relatively higher negative impact on Operational Performance?

In this work, differently from the Wagner and Bode modeling approach, we propose to assess the overall Supply Chain Risks impact upon the operational performance of Brazilian Industries as well as each dimension separately. Such a view is motivated by authors like Chopra & Sodhi (2004) and Punniyamoorthy & Thamaraiselvan (2013) that acknowledge the interconnectedness among the different supply chain risk dimensions.

Secondly, we will investigate specific underlying supply chain risk dimensions and sources, considering the relevance of each different risk construct to the overall risk of the supply chain. Our goal is to provide knowledge about the relative frequence of ocurrence and the negative impact of each 4 dimensions and 13 sources of Risks.

The results of the investigation may support managers to drive their focus on developing risk-mitigating action taking into consideration the importance and relevance of various supply chain risks (Punniyamoorthy & Thamaraiselvan, 2013).

<u>H2: The impact of Supply Chain Risks on Operational Performance is contingent on Supply Chain Complexity sources, Firm Size, and Firm Strategy for Competitive Advantage?</u>

The presence of Supply Chain Complexity may influence the level of disruptions in supply chains (Bode & Wagner, 2015; C. Y. Cheng, Chen, & Chen, 2014; S. Piya et al., 2019; Wiedmer, Rogers, Polyviou, Mena, & Chae, 2021). In parallel, the literature characterized the presence of supply chain complexity as a factor that negatively impacts operational performance (Akın Ateş et al., 2021)

Based on the observations above, since we have proposed to explore the impact of Supply Chain Risks on Operational Performance in this study, the understanding if such a relationship is contingent on Complexity sources or not is relevant from our perspective.

The importance of better understanding the consequences of Supply Chain Complexity, among other factors, is derived from the fact that to reach better performance and customer satisfaction, it is necessary to deploy actions towards analyzing, measuring, and reducing complexity (S. Piya et al., 2019; Serdarasan, 2013a).

Kavilal et al. (2017) and Subramanian, Abdulrahman, & Rahman (2014) suggest that organizations should prioritize specific supply chain complexity drivers rather than all drivers. One empirical academic effort towards such direction was performed by (Bode & Wagner, 2015). The authors promoted an empirical investigation about the relationship between structural characteristics of Supply Chain upstream complexity and the disruption frequency.

To be more specific, (Bode & Wagner, 2015) study hypothesizes and tests a proposed theoretical model that links structural drivers of upstream supply chain complexity with the number of supply chain disruptions experienced by buying firms over 12 months. The results show that three investigated complexity drivers—horizontal, vertical, and spatial complexity increase the frequency of disruptions and interact and amplify each other's effects in a synergistic fashion. In such study, the complexity drivers explored were the following ones: number of first-tier suppliers (Horizontal complexity); supply chain position (vertical complexity); and purchasing volume per geographic region (spacial complexity)

In our research, we proposed to focus on different sources of complexity available in the previous studies by testing the influence of the following sources on the relationship among Overall Supply Chain Risk and Operational Performance: Number of Suppliers, Long and unreliable supplier lead times, Globalization of the supply base (in terms of upstream sources), Number of customers, Heterogeneity in customer needs, Shorter product life cycles and Demand variability (in terms of downstream sources) and Number of products and Number of parts (in terms of Internal manufacturing complexity drivers).

In terms of potential contingents' factors, we will also explore the influence of classical contingency variables such as firm size and type of strategy for competitive advantage in addition to Supply Chain Complexity.

Regarding the use of firm size as a contingent variable, Sousa & Voss (2008) work stresses that such contextual variable is borrowed from other management fields and is not to supply chain specif. Contingency theorists with contradictory findings have widely used it in different scenarios. Nevertheless, we have not found a specific investigation into the influence of size on its moderator effects within the relationship among Supply Chain Risks and Operational Performance.

Concerning the type of strategy for competitive advantage and its potential contingent role, we proposed that the impact of Supply Chain Risk upon Operational Performance may vary according to industries' choice in terms of cost leadership versus differentiation strategy.

In sum, we seek to contribute to the field of contingency theory by providing empirical evidence about the role that the contingencies above may play in the Overall Supply Chain Risk (derived from internal and external environmental and structural elements) on Operational Performance (System Performance).

2.3 - RESEARCH METHODOLOGY

2.3.1 - Research Methodology

We assume a postpositivist philosophical world view, anchored in a deterministic philosophy that seeks to explore the causes that influence outcomes; such worldview is based on the following elements: Determination, Reductionism, Empirical observation, and measurement and Theory verification (Creswell, 2014).

The investigation will follow the deductive approach to research, where the researcher starts with a theory and tests it using empirical data to support or not the theoretical postulates (Bhattacherjee, 2012). It is essential to highlight that "the goal of theory-testing is not just to test a theory, but possibly to refine, improve, and extend it" (Bhattacherjee, 2012, p.3).

The present work follows a quantitative research approach with a nonexperimental correlational form of research. Researchers apply correlational statistics to describe and measure the degree of relationship between two or more variables in such types of studies (Creswell, 2014).

Due to the nature of the phenomenon under investigation, we chose the survey research design to obtain the data. This type of method relies on applying questionnaires to collect data about the people or organizations systematically. (Bhattacherjee, 2012).

The survey approach was selected in this work mainly because we tested the relationship among latent variables. According to (Rungtusanatham, Choi, Hollingworth, Wu, & Forza, 2003), survey studies are generally relational because they tend to be designed to examine relationships among two or more constructs or variables empirically.

Bhattacherjee (2012) emphasizes that survey design has different advantages. Firstly, it is an excellent means for measuring several natural unobservable phenomena. Secondly, it allows the researchers to obtain data remotely about a population that is too large to observe directly; it has unobtrusive nature and can be considered economical in terms of researcher time compared to another means of data collection.

The data collected was subsequently analyzed employing Structural Equation Modeling (SEM). SEM is a multivariate statistical technique with elements from Structural Theory, Measurement Theory. "In PLS-SEM, structural and measurement models are also referred to as inner and outer models. To develop path models, researchers need to draw on structural and measurement theories, which specify the relationships between the elements of a path model". (Sarstedt, Ringle, & Hair, 2017, p.3)

As proposed by (Joseph F. Hair, Risher, Sarstedt, & Ringle, 2019, p.3), "the PLS-SEM method is very appealing to many researchers as it enables them to estimate complex models with many constructs, indicator variables, and structural paths without imposing distributional assumptions on the data."

2.3.2 - Sample and data collection

An electronic survey questionnaire was applied to promote the data collection process. A total of 987 potential participants were contacted by phone and email between January 2020 and June 2020, resulting in 165 usable responses to an electronic survey. Thus, an effective return rate of 16,7% was obtained.

Concerning the sample size, we followed the recommendations from Cohen, (1992),cited by Joseph F. Hair, Hult; Ringle; & Sarstedt (2017, p. 26) regarding the minimum number of respondents. In our case, considering that the number of arrows from dependent variables pointing out at our dependent construct is 1, 33 observations are necessary to detect R2 values of around 0.25 at a significance level of 5% and a power level of 80%. Therefore, in both scenarios, the sample size of 165 cases can be regarded as sufficiently large.

Maximum Number of Arrows Pointing at a Construct (Number of Independent Variables)	Significance Level											
	10%				5%				1%			
	Minimum R^2				Minimum R^2				Minimum R^2			
	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75
2	72	26	11	7	90	33	14	8	130	47	19	10
3	83	30	13	8	103	37	16	9	145	53	22	12
4	92	34	15	9	113	41	18	11	158	58	24	14
5	99	37	17	10	122	45	20	12	169	62	26	15
6	106	40	18	12	130	48	21	13	179	66	28	16
7	112	42	20	13	137	51	23	14	188	69	30	18
8	118	45	21	14	144	54	24	15	196	73	32	19
9	124	47	22	15	150	56	26	16	204	76	34	20
10	129	49	24	16	156	59	27	18	212	79	35	21

Source: Cohen (1992): A Power Primer. Psychological Bulletin 112: 155–159.

Figure II - 5 - Sample Size Recommendation in PLS-SEM for a Statistical Power of 80% extracted from (Sarstedt et al., 2017, p.26)

The unit of analysis employed in this study is at the manufacturing plant level and its relationship between its internal functions, upstream suppliers, and downstream customers. The target profile of respondents was composed of managers selected by their job function (supply chain manager, operation manager, or equivalent). Among the respondents, 100% were from the manufacturing sectors, from segments like automotive companies, chemical sector, electronics sector, oil, and gas. In tables 3 to 6, the demographic details of the sample can be found.

Industrial Segment	Frequency	Percentage
Food and Beverages	44	26,67%
Textile and Garment	19	11,52%
Chemicals and petroleum	14	8,48%
Plastic and latex	14	8,48%
Passenger Vehicles	12	7,27%
Construction	11	6,67%
Wood Products	11	6,67%
Consumer goods	7	4,24%
Fabricated metal products, except machines	7	4,24%
Others	7	4,24%
Pharmaceutical	4	2,42%
Machinery	4	2,42%
Paper Products	4	2,42%
Basics and Manufactured Goods	4	2,42%
Electrical equipment	3	1,82%

Total	165	100,00%

Table II - 4 - Sample Demographics (Industrial Segments)

Sales Volume	Frequency	In Percentage
Less than 10 million reais	87	52,73%
Between 11 and 25 million reais	32	19,39%
Between 26 and 50 million reais	8	4,85%
Between 51 and 75 million reais	2	1,21%
Between 76 and 100 million reais	4	2,42%
Between 101 and 250 million reais	7	4,24%
Between 251 and 500 million reais	5	3,03%
Above 500 million reais	20	12.12%

Table II - 5 - Sample Demographics (Sales Volume)

Number of employees	Frequency	In Percentage
1-50	95	57,58%
51-100	22	13,33%
101-200	12	7,27%
201-500	12	7,27%
501-1000	10	6.06%
Above 1000	14	8,48%

Table II - 6 - Sample Demographics (Number of Employees)

Job Level at the company	Frequency	In Percentage
Director of Supply Chain	38	23,03%
Supply Chain Manager	101	61,21%
Operations Manager	26	15,76%
Years of Job Experience within the actual company	Frequency	In Percentage
Less thanfive5 years	48	29,09%
Between 5 and 10 years	71	43,03%
Between 10 and 20 years	44	26,67%
Above 20 years	2	1,21%
Years of Job experience	Frequency	In Percentage
Less than 5	12	7,27%
Between 5 and 10 years	41	24,85%
Above 10 year	112	67,88%

Table II - 7 - Sample Demographics (Respondents Profile)

2.3.3 - Sample and method bias

We execute the Normality Test, Test of Equality of Variance, and Common Method Bias using SPSS Software to assess the sample. Concerning the normality assessment, the Shapiro-Wilks test is designed to test normality. According to the normality test proposed by Shapiro and Wilk (1968), when the p-value is less than or equal to 0.05, the hypothesis of normality should be rejected. Nevertheless, as emphasized by Hair et al., (2017, p. 27), "Normal distributions are usually desirable, especially when working with CB-SEM. In contrast, PLS-SEM generally makes no assumptions about the data distributions."

We also test the homogeneity of the sample. As Nordstokke, Zumbo, Cairns, & Saklofske (2011, p.1) proposed, "The assumption of homogeneity of variances is essential when comparing two groups because if variances are unequal, the validity of the results is jeopardized". Levene's tests indicate no significant differences between the two groups of the first 2/3 of respondents and 1/3 late respondents.

Following (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), Harman's single-factor test with an exploratory factor analysis was applied to assess the presence of common method bias. If the total variance extracted by one factor exceeds 50%, common method bias is present in your study. Our test with all variables (independent and dependent) resulted in a first factor accounting for 28.78 percent of the total variance, indicating that no single factor explained most of the variance in the model.

2.3.4 - Conceptual Model

"A model is a representation of all or part of a system that is constructed to study that system, while a theory tries to explain a phenomenon, a model tries to represent a phenomenon" (Bhattacherjee, 2012, p 14).

As shown in the figure below, a path model is "a diagram that displays the hypotheses and variable relationships to be estimated in an SEM analysis" (Sarstedt, Ringle, & Hair, 2017, p.4)

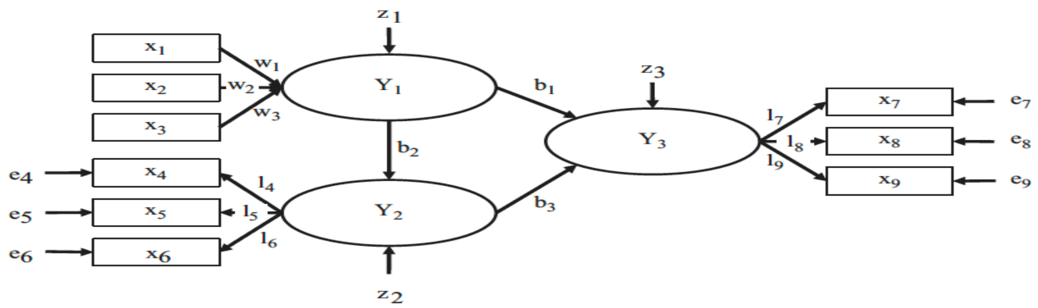

Figure II - 6 - Path Diagram and Latent variable (Sarstedt, Ringle, & Hair, 2017, p.5)

Latent variables "are elements in statistical models that represent conceptual variables that researchers define in their theoretical models" (Sarstedt, Ringle, & Hair, 2017, p.3)

Our research model comprises different constructs one Low Order (Operational Performance) and one High Order (Overall Supply Chain Risks), which is composed of 5 Low Order Construct (Supply Side Risks, Demand Side Risks, Regulatory, Legal, and Bureaucratic Risks, Infrastructural Risks and, Catastrophic Risks).

The one multidimensional construct denominated Overall Supply Chain Risks, "where each dimension represents a unique content domain of the broader construct. Multidimensional constructs differ from first-order constructs in that while the latter also represents a single theoretical concept, they lack distinct dimensions" (Polites, Roberts, & Thatcher, 2012, p. 22) .

When applying a higher-order construct, researchers evaluate the influence of such high order latent variable rather than the influence of its dimensions separately (Polites et al., 2012).

Higher-order constructs, “which facilitate modeling a construct on a more abstract higher-level dimension and its more concrete lower-order subdimensions, have become an increasingly visible trend in applications of partial least squares structural equation modeling (PLS-SEM).” (Sarstedt, Hair, Cheah, Becker, & Ringle, 2019. p. 197)

Model parsimony can be achieved through the reduction in the number of path model relationships, and such condition can be seen as one advantage of using higher-order construct since “instead of specifying relationships between multiple independent and dependent constructs in a path model, researchers can summarize the independent constructs in a higher-order construct, making the relationships from the (then) lower-order components to the dependent constructs in the model obsolete” (Sarstedt et al., 2019, p.198)

The repeated indicators approach was applied to establish the reflective-reflective relationship among Supply Chain Risks higher-order construct and its low-order constructs Demand Risks, Supply Risks, Regulatory Risks, Infrastructural Risks, and Catastrophic Risks. By applying such approach, all 17 indicators of the reflectively measured lower-order components are simultaneously assigned to the reflective measurement model of the higher-order construct.

“A reflective specification is appropriate when there is a more general, abstract construct that explains the correlations between the low-order Constructs. Hence, there should be substantial correlations between the low-order Constructs that—analogous to reflective measurement models—are assumed to be caused by the high-order constructs. That is, the high-order construct is the spurious cause explaining the correlations between the low-order constructs”.(Hair, Sarstedt,, Ringle, & Gudergan, 2017, p.43).

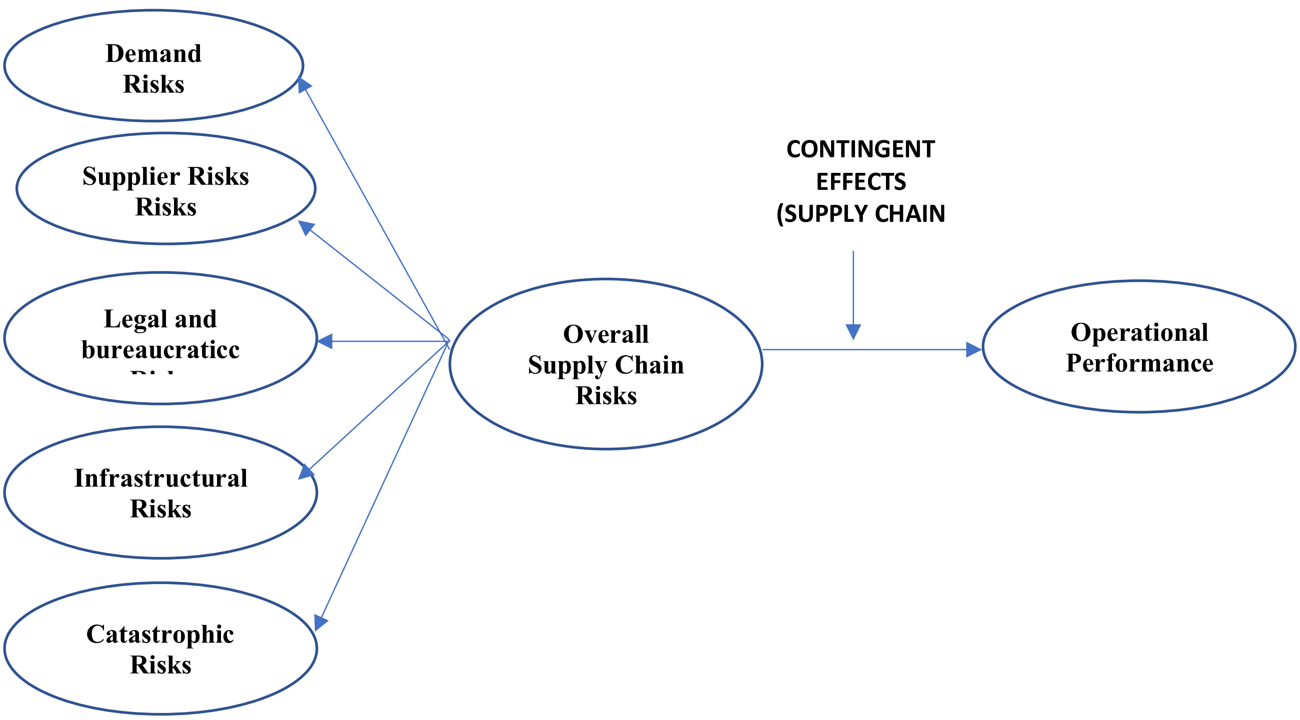

Figure II - 7 - Research Conceptual Model

Bhattacherjeev (2012) reminds that constructs require operational definitions, which explain define how they will be empirically measured. The constructs of the present study can be found in table 8, and all of it's the variables that compound the research questionnaire are presented in Appendix C.

Variable Name	**Reference:**	**Role of variable in study**	**Scale**	**Operational definition**	**Range of values**
Supply Chain Risk	Wagner & Bode, 2008)	Independent	Likert	**Appendix C**	1-7
Organizational performance	(Huo et al., 2014)	Dependent	Likert	**Appendix C**	1-7
Supply Chain Complexity	(Bozarth et al., 2009)	Moderator	Likert	**Appendix C**	1-7

Table II - 8 - Constructs Sources

The model developed and tested covers 17 different types of Supply Chain Risks Sources and 10 different types of Operational Performance indicators, and 10 complexity drivers.

2.3.5 - Measurement model misspecification tetrad analysis (CTA-PLS)

According to Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan (2017), SEM results' validity may be threatened by measurement model misspecification. One approach to assess such conditions relies on the execution of the Confirmatory Tetrad Analysis in PLS-SEM (CTA-PLS).

The application of such analysis enables researchers to empirically evaluate whether the measurement model has specification issues or not. The concept of tetrads (τ) is at the heart of CTA-PLS. It describes the relationship between pairs of covariances.

In reflective measurement models, "differences between pairs of covariances of indicators that represent the concept in a similar manner should be zero, provided the domain sampling model holds as assumed by a reflective measurement model" (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p. 91-92).

In sum, the idea behind CTA-PLS is that in a reflective measurement model, each tetrad (τ) is expected to be zero. In other words, CTA-PLS simply tests the following hypothesis: Ha: $\tau \neq 0$ H0: $\tau = 0$. CTA-PLS only produces results for constructs with at least four indicators per measurement mode.

The assessment was based on the assumption that zero should fall between the Adjusted Confidence Interval (Low and Up) of each tread of the construct being assessed. (Wong, 2019) provide a table for better visualization of such criteria.

	CI Low adj	CI up adj		Measurement model is
If all values are	-	-	then	formative
If all values are	+	+	then	formative
If one or mode of the values are	-	+	Then	reflective

Table II - 9 - CTA-PLS Assessment Criteria (Wong, 2019)

Infrastuctural Risks	T Statistics	P Values	CI Low adj.	CI Up adj.
1: SCRI1,SCRI2,SCRI3,SCRI4	0.35	0.73	-0.15	0.21
2: SCRI1,SCRI2,SCRI4,SCRI3	1.82	0.07	-0.02	0.22

Table II - 10 - Extract of CTA-PLS Assessment (Infrastructural Risks)

Supplier Risks	T Statistics	P Values	CI Low adj.	CI Up adj.
1: SCRS1,SCRS2,SCRS3,SCRS4	2.29	0.02	-0.05	1.02
2: SCRS1,SCRS2,SCRS4,SCRS3	0.12	0.90	-0.65	0.72
4: SCRS1,SCRS2,SCRS3,SCRS5	2.13	0.03	-0.10	1.12
6: SCRS1,SCRS3,SCRS5,SCRS2	1.61	0.11	-0.52	0.11
10: SCRS1,SCRS3,SCRS4,SCRS5	0.96	0.34	-0.79	0.35

Table II - 11 - Extract of CTA-PLS Assessment (Supplier Risks)

MOP	T Statistics	P Values	CI Low adj.	CI Up adj.
MOP 1,MOP 10,MOP 2,MOP 3	0.46	0.65	-0.26	0.20
MOP 1,MOP 10,MOP 3,MOP 2	0.13	0.89	-0.15	0.16
MOP 1,MOP 10,MOP 2,MOP 4	0.21	0.84	-0.29	0.25
6:MOP 1,MOP 2,MOP 4,MOP 10	0.61	0.54	-0.19	0.28

Table II - 12 - Extract of CTA-PLS Assessment (Operational Performance)

In the case of the Demand Risk and Regulatory Risks construct, the CTA-PLS cannot be applied as it has only two measurement items. When such conditions happen, as suggested by Wong (2019, p.43), as a rule of thumb, “if the indicators hang well together and are highly interchangeable among themselves, it is a reflective measurement model. On the other hand, if the indicators are not highly correlated and they are not interchangeable, a formative measurement model is suggested”. In our model, both demand risk items and regulatory risk items are highly correlated.

Concerning the assessment of the reflectiveness among the Low Order Construct (LOC) and High Order Construct (HOC), the direct application of CTA-PLS is not feasible. Nevertheless, (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017,p.54) suggest the use of the two-stage approach if the researcher seeks to assess the nature of the higher-order construct using CTA-PLS

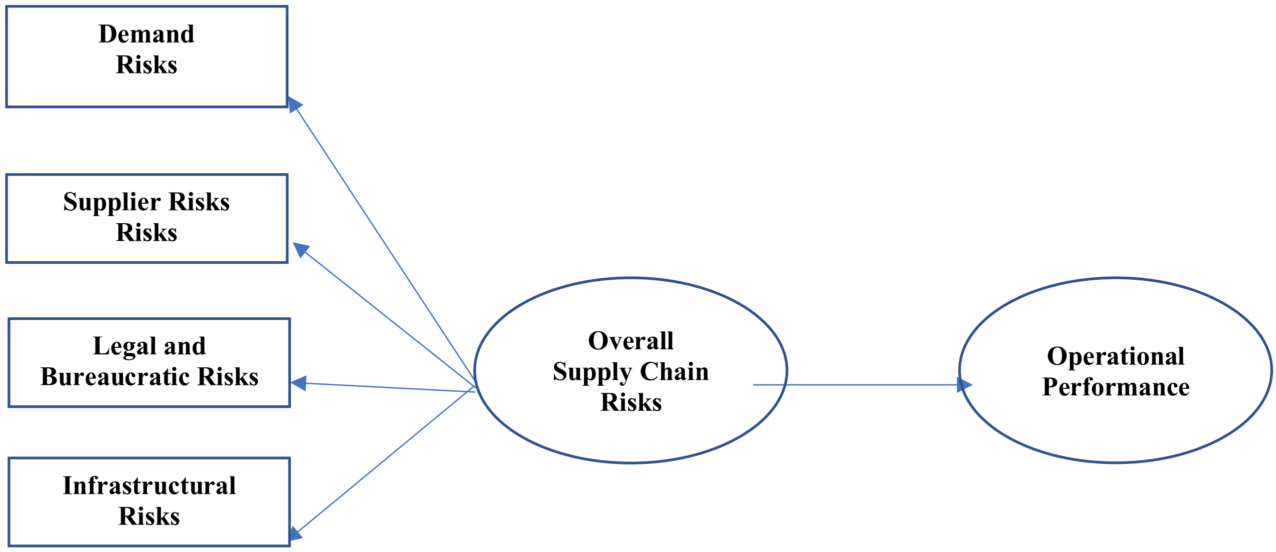

Figure II - 8 - Two-stage approach modelling

Overall Supply Chain Risks	T Statistics	P Values	CI Low adj.	CI Up adj.
1: Demand Risks, Infrastructural Risks, Regulatory Risks, Supplier Risks	0.82	0.41	-0.05	0.12
2: Demand Risks, Infrastructural Risks, Supplier Risks, Regulatory Risks	1.91	0.06	-0.24	0.02

Table II - 13 - Extract of CTA-PLS Assessment (LOC and HOC)

Thus, based on the arguments proposed above, we find support that a *reflective-reflective specification is appropriate.* Despite such results, it is important to emphasize that "CTA-PLS is no silver bullet, and its results do not discharge researchers from closely thinking about the specification of measurement models." Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan (2017, p.96). Furthermore, "researchers should make the formative vs. reflective decision based on sound theoretical considerations" Wong (2019, p.43)

2.3.6 - Low Order Construct Assessment

Model estimation delivers empirical measures of the relationship between the indicators and the constructs and between the constructs (Joe F. Hair, Sarstedt, Ringle, & Mena, 2012).

The traditional criterion for internal consistency is Cronbach's alpha, which provides an estimate of the reliability based on the mutual relationship of the observed indicator variables. "Due to Cronbach's alpha's limitations, it is technically more appropriate to apply a different measure of internal consistency reliability, referred to as composite reliability". (Joseph F. Hair et al., 2017, p.127).

As a reference, the authors mentioned earlier suggest that values below 0.70 (or 0.6 in exploratory research) do not fulfill internal consistency. At the same time, values above 0.95 are not desirable because they indicate that all the indicator variables measure the same phenomenon and are therefore not likely to be a valid measure of the construct.

	Cronbach's Alpha	Composite Reliability
Catastrophic Risks	0,56	0,69
Demand Risks	0,77	0,90
Infrastuctural Risks	0,85	0,90
MOP	0,91	0,93
Regulatory Risks	0,84	0,92
Supplier Risks	0,85	0,89

Table II - 14 - Internal Consistency

As we can find above, the construct Catastrophic Risks does not meet initially internal consistency criteria. The following steps to assess the model consist of evaluating the convergent validity of reflective constructs. As Joseph F. Hair et al. (2017) oriented, researchers should consider the outer loadings of the indicators and the average variance extracted (AVE).

A common rule of thumb is that the standardized outer loadings should be 0.708 or higher (Joseph F. Hair et al., 2017). For those values with values lower than the threshold proposed above, the author suggests that if it ranges on between 0.40 and 0.70, the indicator should be considered for removal from the scale only when deleting the indicator leads to an increase in the composite reliability (average variance extracted) Due to such criteria as exposed below the indicator SCRC 2 is subject to be deleted and the PLS-Algorithm run again.

Indicator	Loadings	Indicator	Loadings
MOP 1	0,71	SCRD1	0,92
MOP 10	0,57	SCRD2	0,88
MOP 2	0,85	SCRI1	0,81
MOP 3	0,73	SCRI2	0,76
MOP 4	0,83	SCRI3	0,85
MOP 5	0,84	SCRI4	0,90
MOP 6	0,85	SCRR1	0,92
MOP 7	0,83	SCRR2	0,93
MOP 8	0,63	SCRS1	0,82
MOP 9	0,62	SCRS2	0,85
SCRC1	0,84	SCRS3	0,66
SCRC2	0,14	SCRS4	0,87
SCRC3	0,76	SCRS5	0,74
SCRC4	0,60		

Table II - 15 - Outer loadings

Concerning the AVE, the value of 0.50 or higher indicates that, on average, the construct explains more than half of the variance of its indicators. The result shows that Catastrophic Construct does not meet such criteria.

Constructs	AVE
Catastrophic Risks	0,41
Demand Risks	0,81
Infrastructural Risks	0,69
MOP	0,57

Regulatory Risks	**0,86**
Supplier Risks	**0,63**

Table II - 16 - Average Variance Extracted (AVE)

The next step consists of evaluating the Internal consistency reliability and convergent validity of the measurement model with the exclusion of SCRC 2. After the adjustments made, the Construct reliability and Convergent validity are met, as shown in Table 16

	Cronbach's Alpha	**rho_A**	**Composite Reliability**	**AVE**
Catastrophic Risks	**0,61**	**0,68**	**0,78**	**0,55**
Demand Risks	**0,77**	**0,80**	**0,90**	**0,81**
Infrastructural Risks	**0,85**	**0,86**	**0,90**	**0,69**
MOP	**0,91**	**0,94**	**0,93**	**0,57**
Regulatory Risks	**0,84**	**0,84**	**0,92**	**0,86**
Supplier Risks	**0,85**	**0,86**	**0,89**	**0,63**

Table II - 17 - Constructs Reliability and Validity (after exclusion SCRC 2)

The next step consists of discriminant validity following the parameters suggested by (Joe F. Hair et al., 2012). Discriminant validity is the extent to which a construct is genuinely distinct from other constructs by empirical standards. Thus, establishing discriminant validity implies that a construct is unique and captures phenomena not represented by other constructs in the model (Joseph F. Hair et al., 2017, p.131).

As point out by Henseler, J., Ringle, C. M., & Sarstedt (2014, p.116) "If discriminant validity is not established, constructs [have] an influence on the variation of more than just the observed variables to which they are theoretically related" and, as a consequence, "researchers can not be certain that results confirming hypothesized structural paths are real or whether they are a result of statistical discrepancies.(Farrell, 2010, p. 324)"

Henseler, J., Ringle, C. M., & Sarstedt, (2014); Joseph F. Hair et al., (2017) suggest that all HTMT values should be below the conservative threshold of 0.85. Based on such criteria, the catastrophic risk construct is subject to be removed from the research framework since its discriminant validity statistical tests are not fulfilled due to its high correlation with the infrastructural risks construct.

With regard to the catastrophic risks construct, it is also important to highlight that its results were inevitably impacted by the Covid-19 pandemic, considering that one of the items in this construct refers exactly to the negative impacts resulting from this type of event. Data collection started in January 2020, before the pandemic outbreak in Brazil, concluded in June 2020, when the negative consequences due to such a event were already in place.

	Catastrophic Risks	**Demand Risks**	**IInfrastructuralRisks**	**MOP**	**Regulatory Risks**	**Supplier Risks**
Catastrophic Risks	0,74					
Demand Risks	0,33	0,90				
Infrastuctural Risks	0,69	0,47	0,83			
MOP	-0,39	-0,40	-0,50	0,75		
Regulatory Risks	0,60	0,47	0,68	-0,40	0,93	
Supplier Risks	0,53	0,60	0,66	-0,62	0,65	0,79

Table II - 18 - Discriminant validity - Fornell-Lacker Criteria (after exclusion SCRC 2)

	Catastrophic Risks	*Demand Risks*	*Infrastructural Risks*	*MOP*	*Regulatory Risks*
Catastrophic Risks					
Demand Risks	*0,40*				
Infrastuctural Risks	*0,93*	*0,56*			
MOP	*0,47*	*0,44*	*0,54*		
Regulatory Risks	*0,73*	*0,57*	*0,80*	*0,43*	
Supplier Risks	*0,68*	*0,72*	*0,77*	*0,67*	*0,77*

Table II - 19 - Heterotrait-Monotrait Ratio (HTMT) -Discriminant Validity Test (after exclusion SCRC 2)

In the light of the results obtained, the catastrophic risk construct was retrieved from the research since it did not meet the required Cronbach's Alpha, Composite Reliability, and Discriminant Validity. Another critical issue taken into consideration was the fact one of the items of this construct is related to the occurrence of Diseases or epidemics (e.g., SARS, Foot, and Mouth Disease), and of appearance of covid from March 2020 partially impacted the data collection that started in November 2019.

We do not consider the discriminant validity between Demand Risks, Supplier Risks, Regulatory Risks, and Infrastructural Risks both and their higher-order construct Supply Chain Risks. According to (Sarstedt et al., 2019), violation of discriminant validity between these constructs is expected because the measurement model of the higher-order component repeats the indicators of its lower-order components.

After the adjustments stated above, all the first-order constructs were retested to check the Outer Loadings and the validity and reliability of the Inner model. Table 4 indicates that the values of Cronbach Alpha, Average Variance Extracted |(AVE), and Composite Reliability (CR), generated by each construct, were above 0.7, 0.5, and 0.7, respectively.

	Cronbach's Alpha	**rho_A**	**Composite Reliability**	**AVE**
Demand Risks	**0,77**	**0,80**	**0,90**	**0,81**
Infrastuctural Risks	**0,85**	**0,86**	**0,90**	**0,69**
MOP	**0,91**	**0,94**	**0,93**	**0,57**
Regulatory Risks	**0,84**	**0,84**	**0,92**	**0,86**
Supplier Risks	**0,85**	**0,86**	**0,89**	**0,63**

Table II - 20 - Internal Consistency (After Adjustments)

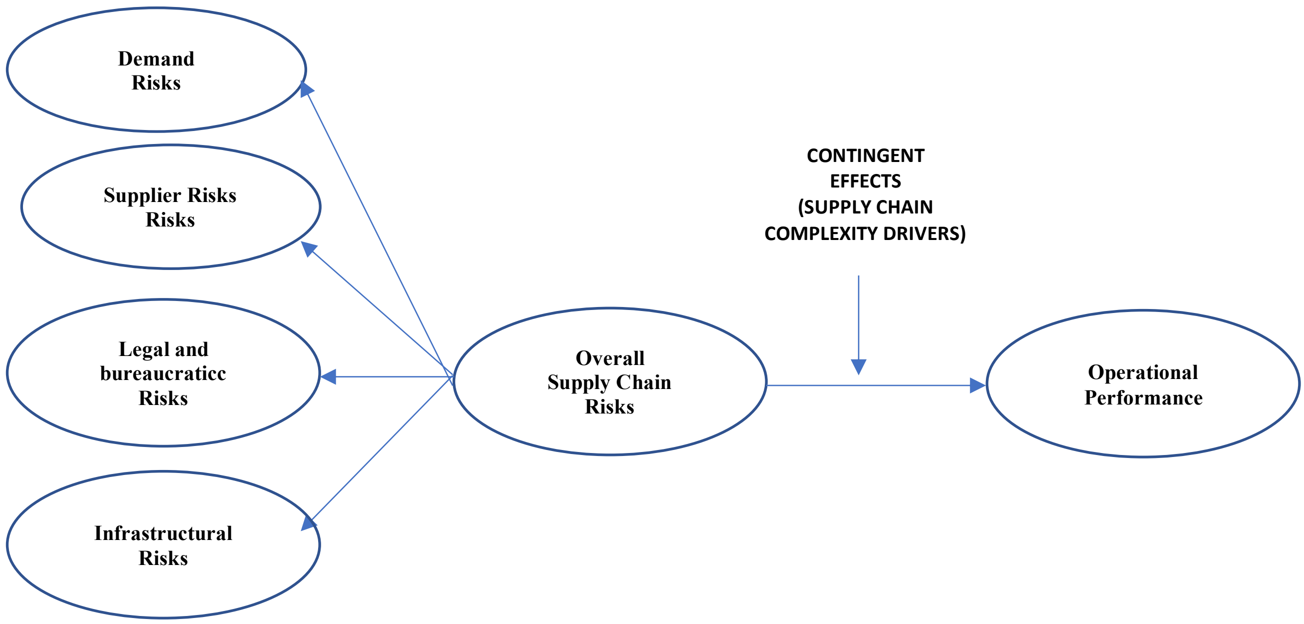

Table II - 21 - Research Model (After Adjustments)

As highlighted by (Wong, 2019), the discriminant validity is a measure of construct validity; then it should also be assessed; the results shown, respectively, in table 6 and table 7 display the assessment performed based on Fornell-Lacker Criteria and Heterotrait-Monotrait Ratio (HTMT)

	Demand Risks	**Infrastructural Risks**	**Operational Performance**	**Regulatory Risks**	**Supplier Risks**
Demand Risks	0,90				
Infrastuctural Risks	0,47	0,83			
Operational Peformance	-0,40	-0,50	0,75		
Regulatory Risks	0,47	0,68	-0,40	0,93	
Supplier Risks	0,60	0,66	-0,62	0,65	0,79

Table II - 22 - Discriminant validity - Fornell-Lacker Criteria (After Adjustments)

	Demand Risks	*Infrastructural Risks*	*Regulatory Risks*
Infrastructural Risks	*0,56*		
Regulatory Risks	*0,57*	*0,80*	
Supplier Risks	*0,72*	*0,77*	*0,77*

Table II - 23 - - Heterotrait-Monotrait Ratio (HTMT) - Discriminant Validity Test (After Adjustments)

We find support for the lower-order components' discriminant validity because all HTMT values are below the conservative threshold of 0.85 (see table 21). However, the discriminant validity between Demand Risks, Supplier Risks, Regulatory Risks and Infrastructural Risks both and their higher-order construct Supply Chain Risks was not assessed. According to Sarstedt et al., (2019, p.203), "violation of discriminant validity between these constructs is expected, because the measurement model of the higher-order component repeats the indicators of its lower-order components."

As suggested by Sarstedt et al. (2019), the assessment of the lower-order components draws on the standard reliability and validity criteria for reflective measurement models as documented in the extant literature (e.g., Hair et al., 2017a; Latan & Noonan, 2017; Sarstedt et al., 2017). Then, based on the results shown in tables 13 to 21 above, the Low Order Constructs of the research model met the convergent validity, internal consistency reliability, and discriminant validity as suggested by the literature.

2.3.7 - High Order Construct Assessment

The reliability and validity assessment of the higher-order construct *Supply Chain Risks* should be assessed considering its relationship with its lower-order components. The constructs *Demand Risks, Supply Risks, Regulatory Risks, and Infrastructural Risks* are interpreted explicitly as indicators of the *Supply Chain Risks* construct. Consequently, the (reflective) relationships between the *High Order* construct and its lower-order components are interpreted as loading, although they appear as path coefficients in the path model (Sarstedt et al., 2019).

The analysis produces loadings of 0,701 for Demand Risks, 0.909 for Supplier Risks, 0,818 for Regulatory Risks, and 0,869 Infrastructural Risks, thereby providing support for indicator reliability. The analysis produces loadings of 0,882 for *Demand Risks,* 0.911 for *Supplier Risks*, 0,788 for *Regulatory Risks* and 0,843 *Infrastructural Risks* for we thereby providing support for indicator reliability.

By using these indicator loadings and the correlation between the constructs (0.665) as input, the higher-order construct'reliability and validity should be calculate out of Smart-PLS Software (manually) based on the equations suggested by (Sarstedt et al., 2019, p.204).

The AVE is the mean of the higher-order construct's squared loadings for the relationships between the lower-order components and the higher-order component:

$$AVE = \frac{\left(\sum_{i=1}^{M} l_i^2\right)}{M},$$

where l_i represents the loading of the lower-order compo- nent *i* of a specific higher-order construct measured with *M* lower-order components ($i = 1,...,M$). For this example, the AVE is ($0.701^2 + 0.909^2 + 0{,}818^2 + 0{,}869^2$)/4 = 0.685, which is above the 0.5 threshold, therefore indicating convergent validity for *Supply Chain Risks* (Sarstedt et al., 2017).

The composite reliability is defined as

$$\rho_C = \frac{\left(\sum_{i=1}^{M} l_i\right)^2}{\left(\sum_{i=1}^{M} l_i\right)^2 + \sum_{i=1}^{M} var(e_i)},$$

where e_i is the measurement error of the lower-order component *i,* and $var(e_i)$ denotes the variance of the measurement error, which is defined as $1 - l_i$. Entering the for loading values yields the following:

Pc =(0.701 + 0.909 + 0,818 + 0,869) ^{2}/ (0.702 + 0.910 + 0,820 + 0,869) + (1- 0.701^2) + (1-0.909^2) + (1-0,818) ^{2} + (1- 0,869) ^{2} = 0,896

Similarly, Cronbach's α is given by

$$Cronbach's\ \alpha = \frac{M \cdot \bar{r}}{(1 + (M-1) \cdot \bar{r})},$$

where $\bar{r}$ represents the average correlation between the lower-order components. Since the higher-order construct Supply Chain Risks has four lower-order components (i.e., *M* = 4), the average correlation is equal to the correlation between the *Demand Risks, Supplier Risks, Regulatory Risks, and Infrastructural Risks* construct scores (i.e., 0.647). Hence, Cronbach's alpha is given by

Cronbach's alpha, α = 4* 0,588/(1+(4-1)* 0,588 = 0,85

Overall, these results provide clear support for the higher-order construct's internal consistency reliability. All criteria (i.e., ρ_C, and Cronbach's α_A) are well above the commonly recommended threshold of 0.708 (Hair et al., 2017a).

The assessment of the structural model should be performed based on the following steps: Collinearity among the latent variables, path coefficients; coefficient of determination R2, Blindfolding a, and predictive relevance Q2.

Collinearity arises when two indicators are highly correlated. Collinearity among latent variables is assessed through Variance Inflated Factor (VIF). VIF values above 5 indicate collinearity among the predictor constructs (Sarstedt, Ringle, & Hair, 2020, p

21). As shown in the table below, all constructs of the model have VIF values lower than the threshold suggested.

	Operational Performance
Overall Supply Chain Risks	1.000

Table II - 24 - VIF value (Latents Variables)

	Operational Performance
Overall Supply Chain Risks	-0.602

Table II - 25 - Path Coefficients

"The strength and significance of the path coefficients are evaluated regarding the relationships (structural paths) hypothesized between the constructs. Similar to the assessment of formative indicator weights, the significance assessment builds on bootstrapping standard errors as a basis for calculating t and p values of path coefficients" (Sarstedt et al., 2017, p.22).

The path coefficients are significant if the T-statistics is larger than 1.96 and the p-value lower than 0,05 (Sarstedt et al., 2017). Using such parameters, we analyze the structural model by using bootstrapping to obtain a better statistical fit and check the statistical significance of the obtained coefficients; a structural model was estimated based on bootstrapping with 5000 subsamples as suggested by (Wong, 2019).

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P-Value
Overall Supply Chain Risks -> MOP	0.64	0.64	0.05	11.85	0.00

Table II - 26 - T-Statistics Bootstrapping

The multiple correlation coefficient R2, also known as the coefficient of determination, is defined as the proportion of variance explained by the regression model. Thus, its results can be seen as a measure of predicting the dependent variable from the independent variables (Nagelkerke, 1991). The coefficient of determination, R2, is 0.358 for the Operational Performance endogenous latent variable. This result means that the Overall Supply Chain Risk explains 35,8 % of the variance in Operational Performance.

As a guideline, $f2$ values of 0.02, 0.15, and 0.35, respectively, represent small, medium, and large effects of an exogenous latent variable. Effect size values of less lhthan.02 indicate that there is no effect. (Sarstedt, Ringle, & Hair, 2020, p 21). Our model teaches that $f2$ value of 0.57 in the relationship among Overall Supply Chain Risk and Operational Performance conveys a large effect.

	Operational Performance
Overall Supply Chain Risks	0.57

Table II - 27 - Effect Size f2

The Q2 value builds on the blindfolding procedure, as proposed by (Joseph F. Hair et al., 2017, p. 202). “in addition to evaluating the magnitude of the R^2 values as a criterion of predictive accuracy, researchers should also examine Stone-Geisser’s Q^2 value (Geisser, 1974; Stone, 1974). This measure “can only be partly considered a measure of out-of-sample prediction, because the sample structure remains largely intact in its computation.” (Sarstedt, M., Ringle, C. M., & Hair, 2017, p.21)

The resulting Q^2 values larger than zero indicate that the exogenous constructs have predictive relevance for the endogenous constructs under consideration. “As a rule of thumb, Q2 values larger than zero for a particular endogenous construct indicate that the path model’s predictive accuracy is acceptable for this particular construct (Sarstedt, Ringle, & Hair, 2020, p 22)”.

As proposed by (Joseph F. Hair et al., 2017), the following rule of thumb allows to interpret the Q^2 results (based on the cross-validated redundancy):

- $0.02 \leq Q^2 < 0.15$: weak predictive power
- $0.15 \leq Q^2 < 0.35$: moderate predictive power
- $Q^2 \geq 0.35$: strong predictive power

Thus, the value of 0,18 indicates that the Overall Supply Chain Risks has moderate predictive relevance upon Operational Performance.

	SSO	SSE	Q^2 (=1-SSE/SSO)
Operational Performance	1.650.00	1344.47	0.18

Table II - 28 - Blindfolding and predictive relevance Q2

2.3.8 Alternative Modeling

Even though we found statistical support to apply reflective-reflective specification, there is criticism about using such an approach. *As highlighted by (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017 pp.44-45),* “the use of reflective-reflective HCMs has been subject to considerable debate, with critics arguing that such models do not exist (or are meaningless) since reflective measures should be unidimensional and conceptually interchangeable, which conflicts with the view of multiple underlying dimensions being distinct in nature” (Cadogan & Lee, 2012).

Conversely, (Temme & Diamantopoulos, 2016, p.180) (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, *pp.44-4*) emphasize that the arguments of (Cadogan & Lee, 2012) “are fundamentally flawed both conceptually and statistically, rendering their conclusions invalid. The authors suggested that “higher-order factor models are still a legitimate operationalization option for multidimensional construct.”.

Even though the CTA-PLS results discussed previously supported the reflective-reflective assumption, due to conflicting academic view presented, we propose to model the phenomenon under investigation following the reflective-formative approach for the sake of improving our analysis by verifying redundancy analysis, if changes on the nature of the Low order and High order model may render different result in terms of the central hypotheses of the present study.

As suggested by Chin, W. W. (2010, p. 687), If the formative indicators are applied in a theoretical model where a reflective set had been used in the past, a structural pattern comparison can be made. Specifically, we would expect that the structural paths linking the emergent construct with other constructs should follow the same pattern as those estimated in previous studies that applied the latent construct using reflective measures.”

As shown in the table below (Chin, 1998a; Hair et al., 2011 (Becker et al., 2012), the first-order constructs' weights and significance were assessed. In terms of weights, it should be higher than 0.10 a, and their signs should be consistent with the underlying theory as far as the significance,e it should be lower than 0.05.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Demand Risks -> Overall Supply Chain Risks	0.18	0.18	0.01	13.75	0.00
Infrastructural Risks -> Overall Supply Chain Risks	0.36	0.36	0.02	21.25	0.00
Regulatory Risks -> Overall Supply Chain Risks	0.21	0.21	0.01	20.92	0.00
Supplier Risks -> Overall Supply Chain Risks	0.43	0.43	0.02	27.09	0.00

Table II - 29 - T Statistic (Bootstrapping)

Multicolinearity is another critical aspect of the evaluation of formative construct measurements. As suggested by the literature, a formative nature for the second-order construct would be inappropriate if there is a high correlation among the first-order constructs. Therefore, to ensure that multicollinearity is not present, the variance inflation factor (VIF) should be analyzed. As shown in the table below, all constructs fulfill such criteria as the values are below 5.0.

Dimensions	Overall Supply Chain Risks
Demand Risks	1.59
Infrastructural Risks	2.23
Regulatory Risks	2.16
Supplier Risks	2.40

Table II - 30 - Variance Inflation Factor (VIF)

In terms of the main parameters utilized to assess the structural model, the coefficient of determination, R2 , the effect size, *f*2, and the predictive relevance, Q2, were the same found in the model with reflective assumption. Then, we can assume that there are no differences among the two modeling perspectives proposed.

	Coefficient of determination (R2)	Path Coefficient	Effect size (*f*2)	Predictive relevance (Q2)
Overall Supply Chain Risks -> Operational Peformance	0.358	-0.602	0.57	0.18

Table II - 31 - Alternative Modeling Results

2.3.9 - Multigroup Analysis (MGA)

The second hypothesis proposed in this study suggests that the impact of Supply Chain Risks on Operational Performance is contingent on Supply Chain Complexity sources, Firm Size, and Firm Strategy for Competitive Advantage. To evaluate possible contingency effects Multigroup Analysis (MGA) method, proposed by Henseler, Ringle, & Sinkovics (2009), will be applied.

As suggested by Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, (2017, p.148) “Path coefficients generated from different samples are almost always numerically different, but the question is whether the differences are statistically significant. Multigroup analysis helps to answer this question.”

The first multigroup analysis (MGA I) was related to the number of customers (DCP-1); we contrast industries with less than 100 different customers against those with more than a hundred. MGA (II) compares industries that manifest to face lower customer heterogeneity (DCP-2) with the industries in the sample with a relatively higher customer heterogeneity to identify the cut-off point we calculate the median. MGA (III) regards product life cycle (DCP-3), the two groups were compared using the threshold of 6 years as life cycle parameter. MGA (IV) considers high and low demand variability based on median value responses to question DCP-4 (Appendix C). MGA (V) consists of two groups, based on the number of distinct parts numbers required to manufacture a product (MCP-1; the first group comprises companies that require up to 50 and the second one with those that use more than 50 different distinct part numbers.

Additionally, MGA (VI) considers the number of product models manufactured at the plant (MCP-2); the threshold of 50 products was assumed as the threshold to split the groups. The number of distinct suppliers (UCP-1) that the company has was used as MGA (VII), in our sample industries with up to 50 different suppliers were compared against those with a more significant number of suppliers. MGA (VIII) compares industries that manifest to face longer supplier lead time concerning the industries in the sample with a relatively higher supplier lead time to identify the cut-off point to split the groups UCP-2 and UCP-3. MGA (IX) contrast industries with lower and higher supplier delivery unreliability; the cut-off point to separate the groups was the median to question UCP-4. In MGA (X), we compare companies with no dependency on imported supplies against those that use imported supplies; question UCP-5 provides such a view.

We also run the two MGA analyses to assess firm size has a contingent effect. In MGA (XI), we considered the number of employees (group 1 with industries with less than a hundred and group 2 above a hundred) whereas, in MGA XII, the sales volume was applied.

Finally, the last MGA investigated concerns industries' choices about its strategy in the market. We compare two groups based on the two classical Porter’s (1985) types of strategy for competitive advantage named cost leadership and differentiation advantage. As suggested by (Wen-Cheng, Chien-Hung, & Ying-Chien, 2011, p.100), “competitive advantage exists when the firm is able to deliver the same benefits as competitors but at a lower cost (cost leadership), or deliver benefits that exceed those of competing products (differentiation advantage).”

Before running the MGA analysis, some criteria must be evaluated, such as the number of observations for each group being compared and the Measurement of Invariance. Concerning the group sample size, we follow the recommendations from a power analysis (Hair et al., 2017) in terms of a minimum number of the respondent, 33 observations per group are needed to detect R2 values of around 0.25 at a significance level of 5% and a power level of 80%. Based on the above explanation, the group-specific sample sizes can be considered fulfilled.

The next step before performing a MGA consist of promoting the evaluation of measurement invariance. In this study, such analysis was achieved by applying the measurement invariance of composites (MICOM) approach (Henseler et al., 2016a). “By establishing measurement invariance, researchers can be confident that group differences in model estimates result from neither the distinctive content and/or meanings of the latent variables across groups nor the measurement scale. To assess measurement invariance in a PLS-SEM context, researchers can use the measurement invariance of the composite models (MICOM) procedure." (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p.135)

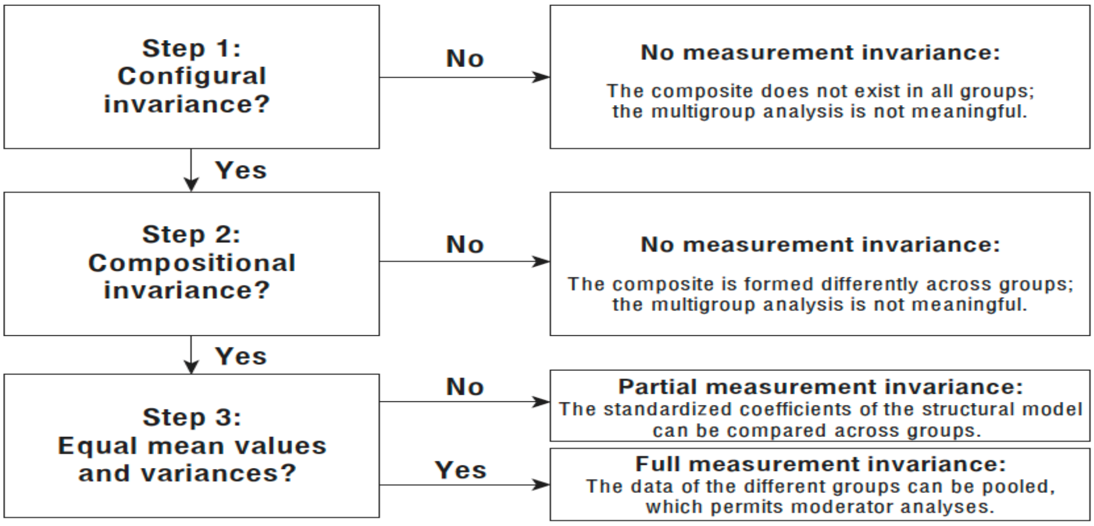

Figure II - 9 - MICOM Procedure extract from *(Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p. 315)*

Before running the MGA through PLS-SEM Software the fulfillment of Step 1 is achieved by default since the software ensure that for both groups the model and dataset were applied. Concerning step 2 and step 3, we run the permutation test to assess the Compositional Invariance. The MGA was performed for the contingencies that fulfilled at least the step 2. The detailed calculation is available in Appendix D and the compiled results are summarized below.

Groups	**MICOMM (Compositional Invariance)**	**MGA**
Number of Customers (DCP1)	Supported (partial invariance was established).	No differences
Customer Heterogeneity (DCP2)	Supported (partial invariance was established).	No differences
Product Life Cycle (DCP-3)	Supported (partial invariance was established).	**There are differences among groups**
Demand Variability (DCP-4	Supported (partial invariance was established).	No differences
Number of Active Parts (MCP-1)	Supported (partial invariance was established).	No differences

Number of Distinct Products (MCP-2)	Supported (partial invariance was established).	**There are differences among groups**
Number of Suppliers (UPC-1)	Supported (partial invariance was established).	No differences
Longer supplier lead time (UPC-2 e (UPC-3)	Supported (partial invariance was established).	**There are differences among groups**
Supplier Delivery unreliability (UCP-4)	Not Supported	Not feasible
Globalization of Supply Chain Base (UCP-5)	Supported (partial invariance was established).	No differences
Firm Size (Employees)	Supported (partial invariance was established).	No differences
Firm Size (Sales Volume)	Supported (partial invariance was established).	No differences
Type of Strategy for Competitive Advantages	Supported (partial invariance was established).	No differences

Table II - 32 - MICOMM and MGA Results

In terms of the contingent effects from different sources of Supply Chain Complexity Sources, we found that the impact of Supply Chain Risk on Operational Performance is higher for industries with Shorter Product Life Cycle (up to 6 years), with a greater amount of different products (above 50) and Longer or unreliable Supplier Lead Time. In contrast, the remaining contingent effects produce no difference concerning the impact of Overall Supply Chain Risks on Operational Performance.

- Multigroup analysis (MGA) – Differences in path coefficients

MGA III	MOP	Contingent Effect
Overall Supply Chain Risks	-0.71	Product Life Cycle up to 6 years
Overall Supply Chain Risks	-0,60	Full data set
Overall Supply Chain Risks	-0,50	Product Life above above 6 years

Table II - 33 - Multigroup analysis (MGA) – Differences in path coefficients (Product Life Cycle)

MGA III	MOP	Contingent Effect
Overall Supply Chain Risks	-0,75	Number of distinct Products (above 50)
Overall Supply Chain Risks	-0,60	Full data set
Overall Supply Chain Risks	-0.54	Number of distinct Products (up to 50)

Table II - 34 - Multigroup analysis (MGA) – Differences in path coefficients (Number of Distinct Products)

MGA III	MOP	Contingent Effect
Overall Supply Chain Risks	-0,68	Long Supplier Lead Time
Overall Supply Chain Risks	-0,60	Full data set
Overall Supply Chain Risks	-0.41	Long Supplier Lead Time

Table II - 35 - Multigroup analysis (MGA) – Differences in path coefficients (Longer or unreliable Supplier Lead Time.

2.3.10 - Importance Performance Map Analysis (IPMA)

We can refine our interpretation and analysis based on Importance-Performance Map Analysis (IPMA). "This type of analysis extends the standard PLS-SEM results reporting of path coefficient estimates and other parameters by adding a procedure that considers the average values of the latent variable scores" (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, p. 105, 2017)

Using such type of analysis, we can learn more about which risks types are most frequently observed (manifested in terms of its Performance) and those with greater relevance on negatively influencing the Operational Performance in the context of Brazilian Industries (displayed in terms of its Importance).

In IPMA analysis, the computation performance parameter "the indicator data determine the latent variable scores and, thus, their performance. Similarly, when conducting an IPMA on the indicator level, the mean value of an indicator represents its average performance". (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p.110).

In regards to the importance dimension, as explained by (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p. 116-117), "a construct's importance in terms of explaining another directly or indirectly linked (target) construct in the structural model is derived from the total effect of the relationship between these two constructs. The total effect is the sum of the direct and all the indirect effects in the structural model (Hair et al., 2017)".

The data collection about a different source of Supply Chain Risk was based on the following question: "To what extent has your firm in the past 3 years experienced a negative impact in supply chain management due to…". (1 not at all– 7 to a very large extent). Thus, we can interpret that the higher the performance values at the construct level or at the indicator level, the higher the occurrence of the specific risk.

It is important to emphasize that the results about the total effect of each risk source (Demand, Supplier, Regulatory and Infrastructure) upon Operational Performance were obtained through the application of IPMA considering the reflective formative approach since in the reflective-reflective model, we only get the view about the performance and importance, at the construct level, about the overall Supply Chain Risks.

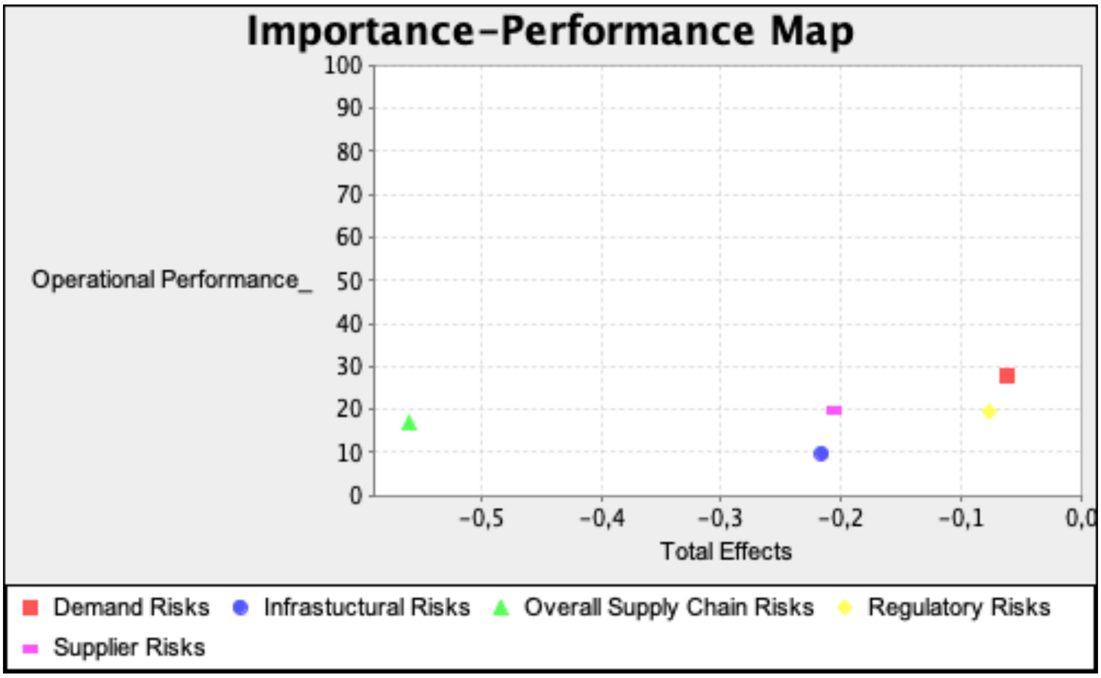

Figure II - 10 - Importance and Performance Analysis plot (Construct Level)

Risk Dimensions	Performances Results	Importance Results
Demand Risks	27.88	**- 0.06**
Supplier Risks	20.03	**- 0.21**
Regulatory Risks	19.34	**- 0.08**
Infrastructural Risks	9.84	**- 0.22**
Average	19,27	**-0,14**

Table II - 36 - Importance and Performance Results (Construct Level)

As highlighted by (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, pp. 119-120, 2017), IPMA is not limited to the construct level. We can also conduct an IPMA on the indicator level to identify relevant and even more specific areas of improvement. More precisely, we can interpret the rescaled outer weights as an indicator's relative importance compared to the other indicators in a particular measurement model.

The IPMA analysis at the construct and indicator level in produces the following results available at table 37 and figures 11 to 15.

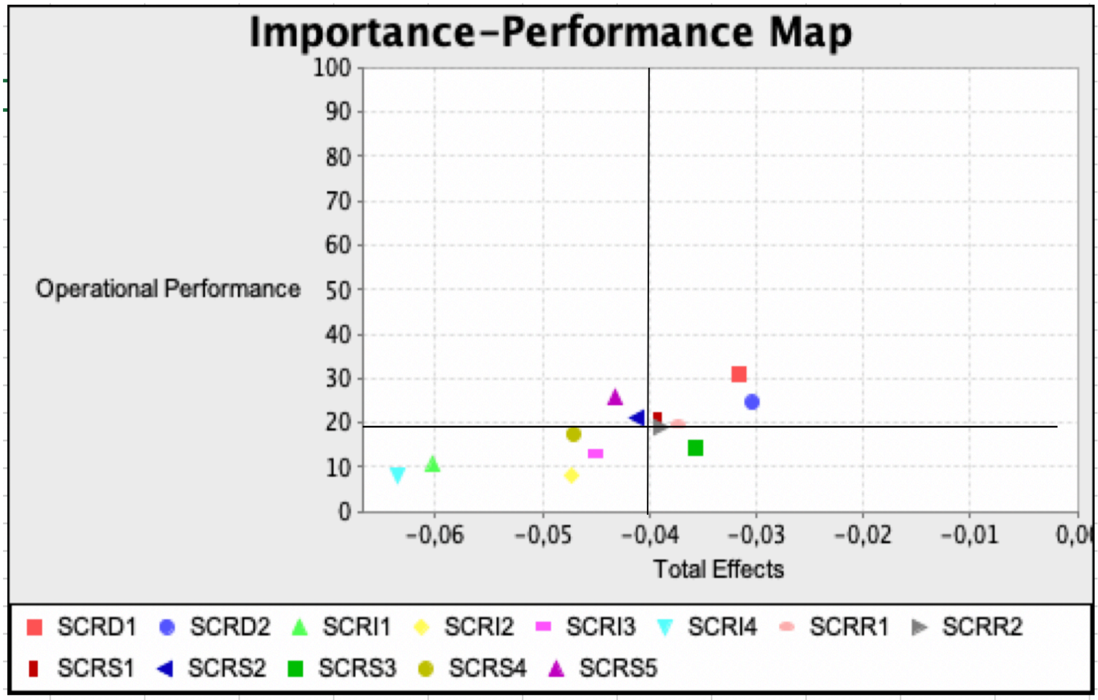

Figure II - 11 - Importance and Performance Analysis plot (Indicator Level)

Risk Sources	Performance Results	Importance Results
SCRD1 - Unanticipated or very volatile demand	31.01	- 0.03
SCRS5 - Capacity fluctuations or shortages on the supply markets	25.66	- 0.04
SCRD2 - Insufficient or distorted information from your customer about orders or demand quantities	24.55	-0.03
SCRS2 - Supplier quality problems	21.11	-0.04
SCRS1 - Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity)	20.71	-0.04
SCRR1 - Changes in the political environment due to the introduction of new laws, stipulations, etc.	19.6	-0.04
SCRR2 - Administrative barriers for the setup or operation of supply chains (e.g., authorizations).	19.09	-0.04
SCRS4 - Poor logistics performance of logistics service providers	17.47	-0.05
SCRS3 - Sudden demise of a supplier (e.g., due to bankruptcy)	14.44	-0.04
SCRI3 - Loss of own production capacity due to technical reasons (e.g., machine deterioration).	13.33	-0.05

SCRI1 - Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents).	10.51	-0.06
SCRI2 - Perturbation or breakdown of internal IT infrastructure (e.g., caused by computer viruses, software bugs).	8.08	-0.05
SCRI4 - Perturbation or breakdown of external IT infrastructure.	8.08	-0.06
Average	17,97	0,04

Table II - 37 - Importance and Performance Results (Indicator Level)

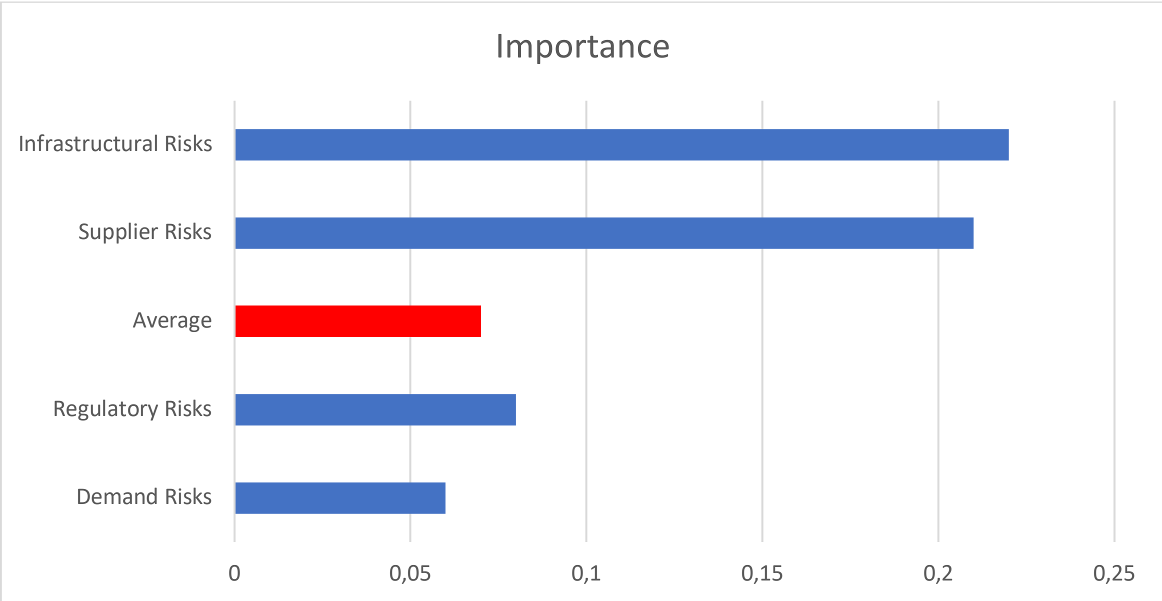

Figure II - 12 - IPMA Importance Dimension (Construct Level)

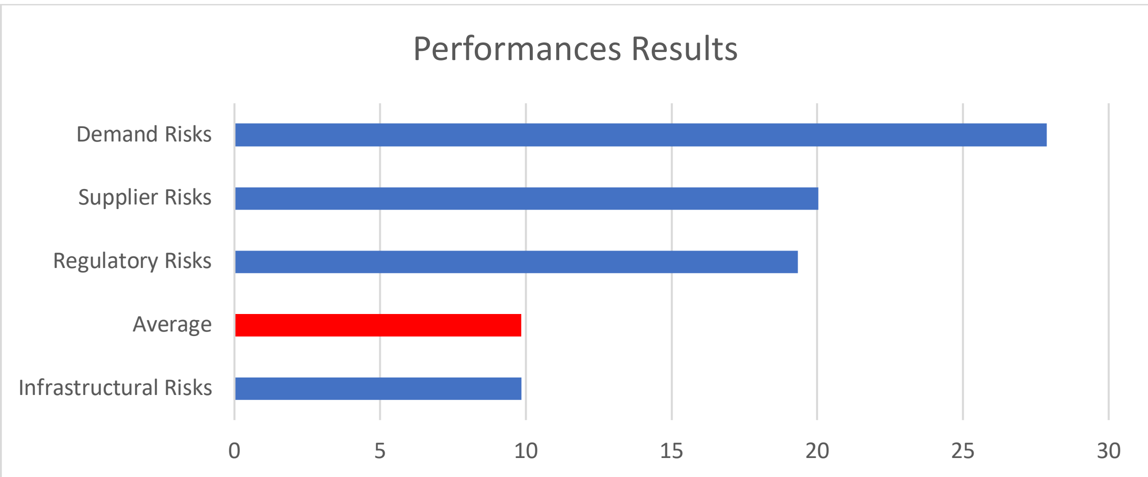

Figure II - 13 - IPMA Performance Dimension (Construct Level)

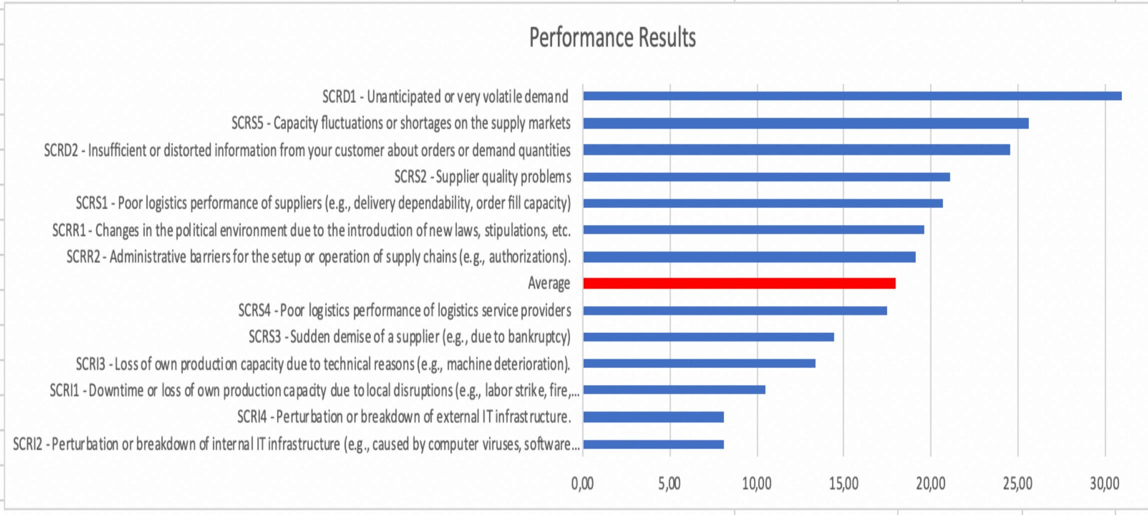

Figure II - 14 - IPMA Performance Dimension (Indicators Level)

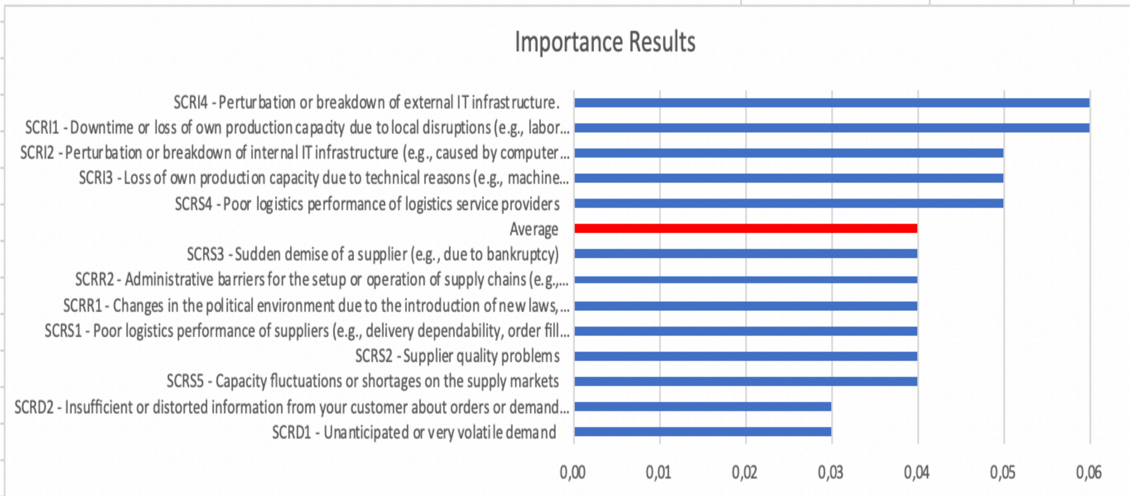

Figure II - 15 - IPMA Importance Dimension (Indicators Level

2.4 - DISCUSSIONS AND IMPLICATIONS FOR RESEARCH AND PRACTICE

This study aims to evaluate and identify the influence of Supply Chain Risks and contingencies on the Operational Performance of Manufacturing companies in Brazil. From such research aim, we established the following Research Objectives:

Objective 1 – To evaluate the influence of overall Supply Chain Risks on the Operational Performance of Manufacturing companies in Brazil.

Objective 2 - To identify which sources of risks have a relatively higher negative impact on the Operational Performance of Manufacturing companies in Brazil

Objective 3 – to identify contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage influence the relationship between Supply Chain Risks and operational performance

From the objectives stated above, the following research questions (RQ) emerge:

RQ1: How does Overall Supply Chain Risks influence Operational Performance?

RQ2: What sources of risks have a relatively higher negative impact on Operational Performance?

RQ3: What are the contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage that influence the relationship between Supply Chain Risks and operational performance?

Our first proposed research question is "How does Overall Supply Chain Risks influence Operational Performance?. The interpretation of the results leads us to conclude that Overall Supply Chain Risks negatively broadly impact and Operational Performance, which means that the risk exposure derived from internal and external environments hinders organizational effectiveness.

Concerning the statistical results obtained from the Structural Equation Model Results at the Inner Model level some additional observation should be made. As suggested by Sarstedt & Danks (2021, p.4), "Researchers evaluate their models' explanatory power based on F-type metrics and the R2 (Cohen, 1988), followed by an assessment of the model coefficients in terms of their significance, direction, and size".

Thus, based on the statistical results, we can assess the explanatory power of our model. The coefficient of determination of 0.358 indicates that our exogenous variables have a moderate, in sample, predictive power, which explains almost 36% of the variance of Operational Performance. The effect size ($f2$ values) of 0.57 conveys that Overall Supply Chain Risks has a large effect on operational performance.

In terms of predictive relevance of our model (out of sample), the blindfolding procedure results (Stone-Geisser's Q^2 value) of 0.18 indicate that the exogenous constructs have predictive relevance for the endogenous constructs under consideration at a moderate level.

The second research question consist of: "What sources of risks has a relatively higher negative impact on Operational Performance?"

From the results obtained from the IPMA analysis performed, at the construct level, we could refine our understanding of the different dimensions and sources of risks, and answer such a question, as follows:

- The results indicate that the different supply chain risks dimension impact operational performance negatively in the following decreasing order in terms of total effect: Infrastructural, Supplier, Regulatory, and Demand .

Based on the information available in figures 11 and 12, further conclusions may be made as follows:

- Supplier Risks are ranked above average either in terms of occurrence and importance. This means that managerial actions to identify and mitigate sources of risks like capacity fluctuations or shortages on the supply markets; supplier quality problems; poor logistics performance of logistics service providers, Sudden demise of a supplier (e.g., due to bankruptcy) should be prioritized by industries since such issues have frequently happen and also have a above average negative influence on operational performance significantly in comparisons with other sources of risks.

- Demand Risks have the highest occurrence but the lowest total effect. These results convey that even though industries frequently face risk sources like unanticipated or very volatile demand and insufficient or distorted information from your customer about orders or demand quantities, such issues are attenuated along with the production, distribution, and sales processes and proportionally have a relative negative lower impact upon operational performance in comparisons with other sources of risks.

- On the other side, infrastructural risks have the larger negative influence on Operational Performance, when present. In contrast, based on our data it figures as lowest frequent (performance) type of disruption. Based on that, we learned that industries should prioritize its actions to avoid infrastructural disruption like downtime or loss of own production capacity due to local disruptions; perturbation or breakdown of external and internal IT infrastructure; and Loss of own production capacity due to technical reasons since relatively to the other dimensions our results demonstrated the highest negative consequences.

- Concerning the Regulatory Risks, such dimension has a level of occurrence very similar to Supplier Risk but with a lower level of importance. Thus, we can conclude that changes in the political environment due to the introduction of new laws, stipulations, etc.; and Administrative barriers for the setup or operation of supply chains (e.g., authorizations) are being observed frequently, but it does not reflect in Operational Performance deterioration at the same level like Supplier or Infrastructural Risks.

The IPMA analysis at the indicator level yields new insights; based on the results of such analysis, each supply chain risk source may be assessed separately. For instance, the results at figure 13 indicates that the following risk sources are observed frequently (above average) concerning the complete set of risk events:

- Unanticipated or very volatile demand;
- Capacity fluctuations or shortages on the supply markets;
- Insufficient or distorted information from your customer about orders or demand quantities;
- Supplier quality problems;
- Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity);
- Changes in the political environment due to the introduction of new laws, stipulations; and
- Administrative barriers for the setup or operation of supply chains (e.g., authorizations).

On the other side, the following risk sources are below average in terms of is frequency:

- Perturbation or breakdown of external IT infrastructure;
- Perturbation or breakdown of internal IT infrastructure (e.g., caused by computer viruses, software bugs);
- Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents);
- Loss of own production capacity due to technical reasons (e.g., machine deterioration);
- Sudden demise of a supplier (e.g., due to bankruptcy); and
- Poor logistics performance of logistics service providers are placed below average.

As shown at figure 14, in terms of the relevance of the negative effect of the risk source on Operational Performance, the following sources were ranked as above average:

- Perturbation or breakdown of external IT infrastructure;
- Perturbation or breakdown of internal IT infrastructure;
- Downtime or loss of own production capacity due to local disruptions;
- Loss of own production capacity due to technical reasons; and
- Poor logistics performance of logistics service providers.

From the results available at figure 13, we learned that the risks sources below have below average impact:

- Sudden demise of a supplier;
- Administrative barriers for the setup or operation of supply chains (e.g., authorizations).
- Changes in the political environment due to the introduction of new laws, stipulations;

- Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity);
- Supplier quality problems;
- Capacity fluctuations or shortages on the supply markets;
- Insufficient or distorted information from your customer about orders or demand quantities;
- Unanticipated or very volatile demand.

Based on the analysis, we observed that among the top 5 most frequent risk sources only one (Poor logistics performance of suppliers) also figure in the list of risk source with above average negative effect. From such find, we can conclude that some sources more keen to happens produces less negative impact. In constract, several sources with low frequency, when present, generates more negative consequences.

Finally, our third research was framed as follows: What are the contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage that influence the relationship between Supply Chain Risks and operational performance? We explored this question based on the application of MGA analysis.

The results of MGA application provide support to confirm that contingencies like product life cycle, number of distinct Products, long supplier lead time have a contingent impact on the relationship between Overall Supply Chain and Operational Performance. Those contingencies are classified, respectively, as Downstream, Manufacturing Internal, and Upstream complexity drivers.

In industries with a product with a life cycle of up to 6 years, the negative impact of Overall Supply Chain Risk on Operational Performance was 42%, relatively stronger than for those industries with products with a life cycle of more than 6 years, in terms of

The number of different products also increases the adverse effects of Overall Supply Chain Risk on Operational Performance. For Industries with more than 50 different products, the negative influence of risk was 39% stronger than for those with a portfolio of products with less than 50 different products in the portfolio.

Industries that face long supplier lead time also observe a relatively more significant impact of risks on operational performance. Our results convey that impact of risk on performance is 65% stronger than for those that experience a low frequency of such conditions.

Interestingly, we found no contingent influence, in the relationship between Overall Supply Chain Risk and Operational Performance, concerning the other contingencies as such: the number of suppliers and globalization of the supply base (upstream complexity drivers); the number of customers, the Heterogeneity in customer needs and the demand variability (Downstream complexity drivers); and Number of products; number of parts (Internal manufacturing complexity drivers).

Furthermore, our analyses also shown that firm size, both in terms the number of employees the sales volume presented, has no contingent effect. Finally, the proposition that organizational choices concerning its type of strategy for competitive advantage (cost leadership and differentiation advantage) could also influence the relationship among Supply Chain Risks and Operational Performance was not supported as well.

Our findings also provide valuable observations to the undergoing academic discussion about the impact of Risks upon Performance either by providing alignment with previous research or a different perspective. In the next paragraphs, we constrant our hypotheses conclusions against previous studies.

For instance, based on the Moroccan business environment, El Hiri et al. (2018), suggest that the Supply chain is strongly influenced by supplier and demand risk. In contrast, external risks and infrastructure risks weakly affect performance Our findings are aligned with such a study in terms of relative strong impact of Supplier Risks upon Operational Performance, but we did not find the same results for demand risks since despite its relatively high frequency, its relevance concerning negative effects on Operational Performance were the lowest in comparison with other risks dimensions, at Brazilian environment.

We also have different results concerning the impact of external risks and the infrastructure risks. As mentioned, El Hiri et al. (2018) suggests such dimensions of risks affect weakly performance. Nevertheless, in our case, we found an above average relevance of Infrastructural Risks concerning its impact on Operational Performance. In terms of external risks, named in our research as Regulatory, legal and bureaucratic risks we also found low effect but with an above-average frequency of occurrence, at the Brazilian environment.

Yeboah & Yuansheng (2017) observed at agri-food supply chain operations in Ghana that demand, supply, weather, logistics/infrastructure and financial risk sources significantly undermined the chain's performance while risks emerging from biological/ environmental, management/operational, policy/regulations and political-related issues insignificantly affect the performance. The author's findings are aligned with ours results in terms of the Supplier and Infrastructural risk dimensions which also produce significant negative effect at Brazilian industries. We also found convergency concerning the low total negative effect on Operational Performance due to policy/regulations and political-related issues, despite the relative high frequency of its occurrence in Brazil.

Wagner & Bode (2008) investigation among German industries yields empirical evidences about the negative effects of supply and demand risks. On the other side, in terms of regulatory, legal and bureaucratic risks, infrastructure risks, and catastrophic risks, no empirical evidence supports a negative relationship with supply chain performance. As discussed, at Brazilian Industries, we found different results in terms of regulatory, legal, and bureaucratic risks, infrastructure risks dimension for which we found support for adverse effects.

Punniyamoorthy & Thamaraiselvan (2013) research found that Demand risk has the most adverse impact on the supply chain, followed by manufacturing side risk and supply-side risk. Logistics, information, and environment are rated lower compared to demand, manufacturi,ng and supply side risks. In our research we found similar results concerning the relevant impact from Supplier Risk dimension but we differently found a weak effect of Demand Risk Source (despite its higher frequency in Brazil).

We also found different empirical evidence concerning the impact of Informations sources of risks. since in our study, such risks as infrastructural risk yield a relative higher importance from all others three dimensions (demand, supplier, and regulatory). In regards to environment risks explored by Punniyamoorthy & Thamaraiselvan (2013), in our research, such dimension was called regulatory, legal, and bureaucratic risks, and we similarly found relatively lower importance in regards to the other risks constructs (despite its above-average occurrence)

Chen et al. (2013) found that supply risk has no direct effect on supply chain performance. In contrast, demand risk and process have a direct negative effect on operational performance. In terms of the effect of Supply Risks such findings are conflicting with our results as well as the results of Yeboah & Yuansheng (2017), El Hiri et al. (2018) and Wagner & Bode (2008).

2.5 - CONCLUSION

At the level of a manufacturing plant, in the specific context of the Brazilian business environment, this article explored the impact of Supply Chain Risk on Operational Performance using Contingency Theory to support the investigation. Furthermore, the present research also investigated potential contingent effects from environmental and structural sources like Supply Chain Complexity, Firm Size, and Strategy. This research pursued.

Section 2.2 presents a review of the relevant literature concerning the Contingency Theory, Supply Chain Risks, Supply Chain Complexity, and Operational Performance to provide a comprehensive conceptual framework explanation and enrich the discussion about the phenomenon of interest.

In section 2.3. the structural equation model was detailed based on the theoretical constructs of interest and the proposed hypotheses. In this section, the collection method, the sample size, the research design, and the complete statistical analysis of the inner and outer model, which includes high order and low order constructs, were presented in detail. This section also contains an explanation about the application of MGA and IPMA and their results.

In section 2.4, we analyze the empirical results from both the theoretical and managerial lenses, discussing the implication of the findings for both academics and managers.

This article contributes to the academic world through a quantitative study of a phenomenon of great interest, namely, the effect of supply chain risks on operational performance. We structure our analysis in 4 layers.

In the first layer, we explored the overall impact of supply chain risks on the operational performance of Brazilian industries in order to attend the first objective of this research which was proposed as follows: evaluate the influence of overall Supply Chain Risks on the Operational Performance of Manufacturing companies in Brazil. Our results provides statistical support about the negative influence of Supply Chain Risks and Operational Performance.

In the second layer, we assess how each dimension (Supply, Demand, Regulatory, legal and bureaucratic risks, and infrastructure risks) affects performance in order to fulfill the objective number 2 of the research (to identify which sources of risks have a relatively higher negative impact on the Operational Performance of Manufacturing companies in Brazil).

Based on our analysis and results, the study presents for science and practical fields a relative hierarchy in terms of frequency and the negative impact of 04 distinct dimensions and 13 different sources of risk in the daily lives of organizations. Such a unprecedent analysis offers detailed knowledge to scientists and market professionals about the specific events that cause disruptions in supply chains systems.

Concerning our third and last research objective, which consists of identifying contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage influence the relationship between Supply Chain Risks and operational performance, our investigation offers interesting results.

After analyzing the contingent role played by 13 different variables related to supply complexity (upstream, internal, and downstream) firm size and its strategy to competitive advantage, we concluded that among the contingencies analyzed only three increases the negative effect of risks on performance. From our observations, we learned that contingencies like product life cycle, number of distinct Products, long supplier lead time have a contingent impact on the relationship between Overall Supply Chain and

Operational Performance. Those contingencies are classified, respectively, as Downstream, Manufacturing Internal, and Upstream complexity drivers.

We consider the findings above valuable since it can support organizations important step towards gaining a better understanding in regards to the consequences of Supply Chain Risks and Supply Chain Complexity and its negative consequences on Operational Performance.

The results produced in this research may support organizations and practioners in prioritizing their attention upon specific Supply Chain Risks dimensions and sources as well as complexity drivers and consequently contribute positively to the decision making process concerning the definition and the deployment of the adequate managerial actions.

The value and originality of this research rely on the following reasons:

- To the best of our knowledge this one of the first study investigated an influencing factor that negatively influences Brazilian industries' operational performance since the previous scientific studies focused on enablers of better operational performance.
- To the best of our knowledge, it is one of the first empirical study about the relationship between Supply Chain Risk and Operational Performance in Brazil. The context and the particularities of the business environment have to be considered when studying the behavior of risk dimensions and sources. Thus, the application solely in Brazil may bring value to the field for the research in the supply chain risk research field.
- This study also contributes to academia by confronting our findings against pre-established antecedent research hypotheses concerning the relationship between supply chain risks and operational performance.
- This study is one of the first in supply chain risks research that explored its sources in detail to understand the relatively particular of distinct dimensions and sources of risks concerning the frequency of occurrence and the negative impact on operational performance and its relative behavior against each other.

In sum, our findings, produced in the specific context of Brazilian Industries environment contributes to reduce the current empirical, theoretical and population gap concerning such a phenomenon in the available literature.

Nevertheless, despite its contribution, originality and value, the present study has significant limitations, as detailed below:

- The study was executed taking into consideration only the Brazilian industries segment;
- The study does not cover service industries;
- Our sample comprises 52% small and medium industries and 48% of larger firms based on sales volume parameters.

According to the author's views, these limitations are acceptable. We chose Brazilian industries due to distinguish characteristics compared to other environments where the studies about dynamic capabilities in Supply Chains have been executed. The limited number of scientific researches dedicated to this environment is another motivating factor. The manufacturing plant was selected as the unit of analysis in this research. Thus, due to this reason, no service industries were considered. Finally, the sample size profile of mix size companies does not conflict with the general purpose of this study.

Future studies may expand this research by applying our conceptual model in different segments set. Researchers could also investigate how the relationship between risk and performance behaves, particularly, in larger, medium, or small industries. Another opportunity consists of studying how risk influences performance over time. Finally, there is also an opportunity to further understand the phenomenon of interest by applying a triangulation method approach (quantitative e qualitative) to refine the generalized finding with few companies.

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APPENDIX A - Scientific research about the potential factors that may influence operational performance in the context of Brazilian Industries environment

Authors	Context	Influence Factors	Operational Performance Measures	Findings
(G. L. Tortorella, Saurin, Filho, Samson, & Kumar, 2021)	110 Brazilian Industries	Lean Automation practices and principles.	Safety (work accidents), Quality (scrap and rework), Delivery service, Produc- tivity and Inventory.	Lean Automation practices positively mediate the relationship between Lean Automation principles and the company's operational performance
(Cesar da Silva, Cardoso de Oliveira Neto, Ferreira Correia, & Pujol Tucci, 2021)	110 Large textile industries	Cleaner production practices (CPP)	Production capacity; Production flexibility on customer service; Quality; Waste of raw materials ; and Health and safety aspects of workers were	Cleaner production practices positively impacts Operational Performance
(G. Tortorella, Miorando, Caiado, Nascimento, & Portioli Staudacher, 2021)	147 Brazilian manufacturers	Industry 4.0 technologies Employees' Involvement	Delivery service level Quality Productivity Inventory level	Employees' Involvement a positive mediate the effect of Industry 4.0 adoption upon operational performance improvement.
(Letícia, Jiju, José, & Toledo, 2020)	243 Medium and large-sized manufacturing	Statistical Thinking	Nonconformity of products; Product return rate and customer complaints; Costs of poor quality; Production costs; Productivity; Process capability	Statistical Thinking positively influence Operational Performance.

	companies at São Paulo State	Continuous Improvement Program	indices (CPk); Process stability; andProcess variability	Continuous Improvement Program positively influence Statistical Thinking and Operational Performance
(Schuldt & Carvalho, 2020)	112 medium-sized textile manufacturing companies	Supplier Integration and lean practices	Cost, quality, delivery, flexibility and speed of new products introduction.	Supplier integration positively impacts the speed of new products introduction, Lean practices positively impacts operational performance indicators, except delivery
(G. L. Tortorella, Giglio, & Dun, 2019)	147 Brazilian manufacturing companies	Lean production and Industry 4.0 technologies	Productivity; Delivery Service Level; Inventory Level; Quality and Safety.	Industry 4.0 moderates the effect of LP practices on operational performance improvement, in different directions.
(G. Tortorella & Giglio, 2019)	135 Brazilian manufacturing companies	Total quality management practices; and Learning organization	Productivity; Delivery Service Level; Inventory Level; Quality and Safety.	Learning organization positively impacts the level of operational performance through the application of total quality management practices.
(Marodin, Frank, Luz, & Fetterman, 2017)	64 companies of the Brazilian automotive supply chain. Results	Lean production (LP)	Lead time, inventory, quality, on-time delivery and turnover	Results suggest that Brazilian companies are experiencing reduction of Lead time due to the implementation of total productive maintenance practices; and reducing inventory based on the adoption of just-in-time practices.

(A. T. Simon, Maria, Campos, Cavalcanti, & Paulo, 2019)	57 Supplier of automotive supply chain, supply,	Operational capabilities (cooperation, improvement and customization)	Quality, Delivery and Cost	Three operational capabilities have positive and significantly operational performance. These operational capabilities are cooperation, improvement and customization
(Santos Bento & Tontini, 2018)	90 manufacturing companies located in Santa Catarina State,	Lean manufacturing maturity	Cost New products Quality Flexibility Delivery Overtime Inventory turnover Lead time Setup	Lean manufacturing maturity tends to influence operational performance in a positive and statistically valid way

(Thomé, Sousa, & Do Carmo, 2014)	725 manufacturers from 34 countries (37 Brazilian Industries)	Sales and operations planning	Cost, Delivery, Flexibilty and Quality.	. There was no significant impact of supply chain integration on manufac-turing performance.

Table II - 38 - Scientific research about the potential factors that may influence operational performance in the context of Brazilian Industries environment

APPENDIX B - Previous empirical study about Impact of Supply Chain Risks in Organizational Performance

Authors	Context	Risks - Measures	Performance Measures	Findings
(El Hiri et al., 2018)	29 Moroccan companies.	Demand risks, Supply risks, Infrastructure risks and External risks	Performance of the supply chain	Supply chain is strongly influenced supply chain risk (in particular the supplier and demand risks) chain. External risks and the infrastructure risks affect weakly the performance of the chains.
(Truong Quang & Hara, 2018)	283 Vietnam construction sector	External risk, Time risk, Information risk, Financial risk, Supply risk, Operational risk, Demand risk	Supplier Performance Internal business Innovation and learning Finance Customer Service	Supply Chain Performance is impacted by external risk, time risk, information risk, financial risk, supply risk, operational risk and demand risk
(Yeboah & Yuansheng, 2017)	604 Ghana's agri-food chain	Demand risk, Supply risk, Biological and Environmental risk, Managerial and Operation risk, Logistics and Infrastructure risk, Public Policies and Institutional	Supply Chain Performance	Demand, supply, weather, logistics/infrastructure and financial risk sources significantly undermined the chain's performance/ Risks emerging from biological/

		risk, Political related risk and Financial related		environmental, management/operational, policy/regulations and political-related issues insignificantly affect the performance.
(J. Chen et al., 2013)	203 manufacturing companies in Australia	Supply risk, Demand risk and Process risk	- Product quality - Order fill capacity - Delivery dependability -Delivery speed -- Customer satisfaction	Demand risk and process risk have a significant impact on supply chain performance whereas in terms of Supply Risk no relationship was found
Punniyamoorthy & Thamaraiselvan (2013)	133 Heavy Industries in India	Supply risk, demand risk, manufacturing risk, logistical risk, information risk and environmental risk	Supply Chain Performance	Demand risk has the most adverse impact on the supply chain, followed by manufacturing side risk and supply side risk Logistics, information and environment are rated lower compared to demand, manufacturing and supply side risks.
(Wagner & Bode, 2008a)	760 German Industries	Demand, Supply, Regulatory, Infrastructure and Catastrophic Risks	Supply Chain Performance	Supply and Demand side risks are negatively associated with supply chain performance. In terms of regulatory, legal and bureaucratic risks, infrastructure risks and catastrophic risks yields no empirical evidence for a negative relationship with supply chain performance.

Table II - 39 - Previous empirical study about Impact of Supply Chain Risks in Organizational Performance

APPENDIX C - CONSTRUCTS ITEMS

SUPPLY CHAIN RISKS MEASURES

Instructions:
- Questions regarding Supply Chain Risk Measures starts with the letters "SCR"
- To what extent has your firm in the past 3 years experienced a negative impact in supply chain management due to…. (1 not at all– 7 to a very large extent)

Demand side risks measurements	1	2	3	4	5	6	7
SCR-D1 Unanticipated or very volatile demand							
SCR-D2 Insufficient or distorted information from your customer about orders or demand quantities							

Supply side risks measurements	1	2	3	4	5	6	7
SCR-S1 Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity)							
SCR-S2 Supplier quality problems							
SCR-S3 Sudden demise of a supplier (e.g., due to bankruptcy)							
SCR-S4 Poor logistics performance of logistics service providers							
SCR-S5 Capacity fluctuations or shortages on the supply markets							

Regulatory, legal and bureaucratic risks	1	2	3	4	5	6	7
SCR-R1 Changes in the political environment due to the introduction of new laws, stipulations, etc.							
SCR-R2 Administrative barriers for the setup or operation of supply chains (e.g., authorizations).							

Infrastructural risks	1	2	3	4	5	6	7
SCR-I1 Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents).							
SCR-I2 Perturbation or breakdown of intemal IT infrastructure (e.g., caused by computer viruses, software bugs).							
SCR-I3 Loss of own production capacity due to technical reasons (e.g., machine deterioration).							

SCR-I4 Perturbation or breakdown of external IT infrastructure.							

Catastrophic risks	1	2	3	4	5	6	7
SCR-C1 Political instability, war, civil unrest or other sociopolitical crises.							
SCR-C2 Diseases or epidemics (e.g., SARS, Foot and Mouth Disease).							
SCR-C3 Natural disasters (e.g., earthquake, flooding, extreme climate, tsunami).							
SCR-C4 International terror attacks (e.g., 2005 London or 2004 Madrid terror attacks).							

Table II - 40 -- Supply Chain Risks Indicators (Wagner & Bode, 2008b)

OPERATIONAL PERFORMANCE MEASURES

Instructions:

- Questions regarding Operational Performance Measures starts with the letters "MOP"
- Indicate your evaluation for each variable based on the following question: How does your company perform compared with your major competitors (1-much worse; 7-much better)?

Operational Performance measurements	1	2	3	4	5	6	7
MOP 1 Overall product quality							
MOP 2 Customer service level							
MOP 3 Pre-sale customer service							
MOP 4 Product Support							
MOP 5 Responsiveness to customer							
MOP 6 Delivery Speed							
MOP 7 Delivery Dependability							
MOP 8 Volume flexibility							
MOP 9 Product Mix flexibility							
MOP 10 New product Flexibility							

Table II - 41 - Operational Performance Indicators (Huo et al., 2014)

SUPPLY CHAIN COMPLEXITY MEASURES

Upstream complexity drivers:	**Type**	**Measurement Item**
Number of suppliers	Detail and dynamic	How many suppliers does the plant have?
Long supplier lead times	Detail and dynamic	We seek short lead times in the design of our supply chains. (reverse scored) ? Our company strives to shorten supplier lead time, in order to avoid inventory nventory and stockouts. (reverse scored)?
Supplier delivery unreliability	Dynamic	We can depend upon on-time delivery from our suppliers. (reverse scored)
Globalization of the supply base	Dynamic	What percentage of purchases come from your home country? (reverse scored)

Internal manufacturing complexity drivers:	**Type**	**Measurement Item**
Number of distinct products	Detail	How many product models are manufactured at this plant?
Number of active parts	Detail	This plant's output requires approximately how many individual active part numbers of material items?

Downstream complexity drivers:	**Type**	**Measurement Item**
Number of customers	Detail	How many customers does this plant serve (approximately)?
Heterogeneity in customer needs	Detail and dynamic	All of our customers desire essentially the same products. (reverse scored)
Shorter product life cycles	Detail and dynamic	What is the average life cycle of your products (years)? (inverse)
Demand variability	Dynamic	Our total demand, across all products is relatively stable. (reverse scored) Manufacturing demands are stable in our firm. (reverse scored)

Table II - 42 - Supply Chain Complexity Indicators (Bozarth et al., 2009)

APPENDIX D - Measurement of Invariance of Composites (MICOM) and multi Group Analysis (MGA) results

1) Number of Customers

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.27
Infrastuctural Risks	1.00	1.00	1.00	0.58
Operational Performance	0.99	1.00	0.99	0.20
Regulatory Risks	1.00	1.00	1.00	0.56
Supplier Risks	1.00	1.00	1.00	0.07
Supply Chain Risks	1.00	1.00	1.00	0.32

STEP 3	Mean - Original Difference (	Mean - Permutation Mean Differ	2.5%	97.5%	Permutation	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	-0.00	0.01	-0.29	0.31	0.99	0.15	0.00	-0.39	0.38	0.45
Infrastuctural Risks	-0.09	0.01	-0.30	0.32	0.55	-0.52	0.02	-0.62	0.71	0.13
Operational Performance	0.37	-0.01	-0.32	0.29	0.01	-0.35	0.01	-0.42	0.48	0.12
Regulatory Risks	0.00	0.01	-0.31	0.32	0.99	-0.26	0.01	-0.51	0.53	0.33
Supplier Risks	-0.13	0.01	-0.31	0.32	0.44	0.10	0.01	-0.42	0.49	0.67
Supply Chain Risks	-0.09	0.01	-0.29	0.32	0.58	-0.03	0.02	-0.44	0.49	0.90

Table II - 43 - MICOM Results – Number of Customers

MGA	Path Coefficients-diff (Customer (higher than 100) - Customer (up to 100))	p-Value original 1-tailed (Customer (higher than 100) vs Customer (up to 100))	p-Value new (Customer (higher than 100) vs Customer (up to 100)
Overall Supply Chain Risks -> Demand Risks	0.08	0.17	0.34
Overall Supply Chain Risks -> Infrastuctural Risks	0.03	0.16	0.32
Overall Supply Chain Risks -> Operational Perfomance	-0.07	0.74	0.52
Overall Supply Chain Risks -> Regulatory Risks	0.00	0.47	0.93
Overall Supply Chain Risks -> Supplier Risks	0.06	0.01	0.03

Table II - 44 - MGA Results - Number of Customers

2) Customer Heterogeneity

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.46
Infrastuctural Risks	0.99	1.00	1.00	0.00
Operational Performance	0.99	1.00	0.99	0.22
Regulatory Risks	1.00	1.00	1.00	0.05
Supplier Risks	1.00	1.00	0.99	0.84
Supply Chain Risks	1.00	1.00	1.00	0.08

STEP 3	Mean - Original Diffe	Mean - Permutation Mean Diffe	2.5%	97.5%	Permutation p-Values	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	0.87	0.00	-0.29	0.30		0.52	0.01	-0.37	0.40	0.01
Infrastuctural Risks	1.06	0.01	-0.28	0.31		2.32	0.01	-0.61	0.65	
Operational Performance	-0.66	-0.02	-0.32	0.30		0.72	0.01	-0.42	0.44	0.00
Regulatory Risks	1.05	-0.00	-0.30	0.29		1.89	-0.02	-0.55	0.55	
Supplier Risks	0.85	0.01	-0.29	0.29		0.56	0.01	-0.41	0.45	0.01
Supply Chain Risks	1.17	0.01	-0.30	0.31		1.27	0.01	-0.45	0.44	

Table II - 45 - MICOM Results - Customer Heterogeneity

	Path Coefficients-diff (Customer heterogeneity (high) - Customer heterogeneity (low))	p-Value original 1-tailed (Customer heterogeneity (high) vs Customer heterogeneity (low))	p-Value new (Customer heterogeneity (high) vs Customer heterogeneity (low))
Overall Supply Chain Risks -> Demand Risks	-0.16	0.91	0.18
Overall Supply Chain Risks -> Infrastuctural Risks	0.02	0.56	0.87
Overall Supply Chain Risks -> Operational Perfomance	-0.11	0.86	0.29
Overall Supply Chain Risks -> Regulatory Risks	-0.14	0.93	0.14
Overall Supply Chain Risks -> Supplier Risks	0.17	0.00	0.01

Table II - 46 - MGA Results - Customer Heterogeneity

3) Product Life Cycle

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.58
Infrastuctural Risks	1.00	1.00	1.00	0.68
Operational Performance	1.00	1.00	0.99	0.63
Regulatory Risks	1.00	1.00	1.00	0.23
Supplier Risks	1.00	1.00	1.00	0.64
Supply Chain Risks	1.00	1.00	1.00	0.28

STEP 3	Mean - Original Difference (Life C	Mean - Permutation Mean Difference (Life Cycl	2.5%	97.5%	Permutation	Variance - Original Difference (	Variance - Permutation N	2.5%	97.5%	Permutation p-Values
Demand Risks	-0.08	-0.00	-0.30	0.30	0.60	-0.05	-0.00	-0.41	0.37	0.84
Infrastuctural Risks	-0.24	-0.01	-0.30	0.29	0.12	-0.46	-0.02	-0.67	0.64	0.17
Operational Performance	0.11	-0.00	-0.30	0.30	0.43	0.34	0.00	-0.43	0.41	0.12
Regulatory Risks	-0.23	-0.01	-0.31	0.31	0.14	-0.41	-0.02	-0.54	0.48	0.11
Supplier Risks	-0.10	-0.01	-0.32	0.29	0.51	-0.24	-0.01	-0.47	0.43	0.33
Supply Chain Risks	-0.19	-0.01	-0.31	0.31	0.21	-0.36	-0.01	-0.46	0.43	0.11

Table II - 47 - MICOM Results - Product Life Cycle

PLS - MGA	Path Coefficients-diff (Life Cycle (up to 6 year) - Life Cycle (above 6 years))	p-Value original 1-tailed (Life Cycle (up to 6 year) vs Life Cycle (above 6 years))	p-Value new (Life Cycle (up to 6 year) vs Life Cycle (above 6 years))
Supply Chain Risks -> Demand Risks	-0.09	0.86	0.29
Supply Chain Risks -> Infrastuctural Risks	0.07	0.03	0.07
Supply Chain Risks -> Operational Performance	-0.21	0.98	0.04
Supply Chain Risks -> Regulatory Risks	0.03	0.30	0.60
Supply Chain Risks -> Supplier Risks	0.02	0.30	0.59

Table II - 48 - MGA Results - Product Life Cycle

4) Number of Suppliers

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.49
Infrastuctural Risks	1.00	1.00	1.00	0.93
Operational Performance	0.99	1.00	0.99	0.08
Regulatory Risks	1.00	1.00	1.00	0.49
Supplier Risks	1.00	1.00	1.00	0.43
Supply Chain Risks	1.00	1.00	1.00	0.27

STEP 3	Mean - Original Diffe	Mean - Permutation Mean Diffe	2.5%	97.5%	Permutation p-Values	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	0.31	-0.01	-0.33	0.32	0.06	-0.13	-0.02	-0.45	0.38	0.53
Infrastuctural Risks	0.19	0.00	-0.29	0.33	0.23	0.21	-0.01	-0.73	0.63	0.53
Operational Performance	0.08	-0.01	-0.31	0.28	0.57	-0.22	-0.00	-0.46	0.45	0.30
Regulatory Risks	0.30	0.00	-0.32	0.33	0.06	-0.11	-0.02	-0.55	0.49	0.70
Supplier Risks	0.14	-0.00	-0.32	0.32	0.38	0.09	-0.03	-0.50	0.43	0.72
Supply Chain Risks	0.25	-0.00	-0.30	0.33	0.13	0.01	-0.02	-0.51	0.42	0.95

Table II - 49 - MICOM Results - Number of Suppliers

MGA	Path Coefficients-diff (Suppliers (up to 50) - Suppliers (above 50))	p-Value original 1-tailed (Suppliers (up to 50) vs Suppliers (above 50))	p-Value new (Suppliers (up to 50) vs Suppliers (above 50))
Overall Supply Chain Risks -> Demand Risks	0.13	0.08	0.17
Overall Supply Chain Risks -> Infrastuctural Risks	0.01	0.44	0.88
Overall Supply Chain Risks -> Operational Perfomance	0.13	0.09	0.18
Overall Supply Chain Risks -> Regulatory Risks	0.04	0.22	0.44
Overall Supply Chain Risks -> Supplier Risks	-0.02	0.70	0.59

Table II - 50 - MGA Results – Number of Supplier

5) Demand Variability

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.32
Infrastuctural Risks	1.00	1.00	1.00	0.42
Operational Performance	0.98	0.99	0.98	0.07
Regulatory Risks	0.99	1.00	0.99	0.10
Supplier Risks	0.99	1.00	1.00	
Supply Chain Risks	1.00	1.00	1.00	0.11

STEP 3	Demand variability (High)	erence (Demand variability (Hig	2.5%	97.5%	utation p-Va	and variabilit	Demand var	2.5%	97.5%	Permutation p-Values
Demand Risks	1.01	0.00	-0.31	0.34		0.33	-0.00	-0.42	0.38	0.10
Infrastuctural Risks	1.05	0.01	-0.33	0.32		0.66	-0.01	-0.72	0.72	0.07
Operational Performance	-1.10	-0.00	-0.33	0.33		0.65	-0.01	-0.53	0.50	0.01
Regulatory Risks	1.20	0.00	-0.30	0.32		0.53	-0.00	-0.50	0.48	0.04
Supplier Risks	1.34	0.00	-0.30	0.31		0.63	-0.02	-0.50	0.49	0.01
Supply Chain Risks	1.37	0.00	-0.29	0.30		0.26	-0.01	-0.48	0.48	0.30

Table II - 51 - MICOM Results - Demand Variability

MGA	Path Coefficients-diff (Demand variability (High) - Demand variability (low))	p-Value original 1-tailed (Demand variability (High) vs Demand variability (low))	p-Value new (Demand variability (High) vs Demand variability (low))
Overall Supply Chain Risks -> Demand Risks	-0.10	0.71	0.58
Overall Supply Chain Risks -> Infrastuctural Risks	-0.14	0.97	0.05
Overall Supply Chain Risks -> Operational Perfomance	-0.11	0.77	0.47
Overall Supply Chain Risks -> Regulatory Risks	-0.17	0.97	0.05
Overall Supply Chain Risks -> Supplier Risks	-0.07	0.87	0.26

Table II - 52 - MGA Results - Demand Variabilit

6) Number of Active Parts

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.46
Infrastuctural Risks	1.00	1.00	1.00	0.79
Operational Peformance	0.99	1.00	0.99	0.04
Overall Supply Chain Risks	1.00	1.00	1.00	0.80
Regulatory Risks	1.00	1.00	1.00	0.55
Supplier Risks	1.00	1.00	1.00	0.49

STEP 3	Mean - Original Differer	Mean - Permutation Mean Diffe	2.5%	97.5%	Permutation	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	0.26	-0.00	-0.31	0.33	0.10	0.21	-0.01	-0.47	0.41	0.33
Infrastuctural Risks	0.37	-0.00	-0.31	0.34	0.03	0.36	-0.02	-0.75	0.64	0.31
Operational Peformance	-0.09	-0.00	-0.31	0.31	0.60	0.44	-0.01	-0.46	0.40	0.05
Overall Supply Chain Risks	0.32	-0.00	-0.31	0.35	0.05	0.13	-0.02	-0.54	0.44	0.60
Regulatory Risks	0.34	-0.00	-0.31	0.33	0.04	-0.06	-0.01	-0.55	0.52	0.81
Supplier Risks	0.17	-0.00	-0.32	0.33	0.29	0.05	-0.02	-0.50	0.47	0.84

Table II - 53 - MICOM Results - Number of Active Parts

MGA	Path Coefficients-diff (Number of Parts (above 50) - Number of Parts (up to 50))	p-Value original 1-tailed (Number of Parts (above 50) vs Number of Parts (up to 50))	p-Value new (Number of Parts (above 50) vs Number of Parts (up to 50))
Overall Supply Chain Risks -> Demand Risks	0.04	0.33	0.66
Overall Supply Chain Risks -> Infrastuctural Risks	-0.03	0.77	0.46
Overall Supply Chain Risks -> Operational Perfomance	0.01	0.49	0.97
Overall Supply Chain Risks -> Regulatory Risks	-0.04	0.77	0.45
Overall Supply Chain Risks -> Supplier Risks	0.02	0.29	0.59

Table II - 54 - MGA Results - Number of Active Parts

7) Number of Products

STEP 2	Original Correlation	Correlation Permutation Me	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.40
Infrastuctural Risks	1.00	1.00	1.00	0.54
Operational Performance	0.99	1.00	0.99	0.07
Regulatory Risks	1.00	1.00	1.00	0.14
Supplier Risks	1.00	1.00	1.00	0.95
Supply Chain Risks	1.00	1.00	1.00	0.63

STEP 3	Mean - Original Diff	Mean - Permutation Mean	2.5%	97.5%	Permutation	Variance - O	Variance - Permutation Mea	2.5%	97.5%	Permutation p-Values
Demand Risks	0.39	-0.01	-0.33	0.32	0.01	0.07	-0.03	-0.47	0.38	0.72
Infrastuctural Risks	0.44	-0.00	-0.32	0.32	0.01	0.19	-0.02	-0.77	0.63	0.61
Operational Performance	-0.28	0.01	-0.32	0.35	0.10	0.18	-0.03	-0.58	0.46	0.51
Regulatory Risks	0.42	0.00	-0.32	0.32	0.00	-0.19	-0.01	-0.53	0.45	0.42
Supplier Risks	0.48	-0.01	-0.32	0.32	0.00	0.05	-0.03	-0.57	0.46	0.88
Supply Chain Risks	0.52	-0.01	-0.31	0.31	0.00	-0.01	-0.02	-0.53	0.43	0.97

Table II - 55 - MICOM Results - Number of Products

MGA	Path Coefficients-diff (Distintics Procuct Types (up to 50) - Disctintic Product Types (above 50))	p-Value original 1-tailed (Distintics Procuct Types (up to 50) vs Disctintic Product Types (above 50))	p-Value new (Distintics Procuct Types (up to 50) vs Disctintic Product Types (above 50))
Supply Chain Risks -> Demand Risks	-0.01	0.54	0.91
Supply Chain Risks -> Infrastuctural Risks	0.03	0.24	0.47
Supply Chain Risks -> Operational Performance	0.21	0.01	0.01
Supply Chain Risks -> Regulatory Risks	0.14	0.02	0.04
Supply Chain Risks -> Supplier Risks	-0.01	0.59	0.82

Table II - 56 - MGA Results - Number of Products

8) Number of Suppliers

STEP 2	Original Correlation	on Permutati	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.51
Infrastuctural Risks	1.00	1.00	1.00	0.92
Operational Performance	0.99	1.00	0.99	0.07
Regulatory Risks	1.00	1.00	1.00	0.50
Supplier Risks	1.00	1.00	1.00	0.45
Supply Chain Risks	1.00	1.00	1.00	0.27

STEP 3	e (Suppliers (above 5	ice (Supplier	2.5%	97.5%	nutation p-Va	Suppliers (a	ence (Supplie	2.5%	97.5%	Permutation p-Values
Demand Risks	0.31	0.00	-0.31	0.31	0.05	-0.13	-0.01	-0.45	0.41	0.53
Infrastuctural Risks	0.19	0.00	-0.29	0.29	0.23	0.21	-0.01	-0.68	0.63	0.53
Operational Performance	0.10	-0.00	-0.32	0.29	0.54	-0.26	-0.01	-0.46	0.48	0.29
Regulatory Risks	0.30	0.01	-0.31	0.32	0.06	-0.16	-0.00	-0.49	0.45	0.52
Supplier Risks	0.13	0.00	-0.32	0.30	0.45	0.08	-0.00	-0.51	0.50	0.76
Supply Chain Risks	0.25	0.00	-0.31	0.32	0.12	0.01	-0.00	-0.48	0.48	0.97

Table II - 57 - MICOM Results - Number of Suppliers

MGA	Path Coefficients-diff (Suppliers (above 50) - Suppliers (up to 50))	p-Value original 1-tailed (Suppliers (above 50) vs Suppliers (up to 50))	p-Value new (Suppliers (above 50) vs Suppliers (up to 50))
Overall Supply Chain Risks -> Demand Risks	-0.13	0.92	0.17
Overall Supply Chain Risks -> Infrastuctural Risks	-0.01	0.56	0.88
Overall Supply Chain Risks -> Operational Perfomance	-0.13	0.91	0.18
Overall Supply Chain Risks -> Regulatory Risks	-0.04	0.78	0.44
Overall Supply Chain Risks -> Supplier Risks	0.02	0.29	0.59

Table II - 58 MGA Results - Number of Suppliers

9) Long Supplier Lead Times

STEP 2	Original Correlation	elation Permutation M	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.82
Infrastuctural Risks	1.00	1.00	1.00	0.59
)perational Performanc	1.00	1.00	1.00	0.05
Regulatory Risks	1.00	1.00	0.99	0.40
Supplier Risks	1.00	1.00	1.00	0.14
Supply Chain Risks	1.00	1.00	1.00	0.45

STEP 3	upplier lead times (hig	ong supplier lead times	2.5%	97.5%	Permutation p-Values	supplier lead times (hi	Long supplier lead tim	2.5%	97.5%	Permutation p-Values
Demand Risks	0.77	-0.01	-0.35	0.33		0.25	-0.01	-0.43	0.39	0.24
Infrastuctural Risks	0.62	0.00	-0.31	0.33		0.55	-0.00	-0.68	0.69	0.12
)perational Performanc	-0.74	0.00	-0.32	0.29		0.83	0.00	-0.50	0.51	0.00
Regulatory Risks	0.52	0.00	-0.30	0.34	0.00	0.17	0.00	-0.49	0.48	0.49
Supplier Risks	0.81	-0.00	-0.30	0.30		0.53	-0.02	-0.49	0.44	0.02
Supply Chain Risks	0.80	-0.00	-0.31	0.33		0.31	-0.01	-0.46	0.44	0.19

Table II - 59 - MICOM Results - Long Supplier Lead Time

MGA	Path Coefficients-diff (Long supplier lead times (low) - Long supplier lead times (high))	p-Value original 1-tailed (Long supplier lead times (low) vs Long supplier lead times (high))	p-Value new (Long supplier lead times (low) vs Long supplier lead times (high))
Supply Chain Risks -> Demand Risks	0.06	0.30	0.60
Supply Chain Risks -> Infrastuctural Risks	-0.03	0.73	0.54
Supply Chain Risks -> Operational Performance	0.26	0.01	0.02
Supply Chain Risks -> Regulatory Risks	0.02	0.32	0.63
Supply Chain Risks -> Supplier Risks	0.08	0.01	0.03

Table II - 60 – MGA Results - Long Supplier Lead Time

10) Supplier Delivery Unreliability

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	0.99	1.00	0.99	0.08
Infrastuctural Risks	1.00	1.00	1.00	0.69
Operational Perfomance	0.94	0.99	0.98	
Overall Supply Chain Risks	1.00	1.00	1.00	0.03
Regulatory Risks	1.00	1.00	1.00	0.88
Supplier Risks	0.99	1.00	1.00	

STEP 3	Mean - Original Diffe	Mean - Permutation Mean Diffe	2.5%	97.5%	Permutation	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	-1.07	0.00	-0.33	0.33		-0.42	0.02	-0.41	0.46	0.05
Infrastuctural Risks	-1.02	0.00	-0.32	0.31		-1.11	0.03	-0.62	0.71	0.00
Operational Perfomance	1.28	0.01	-0.32	0.34		-1.33	-0.00	-0.44	0.47	
Overall Supply Chain Risks	-1.41	-0.00	-0.35	0.30		-0.74	0.01	-0.45	0.48	0.00
Regulatory Risks	-1.06	0.00	-0.35	0.30		-1.03	0.01	-0.53	0.50	
Supplier Risks	-1.46	-0.01	-0.33	0.31		-0.98	0.00	-0.48	0.48	

Table II - 61 - MICOM Results - Supplier Delivery Unreliability

MGA	Path Coefficients-diff (Supplier delivery unreliability (low) - Supplier delivery unreliability (medium-high))	p-Value original 1-tailed (Supplier delivery unreliability (low) vs Supplier delivery unreliability (medium-high))	p-Value new (Supplier delivery unreliability (low) vs Supplier delivery unreliability (medium-high))
Overall Supply Chain Risks -> Demand Risks	0.16	0.11	0.22
Overall Supply Chain Risks -> Infrastuctural Risks	0.07	0.12	0.24
Overall Supply Chain Risks -> Operational Perfomance	0.17	0.24	0.48
Overall Supply Chain Risks -> Regulatory Risks	-0.00	0.52	0.95
Overall Supply Chain Risks -> Supplier Risks	0.13	0.04	0.09

Table II - 62 – MGA Results - Supplier Delivery Unreliability

11) Globalization of Supply Chain Base

STEP 2	Original Correlation	Correlation P	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.96
Infrastuctural Risks	1.00	1.00	1.00	0.13
Operational Performance	0.99	1.00	0.99	0.29
Regulatory Risks	1.00	1.00	1.00	0.31
Supplier Risks	1.00	1.00	1.00	0.66
Supply Chain Risks	1.00	1.00	1.00	0.92

STEP 3	Mean - Original Diffe	Mean - Perm	2.5%	97.5%	Permutation	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	-0.60	0.00	-0.30	0.31	0.00	-0.36	-0.00	-0.40	0.40	0.08
Infrastuctural Risks	-0.60	0.00	-0.29	0.32		-0.51	0.00	-0.67	0.66	0.14
Operational Performance	0.48	-0.00	-0.30	0.30	0.00	-0.70	-0.01	-0.46	0.40	0.00
Regulatory Risks	-0.67	0.00	-0.30	0.32		-0.23	-0.00	-0.49	0.49	0.40
Supplier Risks	-0.62	0.00	-0.32	0.30		-0.03	0.00	-0.51	0.45	0.88
Supply Chain Risks	-0.73	0.00	-0.30	0.31		-0.09	0.00	-0.48	0.45	0.71

Table II - 63 - MICOM Results - Globalization of Supply Chain Base

MGA	Path Coefficients-diff (Imported dependent - imported supplies independent)	p-Value original 1-tailed (Imported dependent vs imported supplies independent)	p-Value new (Imported dependent vs imported supplies independent)
Overall Supply Chain Risks -> Demand Risks	-0.13	0.91	0.19
Overall Supply Chain Risks -> Infrastuctural Risks	-0.05	0.90	0.19
Overall Supply Chain Risks -> Operational Perfomance	0.01	0.47	0.94
Overall Supply Chain Risks -> Regulatory Risks	-0.14	0.99	0.02
Overall Supply Chain Risks -> Supplier Risks	-0.02	0.73	0.53

Table II - 64 - MGA MICOM Results - Globalization of Supply Chain Base

12) Firm Size (Employees)

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	0.99	1.00	0.99	0.05
Infrastuctural Risks	1.00	1.00	1.00	0.32
Operational Perfomance	0.99	0.99	0.98	0.16
Overall Supply Chain Risks	1.00	1.00	1.00	0.15
Regulatory Risks	1.00	1.00	1.00	0.22
Supplier Risks	1.00	1.00	1.00	0.19

STEP 3	Mean - Original Diffe	Mean - Permutation Mean Diff	2.5%	97.5%	Permutation	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	-0.51	-0.00	-0.36	0.33	0.00	0.00	0.01	-0.41	0.45	0.98
Infrastuctural Risks	-0.39	0.00	-0.34	0.31	0.02	-0.37	0.05	-0.68	0.87	0.30
Operational Perfomance	0.04	-0.00	-0.33	0.33	0.82	-0.21	0.02	-0.45	0.52	0.41
Overall Supply Chain Risks	-0.51	0.00	-0.34	0.33	0.00	0.01	0.03	-0.48	0.53	0.98
Regulatory Risks	-0.48	-0.00	-0.35	0.32	0.00	0.21	0.02	-0.51	0.58	0.47
Supplier Risks	-0.41	0.00	-0.32	0.34	0.01	-0.06	0.03	-0.48	0.54	0.82

Table II - 65 - MICOM Results - Firm Size (Employees)

MGA	Path Coefficients-diff (Firm size (large) - Firm size (small_Medium))	p-Value original 1-tailed (Firm size (large) vs Firm size (small_Medium))	p-Value new (Firm size (large) vs Firm size (small_Medium))
Overall Supply Chain Risks -> Demand Risks	-0.16	0.91	0.17
Overall Supply Chain Risks -> Infrastuctural Risks	-0.01	0.59	0.83
Overall Supply Chain Risks -> Operational Perfomance	0.02	0.48	0.97
Overall Supply Chain Risks -> Regulatory Risks	-0.07	0.84	0.32
Overall Supply Chain Risks -> Supplier Risks	0.00	0.45	0.91

Table II - 66 - MGA Results - Firm Size (Employees)

13) Firm Size (Sales Volume)

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.52
Infrastuctural Risks	1.00	1.00	1.00	0.29
Operational Perfomance	1.00	1.00	0.99	0.32
Overall Supply Chain Risks	1.00	1.00	1.00	0.83
Regulatory Risks	1.00	1.00	1.00	0.36
Supplier Risks	1.00	1.00	1.00	0.28

STEP 3	Mean - Original Diffe	Mean - Permutation Mean Diffe	2.5%	97.5%	Permutation	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	0.37	-0.00	-0.35	0.31	0.02	0.30	-0.01	-0.41	0.38	0.16
Infrastuctural Risks	0.02	0.00	-0.30	0.33	0.91	-0.16	-0.00	-0.70	0.65	0.67
Operational Perfomance	0.21	0.00	-0.30	0.30	0.16	-0.16	-0.00	-0.49	0.42	0.49
Overall Supply Chain Risks	0.14	-0.00	-0.31	0.31	0.40	-0.21	-0.01	-0.47	0.49	0.38
Regulatory Risks	0.20	-0.00	-0.32	0.32	0.23	-0.32	-0.01	-0.52	0.50	0.22
Supplier Risks	0.05	-0.00	-0.31	0.31	0.76	-0.29	-0.00	-0.47	0.48	0.23

Table II - 67 - MICOM Results - Firm Size (Sales Volume)

MGA	Path Coefficients-diff (Income Higher - Income Small)	p-Value original 1-tailed (Income Higher vs Income Small)	p-Value new (Income Higher vs Income Small)
Overall Supply Chain Risks -> Demand Risks	0.01	0.49	0.97
Overall Supply Chain Risks -> Infrastuctural Risks	-0.01	0.65	0.70
Overall Supply Chain Risks -> Operational Perfomance	0.10	0.19	0.37
Overall Supply Chain Risks -> Regulatory Risks	-0.05	0.82	0.37
Overall Supply Chain Risks -> Supplier Risks	-0.00	0.55	0.90

Table II - 68 - MGA Results - Firm Size (Employees)

14) Type of Strategy for Competitive Advantages

STEP 2	Original Correlation	Correlation Permutation Mean	5.0%	Permutation p-Values
Demand Risks	1.00	1.00	0.99	0.35
Infrastuctural Risks	1.00	1.00	1.00	0.05
Operational Perfomance	0.98	1.00	0.99	0.02
Overall Supply Chain Risks	1.00	1.00	1.00	0.07
Regulatory Risks	1.00	1.00	1.00	0.04
Supplier Risks	1.00	1.00	1.00	0.01

STEP 2	Mean - Original Diffe	Mean - Permutation Mean Diffe	2.5%	97.5%	Permutation	Variance - O	Variance - Pe	2.5%	97.5%	Permutation p-Values
Demand Risks	0.50	-0.00	-0.33	0.32	0.00	0.19	-0.01	-0.44	0.37	0.36
Infrastuctural Risks	0.73	-0.00	-0.31	0.31		0.82	-0.04	-0.76	0.63	0.03
Operational Perfomance	-0.25	-0.00	-0.31	0.32	0.11	0.02	-0.01	-0.52	0.42	0.95
Overall Supply Chain Risks	0.72	-0.00	-0.31	0.32		0.39	-0.02	-0.51	0.48	0.09
Regulatory Risks	0.66	0.00	-0.29	0.32		0.53	-0.02	-0.57	0.47	0.04
Supplier Risks	0.54	-0.00	-0.30	0.32	0.00	0.34	-0.02	-0.46	0.47	0.17

Table II - 69 - MICOM Results - Type of Strategy

MGA	Path Coefficients-diff (Differentiation - Low cost)	p-Value original 1-tailed (Differentiation vs Low cost)	p-Value new (Differentiation vs Low cost)
Overall Supply Chain Risks -> Demand Risks	-0.00	0.51	0.97
Overall Supply Chain Risks -> Infrastuctural Risks	-0.03	0.77	0.46
Overall Supply Chain Risks -> Operational Perfomance	0.07	0.28	0.57
Overall Supply Chain Risks -> Regulatory Risks	-0.11	0.96	0.07
Overall Supply Chain Risks -> Supplier Risks	-0.02	0.73	0.54

Table II - 70 - MGA Results - Type of Strategy

CHAPTER 3

Article 2

The Impact of Supply Chain Risks, Supply Chain Risk Management and Supply Chain Agility on Operational Performance.

3.1 - INTRODUCTION

In chapter 2, the results indicate that Overall Supply Chain Risks negatively influence Operational Performance in the Brazilian Industries environment. The findings also detail how each dimension (Supply; Demand; Regulatory, legal, and bureaucratic risks; and infrastructure risks) and their respective sources affect performance. Finally, the results also convey the contingent role of specific supply complexity sources, increasing the negative influence of risks, such as product life cycle, number of different products, and long supplier lead Time.

Based on the findings of the previous chapter, the present work emerges in an environment where supply chains must deploy actions to strive in today’s turbulent and risky environment (Wieland & Wallenburg, 2012). In the decades, researchers have used the Dynamic Capabilities Theory to understand how companies should develop their managerial practices to cope with the constant changes in such business conditions.(Sandberg, Kindström, & Haag, 2021). As emphasized by El Baz & Ruel (2020, p.2), “dynamic capabilities constitute a relevant framework to examine how firms coordinate their resources and capabilities in response to Supply Chain Risks.”

Dynamic Capabilities is recognized due to their effectiveness in improving performance and sustaining competitive advantage in an uncertain global supply chain environment. (Teece et al., 1997; Um & Han, 2020). According to this theory, organizations should promote actions to sense and seize opportunities and threats and transform their processes and operations to cope with an increasingly volatile and turbulent environment (Teece, Pisano, & Amy, 1997). Nevertheless, despite its importance in the literature, to this date, the role of dynamic capabilities as a factor to improve performance has not been widely reported in the field of Supply Chain Management (Kareem & Kummitha, 2020).

In the present research, among different resources and processes, we chose to study Supply Chain Agility and Supply Chain Risk Management as two types of dynamic capabilities that may alleviate the adverse effects produced by Supply Chain Risks by improving Operational Performance.

In the literature, scholars like (Aslam et al., 2020; Eckstein, Goellner, Blome, & Henke, 2015, Altay et al., 2018) consider Supply Chain Agility an important Dynamic Capability required to improve a company’s performance. As per Al Humdan, Shi, & Behnia (2020, p. 292), “Supply Chain Agility is the level of agility demonstrated by a supply chain. Agility, in its broadest sense, is the ability of an entity to respond to changes in a timely manner”. Agility concerns organizations’ capacity to react, respond, adapt, or re-configure in the face of change, marketplace uncertainty, and risks. (Bakshi & Kleindorfer, 2009) (Khan K, Bakkappa, Metri, & Sahay, 2009) (Wieland & Marcus Wallenburg, 2012).

It is crucial to notice that agility is a relatively new concept under investigation in science (Sharma, Sahay, Shankar, & Sarma, 2017, p. 7; Yusuf, Sarhadi, & Gunasekaran, 1999), but due to its influence on performance and the ability to support organization in a turbulent environment, it is seen as an essential and required capability to reconfigure supply chain resources to respond to changes in a timely manner (Li et al., 2019; Wieland & Marcus Wallenburg, 2012).

Nevertheless, due to its novelty, different scholars call for further empirical research to validate and expand the theoretical models introduced so far to understand how supply chain agility manifests itself in different cultural settings. Chiang, Kocabasoglu-Hillmer, & Suresh (2012), Eckstein, Goellner, Blome, & Henke (2015) and Ahmed, Najmi, Mustafa, & Khan (2019)

According to (Uta Jüttner, Peck, & Christopher, 2003), Supply Chain Risk

Management can be understood as identifying and managing risks for the supply chain through a coordinated approach amongst supply chain members to reduce supply chain vulnerability. The authors suggest that supply chain risk management aims to identify potential risks in order to deploy appropriate actions to mitigate or avoid supply chain vulnerability.

(Huo et al., 2014) (Colicchia & Strozzi, 2012) (Trkman & McCormack, 2009) (Wagner & Bode, 2008a) suggest that Supply Chain Risk Management has received considerable attention by scholars due to two parallel issues: recent series of crises and catastrophes and the fact that modem supply chains seem to be more vulnerable than ever.

Gurtu & Johny (2021) exemplified such issues. The authors point out that the growing occurrence of incidents like terrorist attacks, wars as the outbreak of a pandemic (e.g., coronavirus disease 2019) as well as risks sources that derive from shorter products life cycle, globalization, demand and supply volatile, offshoring, and outsourcing decisions are examples of factors that contribute to the importance of deploying Supply Chain Risk Management approach within the organization.

Aligned with this view, (Tang; & Musa, 2014, p.21) states that "empirical evidence has shown severe consequences after supply chain disruptions, such as loss of profit, damage of market share, etc. This leads to a generally increasing interest in Supply Chain Risk Management."

Krzakiewicz & Cyfert (2015) and (Nair, Rustambekov, Mcshane, & Fainshmidt, 2014) contends that risk management should be considered a dynamic capability and have applied it in the management field of research. In the specific area of Supply Chain Management, (Um & Han, 2020) also defined supply chain risk management, a dynamic success capability together with an appropriate risk mitigation strategy is critical in the highly uncertain global supply chain environment.

The context of the present study is the Brazilian business environment due to its distinguishing characteristics, like different regulatory and bureaucratic systems concerning other businesses environments, and because the role of Supply Chain Risk Management and Supply Chain Agility on Operational Performance has not been empirically investigated.

Hence, in this research, following a deductive approach, in which "the goal of the researcher is to test concepts and patterns known from theory using new empirical data" (Bhattacherjee, 2012, p.3), this study aim to evaluate and distinguish the influence of a different set of dynamic capabilities (Supply Chain Management Strategies) on Operational Performance. From such research aim, we established the following Research Objectives:

Objective 4 –to evaluate the influence of Supply Chain Risk Management and Supply Chain Agility on Operational Performance of Manufacturing companies in Brazil

Objective 5 – to distinguish the influence of Supply Chain Risks Management and Supply Chain Agility in terms of its relevance and performance to increase Operational Performance of Manufacturing companies in Brazil.

From the objectives stated above, the following research questions emerge:

> RQ4: How do Supply Chain Risk Management and Supply Chain Agility influence the Operational Performance of Manufacturing companies in Brazil?
>
> RQ5: Which Supply Chain Strategy has relatively higher relevance and performance to increase the Operational Performance of Manufacturing companies in Brazil?

Concerning the value and the originality of this research, the present scientific effort is one of the first studies that empirically investigated Supply Chain Risk Management and Supply Chain Agility as dynamic capabilities to sustain or improve performance in a risky environment. For that purpose, an unique structural model will be built to explore the proposed hypotheses using data solely collected from manufacturing industries located in several states of Brazil. Finally, the findings of this study may provide relevant managerial implications for different types of industries in Brazil, which urges for more profound and structured scientific research on the subject proposed here.

3.2 - LITERATURE REVIEW

3.3.1 - Dynamic Capabilities

In 1991, Jay Barney, in his seminal article name Firm Resources and Sustained Competitive Advantage, proposed the Resource-Based View to the field of management. In the scope of this theory, "sustained competitive advantage derives from the resources and capabilities a firm controls that are valuable, rare, imperfectly imitable, and not substitutable" Barney, Wright, & Ketchen p. 625, 2001).

Due to the rapidly changing environment, in 1997, another theoretical view emerged as an expansion of Resource-Based Theory. In the article named Dynamic Capability and Strategic Management, Teece, Pisano, & Amy (1997) proposed a different perspective to support companies' achievement and competitive advantage. According to them, organizations should develop the ability to integrate, build and reconfigure internal and external competencies constantly.

When developing such a theory, the authors' objectives were to explore how and why a set of firms can build competitive advantage in an unstable business arena and provide recommendations concerning specific managerial actions toward better performance.

"Dynamic capabilities have been defined as abilities (or capacities) but also as processes or routines" (Barreto, 2010, p.260). This perspective finds alignment with Teece et al.'s (1997) view. When developing the framework for theory application, the authors suggested that the essence of an organization's dynamic capabilities and competitive advantage relies on its assets, processes, and paths (strategic choices).

Eisenhardt and Martin (2000) also consider specific processes, routines, and resources in the core of Dynamic Capabilities. According to them, dynamic capabilities are "the firm's processes that use resources—specifically the processes to integrate, reconfigure, gain and release resources—to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die." Eisenhardt & Martin (2000, p.1107).

As discussed above, processes and resources are essential elements of dynamic capabilities. Such conditions find alignment with different definitions of Supply Chain Management where find that the presence of aforementioned organizational elements at the heart of the supply chain concept.

For instance, concerning the process view, the Council of Supply Chain Management defined supply Chain Management as "the integration of business process from end users through original suppliers that provides products service and information that add value to customers." (Cooper, Lambert, & Pagh, 1997, p. 2).

Regarding resources, the same protagonist is present. As discussed by Jain (2020, p.357) "Supply chain Management underlines the organization's total value maximization while utilizing and implementing the chain of resources to the whole company."

Thus, based on the theoretical point of view above, we can assume that organizations should structure their processes and resources to foster capacities that, in turn, will support superior performance and, ultimately, competitive advantage. The dynamic capabilities theory also helps us understand what those capabilities would be, as shown below.

For analytical ends, Teece (2007) segmented the Dynamic Capabilities in specific capabilities: sensing opportunities and threats, seizing them, and transforming the business. "The sensing capability entails processes for gathering and interpreting data, allocating resources and tasks and communicating decisions and information" (Sanchez and Heene, 1996).

The "Seizing capability" includes enterprise structures and procedures for identifying threats and opportunities. whereas "Transformation capability" is the continuous alignment and realignment of operational practices (Teece, 2007). (Vanpoucke et al., 2014, p.3)

In essence, Dynamic Capabilities offers researchers and professionals a framework for explaining "an extremely seminal and complicated issue: how a business enterprise and its management can first spot the opportunity to earn economic profits, make the decisions and institute the disciplines to execute on that opportunity, and then stay agile so as to continuously refresh the foundations of its early success, thereby generating economic surpluses over time?" (Teece, 2007, p. 1347)

Due to the pressing need to identify the required set of capacities and processes to support organizations in sensing relevant data and information, seizing identifying threats and opportunities, and transforming business behavior to achieve and sustain greater performance, we carry over the question above to the Supply Chain Management research field

L. Y. Wu (2010) points out that empirical investigation about Dynamic Capability is minimal, which opens a vast opportunity to test and improve the measures related to such theory. Based on Miles' (2017) taxonomy of the research gap, this type of issue is characterized as an empirical gap. Thus, this research seeks to reduce such a gap by developing an empirical investigation into how specific dynamic capabilities impact Brazilian industries' performance.

The present investigation's central theme assumes that the variance in organizational performance results from various dynamic capabilities that steam from routines that seek to exploit the firm's internal and external resources. (Barreto, 2010; Brusset & Teller, 2017; Jajja, Chatha, & Farooq, 2018b; Teece et al., 1997; L. Y. Wu, 2010; Zhou & Li, 2010)

To this date, despite the relevance of the Dynamic Capabilities to organizations, as suggested by Vanpoucke, Vereecke, & Wetzels (2014, p.3) "the role of dynamic capabilities on performance is a central but as yet unresolved issue among strategic scholars."

We will build the present scientific and empirical investigation upon the model tested in Chapter 2. So far, we have found empirical evidence to support that Overall Supply Chain Risks and specific contingencies negatively influence operational performance. This chapter expands the conceptual model with a set of routines and processes related to Supply Chain Risk Management and Supply Chain Agility to understand if those Dynamic Capabilities may positively influence operational performance.

3.3.2 - Supply chain Agility

Agility is a relatively new concept under investigation in science (Sharma, Sahay, Shankar, & Sarma, 2017, p. 7; Yusuf, Sarhadi, & Gunasekaran, 1999). "The concept of agility in business was introduced by a report titled '21st Century Manufacturing

Enterprise Strategy, 1991', published by Iacocca Institute, Lehigh University, USA". (Sharma et al., 2017).

Agility is considered an evolving concept, and the empirical research on supply chain agility is in its early stages. In the field of Supply Chain Management, agility was firstly addressed by (Dove, 1996) as related to Change Proficiency and adaptive transformation,

There is a call for further empirical investigations to validate and expand the theoretical models applied so far to understand how supply chain agility manifests itself in different cultural settings and what kind of conditions need to be in place to facilitate (Ahmed et al., 2019; Chiang et al., 2012; Eckstein et al., 2015).

Based on our research, the two most recent relevant literature review about Supply Chain Agility are the studies executed by Sharma et al. (2017) and Al Humdan, Shi, & Behnia (2020). According to the former and latter studies and our research, different authors define agility either as ability or capability (see table 1).

Authors	Definition of Supply Chain Agility
(Christopher & Towill, 2000)	"Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes, and, in particular, mindsets."
(Christopher, 2000, p.38)	"The ability of an organization to respond rapidly to changes in demand in terms of both volume and variety"
(Yusuf, Gunasekaran, Adeleye, & Sivayoganathan, 2004, p. 379)	"The ability to respond, in real-time, to the unique needs of customers and markets"
(Lee, 2003, p.4)	"The ability to respond to short-term changes in demand or supply quickly and handle external disruptions smoothly"
(Swafford et al., 2006, p.172)	"Supply chain's capability to adapt or respond in a speedy manner to a changing marketplace environment"
(Ismail & Sharifi, 2006, p.431)	"The ability of the supply chain as a whole and its members to rapidly align the network and its operations to the dynamic and turbulent requirements of the demand network"
(Lin, Chiu, & Chu, 2006, p.287)	"'the ability of a supply chain to rapidly respond to changes in market and customer demands."
(Bernardes & Hanna, 2009, p.41)	"The ability of the system to rapidly reconfigure (with a new parameter set)"
(Bottani, 2010, p. 251)	"The ability of companies to respond quickly and effectively to (unexpected) changes in market demand with the aim to meet varied customer requirements in terms of price, specification, quality, quantity, and delivery"
(Charles, Lauras, & van Wassenhove, 2010, p.727)	"Ability to respond quickly and adequately to short-term changes in demand, supply, or the environment. It is

	derived from the flexibility, responsiveness, and effectiveness of the supply chain”
(Gligor, Holcomb, & Stank, 2013, p.95)	“Supply chain’s ability to quickly adjust its tactics and operations. This ability can manifest itself proactively or reactively”
(Li, Chung, Goldsby, & Holsapple, 2008, p.422)	“ the result of integrating a supply chain’s alertness to changes (opportunities/challenges) – both internal and environmental – with the supply chain’s capability to use resources in responding (proactively/ reactively) to such changes, all in a timely and flexible manner.”
(Braunscheidel & Suresh, 2009, p.121)	“the capability of the firm, both internally and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to marketplace changes as well as to potential and actual disruptions, contributing to the agility of the extended supply chain”
(Yang, 2014, p.105)	“operational and relational capability in quick response to uncertain and turbulent markets.”
(Li, Wu, & Holsapple, 2015, p. 1690)	“The capability of a supply chain to be alert and respond to sudden changes in demand or supply”
(Brusset, 2016, p. 48)	“a supply chain is an operational capability stemming from the ability to manage across networks demand-side, supply-side processes, systems, and routines”
(V. Jain, Benyoucef, & Deshmukh, 2008, p. 6650)	“The capability to survive and prosper by reacting quickly and effectively to changing markets. It concerns change, uncertainty, and unpredictability within its business environment and makes appropriate responses to changes.”
(Ngai, Chau, & Chan, 2011, p.233)	“The capability of an organization to respond to the market changes visible to customers using a set of supply chain competencies that enable such capability”
(Wieland & Wallenburg, 2012, p. 890)	“The ability of a supply chain to rapidly respond to change by adapting its initial stable configuration”
(Eckstein et al., 2015)	“The ability of the firm to sense short-term, temporary changes in the supply chain and market environment (e.g.,

	demand fluctuations, supply disruptions, changes in suppliers' delivery times), and to rapidly and flexibly respond to those changes with the existing supply chain (e.g., reducing replacement times of materials, reducing manufacturing throughput times, adjusting delivery capacities)."
(Razmi & Sangari, 2015, p.357)	"The ability of the supply chain to cope with turbulence and unexpected changes in the competitive market and the business environment and to provide a strategic advantage by converting uncertainties and threats into opportunities through assembling requisite assets, knowledge, and relationships with speed and surprise."
(Tse, Y. K., Zhang, M., Akhtar, P., & MacBryde, 2016, p. 142)	"A firm's ability to transform the threats of market uncertainty and SC disruption into competitive opportunities by increasing visibility in inventory and demand levels, and satisfying various customer needs with speed and flexibility."
(Fayezi, Zutshi, & O'Loughlin, 2017, p,2)	"A strategic ability that assists organizations rapidly to sense and respond to internal and external uncertainties via effective integration of supply chain relationships."

Table III - 1 - Definitions of Supply Chain Agility as a Capability adapted from Sharma et al. (2017) and Al Humdan, Shi, & Behnia (2020) and authors research

Wieland & Marcus Wallenburg (2012) and Li et al. (2019) contend that Supply Chain Agility is a required capability of a firm to reconfigure supply chain resources to respond to changes promptly. Supply Chain Agility is also a critical element that can affect a firm's competitiveness at the strategic level (Tse, Y.K., Zhang, M., Akhtar, P. and MacBryde, 2016).

In this study, we structured our analysis assuming that Supply Chain Agility is a dynamic capability. Taking the premises of such theory, we consider that companies have to develop and deploy actions to enable core capacities defined in this theory like sensing and seizing opportunities or threats and transforming (adapting) its operations.

Based on this theoretical view, among sense, seize, and transform (adapt), we conceptualize Supply Chain Agility as an essential Dynamic Capability to allow companies to change or adapt their processes, structures, and actions. From the definitions provided in table 1, it is possible to identify that some authors, when defining Supply Chain Agility, just related it to the ability to respond to changes without considering the organization's capacity to adapt, adjust or transform as a pre-condition to respond.

Thus, considering that the latter view better fits our understanding of Supply Chain Agility as a Dynamic Capability. In the table below, we organize the definitions in the literature that consider the adaption and transformation as part of the Supply Chain

Agility definition.

Authors	Transform or Adapt capability
(Swafford et al., 2006)	"Supply chain's capability to **adapt** or respond in a speedy manner to a changing marketplace environment "
(Ismail & Sharifi, 2006)	"The ability of the supply chain as a whole and its members to rapidly **align the network and its operations** to the dynamic and turbulent requirements of the demand network"
(Bernardes & Hanna, 2009)	"The ability of the system to **rapidly reconfigure** (with a new parameter set)"
(Braunscheidel & Suresh, 2009)	"A firm's supply chain agility (FSCA) is the capability of the firm, both internally and in conjunction with its key suppliers and customers, to **adapt** or respond in a speedy manner to marketplace changes as well as to potential and actual disruptions, contributing to the agility of the extended supply chain."
(Wieland & Wallenburg, 2012)	"The ability of a supply chain to rapidly respond to change by **adapting** its initial stable configuration"
(Gligor, Holcomb, & Stank, 2013)	"Supply chain's ability to quickly **adjust its tactics and operations**. This ability can manifest itself proactively or reactively."
(Razmi & Sangari, 2015)	"The ability of the supply chain to cope with turbulence and unexpected changes in the competitive market and in the business environment and to provide a strategic advantage by converting uncertainties and threats into opportunities **through assembling requisite** assets, knowledge, and relationships with speed and surprise."
(Eckstein et al., 2015)	"The ability of the firm to sense short-term, temporary changes in the supply chain and market environment (e.g., demand fluctuations, supply disruptions, changes in suppliers' delivery times), and to rapidly and flexibly respond to those changes with the existing supply chain."

Table III - 2 - Agility definition with adaption perspective

As suggested in the literature, there are several enablers of Supply Chain Agility. Wieland & Marcus Wallenburg (2012) suggest approaches like Supplier/buyer communication, Business continuity planning, Visibility, Assortment, Planning Make-to-order/postponement. (Kumar Sharma & Bhat, 2014) classified operational attributes like Build-to-order capabilities; Market sensitivity; Flexibility; Adaptability; Collaborative relationship; Virtual integration, and Network-based.

Al Humdan et al. (2020) list as enablers the following elements: Market sensitivity; Operational alignment (e.g., production planning); adoption of IT and IS tools to boost connectivity amongst members; Collaborative relationship; Contingency planning: forming backup teams to tackle disruption; Strategic orientation: aligning collective capabilities are examples of action that companies must deploy to foster agility.

Al-Zabidi, Rehman, & Alkahtani (2021) propose four capabilities, six enablers, and 93 attributes to achieve Supply Chain Agility. According to the authors, the enablers are Organization Management; Strategic Management; Strategic Commitment; Information Management; Customer Sensitivity; and Human Competence. From their study, we select five examples of attributes associated with each enabler that is closer to the operation of manufacturing companies (unit of analysis of this research):

- Organization Management attributes Material planning and control; Virtual logistics networks; Integrated Manufacturing Network; Digitalization of Supply Chain; and Digitalization in product design.
- Strategic Management: Transparent information sharing; Pull production system; Zero-inventory system; Supplier negotiation; and Excellent communication.
- Strategic Commitment: Networking with partners; Interlinking departments; Integration of marketing network; Interpreting business environment; and Interlinking departments.
- Information Management: Digitalization of demand information; Information Accessibility Dimensions; Incorporating radio-frequency identification technology; Response time to the customer; and Early disturbances detection
- Customer Sensitivity: Customer-driven manufacturing; Modular products structure; Acceleration of product release; Effective forecasting method; Market trend analysis;
- Human Competence: Employees involvement in the decision; Manage resistance to change; Embrace to market dynamics.

Al Humdan et al.'. (2020) literature review also reveals that the research about the relationship between Supply Chain Agility and Performance is limited in the number of studies. According to those authors, only 18 articles addressed such topic. Among those, just four papers explored the relationship between Supply Chain Agility and Operational Performance, as summarized in the table below. We add to the table below new references about articles assessing the relationship among not cited by the author

Authors	Findings	Operational Performance Dimensions
(D. M. Gligor & Holcomb, 2012)	A positive impact is supported.	• Undamaged deliveries; • Orders deliveries accuracy • On-time deliver
(Degroote & Marx, 2013)	A positive impact is supported.	• Speed to market Customer service
(Blome & Rexhausen, 2013)	A positive impact is supported.	• Delivery • Flexibility • Cost Performance • Service Level.
(Eckstein et al., 2015)	A positive impact is supported.	• Product quality • Service level • On-time deliver
(Um, 2017)	A positive impact is supported.	• Quality • Order lead time • Customer complaints reduction • Customer satisfaction • Stock-out reduction • Deliver high quality product quickly with volume flexibility • Develop new product quickly with designing lexibility depending on customer demand • Control sales/distribution network
(Nazempour et al., 2018)	A positive impact is supported.	• Per operation cost/hour • Information carry cost • Utilization of the capacity • Rate of rejection by suppliers • Quality of documentation/Delivery • Delivery quality of products • Ensuring defected free products to final users Delivery frequency Reliability driver which may enhance its performance

Table III - 3 - Previous Studies about Supply Chain Agility and Operational Performance adapted and improved from Al Humdan et al.'. (2020)

For this research, we will use the following definition of agility: “ability of a supply chain to rapidly respond to change by adapting its initial stable configuration” provided by (Wieland & Wallenburg, 2012, p. 890). The measurement items will be operationalized using the instrument suggested by the author above (see Appendix C), which encompasses the following areas: organizations' ability to adapt the manufacturing lead times, adapt the level of customer service, adapt the delivery reliability, and adapt the delivery the responsiveness to changing market needs.

The limited number of empirical researches in table 2, as well as lack of research about Supply Chain Agility in European and emerging economies (as point out by Al Humdan et al. (2020)), characterize, respectively, the existence of empirical, population, and theoretical types of gaps, according to Miles's (2017) taxonomy.

Motivated by such arguments, in the present research, we propose investigating the relationship between Supply Chain Agility and Performance in Brazilian Industries to foster the development of Dynamic Capability Theory development in Academia.

3.3.3 - Supply chain risk management

Companies are increasingly investing in risk management tools, such as mitigation practices and contingency planning, to manage the various forms of risk to which supply chains are exposed (Wiengarten, Humphreys, Gimenez, & McIvor, 2016b). Supply Chain Risk Management emerged from the intersection of risk management and Supply Chain Management (Blos, Watanabe, Quaddus, & Wee, 2009).

From the practical and research perspectives, few areas of interest in the scope of Supply chain have gained much attention in recent years as Supply Chain Risk Management (Colicchia & Strozzi, 2012; Huo et al., 2014; Trkman & McCormack, 2009). Wagner & Bode (2008) suggest that the considerable attention by scholars about the subject of Supply Chain Risk Management is due to two parallel issues: recent series of crises and catastrophes and the fact that modem supply chains seem to be more vulnerable than ever.

Nevertheless, in the literature review performed by Taylor, Rangel, Oliveira, Silene, & Leite (2014), the authors highlighted that among 250 articles published on SCRM from 2004 until 2015, none developed what can be called research profiling on the theme. It is also essential to note that Supply Chain Risk Management research is fragmented (Raghunath & Devi, 2018), still at its early stage (Huo et al., 2014; Jüttner, 2005), and there is not many empirical researches available (Wieland & Wallenburg, 2012).

In terms of its definition, no standard definition is available for the term Supply Chain Risk Management (Gurtu & Johny, 2021). Researchers have tried to provide explanations for such a broad area. For instance, according to Uta Jüttner, Peck, & Christopher (2003), Supply Chain Risk Management consist of identifying and managing risks for the supply chain through a coordinated approach to reduce supply chain members' vulnerability as a whole. The authors also state that Supply Chain Risk management aims to identify the potential sources of risk and implement appropriate actions to avoid or contain supply chain vulnerability.

Supply Chain Risk Management can also be defined as “the integrated processes of identification, analysis and either acceptance or mitigation of uncertainty and risk in the supply chain.” (Wiengarten et al., 2016, p. 364) that involves both strategic and operational horizons for long-term and short term assessment (Lavastre, Gunasekaran, & Spalanzani, 2012). At the operational level, Supply Chain Risk Management activities seek to prevent, detect, respond, and recover from risks events (Shou, Hu, Kang, Li, & Park 2018)

In table 4, we summarize Supply Chain Risk examples of definitions available in the literature:

Authors	Definition of Supply Chain Risk Management
(Uta Jüttner et al., 2003, p.6)	"The identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole."
(Norrman, Andreas; Jansson, 2004, p.436)	"To collaborate with partners in a supply chain apply risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources."
(Goh, Lim, & Meng, 2007, p.164-165)	"The identification and management of risks within the supply network and externally through a coordinated approach amongst supply chain members to reduce supply chain vulnerability as a whole."
(Tang, 2006, p.453)	"The management of supply chain risk through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity"
(Lavastre et al., 2012, p.830)	"Refers to risks that can modify or prevent part of the movement and efficient flow of information, materials and products between the actors of a supply chain within an organization, or among actors in a global supply chain (from the supplier's supplier to the customer's customer)."
(Wieland & Wallenburg, 2012, p.890)	"The implementation of strategies to manage both everyday and exceptional risks along the supply chain based on continuous risk assessment with the objective of reducing vulnerability and ensuring continuity."

Table III - 4 - Supply Chain Risk Management definition adapted and improved from Gurtu & Johny (2021) and Ceryno, Scavarda, Klingebiel, & Yüzgülec (2013)

The implementation of Supply Chain Risk Management strategies relies on different factors. (Norrman & Wieland, 2020) suggest a set of enablers. Four related to the success of Supply Chain Risk Management outcomes: Top management support; Intra-functional processes; Cross-functional relationships; and Inter-organizational relationships. Another four enablers, which in turn are associated with the successful implantation of Supply Chain Risk Management by the organization: Adaptability; Monitoring risk; Risk-management scope; and Technological capabilities.

Kilubi, Irène; Haasis (2015) also point out the following enablers for deploying such managerial approach: Visibility; Flexibility; Relationships; Redundancy; Coordination;

Postponement; Multiple sourcing; Collaboration; Risk Awareness; Agility; Avoidance Contingency, Contingency planning; Risk monitoring; and Transferring or sharing risk.

Another area of interest in the field of Supply Chain Risk Management consists of understanding its relationship with performance. This interest emerges as a natural consequence of the current competitive conditions of the business environment where unexpected events are increasingly present, turning performance patterns increasingly uncertain. (Heckmann, Comes, & Nickel, 2015).

Different researchers suggest that firms can improve performance through the implementation of Supply Chain Risk Management. (Kilubi & Haasis, 2016; I. Manuj & Mentzer, 2008; Thun, Drüke, & Hoenig, 2011, Chaudhuri, et. al, 2018). Following such a view, several scholars have attempted to understand better the relationship between Supply Chain Risk Management and essential aspects of business performance.

In the literature, we found relevant examples of causal/empirical studies concerning the assessment of the impact of Supply Chain Risk Management on Operational Performance as follows:

Authors	Findings	Operational Performance Dimensions
(Munir et al., 2020)	A positive impact is supported.	Quality, flexibility, delivery and customer service performance (Rho
(Hu et al., 2020)	A positive impact is supported.	Conformance quality Product quality and reliability Volume flexibility Mix flexibility Delivery speed Delivery reliability
(Shou, Hu, et al., 2018)	A positive impact is supported for both operational efficiency and flexibility; on-time delivery	Operational efficiency and flexibility
(Chaudhuri et al., 2018)	A positive impact is supported	Volume flexibility Mix flexibility
(H. Fan, Li, Sun, & Cheng, 2017)	A positive impact is supported.	Fast product modification, fast introduction of product market; fast response to changes in market demand; lead time for fulfilling customer

		orders; high level of customer service
(Kauppi et al., 2016)	A positive impact is supported.	Quality, Flexibility, Customer service, Delivery, and cost
(H. Fan, Cheng, Li, & Lee, 2016)	A positive impact is supported.	Fast product modification, fast introduction of product market; fast response to changes in market demand; lead time for fulfilling customer orders; high level of customer service
(Wiengarten et al., 2016b)	A positive impact is supported.	Cost and Innovation Performance

Table III - 5 - Previous research about Supply Chain Risk Management and Operational Performance

Concerning the investigation about the pattern of relationship among Supply Chain Risk Management and Operational Performance among Brazilian Industries, we observe that out of studies detailed in table 3 (above), two researchers, Shou et al. (2018) and (Kauppi et al., 2016), collected data from companies located in Brazil as well as from other countries.

In addition to the studied above, we retrieved, from the Scopus database, articles that tackle explore Supply Chain Risk Management considering data solely from Brazilian companies (see table 6)

Authors	The main objective of the Study
(Dias, de Oliveira, Lima, & Fernandes, 2021)	Among ISO 31010 tools identify which can be applied in risk management process.
(Vanalle, Lucato, Ganga, & Alves Filho, 2020)	Identify the risk management characteristics in the automotive supply chain in Brazil (first and second tiers).
(Senna, Da Cunha Reis, Castro, & Dias, 2020)	Investigate about the human factors that impact supply chain risk management
(Pires, Matos, & Díaz, 2019)	Identify, systematize and analyze how global automaker conducted the Supply Chain Risk Management in their supply chain.
(L. M. F. Silva, de Oliveira, Leite, & Marins, 2021)	Present a proposed application for systematic risk assessment considering the dependence between risks.
(J. Silva, Araujo, & Marques, 2020)	Map risk perception across the pharmaceutical supply chain in Brazil.
(Blos & Wee, 2018)	Investigate different perspectives of the Supply Chain Risk Management and how they are associated industries in Brazil
(Araujo, Tessaro, & Sardim, 2016)	Identify imminent risk to Supply Chain and actions to reduce or eliminate these risks in automotive sector
(Ceryno et al., 2015)	Identify the main risks along the automotive supply chain by investigating their manifestation in three supply chains in Brazil and offers an initial risk profile for the Brazilian automotive industry.
(Schroeder & Gomes, 2014)	Identify and classify potential risks international trade operations and supply chain risk management measures to support organizations to face those risks.
(Funo, Muniz, Silva Marins, & Salomon, 2011)	Analyze supply chain risk factors in aerospace industry.
(Blos et al., 2009)	Identify the supply chain risks industries in Brazil and emphasize the development of supply chain risk management actions in Brazil.

Table III - 6 - Supply Chain Risk Management Research (Brazilian Business Environment

The limited number of empirical researches among Supply Chain Risk Management and Operational Performance (see table 4), as well as the absence of this type of investigation using data solely from Brazilian Industries (see table 5), characterize, respectively, the existence of empirical, population, and theoretical types of gaps, according to Miles's (2017) taxonomy.

Finally, in this study, an investigation about a possible moderation role of risk management practices between the relationship of Supply Chain Agility and Operational Performance will be performed. Further theoretical support for the suggested hypotheses raised above will be provided in the following section.

To enable an empirical investigation of such latent construct in the present research, the operational definition of Supply Chain Risk Management as an approach that involves the identification, assessment, controlling, and monitoring of possible risks within the supply chain and the related measurement items suggested by (Hallikas et al., 2004; Kern et al., 2012; Wieland & Wallenburg, 2012) will be adopted in this article. The survey items for Supply Chain Risk Management can be found in the Appendix A.

3.3.4 - Hypothesis Development

In this section, further theoretical support for the hypothesis below will be present. It is important to highlight that the theoretical basis for H1 was presented in Chapter 2.

H1: Supply Chain Risks negatively impacts Operational Performance.

H2: Supply Chain Risks Management positively impacts Operational Performance.

H3: Supply Chain Risks Management positively moderates the relationship between Supply Chain Agility and Operational Performance.

H4: Supply Chain Agility positively impacts Operational Performance

According to (Teece, 2007), at the core of dynamic capability theory lies the assumption that the design of business models may support companies in obtaining competitive advantages against competitors. In this context, processes must be delineated and deployed to enable the organization to track opportunities and also uncertainties.

Jajja, Chatha, & Farooq (2018, p.119) suggest that "the Dynamic Capability View logic draws that an organization operating in a dynamic environment and facing uncertainties in the supply chain needs to develop capabilities to manage the uncertainties and the ensuing supply chain risk (Teece, 2007)".

In the field of Supply Chain Management, Supply Chain Risk Management and Supply Chain Agility emerges as potential capabilities to be integrated by organizations as part of their business models to achieve higher Operational Performance and alleviate the negative impact of Supply Chain Risks.

We hypothesized that Supply Chain Risk Management increases Operational Performance. Implementing and executing such a strategy may support companies in dealing with volatile and complex environments and, consequently, alleviate the negative impact on performance generated from different types of risk within supply chains. Such a call is aligned with Alkhudary, Brusset, & Fenies' (2020) and Gurtu & Johny (2021) views.

Thus, we understand the Supply Chain Risk Management process and routines as a required dynamic capability for gathering and interpreting data (sensing) and identifying threats and opportunities out of this data (seizing). This view is in line with Krzakiewicz & Cyfert (2015) and (Nair et al., 2014). Those authors contend that risk management should be considered dynamic capabilities and applied in the management field of research.

In the specific area of Supply Chain Management, previous researchers have also explored the benefits of Supply Chain Risk Management in Supply Chain Management arena with relation to Dynamic Capability's theoretical perspective. For instance, (Beske, Land, & Seuring, 2014) (S. Y. Ponomarov, 2012) explored it as one type of supply chain preventive practice that may enable companies' to evolve specific dynamic capabilities.

In this research, differently from the authors cited in the previous paragraph, Supply Chain Risk Management is conceptualized and operationalized as a Dynamic Capability. This vision is similar to Um & Han's (2020) understanding. Those researchers defined supply chain risk management together with supply chain resilience as critical dynamic capabilities for the success of the Supply Chain when operating in a highly uncertain environment.

Then, for analytical purposes, Supply Chain Risk Management strategic routines and practices will be explored as an indispensable capability in risky environments to support the achievement of superior operational performance in the context of Brazilian industries.

The exploration of risks at manufacturing setting answers, for instance, to the call of Gurtu & Johny (2021) and Tang; & Musa (2014). According to those authors, to evolve, Supply Chain Risks Management needs to incorporate risk issues from industry practice. However, to this date, most studies provide mainly descriptive and conceptual models rather than quantitative models.

Finally, as emphasized (Kilubi & Haasis, 2016), based on a systematic literature review including 60 academic journals, only partial evidence is provided by a few studies about the positive relationship between risk management and performance in the field of Supply Chain Management.

Thus, the present study seeks to contribute to such call in complement with the previous studies that already investigated the relationship between Supply Chain Risk Management and Operational Performance, as exposed in table 4. Finally, we aim to reduce current empirical, population, and theoretical types of research gaps identified as discussed previously in the chapter.

Based on the argument exposed above and in the previous section, the following hypothesis is proposed: **Supply Chain Risks Management positively impacts Operational Performance (H2)**

According to the literature, few studies have already tested the relationship between Supply Chain Risk Management and Supply Chain Agility. For instance, Wieland & Marcus Wallenburg (2012) empirically tested and found support to such a proposition using data from 270 manufacturing companies. Recently, (Hamdi, Saikouk, & Bahli, 2020) assess such relationships in the context of business organizations in the US and France and found a positive relationship.

Here, we propose a slightly different relationship. In our conceptual model, we suggest assessing the hypothetical positive impact of Supply Chain Agility upon Operational Performance will be more substantial due to the presence of Supply Chain Risk Management practices as a moderator variable.

This investigation is also proposed, for instance, by Nazempour, Yang, & Waheed (2018), who suggested the development of empirical scientific research about the role of moderating factors among Supply Chain Agility and Operational Performance.

We have not found specific academic research to this date concerning such a relationship. Our study aims to contribute to academia to reduce current empirical, population, and theoretical research gaps usually identified in such a scenario.

Thus, based theoretical arguments above, the following hypothesis is proposed: **Supply Chain Risks Management positively moderates the relationship between Supply Chain Agility and Operational Performance (H3)**

As discussed previously, here, we hypothesize Supply Chain Agility as one type of Capability required to enable companies to adapt their operations. This theoretical view finds support in the available literature. For instance, as Fayezi, Zutshi, & O'Loughlin, 2017 (p.380) proposed, "Supply Chain Agility is a strategic ability that assists organizations rapidly to sense and respond to internal and external uncertainties via effective integration of supply chain relationships." C.R, Sridharan, Gunasekaran, & Ram Kumar (2020) also share such view. The authors characterized agility as one of eight key strategic capabilities in the Supply Chain for managing risks together with flexibility, reliability, resilience, robustness, adaptability, alignment, and responsiveness.

Supply Chain Agility is also considered a required dynamic capability within the scope of supply chains to support managing uncertainties, risk, and continuous service to customers to improve the company's performance. (Altay et al., 2018; Aslam et al., 2020; Eckstein et al., 2015; Khan K et al., 2009; Sharma et al., 2017)

In the present research, Supply Chain Agility is modeled as a dynamic capability to enable companies to adapt a different aspect of their operations in response to risks derived from the marketplace to reach better performance and, consequently, competitive advantage.

Based on the argument exposed above and in the previous section, the following hypothesis is proposed: **H4: Supply Chain Agility positively impacts Operational Performance**

3.4 - RESEARCH METHODOLOGY

3.4.1 - Research methodology

We assume a postpositivist philosophical world view, anchored in a deterministic philosophy that seeks to explore the causes that influence outcomes; such worldview is based on the following elements: Determination, Reductionism, Empirical observation, and measurement and Theory verification (Creswell, 2014).

The investigation will follow the deductive approach to research, where the researcher starts with a theory and tests it using empirical data to support or not the theoretical postulates (Bhattacherjee, 2012). It is essential to highlight that "the goal of theory-testing is not just to test a theory, but possibly to refine, improve, and extend it" (Bhattacherjee, 2012, p.3).

The present work follows a quantitative research approach with a nonexperimental correlational form of research. Researchers apply correlational statistics to describe and measure the degree of relationship between two or more variables in such types of studies (Creswell, 2014).

Due to the nature of the phenomenon under investigation, we chose the survey research design to obtain the data. This type of method relies on applying questionnaires to collect data about the people or organizations systematically. (Bhattacherjee, 2012).

The survey approach was selected in this work mainly because we tested the relationship among latent variables. According to (Rungtusanatham, Choi, Hollingworth, Wu, & Forza, 2003), survey studies are generally relational because they tend to be designed to examine relationships among two or more constructs or variables empirically.

Bhattacherjee (2012) emphasizes that survey design has different advantages. Firstly, it is an excellent means for measuring several natural unobservable phenomena. Secondly, it allows the researchers to obtain data remotely about a population that is too large to observe directly; it has unobtrusive nature and can be considered economical in terms of researcher time compared to another means of data collection.

The data collected was subsequently analyzed employing Structural Equation Modeling (SEM). SEM is a multivariate statistical technique with elements from Structural Theory, Measurement Theory. "In PLS-SEM, structural and measurement models are also referred to as inner and outer models. To develop path models, researchers need to draw on structural and measurement theories, which specify the relationships between the elements of a path model". (Sarstedt, Ringle, & Hair, 2017, p.3)

As proposed by (Joseph F. Hair, Risher, Sarstedt, & Ringle, 2019, p.3), "the PLS-SEM method is very appealing to many researchers as it enables them to estimate complex models with many constructs, indicator variables, and structural paths without imposing distributional assumptions on the data."

3.4.2 - Sample and data collection

An electronic survey questionnaire was applied to promote the data collection process. A total of 987 potential participants were contacted by phone and email between January 2020 and June 2020, resulting in 165 usable responses to an electronic survey. Thus, an effective return rate of 16,7% was obtained.

Concerning the sample size, we followed the recommendations from Cohen, (1992),cited by Joseph F. Hair, Hult; Ringle; & Sarstedt (2017, p. 26) regarding the minimum number of respondents. In our case, considering that the number of arrows from dependent variables pointing out at our dependent construct is 3, 37 observations are necessary to detect R2 values of around 0.25 at a significance level of 5% and a power level of 80%. Therefore, in both scenarios, the sample size of 165 cases can be regarded as sufficiently large.

Maximum Number of Arrows Pointing at a Construct (Number of Independent Variables)	Significance Level											
	10%				5%				1%			
	Minimum R^2				Minimum R^2				Minimum R^2			
	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75
2	72	26	11	7	90	33	14	8	130	47	19	10
3	83	30	13	8	103	37	16	9	145	53	22	12
4	92	34	15	9	113	41	18	11	158	58	24	14
5	99	37	17	10	122	45	20	12	169	62	26	15
6	106	40	18	12	130	48	21	13	179	66	28	16
7	112	42	20	13	137	51	23	14	188	69	30	18
8	118	45	21	14	144	54	24	15	196	73	32	19
9	124	47	22	15	150	56	26	16	204	76	34	20
10	129	49	24	16	156	59	27	18	212	79	35	21

Source: Cohen (1992): A Power Primer. Psychological Bulletin 112: 155–159.

Table III - 7 - Sample Size Recommendation in PLS-SEM for a Statistical Power of 80% extracted from (Sarstedt et al., 2017, p.26)

The unit of analysis employed in this study is at the manufacturing plant level and its relationship between its internal functions, upstream suppliers, and downstream customers. The target profile of respondents was composed of managers selected by their job function (supply chain manager, operation manager, or equivalent). Among the respondents, 100% were from the manufacturing sectors, from segments like automotive companies, chemical sector, electronics sector, oil, and gas. In tables 3 to 6, the demographic details of the sample can be found.

Industrial Segment	Frequency	Percentage
Food and Beverages	44	26,67%
Textile and Garment	19	11,52%
Chemicals and petroleum	14	8,48%
Plastic and latex	14	8,48%
Passenger Vehicles	12	7,27%
Construction	11	6,67%
Wood Products	11	6,67%
Consumer goods	7	4,24%
Fabricated metal products, except machines	7	4,24%
Others	7	4,24%
Pharmaceutical	4	2,42%
Machinery	4	2,42%
Paper Products	4	2,42%

Basics and Manufactured Goods	4	2,42%
Electrical equipment	3	1,82%
Total	165	100,00%

Table III - 8 - Sample Demographics (Industrial Segments)

Sales Volume	Frequency	In Percentage
Less than 10 million reais	87	52,73%
Between 11 and 25 million reais	32	19,39%
Between 26 and 50 million reais	8	4,85%
Between 51 and 75 million reais	2	1,21%
Between 76 and 100 million reais	4	2,42%
Between 101 and 250 million reais	7	4,24%
Between 251 and 500 million reais	5	3,03%
Above 500 million reais	20	12.12%

Table III - 9 - Sample Demographics (Sales Volume)

Number of employees	Frequency	In Percentage
1-50	95	57,58%
51-100	22	13,33%
101-200	12	7,27%
201-500	12	7,27%
501-1000	10	6.06%
Above 1000	14	8,48%

Table III - 10 - Sample Demographics (Number of Employees)

Job Level at the company	Frequency	In Percentage
Directorate	38	23,03%
Manager/Supervisor	101	61,21%
Operational	26	15,76%
	Frequency	In Percentage
Years of Job Experience within the actual company		
Less thanfive5 years	48	29,09%
Between 5 and 10 years	71	43,03%
Between 10 and 20 years	44	26,67%
Above 20 years	2	1,21%
Years of Job experience	Frequency	In Percentage
Less than 5	12	7,27%
Between 5 and 10 years	41	24,85%
Above 10 year	112	67,88%

Table III - 11 - Sample Demographics (Respondents Profile)

3.4.3 - Sample and method bias

We execute the Normality Test, Test of Equality of Variance, and Common Method Bias using SPSS Software to assess the sample. Concerning the normality assessment, the Shapiro-Wilks test is designed to test normality. According to the normality test proposed by Shapiro and Wilk (1968), when the p-value is less than or equal to 0.05, the hypothesis of normality should be rejected. Nevertheless, as emphasized by Hair et al., (2017, p. 27), "Normal distributions are usually desirable, especially when working with CB-SEM. In contrast, PLS-SEM generally makes no assumptions about the data distributions."

We also test the homogeneity of the sample. As Nordstokke, Zumbo, Cairns, & Saklofske (2011, p.1) proposed, "The assumption of homogeneity of variances is essential when comparing two groups because if variances are unequal, the validity of the results is jeopardized". Levene's tests indicate no significant differences between the two groups of the first 2/3 of respondents and 1/3 late respondents.

Following (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), Harman's single-factor test with an exploratory factor analysis was applied to assess the presence of common method bias. If the total variance extracted by one factor exceeds 50%, common method bias is present in your study. Our test with all variables (independent and dependent) resulted in a first factor accounting for 28.78 percent of the total variance, indicating that no single factor explained most of the variance in the model.

3.4.4 - Conceptual Model

"A model is a representation of all or part of a system that is constructed to study that system, while a theory tries to explain a phenomenon, a model tries to represent a phenomenon" (Bhattacherjee, 2012, p 14). "A path model is a diagram that displays the hypotheses and variable relationships to be estimated in an SEM analysis", as shown in the figure below (Sarstedt, Ringle, & Hair, 2017, p.4)

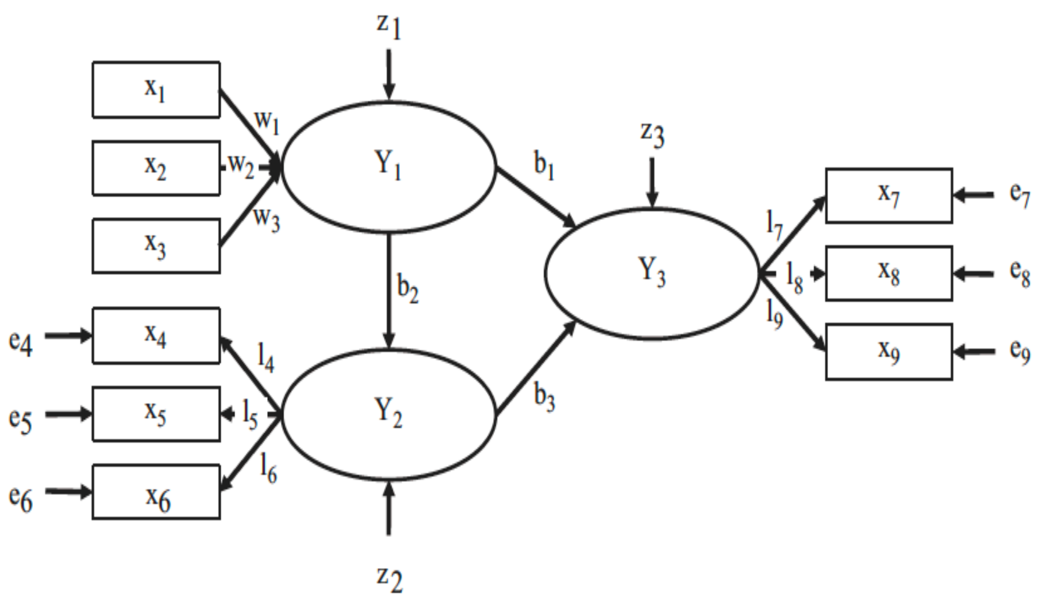

Figure III - 1 - Path Diagram and Latent variable (Joseph F. Hair et al., 2017, p.5)

Latent variables “are elements in statistical models that represent conceptual variables that researchers define in their theoretical models” (Sarstedt, Ringle, & Hair, 2017, p.3)

Our research model comprises different constructs three Low Order (Operational Performance, Supply Chain Risk Management and Supply Chain Agility) and one High Order (Overall Supply Chain Risks), which is composed of 5 Low Order Construct (Supply Side Risks, Demand Side Risks, Regulatory, Legal, and Bureaucratic Risks, Infrastructural Risks and, Catastrophic Risks).

The one multidimensional construct denominated Overall Supply Chain Risks, “where each dimension represents a unique content domain of the broader construct. Multidimensional constructs differ from first-order constructs in that while the latter also represents a single theoretical concept, they lack distinct dimensions” (Polites, Roberts, & Thatcher, 2012, p. 22) .

When applying a higher-order construct, researchers evaluate the influence of such high order latent variable rather than the influence of its dimensions separately (Polites et al., 2012).

Higher-order constructs, “which facilitate modeling a construct on a more abstract higher-level dimension and its more concrete lower-order subdimensions, have become an increasingly visible trend in applications of partial least squares structural equation modeling (PLS-SEM).” (Sarstedt, Hair, Cheah, Becker, & Ringle, 2019. p. 197)

Model parsimony can be achieved through the reduction in the number of path model relationships, and such condition can be seen as one advantage of using higher-order construct since “instead of specifying relationships between multiple independent and dependent constructs in a path model, researchers can summarize the independent constructs in a higher-order construct, making the relationships from the (then) lower-order components to the dependent constructs in the model obsolete” (Sarstedt et al., 2019, p.198)

The repeated indicators approach was applied to establish the reflective-reflective relationship among Supply Chain Risks higher-order construct and its low-order constructs Demand Risks, Supply Risks, Regulatory Risks, Infrastructural Risks, and Catastrophic Risks. By applying such approach, all 17 indicators of the reflectively measured lower-order components are simultaneously assigned to the reflective measurement model of the higher-order construct.

“A reflective specification is appropriate when there is a more general, abstract construct that explains the correlations between the LOCs. Hence, there should be substantial correlations between the LOCs that—analogous to reflective measurement models—are assumed to be caused by the HOC. That is, the HOC is the spurious cause explaining the correlations between the LOCs.(Hair, Sarstedt,, Ringle, & Gudergan, 2017, p.43).

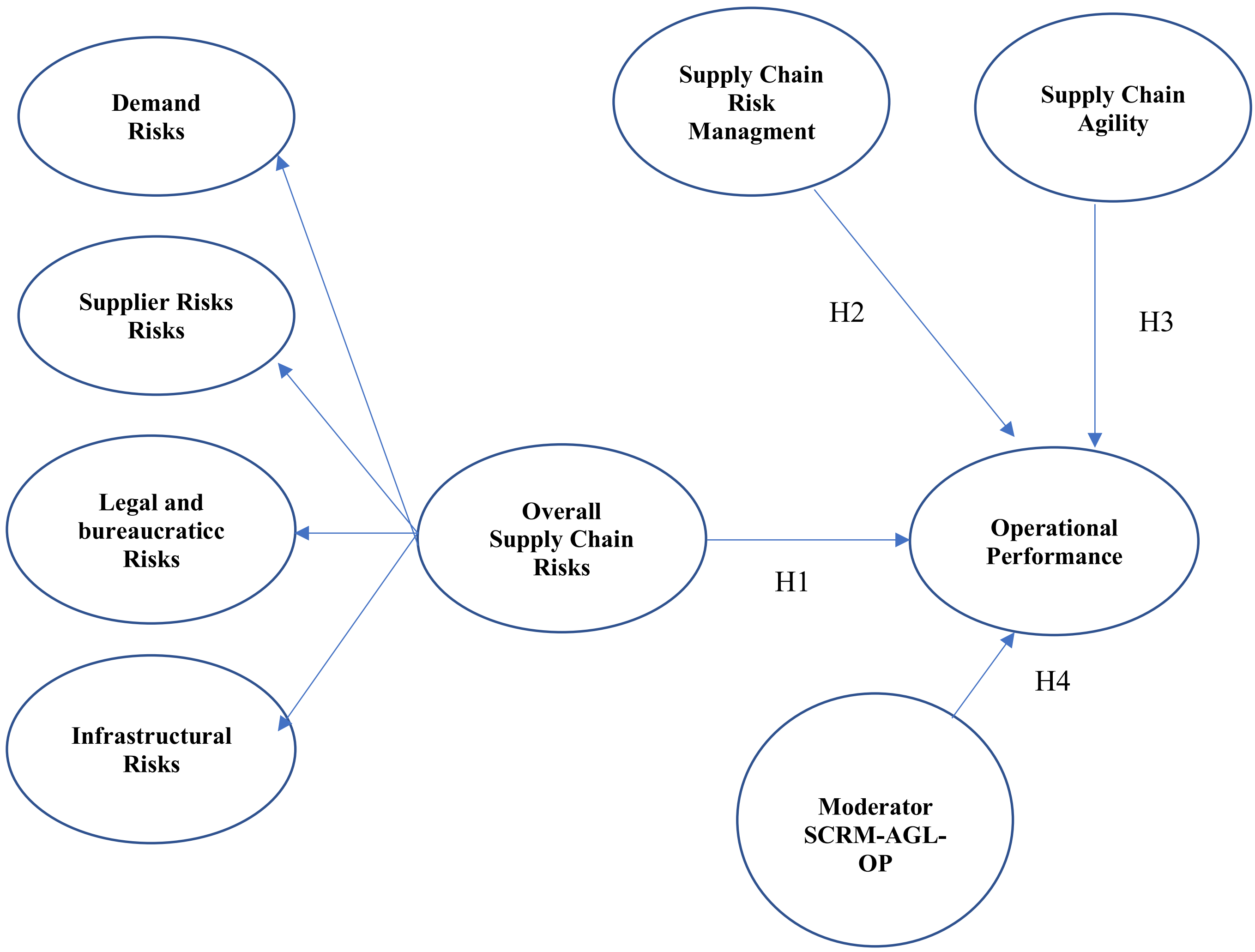

Figure III - 2 - Research Model

(Bhattacherjee, 2012) reminds that constructs require operational definitions, which explain define how they will be empirically measured. The constructs of the present study can be found in table 6, and all of it's the variables that compound the research questionnaire are presented in Appendix C.

Variable Name	Reference:	Role of variable in study	Operational definition	Range of values
Supply Chain Risk	Wagner & Bode, 2008)	Independent	See Appendix	1-7
Supply Chain Agility	(Wieland & Wallenburg, 2012)	Independent	See Appendix	1-7
Supply Chain Risk Managment	(Wieland & Wallenburg, 2012)	Independent	See Appendix	1-7
Organizational performance	(Huo et al., 2014)	Dependent	See Appendix	1-7

Table III - 12 - Construct Sources

The model developed and tested covers 17 different types of Supply Chain Risks Sources, 10 different types of Operational Performance indicators, 4 indicators of Supply Chain Agility, and 4 measures of Supply Chain Risk Management.

Based on the proposed the research framework shown in Fig. 2 below, the following main hypothesis were developed:

H1: Supply Chain Risks negatively impacts Operational Performance
H2: Supply Chain Risks Management positively impacts Operational Performance
H3: Supply Chain Risks Management positively impacts Supply Chain Agility
H4: Supply Chain Agility positively impacts Operational Performance
H5: Supply Chain Risks Management positively moderates the relationship Supply Chain Agility and Operational Performance.

3.4.5 - Measurement model misspecification tetrad analysis (CTA-PLS)

According to Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan (2017), SEM results' validity may be threatened by measurement model misspecification. One approach to assess such conditions relies on the execution of the Confirmatory Tetrad Analysis in PLS-SEM (CTA-PLS).

The application of such analysis enables researchers to empirically evaluate whether the measurement model has specification issues or not. The concept of tetrads (τ) is at the heart of CTA-PLS. It describes the relationship between pairs of covariances.

In reflective measurement models, "differences between pairs of covariances of indicators that represent the concept in a similar manner should be zero, provided the domain sampling model holds as assumed by a reflective measurement model" (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p. 91-92).

In sum, the idea behind CTA-PLS is that in a reflective measurement model, each tetrad (τ) is expected to be zero. In other words, CTA-PLS simply tests the following hypothesis: Ha: $\tau \neq 0$ H0: $\tau = 0$. CTA-PLS only produces results for constructs with at least four indicators per measurement mode.

The assessment was based on the assumption that zero should fall between the Adjusted Confidence Interval (Low and Up) of each tread of the construct being assessed. (Wong, 2019) provide a table for better visualization of such criteria.

	CI Low adj	CI up adj		Measurement model is
If all values are	-	-	then	formative
If all values are	+	+	then	formative
If one or mode of the values are	-	+	Then	reflective

Table III - 13 - CTA-PLS - Adjusted Confidence Interval (Wong, 2019)

Supply Chain Agility	T Statistics (|O/STDEV|)	P Values	CI Low adj.	CI Up adj.
1: AGL 1,AGL2,AGL3,AGL 4	0.69	0.4 9	-0.15	0.3 1
2: AGL 1,AGL2,AGL4,AGL 3	1.07	0.2 9	-0.57	0.1 6

Table III - 14 - CTA-PLS Results (Supply Chain Agility)

Supply Chain Riks Management	T Statistics (|O/STDEV|)	P Values	CI Low adj.	CI Up adj.
1: SCRM 1,SCRM2 - ,SCRM3,SCRM4	0.81	0.42	-0.38	0.15
2: SCRM 1,SCRM2 - ,SCRM4,SCRM3	1.09	0.27	-0.41	0.11

Table III - 15 - CTA-PLS Results (Supply Chain Risk Management)

Thus, based on the results above, we also found statistical support that a reflective-reflective specification is appropriate to both Supply Chain Risk Management and Supply Chain Agility. Despite such results, it is important to emphasize that "CTA-PLS is no silver bullet and its results do not discharge researchers from closely thinking about the specification of measurement models." (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017,p.96). Furthermore "researchers should make the formative vs. reflective decision based on sound theoretical considerations" (Wong, 2019, p.43).

3.4.6 - Low Order Construct Assessment

Model estimation delivers empirical measures of the relationship between the indicators and the constructs and between the constructs (Joe F. Hair et al., 2012).

The traditional criterion for internal consistency is Cronbach's alpha, which provides an estimate of the reliability based on the mutual relationship of the observed indicator variables. "Due to Cronbach's alpha's limitations, it is technically more appropriate to apply a different measure of internal consistency reliability, referred to as composite reliability". (Joseph F. Hair et al., 2017, p.127).

As a reference, the authors mentioned earlier suggest that values below 0.70 (or 0.6 in exploratory research) do not fulfill internal consistency. At the same time, values above 0.95 are not desirable because they indicate that all the indicator variables measure the same phenomenon and are therefore not likely to be a valid measure of the construct.

	Cronbach's Alpha	**Composite Reliability**
Demand Risks	**0,77**	**0,90**
Infrastuctural Risks	**0,85**	**0,90**
Operational Performance	**0,91**	**0,93**
Regulatory Risks	**0,84**	**0,92**
Supplier Risks	**0,85**	**0,89**
Supply Chain Agility	**0,91**	**0,93**
Supply Chain Riks Management	**0,93**	**0,95**

Table III - 16 - Internal consistency reliability

The next steps to assess the model consist of evaluating the convergent validity of reflective constructs. As oriented by (Joseph F. Hair et al., 2017) researchers should consider the outer loadings of the indicators and the average variance extracted (AVE).

A common rule of thumb is that the standardized outer loadings should be 0.708 or higher. For those values with values lower than the threshold proposed above, the author suggest that if it ranges on between 0.40 and 0.70 the indicator should be considered for removal from the scale only when deleting the indicator leads to an increase in the composite reliability (average variance extracted).

Indicator	**Loadings**	**Indicator**	**Loadings**
AGL 1	**0,85**	**SCRI1**	**0,81**
AGL2	**0,88**	**SCRI2**	**0,76**
AGL3	**0,92**	**SCRI3**	**0,85**
AGL4	**0,87**	**SCRI4**	**0,90**
MOP 1	**0,71**	**SCRM 1**	**0,92**
MOP 10	**0,61**	**SCRM2 -**	**0,90**
MOP 2	**0,83**	**SCRM3**	**0,90**
MOP 3	**0,72**	**SCRM4**	**0,89**
MOP 4	**0,82**	**SCRR1**	**0,92**
MOP 5	**0,83**	**SCRR2**	**0,93**
MOP 6	**0,83**	**SCRS1**	**0,82**
MOP 7	**0,81**	**SCRS2**	**0,85**
MOP 8	**0,67**	**SCRS3**	**0,66**
MOP 9	**0,67**	**SCRS4**	**0,87**
SCRD1	**0,92**	**SCRS5**	**0,74**
SCRD2	**0,88**		

Table III - 17 - Indicator Outer Loadings

	Average Variance Extracted (AVE)
Demand Risks	**0,57**
Infrastuctural Risks	**0,69**
Operational Performance	**0,57**
Regulatory Risks	**0,86**
Supplier Risks	**0,63**
Supply Chain Agility	**0,78**
Supply Chain Riks Management	**0,82**

Table III - 18 - Average Variance Extracted (AVE)

The next step consist of discriminant validity following the parameters suggested by (Joe F. Hair et al., 2012). Discriminant validity is the extent to which a construct is truly distinct from other constructs by empirical standards. Thus, establishing discriminant validity implies that a construct is unique and captures phenomena not represented by other constructs in the model (Joseph F. Hair et al., 2017, p.131).

As point out by Henseler, J., Ringle, C. M., & Sarstedt (2014, p.116) "If discriminant validity is not established, constructs [have] an influence on the variation of more than just the observed variables to which they are theoretically related" and, as a consequence, "researchers can not be certain that results confirming hypothesized structural paths are real or whether they are a result of statistical discrepancies.(Farrell, 2010, p. 324)"

	Demand Risks	***Infrastuctural Risks***	***Operational Performance***	***Regulatory Risks***	***Supplier Risks***	***Supply Chain Agility***	***Supply Chain Riks Management***
Demand Risks	***0,90***						
Infrastuctural Risks	*0,47*	***0,83***					
Operational Performance	*-0,39*	*-0,49*	***0,75***				
Regulatory Risks	*0,47*	*0,68*	*-0,39*	***0,93***			
Supplier Risks	*0,60*	*0,66*	*-0,61*	*0,65*	***0,79***		
Supply Chain Agility	*-0,04*	*-0,17*	*0,41*	*-0,16*	*-0,25*	***0,88***	
Supply Chain Riks Management	*-0,35*	*-0,36*	*0,61*	*-0,30*	*-0,53*	*0,48*	***0,91***

Table III - 19 - - Discriminant validity - Fornell-Lacker Criteria

	Demand Risks	Infrastuctural Risks	Operational Performance	Regulatory Risks	Supplier Risks	Supply Chain Agility
Infrastuctural Risks	**0,56**					
Operational Performance	**0,44**	**0,54**				
Regulatory Risks	**0,57**	**0,80**	**0,43**			
Supplier Risks	**0,72**	**0,77**	**0,67**	**0,77**		
Supply Chain Agility	**0,14**	**0,17**	**0,43**	**0,15**	**0,25**	
Supply Chain Riks Management	**0,41**	**0,41**	**0,66**	**0,35**	**0,59**	**0,48**

Table III - 20 - Heterotrait-Monotrait Ratio (HTMT) Test

We found support for the lower-order components' discriminant validity, because all HTMT values (Franke & Sarstedt, 2019; Henseler et al., 2015; Voorhees et al., 2016) are below the conservative threshold of 0.85 (Table 13). However, the discriminant validity between Demand Risks, Supplier Risks, Regulatory Risks and Infrastructural Risks both and their higher-order construct Supply Chain Risks was not assessed. According to Sarstedt et al., (2019, p.203), "violation of discriminant validity between these constructs is expected, because the measurement model of the higher-order component repeats the indicators of its lower-order components."

As suggested by (Sarstedt et al., 2019), the assessment of the lower-order components draws on the standard reliability and validity criteria for reflective measurement models as documented in the extant literature. Then, based on the results shown at tables 16 to 20 above, the Low Order Constructs of the research model met the convergent validity, internal consistency reliability, and discriminant validity as suggested by the literature

3.4.7 - High Order Construct Assessment

The repeated indicators approach was applied to establish the reflective-reflective relationship among Supply Chain Risks higher-order construct and is low-order constructs *Demand Risks, Supply Risks, Regulatory Risks and Infrastructural Risks. By applying such approach* all 13 indicators of the reflectively measured lower-order components are simultaneously assigned to the reflective measurement model of the higher-order construct.

"A reflective specification is appropriate when there is a more general, abstract construct that explains the correlations between the LOCs. Hence, there should be substantial correlations between the LOCs that—analogous to reflective measurement models—are assumed to be caused by the HOC. That is, the HOC is the spurious cause explaining the correlations between the LOCs.(Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p.43)

In order to verify the conditions suggested above by Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan (2017) the correlations among the LOC were found to be relevant as show in the table below:

	Demand Risks	Infrastuctural Risks	Regulatory Risks	Supplier Risks
Demand Risks	1.000	0.467	0.469	0.599
Infrastuctural Risks	0.467	1.000	0.685	0.661
Regulatory Risks	0.469	0.685	1.000	0.649
Supplier Risks	0.599	0.661	0.649	1.000

Table III - 21 - Latent Variable Correlations

The reliability and validity assessment of the higher-order construct *Supply Chain Risks* should be assessed taking into consideration its relationship with its lower-order components. The constructs *Demand Risks, Supply Risks, Regulatory Risks and Infrastructural Risks* are specifically interpreted as if they were indicators of the *Supply Chain Risks* construct. As a consequence, the (reflective) relationships between the *High Order* construct and its lower-order components, are interpreted as loading although they appear as path coefficients in the path model (Sarstedt et al., 2019).

The analysis produces loadings of 0,882 for *Demand Risks,* 0.911 for *Supplier Risks*, 0,788 for *Regulatory Risks* and 0,843 *Infrastructural Risks* for we thereby providing support for indicator reliability. By using these indicator loadings and the correlation between the constructs (0.665) as input, the higher-order construct'reliability and validity should be calculate out of Smart-PLS Software (manually) based on the equation suggested by (Sarstedt et al., 2019, p.204).

The AVE is the mean of the higher-order construct's squared loadings for the relationships between the lower-order components and the higher-order component:

$$AVE = \frac{\left(\sum_{i=1}^{M} l_i^2\right)}{M},$$

where l_i represents the loading of the lower-order component i of a specific higher-order construct measured with M lower-order components (i = 1,...,M). For this example, the AVE is ($0.702^2 + 0.910^2 + 0{,}820^2 + 0{,}869^2$)/4 = 0.69, which is above the 0.5 threshold, therefore indicating convergent validity for *Supply Chain Risks* (Sarstedt et al., 2017).

The composite reliability is defined as

$$\rho_C = \frac{\left(\sum_{i=1}^{M} l_i\right)^2}{\left(\sum_{i=1}^{M} l_i\right)^2 + \sum_{i=1}^{M} var(e_i)},$$

where e_i is the measurement error of the lower-order component *i,* and $var(e_i)$ denotes the variance of the measurement error, which is defined as $1 - l_i$. Entering the for loading values yields the following:

Pc =$(0.702 + 0.910 + 0{,}820 + 0{,}869)^2$/ (0.702 + 0.910 + 0,820 + 0,869) + (1- 0.702^2) + (1-0.910^2) + $(1-0{,}820)^2$ + $(1- 0{,}869)^2$ = 0,896

Similarly, Cronbach’s α is given by

$$Cronbach's\ \alpha = \frac{M \cdot \bar{r}}{(1 + (M-1) \cdot \bar{r})},$$

where $\bar{r}$ represents the average correlation between the lower order components. Since the higher-order construct Supply Chain Risks has four lower-order components (i.e., *M* = 4), the average correlation is equal to the correlation between the *Demand Risks, Supplier Risks, Regulatory Risks and Infrastructural Risks* construct scores (i.e., 0.647). Hence, Cronbach’s alpha is given by

Cronbach's alpha, α = 4* 0,588/(1+(4-1)* 0,588 = 0,85

Overall, these results provide clear support for the higher-order construct’s internal consistency reliability as all criteria (i.e., ρ_C, and Cronbach’s α_A) are well above the commonly recommended threshold of 0.708 (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017)

3.4.8 - Structural Model Assessment

The assessment of the structural model should be performed based on the following steps: Collinearity among the latent variables, path coefficients; coefficient of determination R2, Effect Size f2, Blindfolding and predictive relevance Q2 and Effect Size q2

Collinearity arises when two indicators are highly correlated. Collinearity among latent variables is assessed through Variance Inflated Factor (VIF). VIF values above 5 indicate collinearity among the predictor constructs (Sarstedt, Ringle, & Hair, 2020, p 21). As shown in the table below, all model constructs have VIF values lower than the threshold suggested.

	Operational Performance	Supply Chain Agility
Supply Chain Agility	1.320	
Supply Chain Riks Management	1.722	1.000
Supply Chain Risks	1.305	

Table III - 22 - VIF values (Latents Variables)

The strength and significance of the path coefficients are evaluated regarding the relationships (structural paths) hypothesized between the constructs. Similar to the assessment of formative indicator weights, the significance assessment builds on bootstrapping standard errors as a basis for calculating t and p values of path coefficients” (Sarstedt et al., 2017, p.22)”.

	Operational Performance
Supply Chain Agility	0.183
Supply Chain Riks Management	0.390
Supply Chain Risks	-0.388

Table III - 23 - Path coefficients

The path coefficients are significant if the T-statistics is larger than 1.96 and the p-value is lower than 0,05 (Sarstedt et al., 2017). Using such parameters, we analyze the structural model by using bootstrapping. As suggested by Wong (2019), the structural model was estimated based on bootstrapping with 5000 subsamples to obtain a better statistical fit and check the statistical significance of the obtained coefficients.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Overall Supply Chain Risks -> Operational Performance	-0,39	-0,40	0,07	5,55	**0,00**
SCA-OP (SCRM-moderator) -> Operational Performance	0,14	0,14	0,06	2,27	**0,02**
Supply Chain Agility -> Operational Performance	0,18	0,18	0,07	2,47	**0,01**
Supply Chain Riks Management -> Operational Performance	0,39	0,39	0,08	4,78	**0,00**

Table III - 24 - T-Statistics – Boostrapping

The multiple correlation coefficient R2, also known as the coefficient of determination, is defined as the proportion of variance explained by the regression model. Thus, its results can be seen as a measure of predicting the dependent variable from the independent variables (Nagelkerke, 1991). The coefficient of determination, R2, is 0.532 for the Operational Performance endogenous latent variable. This result means that the three constructs, Supply Chain Risk, Supply Chain Risk Management, and Supply Chain Agility, explain around 53 % of the variance in Operational Performance.

In addition to evaluating the R2 values of all endogenous constructs, the change in the R2 value when a specific predictor construct is omitted from the model can be used to assess whether the omitted construct has a substantive impact on the endogenous constructs. This measure refers to the $f2$ effect size (Sarstedt, Ringle, & Hair, 2020, p 21).

As a guideline, $f2$ values of 0.02, 0.15, and 0.35, respectively, represent small, medium, and large effects of an exogenous latent variable. Effect size values of less than 0.02 indicate that there is no effect. (Sarstedt, Ringle, & Hair, 2020, p 21).

Based on the results in table 18, supply chain agility has a small effect on operational performance, whereas Supply Chain Risks Management and Supply Chain Risks produce medium effects. We can also observe a medium effect on the relationship among Supply Chain Risks Management and Supply Chain Agility.

	Operational Performance
Supply Chain Agility	0.054
Supply Chain Riks Management	0.190
Supply Chain Risks	0.247

Table III - 25 - Effect Size f2

The Q2 value builds on the blindfolding procedure, as proposed by (Joseph F. Hair et al., 2017, p. 202). “in addition to evaluating the magnitude of the R^2 values as a criterion of predictive accuracy, researchers should also examine Stone-Geisser’s Q^2 value (Geisser, 1974; Stone, 1974). This measure “can only be partly considered a measure of out-of-sample prediction, because the sample structure remains largely intact in its computation.” (Sarstedt, M., Ringle, C. M., & Hair, 2017, p.21)

The resulting Q^2 values larger than zero indicate that the exogenous constructs have predictive relevance for the endogenous constructs under consideration. “As a rule of thumb, Q2 values larger than zero for a particular endogenous construct indicate that the path model’s predictive accuracy is acceptable for this particular construct (Sarstedt, Ringle, & Hair, 2020, p 22)”.

As proposed by (Joseph F. Hair et al., 2017), the following rule of thumb allows to interpret the Q^2 results (based on the cross-validated redundancy):

- $0.02 \leq Q^2 < 0.15$: weak predictive power
- $0.15 \leq Q^2 < 0.35$: moderate predictive power
- $Q^2 \geq 0.35$: strong predictive power

Thus, our model renders a moderate predictive power based on the results below:

	SSO	SSE	Q^2 (=1-SSE/SSO)
Operational Performance	1.650.000	1.175.341	0.288

Table III - 26 - Blindfolding and predictive relevance Q2

Analogous to the f2 effect size, researchers can also analyze the q2 effect size, which indicates the change in the Q2 value when a specified exogenous construct is omitted from the model. As a relative measure of predictive relevance, “q2 values of 0.02, 0.15, and 0.35 indicate that an exogenous construct has a small, medium, or large predictive relevance, respectively, for a certain endogenous construct” (Joseph F. Hair et al., 2017, p. 208). Such calculation is based on the following equation:

$$q^2 = [Q^2(\text{included}) - Q^2(\text{excluded})] / 1 - Q^2(\text{included})$$

q^2 (model without Supply Chain Agility) = (0,29-0,26)/1-0,29 = 0,03/0,71 = 0,04

q^2 (model without Supply Chain Risk Management) = 0,29 – 0,25/ 1-0,29 = 0,04/0,71 = 0,05

q^2 (model without Supply Chain Risks) = 0,29 – 0,22/ 1-0,29 = 0,09

3.4.9 - Moderation analysis

“A moderation effect is a causal model that postulates ‘‘when’’ or ‘‘for whom’’ an independent variable most strongly (or weakly) causes a dependent variable (Baron and Kenny 1986; Frazier et al. 2004; Kraemer et al. 2002). In essence, a moderator modifies the strength or direction (i.e., positive or negative) of a causal relationship” (Wu & Zumbo, 2008, p.370)

Moderation is characterized as a condition in which a third variable interferes in the relationship between a dependent variable and an independent one. From the influence of the moderator, the strength and direction of the effect generated by the predictor variable in the output variable can be changed. (Sarstedt, M., Ringle, C. M., & Hair, 2017)

From such assumptions, we further explore the relationship between Supply Chain Agility and Operational Performance, we introduce supply chain risk management as a moderator variable that can be assumed to positively influence the relationship between Supply Chain Agility and Operational Performance. For industries with better practices of risk management in place, there may be a higher positive impact of supply chain agility upon performance.

Our next concern is with the size of the moderating effect. As shown in Figure 8, the interaction term positively affects Operational Performance (0,140), whereas the simple impact of Supply Chain Agility on Operational Performance is 0,187. Next, we assess whether the interaction term is significant. For this purpose, we run the bootstrapping procedure. The analysis yields a p-value of 0,020. Then, we can consider it significant. Thus, the relationship between Supply Chain Agility on Operational Performance increases by the size of the interaction term (0,187+0,140), equal to 0,327.

Finally, the last step addresses the moderator's f2 effect size. Joseph F. Hair, Hult, Ringle, & Sarstedt (2017) highlights that in the case of moderation analysis, Kenny (2016) proposes that 0.005, 0.01, and 0.025 constitute more realistic standards for small, medium, and large effect sizes than the traditional threshold that represent small, medium, and large effect sizes, respectively, of 0.02, 0.15, and 0.35, as proposed by (J. Cohen, 1988)Cohen (1988). The interaction term f2 effect size has a value of 0,050, representing a large effect of moderator effect.

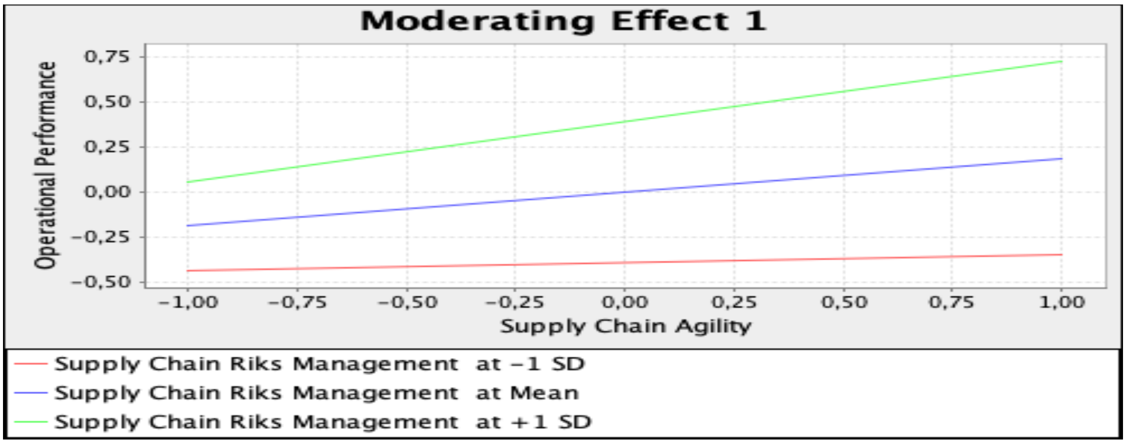

Figure III - 3 - Slope Analysis

3.4.10 – Summary of the analysis

Hypotheses	Results
H1: Supply Chain Risks negatively impacts Operational Performance	Supported
H2: Supply Chain Risks Management positively impacts Operational Performance	Supported
H3: Supply Chain Agility positively impacts Operational Performance	Supported
H4: Supply Chain Risks Management positively moderates the relationship Supply Chain Agility and Operational Performance.	Supported

Table III - 27 - Hypothesis Results

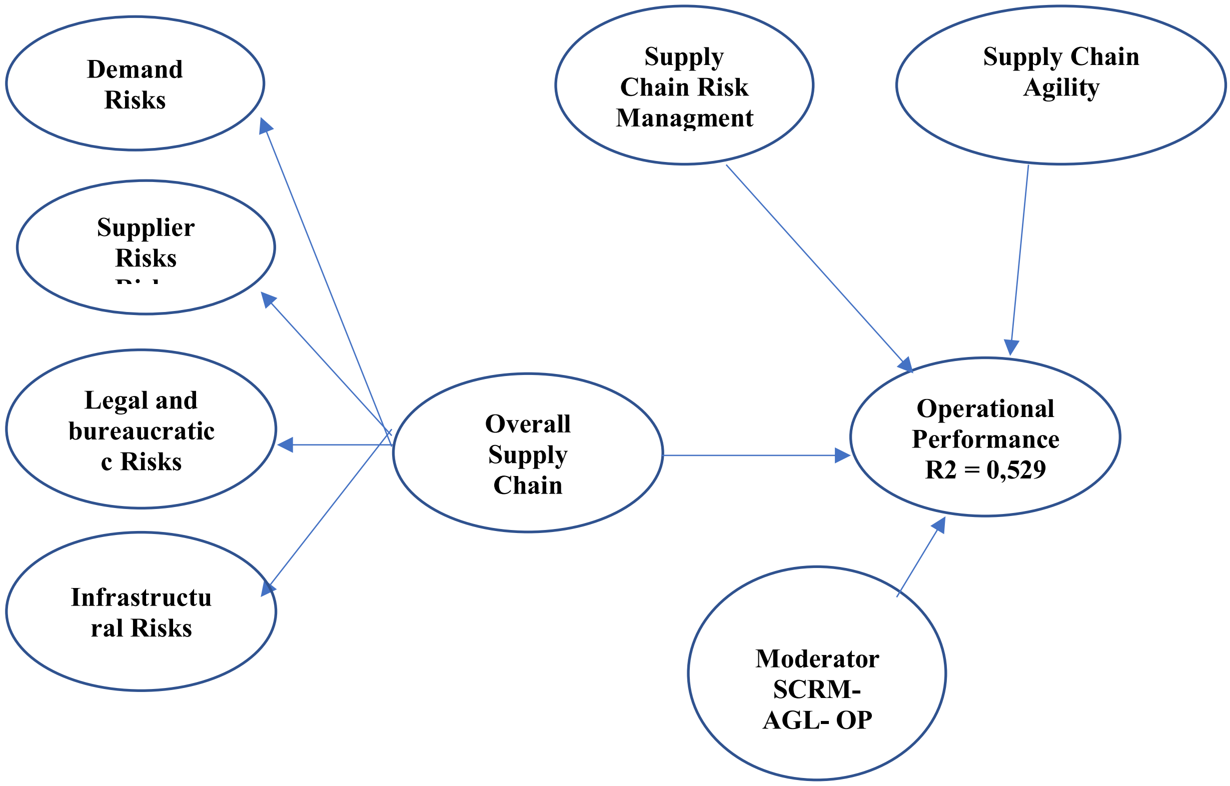

Figure III - 4 - Research Model - R2 Results

3.4.11 – Importance Performance Analysis (IPMA)

"This type of analysis extends the standard PLS-SEM results reporting of path coefficient estimates and other parameters by adding a procedure that considers the average values of the latent variable scores" (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, p. 105, 2017). IPMA allows the assessment of both the importance and the performance of the exogenous variable concerning its impact on an endogenous one, both at construct and indicator levels.

In regards to the importance dimension, as explained by (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p. 116-117), "a construct's importance in terms of explaining another directly or indirectly linked (target) construct in the structural model is derived from the total effect of the relationship between these two constructs. The total effect is the sum of the direct and all the indirect effects in the structural model (Hair et al., 2017)".

In IPMA analysis, the computation performance parameter "the indicator data determine the latent variable scores and, thus, their performance. Similarly, when conducting an IPMA on the indicator level, the mean value of an indicator represents its average performance". (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p.110).

Constructs	Performances Results	Importance
Supply Chain Risk Management	76.14	0.28
Supply Chain Agility	70.67	0.13
Supply Chain Risks	17.50	- 0,39

Table III - 28 - IPMA Results at Construct Level

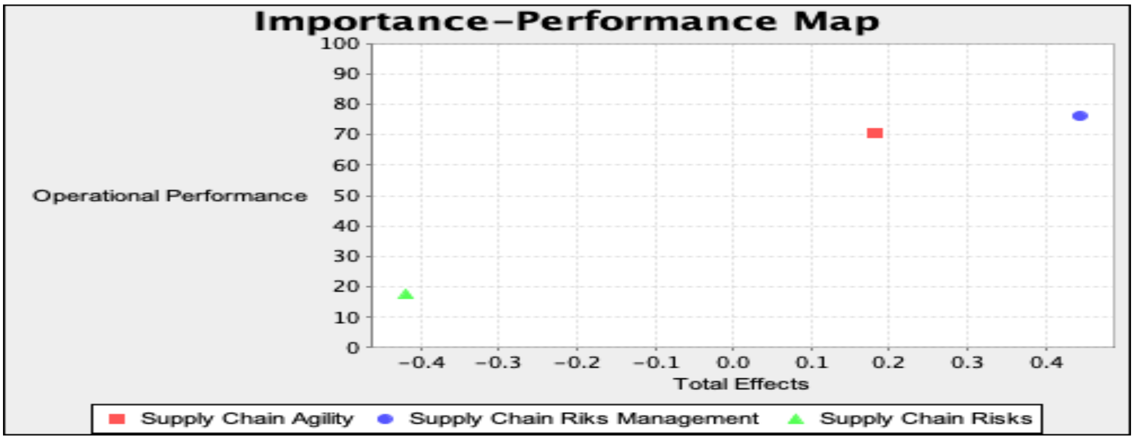

Figure III - 5 - IPMA Results Construct Level

	Performance Results	Importance Results
SCRM 1 - Systematic identification of sources for such disruptions.	74.24	0.07
SCRM2 - Assessment of both own risks and risks of important suppliers and customers	76.46	0.07
SCRM4 - Continuous monitoring of developments that might promote such disruptions.	74.75	0.07
SCRM3 - Assigned persons responsible for the management of such risks.	79.90	0.06
AGL2 - Adapt level of customer service.	76.36	0.05
AGL3 - Adapt delivery reliability.	68.38	0.03
AGL4 - Adapt responsiveness to changing market needs.	68.28	0.03
AGL 1 - Adapt manufacturing lead times.	65.35	0.02
Average	72,96	0,05

Table III - 29 - IPMA Results Indicator Level

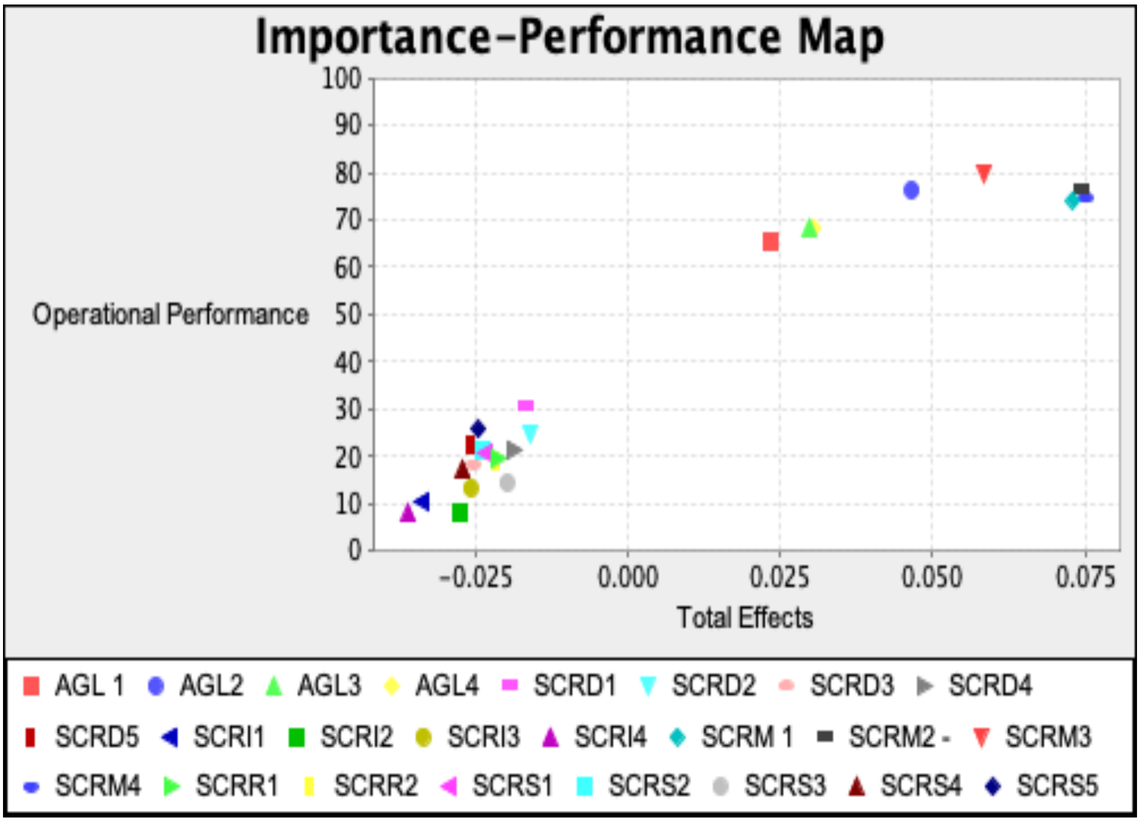

Figure III - 6 - IPMA Results Indicator Level

3.5 – DISCUSSIONS AND IMPLICATIONS FOR RESEARCH AND PRACTICE

This paper aims to empirically investigate the effects of Supply Chain Risks, Supply Chain Agility, and Supply Chain Risk Management upon Operational Performance in the context of the Brazilian business environment. In chapter 2, the results indicate that Overall Supply Chain Risks negatively influence Operational Performance in the Brazilian Industries environment.

Based on the findings of the previous chapter, the present work emerges in an environment where supply chains must deploy appropriate actions to achieve superior performance in today's turbulent and risky environment. The current investigation's central theme assumes that the variance in organizational performance results from both the negative impact from different dimensions of risks and the positive impact produced by various dynamic capabilities that steam from routines that seek to exploit the firm's internal and external resources.

In the present research, among different resources and processes, we chose to study Supply Chain Agility and Supply Chain Risk Management as two types of dynamic capabilities that may alleviate the adverse effects produced by Supply Chain Risks by improving Operational Performance. Thus, this research aims consist of evaluating and distinguishing the influence of a different set of dynamic capabilities (Supply Chain Management Strategies) on Operational Performance.

The first research question proposed was "How do Supply Chain Risk Management and Supply Chain Agility influence the Operational Performance of Manufacturing companies in Brazil? The interpretation of the results leads us to conclude about the positive impact of Supply Chain Risk Management upon Operational Performance, which supports the importance of deploying this strategy to cope with volatile and risky environments. Other scholars, as exposed in table 5, also support such a view.

These results also contribute to support the theoretical proposition of Um & Han's (2020), Krzakiewicz & Cyfert (2015), Nair et al.(2014) that characterized Risk Management as a critical Dynamic Capability. Furthermore, the present study's findings enrich the research field with empirical evidence that Organizations should deploy Supply Chain Risk Management to foster better performance and competitive advantage, as proposed by scholars like Kilubi & Haasis (2016), Alkhudary, Brusset, & Fenies' (2020), and Gurtu & Johny (2021).

Thus, we can conclude that efforts towards implementing and executing Supply Chain Risks Management through identifying risk sources, assessing both own risks and risks of critical suppliers and customers, assigning persons responsible for managing such risks, and continuous monitoring reflect positively on Operational Performance.

Concerning the influence of Supply Chain Agility on Operational Performance, our results conveys a positive impact of such a dynamic capability. This finding is in line with the researches presented in table 3. The results contribute to research in the field where the positive effect of agility on performance is still not apparent (Khan & Wisner, 2019).

In terms of managerial implications, our results strengthen the importance of Supply Chain Agility as a dynamic capability that can support industries to positively impact operational performance to balance or even overcome the negative impact produced by different risks sources. This observation finds alignment with Altay et al. (2018); Aslam et al. (2020); Eckstein et al. (2015); Khan K et al. (2009; Sharma et al., (2017) previous studies.

Our empirical observations also provisionally confirm the role of Supply Chain Risk Management as a moderator among the relationship between Supply Chain Agility and Operation Performance. This finding provides a different perspective since, in the literature, Supply Chain Risk Management has been understood as a direct influencing factor of Supply Chain Agility, as in the studies of Wieland & Marcus Wallenburg (2012) and Hamdi et al. (2020). Our work answers Nazempour et al. (2018) suggestion concerning the need for empirical scientific research about the role of moderating factors among Supply Chain Agility and Operational Performance.

The negative influence of Supply Chain Risks on Performance (H1) tested in chapter 3 was reconfirmed in the improved conceptual model here evaluated. Then, the confirmation of hypotheses 2, 3, and 4 support our proposition that both Supply Chain Risk Management and Supply Chain Agility support our recommendation concerning the role of those capabilities to alleviate the adverse effects produced by Supply Chain Risks by improving Operational Performance.

In regards of the statistical results produced by our analysis, as suggested by Sarstedt & Danks (2021, p.4), “Researchers evaluate their models' explanatory power based on F-type metrics and the R2 (Cohen, 1988), followed by an assessment of the model coefficients in terms of their significance, direction, and size”.

Thus, based on the statistical results, we can assess the explanatory power of our model. The coefficient of determination of 0.529 indicates that our exogenous variables have a moderate, in sample, predictive power, which explains almost 53% of the variance of Operational Performance. The effect size ($f2$ values), available at table 25, conveys that Supply Chain Agility has a small effect on operational performance, whereas Supply Chain Risks Management and Supply Chain Risks produce medium effects.

Regarding Supply Chain Risks, it is important to notice that in the model initially tested in Chapter 2, a Supply Chain Risks on Operational Performance had a large effect on Operational Performance (value of 0.57). In contrast, in the improved model, it shifted to a medium effect (value of 0.24) after the inclusion of Supply Chain Risk Management and Supply Chain Agility. From this results, we may concluded about the role of risks management and agility in producing positive results on performance and then alleviating the adverse effects produced by Supply Chain Risks by improving Operational Performance, as proposed initially.

In terms of predictive relevance of our model (out of sample), the blindfolding procedure results (Stone-Geisser's Q^2 value) of 0.288 indicate that the exogenous constructs have predictive relevance for the endogenous constructs under consideration at a moderate level.

Our second research question was draft as follows: Which Supply Chain Strategy is more relevant in terms of its relevance and performance to increase the Operational Performance of Manufacturing companies in Brazil? To answer such a question, we extended the standard PLS-SEM through the of IPMA analysis, which yielded further and valuable observations.

The application of such analysis on our research, at the latent variable level, supported evaluating the relative influence of the Supply Chain Risk Management and Supply Chain Agility on Operational Performance. In sum, the results indicate that Supply Chain Risks Management has relatively higher importance and performance than Supply Chain Agility in terms of impact upon operational performance. The IPMA calculation shows that Supply Chain Risk Management's importance is more than twice the size of Supply Chain Agility in terms of absolute value (see table 28).

Considering that the level of importance conveys the total effects generated by exogenous construct on an endogenous one, in other words, we may conclude that Supply Chain Risks Management has high predictive strength of Operational Performance in regards to Supply Chain Agility. From such observation, we can conclude about the relatively higher importance of Supply Chain Risk Management as a Dynamic Capability, which entails sensing and seizing threats and opportunities.

The IPMA analysis at the indicator level also yielded compelling insights. All specific actions towards Supply Chain Risk Management entail a higher performance and importance in comparison to Supply Chain Agility (see table 29). We observed that four risk management activities (identifying, assessing, assigning persons responsible, and continuous monitoring risks) have a similar result both in terms of its execution by the industries in Brazil and its relevance regarding the positive effect upon performance.

We can also interpret that the higher the performance values of a specific indicator, the higher the presence of the risk management measure under investigation within organizations daily processes and routines. On average, the actions towards the execution of Supply Chain Risk Management are executed in the following decreasing order: assigned persons responsible for managing such risks; assessing both own risks and risks of important suppliers and customers; and continuous monitoring of developments that might promote such disruptions; Systematic identification of sources for such disruptions.

The same logic applies to Supply Chain Agility. From the results, we can observe that, on average, industries have relative higher speed of reaction to adapt their operations in the following decreasing order: level of customer service; delivery reliability, responsiveness to changing market needs; and manufacturing lead times.

Thus, from the theoretical contribution point of view, we believe that this article also enriched the field of Dynamic Capability since the empirical evidence and the statistical results obtained found congruence with essential and core concepts of this Management Theory. Moreover, our findings reduce the empirical, theoretical, and population gaps identified during the research process.

Based on our findings, Brazilian industries may prioritize using their scarce resources towards improving Supply Chain Risks Management and Supply Chain Agility Dynamic Capabilities. In the case of Supply Chain Risks Management, enterprises may invest in the enabling factors proposed in the literature by Norrman & Wieland (2020) and Kilubi, Irène; Haasis (2015). Organizations should also invest in improving Supply Chain Agility through the development of the enablers proposed by Wieland & Marcus Wallenburg (2012), (Kumar Sharma & Bhat, 2014) Al Humdan et al. (2020), Al-Zabidi, Rehman, & Alkahtani (2021).

As discussed previously, our study considered the business environment of Brazilian industries exclusively. For this reason, we believe that this research achieves its originality to some degree because no other investigation only considered the Brazilian industries. As raised by Manhart, Summers, & Blackhurst (2020), studies in this area of Supply Chain Risk Management should take into consideration of more country-specific characteristics and industries particularities,

In sum, our contribution to the Supply Chain Management field professionals derives from the scientific confirmation that the investments in Supply Chain Risk Management and Supply Chain Agility managerial actions are valuable in their return on Operational Performance results.

3.6 - CONCLUSION

At the level of a manufacturing plant, in the specific context of the Brazilian business environment, this article explored the impact of Supply Chain Risk, Supply Chain Risk Management, and Supply Chain Agility upon Operational Performance using Dynamic Capability Theories to support the investigation. This research pursued expanding the frontier of the current knowledge of supply chain management to enrich the discussion about such phenomena and topics at critical developmental stages. The analysis is built on the model developed and analyzed at Chapter 2.

Our research pursued to fulfill the following two specific objectives as follows:

- to evaluate the influence of Supply Chain Risk Management and Supply Chain Agility on Operational Performance of Manufacturing companies in Brazil.
- to distinguish the influence of Supply Chain Risks Management and Supply Chain Agility in terms of its relevance and performance to increase Operational Performance of Manufacturing companies in Brazil.

To achieve the objectives above, in section 2.3, a review of the relevant literature concerning the Dynamic Capability Theory, Supply Chain Risk Management, and Supply Chain Agility was presented to justify and build a comprehensive conceptual framework explanation. The main definitions of the variables mentioned above, the main empirical studies available in the literature, and the studies performed in Brazil were detailed to enrich the discussion.

Next, in section 2.4, the structural equation model was detailed based on the theoretical constructs of interest, and the proposed hypotheses were presented. In this section, the collection method, the sample size, the research design, and the complete statistical analysis of the inner and outer model, which includes high order and low order constructs, were assessed in detail.

In section 2.5, we analyze the empirical results from both the theoretical and managerial lenses, discussing the implications of the findings for both academics and managers.

In terms of the Dynamic Capability theory perspective, we found empirical evidence that strategies like Supply Chain Risk management and Supply Chain Agility may support companies in the process of sensing risks, seizing and adapting their processes and resources towards better operational performance. The positive impact produced by such a set of strategies contributes to alleviating the negative impact of Supply Chain Risks on Operational Performance, further discussed in chapter 2.

The positive moderation role produced by Supply Chain Risk Management in between the relationship of Supply Chain Agility and Operational Performance opens the venues for further evaluation about this effect, considering other business environments and other performance dimensions like financial, social, and environmental.

The execution of the IPMA also allows us to refine our understanding both in terms of the relative role among the latent variables and in between the indicators. Such analysis suggested a prevalence of Supply Risk Management actions over Supply Chain Agility concerning its current frequency among Brazilian industries and its influence on Performance.

In sum, in terms of managerial analysis, we found evidence that industries must focus on investing in risk management activities to identify, assess, control, and monitor possible risks. Our results also indicate that organizations may benefit, in terms of their Operational Performance, through investing in the capacity to fast react in terms of customer service, delivery reliability, responsiveness to changing market needs, and manufacturing lead times.

The results of this study justify the vanguard position that risk management and agility have taken in recent years, both in terms of research and from a managerial point of view. Our investigation confirm the essential role that such approach have in supporting organizations that deal with an uncertain and extraordinarily dynamic environment, from which countless risks inevitably arise.

We attribute value and originality of since in the context of Brazilian industries', to the best of our knowledge, it is one of the first quantitative studies that investigated the role of Supply Chain Risk, Supply Chain Risks Management, and Supply Chain Agility as potential influencing factors upon operational performance since no the previous scientific studies was found with the same scope.

As consequence, our results contribute to reduce the current scientific gaps identified in literature (empirical, populational, and theoretical). This study also contributes to academia by confronting our findings against pre-established antecedent research hypotheses concerning the influence of Supply Chain Risk Management and Supply Chain Agility upon Operational Performance.

It is essential to acknowledge that this research also has significant limitations as follows: the study took into consideration only the Brazilian industries segment; the study does not cover service industries; our sample comprises 52% small and medium industries and 48% of larger firms based on sales volume parameters.

According to the author's views, these limitations are acceptable. We chose Brazilian industries due to distinguish characteristics compared to other environments where the studies about dynamic capabilities in Supply Chains have been executed. The limited number of scientific researches dedicated to this environment is another motivating factor. The manufacturing plant was selected as the unit of analysis in this research. Thus, due to this reason, no service industries were considered. Finally, the sample size profile of mix size companies does not conflict with the general purpose of this study.

We understood that there are still vast opportunities for further research concerning the phenomena proposed here. For example, the following areas could be offered and investigated as a continuity of the present study:

- Future studies may expand this research by applying our conceptual model in different segments set.
- Future research may also investigate the following questions: (1) What are some of the other potential supply chain strategies which can be configured, at the firm level of analysis, as different essential types of capabilities for improving operational performance? For example, could Supply Chain Integration play a vital role in enhancing operating performance in complement of Supply Chain Risk Management and Supply Chain Agility? (2) What are some of the potential moderators of the relationships between supply chain risk, Operational Performance? (3) What are the necessary conditions to increase Operational Performance?
- The model proposed and tested here may be reproduced and improved by other scholars on specific settings and industry segments since our results indicate predictive relevance in moderate terms.

Additionally, to the questions raised above, further investigation can be deployed based on the principles of the triangulation method to refine the generalized results obtained from the quantitative methods with the complementary application of qualitative methods among a few and specific industries, for example.

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APPENDIX – CONSTRUCTS ITEMS

SUPPLY CHAIN RISKS MEASURES

Instructions:

- Questions regarding Supply Chain Risk Measures starts with the letters "SCR"
- To what extent has your firm in the past 3 years experienced a negative impact in supply chain management due to…. (1 not at all– 7 to a very large extent)

Demand side risks measurements	1	2	3	4	5	6	7
SCR-D1 Unanticipated or very volatile demand							
SCR-D2 Insufficient or distorted information from your customer about orders or demand quantities							

Supply side risks measurements	1	2	3	4	5	6	7
SCR-S1 Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity)							
SCR-S2 Supplier quality problems							
SCR-S3 Sudden demise of a supplier (e.g., due to bankruptcy)							
SCR-S4 Poor logistics performance of logistics service providers							
SCR-S5 Capacity fluctuations or shortages on the supply markets							

Regulatory, legal and bureaucratic risks	1	2	3	4	5	6	7
SCR-R1 Changes in the political environment due to the introduction of new laws, stipulations, etc.							
SCR-R2 Administrative barriers for the setup or operation of supply chains (e.g., authorizations).							

Infrastructural risks	1	2	3	4	5	6	7
SCR-I1 Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents).							
SCR-I2 Perturbation or breakdown of intemal IT infrastructure (e.g., caused by computer viruses, software bugs).							
SCR-I3 Loss of own production capacity due to technical reasons (e.g., machine deterioration).							

SCR-I4 Perturbation or breakdown of external IT infrastructure.							

Catastrophic risks	1	2	3	4	5	6	7
SCR-C1 Political instability, war, civil unrest or other sociopolitical crises.							
SCR-C2 Diseases or epidemics (e.g., SARS, Foot and Mouth Disease).							
SCR-C3 Natural disasters (e.g., earthquake, flooding, extreme climate, tsunami).							
SCR-C4 International terror attacks (e.g., 2005 London or 2004 Madrid terror attacks).							

Table III - 30 - Supply Chain Risks - Retrieved from (Wagner & Bode, 2008a)

SUPPLY CHAIN AGILITY– MEASURES

- Questions regarding Agility starts with the letters "AGL"
- Please indicate the speed of reaction with which your company can engage in the following activities should changes occur (1 – slow; 7 – fast):

Agility measurements	1	2	3	4	5	6	7
AGL 1 - Adapt manufacturing leadtimes.							
AGL 2 - Adapt level of customer service.							
AGL 3 - Adapt delivery reliability.							
AGL 4 - Adapt responsiveness to changing market needs.							

Table III - 31 - Supply Chain Agility - Retrieved from Wieland & Wallenburg (2012)

SUPPLY CHAIN RISK MANAGEMENT – MEASURES

- Questions regarding Supply Chain Risk Management starts with the letters "SCRM"
- In order to counter disruptions of the material flow along our supply chain (both inbound and outbound), the following measures are taken (1 – strongly disagree; 7 – strongly agree):

Supply chain risk management measurements	1	2	3	4	5	6	7
SCRM 1 - Systematic identification of sources for such disruptions.							
SCRM 2 - Assessment of both own risks and risks of important suppliers and customers.							
SCRM 3 - Assigned persons responsible for the management of such risks.							
SCRM 4 - Continuous monitoring of developments that might promote such disruptions.							

Table III - 32 - Supply Chain Risk Management - Retrieved from Wieland & Wallenburg (2012)

OPERATIONAL PERFORMANCE MEASURES

Instructions:

- Questions regarding Operational Performance Measures starts with the letters "MOP"
- Indicate your evaluation for each variable based on the following question: How does your company perform compared with your major competitors (1-much worse; 7-much better)?

Operational Performance measurements	1	2	3	4	5	6	7
MOP 1 Overall product quality							
MOP 2 Customer service level							
MOP 3 Pre-sale customer service							
MOP 4 Product Support							
MOP 5 Responsiveness to customer							
MOP 6 Delivery Speed							
MOP 7 Delivery Dependability							
MOP 8 Volume flexibility							
MOP 9 Product Mix flexibility							
MOP 10 New product Flexibility							

Table III - 33 - Operational Performance - Retrieved from (Huo et al., 2014)

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CHAPTER 4

Article 3

The Impact of Supply Chain Strategies on Operational Performance and Supply Chain Robustness: a sufficiency and necessity logics perspectives.

4.1 INTRODUCTION

The investigation performed so far, in chapter 2, focuses its attention on exploring the effects of overall Supply Chain Risks on Operational Performance and the role of complexity drivers, firm size, and type of strategy for competitive advantage. In Chapter 3, the investigation about the impact of two potential dynamic capabilities named Supply Chain Risk Management and Supply Chain Agility on Operational Performance was the central theme. Empirical data collected among Brazilian industries supported the majority of the hypotheses which steam from the conceptual framework.

To this point of the research, the results show that Supply Chain Risk Management and Supply Chain Agility contributes to generating higher competitive advantage through better Operational Performance levels in contrast to the adverse effects induced by different sources of Supply Chain Risks. Here in complement to the strategies already investigated, we proposed to explore Supply Chain Integration as another set of dynamic capabilities that may positively influence performance and recovery from disruptions (Duong & Chong, 2020).

The aforementioned proposed complementary investigation is motivated by compelling scientific arguments. For instance, Supply Chain Supplier, Internal and Customer Integration have been advocated as a practical approach to supporting organizations to achieve relatively higher Operational Performance. Some studies support such positive relationships, such as Cheng, Chaudhuri, & Farooq, (2016); Lu, Ding, Asian, & Paul, (2018); Munir, Jajja, Chatha, & Farooq, (2020). In contrast, scholar as (Boon-itt & Wong, 2011; Khan & Wisner, 2019; Swink, Narasimhan, & Wang, 2007) found negative, insignificant or mixed results.

Another essential motivation of the current research effort is to put in place an investigation into the Brazilian industry's environment. Flynn, Huo, & Zhao, (2010), for instance, suggest that further studies concerning the relationship between integration and performance in developing economies would interest the scientific community. Kamal & Irani (2014), also call for further research at unexplored regions, such as Brazil, to expand the research about Supply Chain Integration and then to empirically generate more publications concerning this topic

At this stage of the research, we also improve our model by including Supply Chain Robustness into our conceptual framework as second dimension of performance to be investigated in addition to Operational Performance. We propose that organizations should excel not only in outrival the competitors momently concerning quality, service level, product support, responsiveness, delivery speed, and flexibility. As stressed out by Wieland & Wallenburg (2012), industries must also develop capabilities to ensure continuity to operation, continuous capacity to meet customer demand, keep performance on agreed targets, and carry out its regular functions, in case internal or external disruptions occur.

Supply Chain Robustness inclusion as a second dependent variable in the conceptual framework also stems from an emerging interest and importance in academia and manufacturing (Monostori, 2018). Moreover, literature about the relationships between Supply Chain Integration, Supply Chain Agility, and Supply Chain Robustness remains limited (Zhuo et al., 2021).

Industries can benefit from dynamic capabilities, but due to its multidimensionality dimensions, managers must understand that each capability may produce a different effect upon performance (Kareem & Kummitha, 2020). Thus, from a practical perspective, by improving the conceptual model and testing five different types of dynamic capabilities and their relationship with operational performance and supply chain robustness, we seek to explore further which capabilities are vital to Supply Chains.

From an academic perspective, researchers have sought to identify and define Dynamic Capabilities. Still, there is a small number of studies dedicated to exploring the relationship between different dynamic capabilities and performance (Mathivathanan, Govindan, & Haq, 2017).

As we discussed in the previous chapter, Dynamic Capabilities are essential to support companies' performance in a turbulent environment. "Successfully building strong dynamic capabilities allows firms to challenge competitors that are enamored with the resources they currently possess." (Teece, 2014, p.337). Still, despite its importance, there is a poor understanding of such managerial approaches due to the lack of models that enable empirical investigation. (Pavlou & El Sawy, 2011),

Historically, scholars reported dynamic capabilities as necessary conditions to achieve a more significant competitive advantage and outperform rivals but with no appropriate quantitative method to support such calls, as shown in the examples below. Moreover, Tho (2018, p. 323) points out that to the best of the author's knowledge, however, the question of what level of each capability serving as a necessary condition for a wanted level of performance has been largely ignored the literature.

"Dynamic capabilities are necessary, but not sufficient, conditions for competitive advantage" (Eisenhardt & Martin, 2000, p.1106).

"Dynamic capabilities are necessary in turbulent contexts (Castiaux, 2012, p.3)

"Dynamic capabilities are necessary but not sufficient on their own. Sensing, seizing, and reconfiguring capabilities are peripheral to organizational performance, as their cause-effect associations with performance are weak" (Jantunen, Tarkiainen, Chari, & Oghazi, 2018, p.5).

PLS-SEM would not be suitable to evaluate the Dynamic Capabilities as a necessary condition since it is adequate to measure the average net effect and significance of the relationships among the dynamic capabilities and performance. Then, in this chapter, we propose contributing to reducing such a gap in research through Necessary Condition Analysis (NCA) in the complementarity of PLS-SEM.

NCA is an emerging methodological prism recently proposed by (Dul, 2016) based on the necessity of logical reasoning. The necessity logic means that a certain level of X (the condition) is necessary for a certain level of Y (the outcome). Unlike regression-based models where researchers include variables to improve the model predictive capacity through average tendencies, NCA shifts our attention from 'average trends' to the logic of 'the required level.

In quantitative research, several models are anchored based on the regression approach, which follows an additive pattern where factors are included in the model to improve predictions about average tendencies. In contrast, NCA relies on understanding the required level of a specific condition. The objective is to capture the "must-have" factors instead of the "should have." When applied correctly, NCA may support research to identify the conditions that, when absent, will imply the absence of the outcome or, when present, will enable the presence of the outcome (Dul, 2016; Dul, Karwowski, & Kaufman, 2020).

As proposed by (Richter, Schubring, Hauff, Ringle, & Sarstedt, 2020, p. 2243), "PLS-SEM and NCA enable researchers to identify the must-have factors required for an outcome in accordance with the necessity logic. At the same time, this approach shows the should-have factors following the additive sufficiency logic. Combining both logics enables researchers to support their theoretical considerations and offers new avenues to test theoretical alternatives for established models".

It is crucial to notice that, to this date, there is a limited number of studies that have applied the NCA methodological approach in the field of Supply Chain Management to understand the different phenomenon in this field from a necessity logic view. The researches of Stek & Schiele (2021); Van der Valk, Sumo, Dul, & Schroeder (2016) are examples of studies that have applied it.

The present investigation aims to evaluate and distinguish the influence of a different set of dynamic capabilities (Supply Chain Management Strategies) on Operational Performance and Supply Chain Robustness, considering both sufficiency logic and necessity logic view. From such research aim, we established the following Research Objectives:

Objective 6 –to evaluate the influence of Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration on Operational Performance, and Supply Chain Robustness of Manufacturing companies in Brazil

Objective 7 – to evaluate if Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration are necessary conditions to Operational Performance and Supply Chain Robustness in the context of Manufacturing companies in Brazil

Objective 8 - to evaluate if Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration are necessary and significant conditions to Operational Performance and Supply Chain Robustness in the context of Manufacturing companies in Brazil

From the objectives stated above, the following research questions emerge:

RQ6: How do Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration influence Operational Performance and Supply Chain Robustness in the Manufacturing companies in Brazil

RQ7: Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary conditions, to a certain degree, to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

RQ8: Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary, to a certain degree, and significant condition to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

From an academic view, we seek to reduce four research gaps: evidence, methodological, empirical and population gap based on Miles's (2017) taxonomy. The evidence gap stems from the contradictory results about the impact of Dynamic Capabilities, like Supply Chain Integration and Performance. By applying the combined approach PLS-SEM and NCA, we seek to offer a new line of research both to the Dynamic Capabilities and Supply Chain Management field of study. Finally, the empirical investigation in unexplored arenas like the Brazilian Manufacturing industries may reduce the population and empirical gap.

In terms of practical and managerial implications, the results of this research may support companies in the process of deciding in which strategies they should invest in terms of Supply Chain Integration, Supply Chain Risk Management, and Supply Chain Agility to counteract the adverse effects of Supply Chain Risk and ensure higher levels of Operational Performance as well as Supply Chain Robustness.

To meet such research objectives, the organization of study follows this sequence: the first section covers the theoretical background. Subsequently, we explain research methodology, sampling procedures, and analysis techniques. Next, the third section covers the results and discussions. The paper's final part will discuss the managerial implications, limitations, and future directions for academic scholars and professionals.

4.2 - LITERATURE REVIEW

4.2.1- Dynamic Capability

In the previous chapter, we present the following main arguments concerning dynamic capabilities theory and its fit to our conceptual framework:

- Due to the rapidly changing environment, the dynamic capabilities view emerged as an expansion of Resource-Based Theory. The article named Dynamic Capability and Strategic Management proposed a different perspective in which instead of relying on specific and stable resources, organizations should develop the ability to integrate, build, and reconfigure internal and external competencies to achieve and sustain competitive advantage (Teece, Pisano, & Amy, 1997).

- "Dynamic capabilities have been defined as abilities (or capacities) but also as processes or routines" (Barreto, p.260, 2010). When developing the framework for theory application, Teece et al., (1997) suggested that the essence of an organization's dynamic capabilities and competitive advantage relies on its assets, processes, and the paths (strategic choices) that are made.

- Eisenhardt & Martin (2000, p.1107) also consider processes and routines part of Dynamic Capability definition. The authors define it a "The firm's processes that use resources—specifically the processes to integrate, reconfigure, gain and release resources—to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die.".

- "For analytical purposes, dynamic capabilities can be disaggregated into the capacity to sense and shape opportunities and threats, to seize opportunities, and to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets. Dynamic" (Teece, 2007,p. 1319)

- "The sensing capability entails processes for gathering and interpreting data, allocating resources and tasks and communicating decisions and information" (Sanchez and Heene, 1996). The "Seizing capability" includes enterprise structures and procedures for identifying threats and opportunities. whereas "Transformation capability" is the continuous alignment and realignment of operational practices (Teece, 2007)". (Vanpoucke et al., 2014, p.3)

- "Dynamic capabilities can be understood as a relatively parsimonious framework for explaining an extremely seminal and complicated issue: how a business enterprise and its management can first spot the opportunity to earn economic profits, make the decisions and institute the disciplines to execute on that opportunity, and then stay agile so as to continuously refresh the foundations of its early success, thereby generating economic surpluses over time" (Teece, 2007, p. 1347).

- The central role of the relationship among managerial practices (to sense threat and opportunity, mobilize resources and reconfigure internal and external competencies) and performance emerges as a phenomenon of interest in the process of dynamic capability theory empirical testing efforts.

- According to (L. Y. Wu, 2010), the majority of the researches which utilize Dynamic Capabilities as theoretical lenses are focused mainly on conceptual approach and, consequently, the field still lacks empirical evidence. Thus, we seek to enrich the Dynamic Capability Research field following a deductive approach, in which "the goal of the researcher is to test concepts and patterns known from theory using new empirical data" (Bhattacherjee, 2012, p.3).

- The central theme of the present investigation assumes (Teece et al., 1997) (Jajja et al., 2018b) Brusset & Teller (2017) (Barreto, 2010); (Teece et al., 1997) (L. Y. Wu, 2010); (Zhou & Li, 2010) perspectives which are structured at the premise that the variance on organizational performance can be understood as a consequence of an array of different dynamic capabilities which steam from routines that seek to exploit firm's internal and external resources. On the other side, Vanpoucke, Vereecke, & Wetzels, (2014, p.3) suggest that “the role of dynamic capabilities on performance is a central but as yet unresolved issue among strategic scholars.”

By now, according to the empirical investigation performed in Chapters 2 and 3, we assume that supply chain risks may increase the possibility of facing undesirable unknown futures. It is necessary to implement strategies to make companies able to sense the information concerning risks and threats. In addition to that, it is crucial to assess if industries can seize this information through the appropriate enterprise structures, procedures, and strategies for identifying such risks, learning from them, and quickly transforming their processes.

In the previous chapter, we found that Supply Chain Risk Management and Supply Chain Agility processes and routines support companies in sensing, seizing, and transforming their operations and practices to assess, control, and monitor possible risks within the supply chain towards better Operational Performance.

This chapter integrates into the conceptual framework Supply Chain Integration as another type of dynamic capability. It enables a different set of abilities (or capacities) through processes or routines that may support organizations to achieve and sustain competitive advantage.

In the literature, a significant number of researchers classify Integration in the supply chain as a strategic capability (Liu, Blome, Sanderson, & Paulraj, 2018). For instance, as per (Vickery, Koufteros, & Droge, 2013, p.750), based on (Eisenhardt & Martin, 2000; Pavlou & El Sawy, 2011) research, suggest that Supply Chain Integration can be considered as Dynamic Capability since “it catalyzes and accelerates knowledge acquisition from internal and/or external sources, helping managers devise strategies for extending, modifying, and reconfiguring existing capabilities into new ones that better match the environment.”

Other studies like (Giunipero, Hohenstein, Feisel, & Hartmann, 2015; Serhiy Y. Ponomarov & Holcomb, 2009), quoted by (Zhuo et al., 2021), have considered Supply Chain Integration as a resource that supports organizations to adapt their processes and structures to face and react to disruptions.

From such a perspective, we understand that integration, as a collective approach between different companies and internally among functions, is at the heart of what is meant by dynamic capabilities. As stated by (Vickery et al., 2013, p. 760), “Supply Chain Integration represents, in essence, the internal and external structure through which the organization senses the environment, learns from the environment, and integrates and coordinates internally and externally.”

In this sense, here we hypothesized that strategies like internal integration, supplier integration, and customer integration, in complement of Supply Chain Risk Management and Supply Chain Agility, may support companies in the process of sensing and seizing risks and threats and transform their operations and actions towards achieving relative higher Operational Performance against a competitor as well to build Supply Chain Robustness.

4.2.2- Supply Chain Integration

As quoted by (Germain & Iyer, 2006, p.32), "Integration may be defined as the unified control of a number of successive or similar economic or especially industrial processes formerly carried on independently" (Benton, 1966, p.1175)."

Due to competition in the global market, business practices include integration as part of the supply chain strategy. In this context, "the manufacturing industry is expected to build integration with suppliers and customers easily and quickly" (Tarigan, Mochtar, Basana, & Siagian, 2021, p.283).

The meta-analysis of Leuschner, Rogers, & Charvet (2013) demonstrated that starting in 1994, the number of publications about Supply Chain Integration has increased despite a momentary eventual reduction in the publication in specific years of 2001, 2007, 2009, and 2011. Erboz & Szegedi (2020) also emphasized such growing interest through their review of Supply Chain Integration published from 2000 to 2019.

In the academia, there are several definitions of Supply Chain integration from previous research. In the past years, the different authors discussed the definition of Supply Chain Integration. Morash & Clinton (1998) defines that there is, at least, three types of integration: intra-organizational (process integration), inter-organizational (collaborative integration), inter-organizational (operational integration). The integration of cross-functional flows characterizes the first; the second type covers the integration of behavioral, communicational, and interactive flows. The third is based on the integration of physical, spatial, and temporal flows. Schoenherr & Swink (2012) also conceptualize supply chain integration in three dimensions: supplier, customer, and internal integration.

Frohlich & Westbrook's (2001) study suggests two types of supply chain integration (forward and backward). The first comprises the collaboration among manufacturer, supplier, and customer towards the flow delivery of products, whereas the former is concerned with the flow of data from customers to suppliers.

The different research efforts upon supply chain integration have offered several definitions and dimensions characterizing such a concept. For instance, Kamal & Irani (2014) define supply chain integration as the extent to which a company strategically interconnects and aligns its supply chain with its partners, upstream and downstream. Bagchi, Chun ha, Skjoett-Larsen, & Boege Soerensen (2005, p.178) define supply chain integration "as the comprehensive collaboration among supply chain network members in strategic, tactical and operational decision-making."

Y. Liu, Blome, Sanderson, & Paulraj (2018) argue that a supply chain integration includes internal and external integration, and both play distinct roles in the context of Supply Chain Management. According to the authors' internal integration focuses on cross-functional collaboration within a firm, whereas external integration recognizes the importance of establishing collaboration with suppliers and customers.

In the literature reviews performed by (Alfalla-Luque, Medina-Lopez, & Dey, 2013; Erboz & Szegedi, 2020; Kamal & Irani, 2014), the authors discussed that due to the lack of clarity concerning the concept of Supply Chain Integration, several scholars conceptualized it as one dimension construct. In contrast, others understand it as a multiple-dimensional construct. Thus, the definition of Supply Chain Integration "still suffers from a lack of convergence in terms of its dimensions, strategies, and challenges (Erboz & Szegedi, 2020, p.47)

Recently, the literature review executed by Hassan & Abbasi (2021, p.4) reconfirm such a condition: "Though reasonable number of studies have considered SCI by the way of unidimensional construct, yet its multidimensional essence has also been pursued in many studies." The authors above also stress out that "there has been a notable debate on the scarcity of conceptual clarity on the concept of SCI" (Hassan & Abbasi, 2021, p.5).

We organized and elaborate from the work of Hassan & Abbasi (2021), (Kamal & Irani, 2014) and Alfalla-Luque, Medina-Lopez, & Dey (2013), at table 1, with examples of studies and some of the definitions of Supply Chain Integration with respective dimensions along the last 20 years.

Supply Chain Integration	Dimensions	Definition
(Frohlich & Westbrook, 2001, p.197)	Supplier and Customer	"The extent companies organizationally integrate activities with your suppliers and customers"
(Dong, Carter, & Dresner, 2001, p. 480-481)	Supplier and Customer	"The extent that the organization have logistics agreements and programs with customers and supplier"
(Narasimhan & Kim, 2002, p.311)	Supplier, Internal, and Customer	"Company's integration with suppliers, internally and customer, for instance, in terms of Information exchange, participation in design and procurement, data integration, system-wide interaction, computerization for customer orders, and follow-up with customers for feedback"
(Vickery, Jayaram, Droge, & Calantone, 2003, p.524)	Supplier, Internal, and Customer	"Integrating information that facilitates the collection of vital information concerning key business both upstream or supplier integration, downstream or customer integration, and horizontal integration within the firm"
(Briscoe & Dainty, 2005, p.325)	Supplier, Internal, and Customer	"Combination of formal and informal processes"
(Kannan & Tan, 2005, p.153)	Supplier and Customer	"The integration of buyers' and suppliers' decision-making processes to improve material flow throughout the supply chain."
(Bagchi, Chun ha, Skjoett-Larsen, & Boege Soerensen, 2005, p.278)	Supplier and Customer	"Comprehensive collaboration among supply chain network members in strategic, tactical, and operational decision-making."
(Germain & Iyer, 2006, p.32)	Internal and External	"Internal integration refers to unifying functions and processes inside the firm and includes warehousing, transportation, inventory management, purchasing, demand planning, and production." "External integration refers to unified control of functions and processes across trading partners."
(Devaraj et al., 2007)	Customer and Supplier Integration	"Engage in information sharing and other forms of collaboration between customers and suppliers that address the issues of production planning and scheduling of their products"
(Sezen, 2008, p.236)	Supplier and Customer	"Information sharing with customers and supplier"
(Kim, 2009, p.329)	Supplier, Internal, and Customer	" internal cross-functional integration within a firm and external integration with suppliers or customers"
(Flynn, Huo, & Zhao, 2010, p.59)	Supplier, Internal, and Customer	The degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra-and inter-organization processes

(Boon-itt & Wong, 2011, p.254)	Supplier, Internal, and Customer	"Supply chain integration involves the processes of collaboration across functional departments, suppliers, and customers to arrive at mutually acceptable outcomes"
(Prajogo & Olhager, 2012, p.514)	Supplier, Customer and Informatiom	"Logistics integration refers to specific logistics practices and operational activities that coordinate the flow of materials from suppliers to customers throughout the value stream." "Information integration refers to the sharing of crucial information along the supply chain network, which is enabled by information technology"
(Yang, Rui, Rauniar, Ikem, & Xie, 2013, p. 137)	Supplier and Customer	"The degree of searching for new ways to integrate supply chain management activities, reducing response time across the supply chain, improving integration activities, establishing more frequent contact with supply chain members, and creating a compatible communication system."
(Danese & Bortolotti, 2014, p.7067)	Supplier, Internal, and Customer	"Supply Chain Integration includes operational integration activities – e.g., planning and monitoring supply chain activities and customer's involvement in the product design process – and strategic integration activities, e.g., working closely to solve problems and collaborative relationships"
(C. Zhang, Gunasekaran, & Wang, 2015, p.1154)	Supplier, Internal, and Customer	"Supply chain integration involves elements of Benefit alignment; Material integration; information integration; knowledge integration; finance integration; process integration; organizational integration; planning and control integration and strategic"
(Wiengarten, Humphreys, Gimenez, & McIvor, 2016, p.365)	Customer and Supplier	"Coordinate planning decisions and flow of goods with key/strategic suppliers and customers."
(Kumar et al., 2017, p.817)	Customer, Supplier, Internal, and Information	"Internal integration is the coordinated and strategic alignment of business processes and functions within an organization that is organized to ensure that firm achieves maximum performance." "Supplier integration represents a situation where suppliers are involved in the critical decision-making processes of the firm, with information regarding demand forecasts, production, and inventory levels being shared between them."

		"Integrating customers in a supply chain is centered on drawing information from customers such as their buying patterns, their preference for products, and their ability to purchase products which would then be used in making better decisions during the manufacturing process or sales to customers" "Information integration, however, is not just restrained to the efficiency and application of technology. It requires the inputs and role-playing of people, technological systems to originate, sort, process, and disperse information to the designated location at the right time for the decision-making process."
(Sacristán-Díaz, Garrido-Vega, & Moyano-Fuentes, 2018, p.701)	Internal and external	"Internal integration: the degree to which a company structures its organizational strategy, practices, and processes into synchronized collaborative processes to comply efficiently with its customers' needs and interact with its suppliers. (Flynn et al., 2010a)" "External (Rai, Patnayakuni, & Seth, 2006): Information flow integration: the extent of operational, tactical, and strategic information sharing between a focal firm and its supply chain partners. Physical flow integration: the degree to which a focal firm uses global optimization with its supply chain partners to manage the stocking and flow of materials and finished goods. Financial flow integration: the degree to which workflow events drive financial flows between a focal firm and its supply chain partners."
(Kalyar, Shafique, & Ahmad, 2020, p. 366)	Internal and external	"Internal: It refers to the degree to which a firm can structure its organizational practices, procedures, and behaviors into collaborative, synchronized, and manageable processes to fulfill customer requirements. (I. J. Chen & Paulraj, 2004)" "Customer: The degree to which a firm collaborates with its customers to structure inter-organizational strategies, practices, and processes into collaborative, synchronized processes. (Flynn et al., 2010a)" "Supplier: The degree to which a firm collaborates with its suppliers to structure inter-organizational strategies, practices, and processes into collaborative, synchronized processes."

Table IV - 1 - Definition and dimensions of Supply Chain Integration

The definition of Supply Chain Integration adopted in this study is the one offered by (Flynn et al., 2010a, p.58) that explains such concept as "the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra-and inter-organization processes." According to the authors' views, supply chain integration involves three dimensions: supplier (upstream), customer (downstream), and internal integration.

Based on the author view, "Customer and supplier integration are commonly referred to as external integration, which is the degree to which a manufacturer partners with its external partners to structure inter-organizational strategies, practices, and processes into collaborative, synchronized processes (Stank, Keller, & Closs, 2001)" (Flynn et al., 2010a. p.59)

Internal Integration is "the degree to which a manufacturer structures its own organizational strategies, practices, and processes into collaborative, synchronized processes, in order to fulfill its customers' requirements and efficiently interact with its suppliers." (Flynn et al., 2010a. p.59). The measurement items offered by those authors and applied in this study are available in Appendix A.

As suggested by Kim (2009.p.330), "by developing a high level of SC integration, manufacturers are able to identify and eliminate non-value-added activities and subsequently strengthen product quality and delivery reliability capabilities." Thus, in the field of Supply Chain Management, there is strong interest in the relationship between Supply Chain Integration and Performance.

In the recent literature review of Hassan & Abbasi (2021, p.3), the author emphasizes that "the extents and scope of Supply Chain Integration and its relation with multiple aspects of performance have received reasonable attention in past studies." As a result of such interest, several studies concerning the relationship between Supply Chain Integration and Peformance are available in the literature.

After assessing the findings of such studies, we identified that multiple researchers advocate the proposition that Supply Chain Integration generates higher Operational Performance (Feng et al., 2017; Frohlich & Westbrook, 2001; Huo & Wang, 2014; Jajja, Chatha, & Farooq, 2018b; Vanpoucke et al., 2014; Vickery et al., 2013).

Nevertheless, despite the positive results available in the literature, "more Supply Chain Integration does not always improve performance. As highlighted by Q. Yang, Scoglio, & Gruenbacher (2020, p.1), "interdependence among firms not only increases efficiency but also creates more vulnerabilities in the system" and such condition may impact performance negatively.

Definitions and measures of Supply Chain Integration and performance are diverse to the extent that a conclusion such as "the more Supply Chain Integration, the better the performance cannot be drawn." (Fabbe-costes & Jahre, 2001, p.130). As emphasized by In fact, some studies diverge from the positive findings generated through the researches cited in the previous paragraph.

For instance, the investigations of Wiengarten, Pagell, Ahmed, & Gimenez (2014); Danese & Romano (2011); Lu et al., 2018) Danese, Romano, & Romano,(2013); Boon-itt & Wong,(2011) ; Koufteros, Vonderembse, & Jayaram,(2005); Sezen (2008); Devaraj et al. (2007)); Parente, Baack, & Hahn (2011) and Huo et al., (2014) and Schoenherr & Swink (2012) either found negative, insignificant or mixed results. The meta-analysis performed by (Leuschner et al., 2013) also supports such a view.

In Appendix B, we organized some examples studies about the relationship among Supply Chain Integration and Performance based on the studies of Ataseven & Nair,(2017); Huo et al., (2014); Tarifa-Fernandez & De Burgos-Jiménez, (2017).

In terms of the relationship between Supply Chain Integration with Supply Chain Robustness, we identified studies of Wieland & Wallenburg (2013) and (Zhuo et al., 2021). The latter found a significant relationship. In contrast, the former found the impact of integration on performance insignificant.

It is significant to notice that despite interest in the role of Supply Chain Integration within Supply Chain Management, very few studies have been performed in Brazil.. Kamal & Irani (2014) point out that among 740 articles, only two were produced in Brazil. The author, then, suggests that “academics and researchers from these regions may need to explore more avenues for quality research both conceptually and empirically to generate more publications in SCI area.”

Despite the call from Kamal & Irani (2014) for more researches in Brazil, such a movement did not happen. Hassan & Abbasi (2021) identified only one additional study published from January 2015 to April 2020. Among the studies focused solely on Brazilian Industries, the study of (de Mattos & Laurindo, 2016) focused on exploring the role of electronic collaboration (e-collaboration). The results indicate that the higher the e-collaboration, the higher the perception of performance in cost, agility, customer satisfaction, innovation, etc.

The second identified study of Parente, Baack, & Hahn (2011a) examined how international firms' operations strategies affect dynamic capability creation or how cultural distance affects operations management. In this context, supplier integration was evaluated as a potential enabler of new product innovation, but no significant impact was supported.

Another relevant observation produced by the cited authors consists of the methodological approaches adopted in the Supply Chain Integration field of research. The majority of scientific work available (55 out of 113 studies revised) utilized either Structural Equation Modeling or Partial Least Square (Hassan & Abbasi, 2021). Based on this study, we did not identify any research anchored on the application of Necessary Condition Analysis, here suggested as a complementary approach to the model's analysis.

4.2.3 - Supply Chain Robustness

The conceptualization of robustness is anchored in the ability to maintain the status quo. As defined by (H Kitano, 2007; Hiroaki Kitano, 2004) (H Kitano, 2007), cited by (Monostori, 2018, p. 111), from a biological perspective, “robustness is a property that allows a system to maintain its functions against internal and external perturbations” “To discuss robustness, one must identify system, function, and perturbations. It is important to realize that robustness is concerned with maintaining functions of a system rather than system states, which distinguishes robustness from stability”.

In this study, we introduce Supply Chain Robustness as an essential component of Supply Chain Strategy to keep the system capable of sustaining the levels of Operational Performance (also investigated as a dependent variable) in the face of a vulnerable, uncertain, complex, and changing environment. For instance, such a view is aligned with Canetta, Cheikhrouhou, & Glardon (2016, p.1), who proposed that “…modern Supply Chains have to ensure satisfying performances despite an increasing degree of complexity and market uncertainty as well as be capable to limit the negative impacts of disruptive events”.

(Durach, Wieland, & Machuca, 2014) highlight that different researchers have suggested supporting ideas and concepts of supply chain robustness, such as (Meepetchdee & Shah, 2007, p. 203) who defined it as “the extent to which the supply chain is able to carry out its functions despite some damage to it and (Vlajic, Van Der Vorst, & Haijema, 2012, p. 177) that defined supply chain robustness as “the degree to which a supply chain shows an acceptable performance during and after an unexpected event that caused disturbances in one or more logistics processes".

According to (Wieland & Wallenburg, 2012, p. 890), supply chain robustness should be seen as a proactive strategy and can be defined as the "ability of a supply chain to resist change without adapting its initial stable configuration." Following this view, (Durach et al., 2014) argue that a robust supply chain should be capable of resisting such change or taking measures to avoid it. Such capability, according to the authors, may be manifested in two dimensions: resistance and avoidance. Resistance concerns the ability of a supply chain to withstand change. In contrast, avoidance concerns the ability to not be affected.

In table 2, we summarize different definitions of Supply Chain Robustness found in the literature.

Author(s)	Definition
(Meepetchdee & Shah, 2007, p.203)	"The extent to which the supply chain is able to carry out its functions despite some damage done to it."
(Ferdows, 1997, p. 86)	"A robust network is one that can cope with changes in the competitive environment without restoring to extreme measures."
(Klibi, Martel, & Guitouni, 2010, p.290)	"A [supply chain network] design is robust, for the planning horizon considered, if it is capable of providing sustainable value creation under all plausible future scenarios."
(Kouvelis, Chambers, & Wang, 2006, p.452)	"The designed supply chain is robust in the sense that it hedges the firm's performance against the worst contingencies in terms of uncertain factors (demand, exchange rates, commodity prices, etc.) over a planning horizon."
(Vlajic, Van Lokven, Haijema, & Van Der Vorst, 2013)	"The degree to which a Supply Chain shows an acceptable performance in its KPIs at various levels of uncertainty and disturbances. This definition is in line with Taguchi's idea on robust design based on performance tolerance specifications (Taguchi, G., & Rafanelli, 1993)
(Vlajic et al., 2012, p.177)	We define supply chain robustness as the degree to which a supply chain shows an acceptable performance during and after an unexpected event that caused disturbances in one or more logistics processes."
(Wieland & Wallenburg, 2012, p. 890)	"Robustness is a proactive strategy that can be defined as the ability of a supply chain to resist change without adapting its initial stable configuration."
(Brandon-Jones, Squire, Autry, & Petersen, 2014; Hiroaki Kitano, 2004) d	"ability of a supply chain to withstand disruption and continue operating"
(Asbjørnslett, 2009, p. 220)	"a systems ability to resist an accidental event and return to do its intended mission and retain the same stable situation as it had before the accidental event".
(Monostori, 2016, p.68)	Ability to comply with the most important key performance indicators (KPI) during and after unexpected event(s) / disruption(s)
(Adenso-Díaz, Mar-Ortiz, & Lozano, 2018, p.3)	"Ability of a system to continue in operation"
(Fujimoto, 2019, p.17)	"The degree of continuity and the shortness of stoppages affecting design information flows to the customers"

Table IV - 2 - Definition of Supply Chain Robustness - adapted and improved from (Durach, Wieland, & Machuca, 2015)

It is essential to highlight that the concept of robustness has evolved. Recently, Wieland & Durach (2021) propose a broader perspective to understand the real meaning of Robustness. In this sense, the authors define robustness as engineering resilience which stems from the engineering field.

According to this perspective, stability produced by robust systems strives from the time that a system takes to return. By assuming this point of view, the idea of resistance or avoidance, usually achieved through proactive actions in the scope of the Supply Chain, is no longer enough since the notion of time to recover based on reactive efforts is considered a critical aspect of robust systems.

The proposition of (Wieland & Durach, 2021) discussed above clearly associates robustness to reactive behavior in addition to the proactive view. Such reactive nature, to this date, was usually related to Supply Chain Agility and understood as the opposite strategy to Supply Chain Robustness (Wieland & Marcus Wallenburg, 2012). By assuming that robustness encompasses both proactive and reactive dimensions, metrics like time-to-recovery (TTR) and time-to-survive (TTS) are suggested as applicable to quantify the presence of engineering resilience, in order words, the robustness of the system (Wieland & Durach, 2021).

Despite the relevance of Supply Chain Robustness, either in practical and scientific terms, to this date, we have not found a significant number of empirical studies about enablers of such conditions. Wieland & Wallenburg's (2013) and Zhuo et al.'s (2021) studies, which assessed Supply Chain Integration as a potential influence factor, are examples of such type of research, as mentioned previously.

Wieland & Wallenburg's (2012) study is another example of research that empirically explored the potential of the influencing factor to ensure Supply Chain Robustness. In this study, the authors support the proposition that Supply Chain Risk Management contributes, on average, to increase Supply Chain Robustness.

For the present investigation, we assume (Brandon-Jones et al., 2014; Hiroaki Kitano, 2004) definition for Robustness to guide our empirical research. The authors suggest that robustness refers to the "ability of a supply chain to withstand disruption and continue operating." From our perspective, such definition encompasses both proactive and reactive perspectives into the concept of robustness. The measurement items for Supply Chain Robustness can be found in Appendix A.

4.2.4 - Hypothesis Development

There is strong interest in the relationship between Supply Chain Integration and Operational Performance in the field of Supply Chain Management. Different studies have been performed willingly to investigate the impact of the first upon the former. In this sense, various empirical researches have supported the proposition that Supply Chain.

As mentioned, in Appendix B, we organized some of the primary studies about the relationship between Supply Chain Integration and Performance, taking into consideration previous literature reviews of Ataseven & Nair,(2017); Huo et al., (2014); Tarifa-Fernandez & De Burgos-Jiménez, (2017)

Based on the available research in academia, multiple studies advocate the proposition that Supply Chain Integration generates higher Operational Performance (Feng et al., 2017; Frohlich & Westbrook, 2001; Huo & Wang, 2014; Jajja, Chatha, & Farooq, 2018b; Vanpoucke et al., 2014; Vickery et al., 2013). Conversely, the investigations of Wiengarten, Pagell, Ahmed, & Gimenez (2014); Danese & Romano (2011); Lu et al., 2018) Danese, Romano, & Romano,(2013); Boon-itt & Wong,(2011); Koufteros, Vonderembse, & Jayaram,(2005); Sezen (2008); Devaraj et al. (2007)); Parente, Baack, & Hahn (2011) and Huo et al., (2014) and Schoenherr & Swink (2012) either found negative, insignificant or mixed results.

The differences in the results obtained may derive from the fact that despite many benefits, "integrated supply chains bring with them the risk of amplified and propagated disruptions along the supply chain if not managed properly." Furthermore, integration may produce adverse effects due to the higher inter mutual interactions among the parties, resulting in more exposure to risks (Munir et al., 2020, p.15; Terjesen, Patel, & Sanders, 2012).

Another relevant remark concerning Supply Chain Integration scientific efforts is the lack of empirical studies in some regions of the world, including Brazil, where we have identified only studies of de Mattos & Laurindo (2016) and Parente Baack & Hahn

(2011a). As a result, there is an urgent need to perform empirical studies about integration in such an unexplored region (Kamal & Irani, 2014).

In sum, based on Miles (2017) types of research gaps taxonomy, the conditions above may characterize three different research gaps. The first one, is the Evidence gap due to the conflict findings concerning the nature of the impact that integration generates on performance. The second is named Population gap as a consequence of the concentration of research considering industries mainly located in the US, Europe, and Asia. The third is an Empirical gap since there are minimal empirical studies in Brazil about this subject.

To contribute to reducing the verified scientific gaps, we proposed exploring the behavior of the phenomenon herewith under discussion within the Brazilian industries environment. Different from previous studies like Lu et al., (2018), Bae, (2017), and (Feng et al., 2017) , our investigation will consider each dimension separately (supplier integration, internal integration, and customer integration) as, according to the literature, there are differences among the dimensions in terms its effect produced on Operational Performance (i.e., Cheng et al. (2016); Danese & Bortolotti (2014); Flynn et al., (2010b); Boon-itt & Wong (2011) Devaraj et al. (2007), Huo et al. (2014))

Thus, considering the arguments above, we propose to test the following hypothesis: **H5: Supplier Integration positively impacts Operational Performance; H6: Internal Integration positively impacts Operational Performance and H7: Internal Integration positively impacts Operational Performance.**

In addition, to test the direct influence among the first upon the former, in the scope of this study, we will assess Supply Chain Risk Management as a potential mediator between the relationship among each dimension of Integration and Operational Performance.

Such call is aligned with Munir et al., (2020) and Kauppi, Longoni, Caniato, & Kuula (2016), due to the different results concerning the relationship of Supply Chain Integration and Operational Performance. Those authors suggested that considering Supply Chain Risk Management as a mediator may explain the mixed findings available in the literature between Supply Chain Integration and performance measures.

A mediational analysis attempts to ‘‘identify the intermediary process that leads from the independent variable to the dependent variable’ (A. D. Wu & Zumbo, 2008), which cited (Muller, Judd, & Yzerbyt, 2005, p. 852). Then, based on such assumptions, we formulate the following hypotheses: **H8: Supply Chain Risk Management mediates the relationship among Supplier Integration and Operational Performance; H9: Supply Chain Risk Management mediates the relationship among Internal Integration and Operational Performance; and H10: Supply Chain Risk Management mediates the relationship among Customer Integration and Operational Performance.**

Despite the relevance of Robustness, research has not yet sought to establish a comprehensive theoretical basis for understanding supply chain robustness (Durach et al., 2014). In parallel, currently, there is limited literature available concerning the relationship between supply chain integration and robustness (Zhuo et al., 2021).

In the literature available, in the center of the different Supply Chain Robustness definitions (see table 2), we find the idea of sustaining performance at acceptable levels in the face of risks, disruption, unexpected changes, and or disturbances. Previous studies in the literature have suggested the importance of Supply Chain Integration as the capability to support companies to deal with the conditions mentioned above (Giunipero et al., 2015; Munir et al., 2020; Serhiy Y. Ponomarov & Holcomb, 2009; Zhuo et al., 2021). These observations indicate that Supply Chain Integration may contribute positively to Supply Chain Robustness.

Furthermore, when exploring conditions that may enable higher Supply Chain Robustness, we find different factors in the literature. For instance, Durach, Wieland, & Machuca (2015) inter-departmental relationship (internal integration) and Supply Chain visibility. Brandon-Jones et al. (2014) elaborate on the importance of information sharing and visibility, whereas Vlajic (2010) points out the importance of configuration and design as enablers of Robustness. Fujimoto, (2019, p.13) also point out that "coordination and integration between firms in the damaged supply chains are also crucial for effective supply chain recovery and restoration"

In sum, based on such observations, among other enablers, internal and external relationships, coordination information sharing, visibility, and configuration of the Supply Chain are conditions to foster Supply Chain Robustness. Thus, from the definition of Supply Chain Integration (see table 1), Prajogo & Olhager (2012), Vickery, Jayaram, Droge, & Calantone (2003), Sacristán-Díaz, Garrido-Vega, & Moyano-Fuentes (2018), and (Kumar et al., (2017) consider information sharing and consequently visibility as part of Supply Chain Integration definition. Boon-itt & Wong (2011) and Flynn, Huo, & Zhao (2010) point out the role of collaboration among departments, whereas design, collaboration and integration among firms are referred by Germain & Iyer (2006) and C. Zhang, Gunasekaran, & Wang (2015) and (Flynn, Huo, & Zhao, 2010) when defining Supply Chain Integration.

Based on the arguments above, we assume in this research the importance of investing in Supply Chain Integration both with suppliers, internally, and customers to foster higher Supply Chain Robustness. As already mentioned, previous studies by Wieland & Wallenburg (2013) and (Zhuo et al., 2021), also investigated empirically such a relationship.

The studies above explored such a relationship among integration and robustness at Germany, Austria, Switzerland, and China. The findings of the latter research support a significant relationship. In contrast, the former study found the impact of integration on performance insignificant.

Based on Miles (2017) types of research gaps taxonomy discussed previously, the conditions above might characterize three different research gaps. Evidence gap due to the conflict findings concerning the nature of the impact that integration generates on performance. Population gap as a consequence of the concentration of empirical research considering industries mainly located in the Germain Austria and Switzerland; and China. Empirical gap since there are no minimal empirical studies with Brazilian Industries about this subject to the best of the author's knowledge.

To reduce the verified scientific gaps, we proposed exploring the behavior of the phenomenon herewith under discussion within the Brazilian industries environment. Different from previous studies like Lu et al. (2018), Bae, 2017), and (Feng et al., 2017) , our investigation will consider each dimension separately (supplier integration, internal integration, and customer integration), as such: **H11: Supplier Integration positively impacts Robustness?; H12: Internal Integration positively impacts Robustness?; and H13: Customer Integration positively impacts Robustness?**

Durach, Wieland, & Machuca (2015) contend that risk management orientation contributes to increasing Supply Chain Robustness and qualified it as an antecedent of Robustness, among other factors. On the contrary, the level of vulnerability may contribute negatively to the ability of a supply chain to deals with disruption and continue operating.

Monostori, 2016, (p.68) highlighted: "vulnerability is considered as a kind of feature opposite to the robustness, i.e., the more vulnerable a supply chain, the less robust it is." As suggested by Uta Jüttner, Peck, & Christopher (2003), identifying and managing risks for the supply chain through a coordinated approach reduces supply chain members' vulnerability as a whole.

Thus, based on the observations above, it is expected that the higher the presence of Risk Management, the level of vulnerability decreases and, consequently, more robust is the Supply Chain (Durach et al., 2014). Some studies have already supported a positive relationship between Supply Chain Risk Management and Supply Chain robustness (El Baz & Ruel, 2020; Pickert, 2015; Wieland & Marcus Wallenburg, 2012). Those studies were performed respectively in France, Thailand, and Germany, Austria, Switzerland.

Based on Miles (2017) types of research gaps taxonomy discussed previously, the conditions above might characterize two different research gaps. Population gap as a consequence of the concentration of empirical research considering industries mainly located in the Germain Austria and Switzerland; and China. Empirical gap since few empirical studies explored this subject to the best of the author's knowledge. We proposed analyzing the phenomenon's behavior herewith under discussion within the Brazilian industries environment to reduce the verified scientific gaps.

Thus, based on the proposed phenomenon of interest, the following hypothesis will be evaluated empirically: **H14: Supply Chain Risk Management positively impacts Supply Chain Robustness.**

In the scope of supply chain management, Robustness is not consistent and clear as such the definition of Agility (Zitzmann, 2014). Robustness is frequently understood as a static concept since it implies proactive action to resist and avoid undesired consequences of dealing with unexpected events. In contrast, Agility is usually linked to reactive approaches. (Durach et al., 2014; Purvis, Spall, Naim, & Spiegler, 2016; Wieland & Marcus Wallenburg, 2012).

Based on our literature review, we found theoretical support towards a different perspective in which Robustness and Agility are not treated as opposite types of strategies. For instance, Zitzmann (2014, p.371) contends that "the main characteristics of an agile supply chain are its responsiveness and flexibility. Robust planning also enables value networks to react to a wide range of possibilities by establishing flexibility and redundancies".

Another example derives from Zhang & Wang (2011). When discussing the precedents of Supply Chain Robustness, the author points out that the Supply Chain Operational Reference Model (SCOR) defined 20 different conditions to enable organization capacity to resist disruption. Among those variables are the following: Agility of the supply chain planning, Agility of the supply chain purchase, Agility of the supply chain manufacture, Agility of the supply chain delivery, Agility of the supply chain customer service, ability to respond to an emergency.

Recently, Stockmann, Winkler, & Kunath (2021) treated Robustness as a superior capability built upon adjacent capabilities that were otherwise only treated separately, such as flexibility, Agility, resilience, and resistance. Concerning the relationship between Robustness and Agility, the authors conceptualized (p.5) "a robust production system also has to be agile to maneuver itself through substantial changes without instability and without a drop of its performance."

Finally, (Wieland & Durach, 2021) propose a broader perspective to understand the real meaning of Robustness as engineering resilience, which relies on resistance or avoidance and the reactive capacity that may be achieved through Supply Chain Agility capabilities.

Finally, we propose assessing if Supply Chain Risk Management positively moderates the relationship between Supply Chain Agility and Supply Chain Robustness. Such proposition stems from the dynamic capability perspective that organizations process and routines in place for sensing and seize organizations structures and actions will enhance the capacity reaction and, consequently, sustain performance levels.

From such perspectives, we present the following hypotheses:

H15: Supply Chain Agility positively impacts Supply Chain Robustness.

H16: Supply Chain Risks Management positively moderates the relationship between Supply Chain Agility and Robustness.

Thus, based on the proposed arguments discussed above, the following central hypotheses were developed and will be tested in this study:

H1: Supply Chain Risks negatively impacts Operational Performance – Chapter 2
H2: Supply Chain Risks Management positively impacts Operational Performance - Chapter 3
H3: Supply Chain Agility positively impacts Operational Performance - Chapter 3
H4: Supply Chain Risks Management positively moderates the relationship between Supply Chain Agility and Operational Performance. Chapter 3
H5: Supplier Integration positively impacts Operational Performance
H6: Internal Integration positively impacts Operational Performance
H7: Customer Integration positively impacts Operational Performance
H8: Supply Chain Risks Management mediates the relationship among Supplier Integration and Operational Performance
H9: Supply Chain Risks Management mediates the relationship among Internal Integration and Operational Performance
H10: Supply Chain Risks Management mediates the relationship among Customer Integration and Operational Performance
H11: Supplier Integration positively impacts Robustness
H12: Internal Integration positively impacts Robustness
H13: Customer Integration positively impacts Robustness
H14: Supply Chain Risk Management positively impacts Supply Chain Robustness.
H15: Supply Chain Agility positively impacts Supply Chain Robustness.
H16: Supply Chain Risks Management positively moderates the relationship between Supply Chain Agility and Robustness.

Table IV - 3 - Hypothesis statements

4.3 - RESEARCH MODEL AND ANALYSIS

4.3.1 - Research methodology

We assume a postpositivist philosophical world view, anchored in a deterministic philosophy that seeks to explore the causes that influence outcomes; such worldview is based on the following elements: Determination, Reductionism, Empirical observation, and measurement and Theory verification (Creswell, 2014).

The investigation will follow the deductive approach to research, where the researcher starts with a theory and tests it using empirical data to support or not the theoretical postulates (Bhattacherjee, 2012). It is essential to highlight that “the goal of theory-testing is not just to test a theory, but possibly to refine, improve, and extend it” (Bhattacherjee, 2012, p.3).

The present work follows a quantitative research approach with a nonexperimental correlational form of research. Researchers apply correlational statistics to describe and measure the degree of relationship between two or more variables in such types of studies (Creswell, 2014).

Due to the nature of the phenomenon under investigation, we chose the survey research design to obtain the data. This type of method relies on applying questionnaires to collect data about the people or organizations systematically. (Bhattacherjee, 2012).

The survey approach was selected in this work mainly because we tested the relationship among latent variables. According to (Rungtusanatham, Choi, Hollingworth, Wu, & Forza, 2003), survey studies are generally relational because they tend to be designed to examine relationships among two or more constructs or variables empirically.

Bhattacherjee (2012) emphasizes that survey design has different advantages. Firstly, it is an excellent means for measuring several natural unobservable phenomena. Secondly, it allows the researchers to obtain data remotely about a population that is too large to observe directly; it has unobtrusive nature and can be considered economical in terms of researcher time compared to another means of data collection.

The data collected was subsequently analyzed employing Structural Equation Modeling (SEM). SEM is a multivariate statistical technique with elements from Structural Theory, Measurement Theory. “In PLS-SEM, structural and measurement models are also referred to as inner and outer models. To develop path models, researchers need to draw on structural and measurement theories, which specify the relationships between the elements of a path model”. (Sarstedt, Ringle, & Hair, 2017, p.3)

As proposed by (Joseph F. Hair, Risher, Sarstedt, & Ringle, 2019, p.3), “the PLS-SEM method is very appealing to many researchers as it enables them to estimate complex models with many constructs, indicator variables, and structural paths without imposing distributional assumptions on the data.”

In addition to assessing the complete model based on the PLS-SEM method, we further investigate the proposed phenomenon utilizing a different methodological prism recently offered by (Dul 2016) and named Necessary Condition Analysis. The motivation for such additional assessment relies on the fact that such a combined perspective enables the exploration and validation of hypotheses following the complimentary views, encompassing sufficiency logic and necessity logic (Richter et al., 2020). In Section 4.5 of this research, the motivation of the NCA application will be further developed.

4.3.2 - Sample and data collection

An electronic survey questionnaire was applied to promote the data collection process. A total of 987 potential participants were contacted by phone and email between January 2020 and June 2020, resulting in 165 usable responses to an electronic survey. Thus, an effective return rate of 16,7% was obtained.

Concerning the sample size, we followed the recommendations from Cohen, (1992),cited by Joseph F. Hair, Hult; Ringle; & Sarstedt (2017, p. 26) regarding the minimum number of respondents. In our case, considering that the number of arrows from dependent variables pointing out at our dependent construct is 6, 48 observations are necessary to detect R2 values of around 0.25 at a significance level of 5% and a power level of 80%. Therefore, the sample size of 165 cases can be regarded as sufficiently large.

Maximum Number of Arrows Pointing at a Construct (Number of Independent Variables)	Significance Level											
	10%				5%				1%			
	Minimum R^2				Minimum R^2				Minimum R^2			
	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75	0.10	0.25	0.50	0.75
2	72	26	11	7	90	33	14	8	130	47	19	10
3	83	30	13	8	103	37	16	9	145	53	22	12
4	92	34	15	9	113	41	18	11	158	58	24	14
5	99	37	17	10	122	45	20	12	169	62	26	15
6	106	40	18	12	130	48	21	13	179	66	28	16
7	112	42	20	13	137	51	23	14	188	69	30	18
8	118	45	21	14	144	54	24	15	196	73	32	19
9	124	47	22	15	150	56	26	16	204	76	34	20
10	129	49	24	16	156	59	27	18	212	79	35	21

Source: Cohen (1992): A Power Primer. Psychological Bulletin 112: 155–159.

Table IV - 4 Sample Size Recommendation in PLS-SEM for a Statistical Power of 80% extracted from (Sarstedt et al., 2017, p.26)

The unit of analysis employed in this study is at the manufacturing plant level and its relationship between its internal functions, upstream suppliers, and downstream customers. The target profile of respondents was composed of managers selected by their job function (supply chain manager, operation manager, or equivalent). Among the respondents, 100% were from the manufacturing sectors, from segments like automotive companies, chemical sector, electronics sector, oil, and gas. In tables 5 to 8, the demographic details of the sample can be found.

Industrial Segment	Frequency	Percentage
Food and Beverages	44	26,67%
Textile and Garment	19	11,52%
Chemicals and petroleum	14	8,48%
Plastic and latex	14	8,48%
Passenger Vehicles	12	7,27%
Construction	11	6,67%
Wood Products	11	6,67%

Consumer goods	7	4,24%
Fabricated metal products, except machines	7	4,24%
Others	7	4,24%
Pharmaceutical	4	2,42%
Machinery	4	2,42%
Paper Products	4	2,42%
Basics and Manufactured Goods	4	2,42%
Electrical equipment	3	1,82%
Total	165	100,00%

Table IV - 5 - Sample Demographics (Industrial Segments)

Sales Volume	Frequency	In Percentage
Less than 10 million reais	87	52,73%
Between 11 and 25 million reais	32	19,39%
Between 26 and 50 million reais	8	4,85%
Between 51 and 75 million reais	2	1,21%
Between 76 and 100 million reais	4	2,42%
Between 101 and 250 million reais	7	4,24%
Between 251 and 500 million reais	5	3,03%
Above 500 million reais	20	12.12%

Table IV - 6 - Sample Demographics (Sales Volume)

Number of employes	Frequency	In Percentage
1-50	95	57,58%
51-100	22	13,33%
101-200	12	7,27%
201-500	12	7,27%
501-1000	10	6.06%
Above 1000	14	8,48%

Table IV - 7 - Sample Demographics (Number of Employees)

Job Level at the company	Frequency	In Percentage
Directorate	38	23,03%
Manager/Supervisor	101	61,21%
Operational	26	15,76%
Years of Job Experience within the actual company	Frequency	In Percentage
Less than 5 years	48	29,09%
Between 5 and 10 years	71	43,03%
Between 10 and 20 years	44	26,67%
Above 20 years	2	1,21%

Years of Job experience	Frequency	In Percentage
Less than 5	12	7,27%
Between 5 and 10 years	41	24,85%
Above 10 year	112	67,88%

Table IV - 8 - Sample Demographics (Respondents Profile)

4.3.3 - Sample and method bias

We execute the Normality Test, Test of Equality of Variance, and Common Method Bias using SPSS Software to assess the sample. Concerning the normality assessment, the Shapiro-Wilks test is designed to test normality. According to the normality test proposed by Shapiro and Wilk (1968), when the p-value is less than or equal to 0.05, the hypothesis of normality should be rejected. Nevertheless, as emphasized by Hair et al., (2017, p. 27), "Normal distributions are usually desirable, especially when working with CB-SEM. In contrast, PLS-SEM generally makes no assumptions about the data distributions."

"The assumption of homogeneity of variances is essential when comparing two groups because if variances are unequal, the validity of the results is jeopardized" (Nordstokke, Zumbo, Cairns, & Saklofske, 2011, p.1). The Levene test executed the assessment about the equality of variances. Our results indicated no significant differences between the two groups of the first 2/3 of respondents and 1/3 late respondents.

Following (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), Harman's single-factor test with an exploratory factor analysis was applied to assess the presence of common method bias. If the total variance extracted by one factor exceeds 50%, common method bias is present in your study. Our test with all variables (independent and dependent) resulted in a first factor accounting for 28.78 percent of the total variance, indicating that no single factor explained most of the variance in the model.

4.3.4 - Conceptual Model

"A model is a representation of all or part of a system that is constructed to study that system, while a theory tries to explain a phenomenon, a model tries to represent a phenomenon" (Bhattacherjee, 2012, p 14). "A path model is a diagram that displays the hypotheses and variable relationships to be estimated in an SEM analysis", as shown in the figure below (Sarstedt, Ringle, & Hair, 2017, p.4)

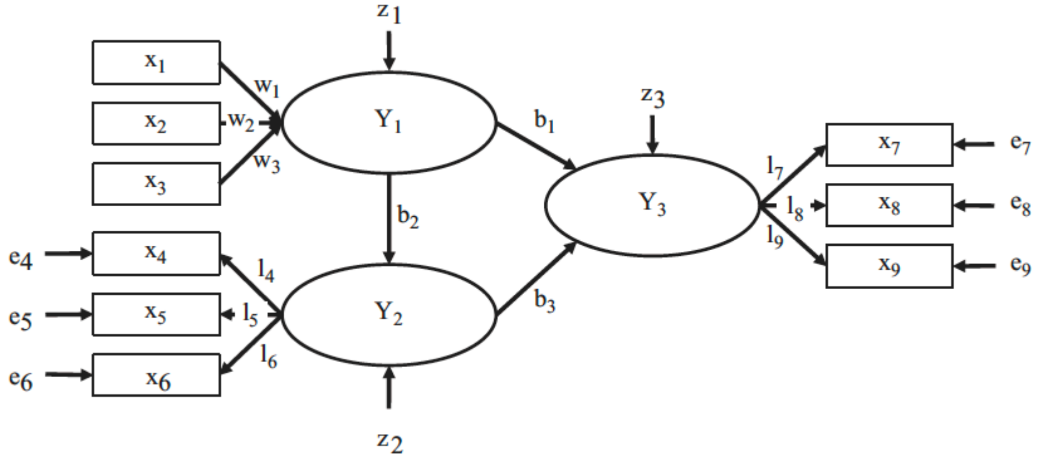

Figure IV - 1 - Path Diagram and Latent variable (Joseph F. Hair et al., 2017, p.5)

Latent variables “are elements in statistical models that represent conceptual variables that researchers define in their theoretical models” (Sarstedt, Ringle, & Hair, 2017, p.3)

Our research model comprises different constructs 6 Low Order Contstructs (Operational Performance, Supply Chain Risk Management, Supply Chain Agility, Internal Integration, Supplier Integration and Customer Integration) and one High Order (Overall Supply Chain Risks), which is composed of 5 Low Order Construct (Supply Side Risks, Demand Side Risks, Regulatory, Legal, and Bureaucratic Risks, Infrastructural Risks and, Catastrophic Risks).

The one multidimensional construct denominated Overall Supply Chain Risks, “where each dimension represents a unique content domain of the broader construct. Multidimensional constructs differ from first-order constructs in that while the latter also represents a single theoretical concept, they lack distinct dimensions” (Polites, Roberts, & Thatcher, 2012, p. 22) .

When applying a higher-order construct, researchers evaluate the influence of such high order latent variable rather than the influence of its dimensions separately (Polites et al., 2012).

Higher-order constructs, “which facilitate modeling a construct on a more abstract higher-level dimension and its more concrete lower-order subdimensions, have become an increasingly visible trend in applications of partial least squares structural equation modeling (PLS-SEM).” (Sarstedt, Hair, Cheah, Becker, & Ringle, 2019. p. 197)

Model parsimony can be achieved through the reduction in the number of path model relationships, and such condition can be seen as one advantage of using higher-order construct since “instead of specifying relationships between multiple independent and dependent constructs in a path model, researchers can summarize the independent constructs in a higher-order construct, making the relationships from the (then) lower-order components to the dependent constructs in the model obsolete” (Sarstedt et al., 2019, p.198)

The repeated indicators approach was applied to establish the reflective-reflective relationship among Supply Chain Risks higher-order construct and its low-order constructs Demand Risks, Supply Risks, Regulatory Risks, Infrastructural Risks, and Catastrophic Risks. By applying such approach, all 17 indicators of the reflectively measured lower-order components are simultaneously assigned to the reflective measurement model of the higher-order construct.

“A reflective specification is appropriate when there is a more general, abstract construct that explains the correlations between the LOCs. Hence, there should be substantial correlations between the LOCs that—analogous to reflective measurement models—are assumed to be caused by the HOC. That is, the HOC is the spurious cause explaining the correlations between the LOCs.(Hair, Sarstedt,, Ringle, & Gudergan, 2017, p.43).

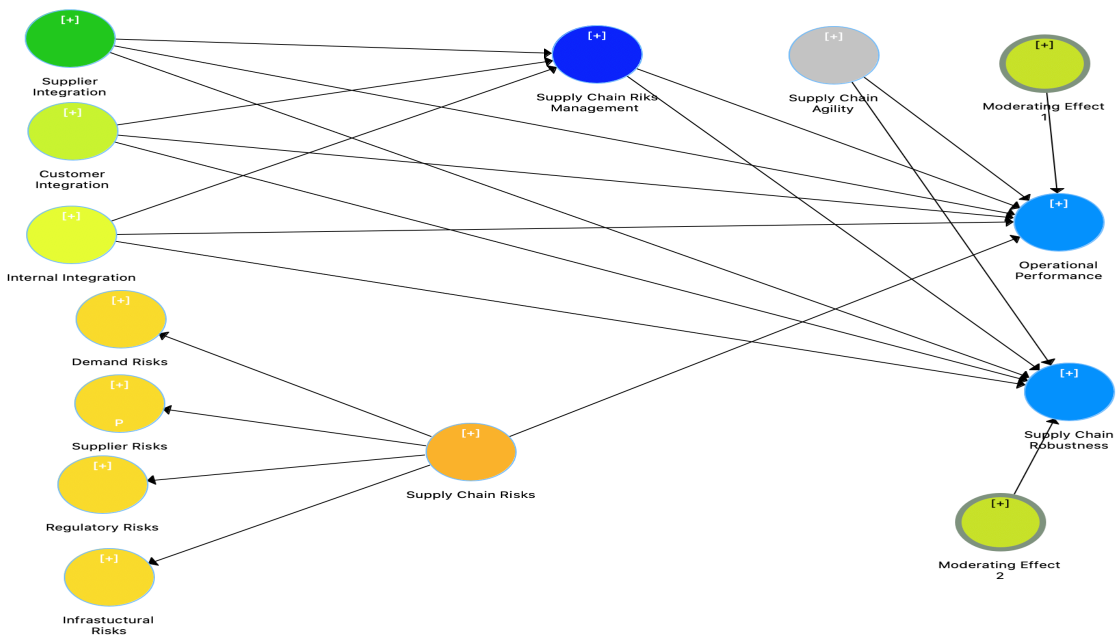

Figure IV - 2 - Conceptual Model

(Bhattacherjee, 2012) reminds that constructs require operational definitions, which explain define how they will be empirically measured. The constructs of the present study can be found in table 6, and all of it's the variables that compound the research questionnaire are presented in Appendix A.

Variable Name	Reference:	Role of variable in study	Operational definition	Range of values
Supply Chain Risk	Wagner & Bode, 2008)	Independent	See Appendix A	1-7
Supply Chain Agility	(Wieland & Wallenburg, 2012)	Independent	See Appendix A	1-7
Supply Chain Risk Managment	(Wieland & Wallenburg, 2012)	Independent Mediador Moderator	See Appendix A	1-7
Supply Chain Supplier, Internal and Customer Integration	(Flynn et al., 2010a)	Independent	See Appendix A	1-7
Supply Chain Robustness	(Brandon-Jones et al., 2014)	Dependent	See Appendix A	1-7
Organizational performance	(Huo et al., 2014)	Dependent	See Appendix A	1-7

Table IV - 9- Construct Sources

The model developed and tested covers 17 different types of Supply Chain Risks Sources, 10 different types of Operational Performance indicators, 4 indicators of Supply Chain Agility, 4 measures of Supply Chain Risk Management, 11 measures of Customer Integration, 13 indicators of Supplier Integration and 9 measures of Internal Integration.

4.3.5 - Measurement model misspecification tetrad analysis (CTA-PLS)

At chapter 2 and 3 we find support that a reflective-reflective specification was appropriate for Supply Chain Risk, Supply Chain Risk Management and Supply Chain Agility and Operational Performance Constructs. Here we will perform similar analysis for the Supplier, Internal and Customer Integration Constructs.

Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan (2017), SEM results' validity may be threatened by measurement model misspecification. One approach to assess such conditions relies on the execution of the Confirmatory Tetrad Analysis in PLS-SEM (CTA-PLS).

The application of such analysis enables researchers to empirically evaluate whether the measurement model has specification issues or not. The concept of tetrads (τ) is at the heart of CTA-PLS. It describes the relationship between pairs of covariances.

In reflective measurement models, "differences between pairs of covariances of indicators that represent the concept in a similar manner should be zero, provided the domain sampling model holds as assumed by a reflective measurement model" (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p. 91-92).

In sum, the idea behind CTA-PLS is that in a reflective measurement model, each tetrad (τ) is expected to be zero. In other words, CTA-PLS simply tests the following hypothesis: Ha: $\tau \neq 0$ H0: $\tau = 0$. CTA-PLS only produces results for constructs with at least four indicators per measurement mode.

The assessment was based on the assumption that zero should fall between the Adjusted Confidence Interval (Low and Up) of each tread of the construct being assessed. (Wong, 2019) provide a table for better visualization of such criteria.

	CI Low adj	CI up adj		Measurement model is
If all values are	-	-	then	formative
If all values are	+	+	then	formative
If one or mode of the values are	-	+	Then	reflective

Table IV - 10 - - CTA-PLS - Adjusted Confidence Interval (Wong, 2019, p 71)

Internal Integration	T Statistics	P Values	CI Low adj.	CI Up adj.
4: SCII1,SCII2,SCII3,SCII5	2.25	0.02	-0.19	1.72
6: SCII1,SCII3,SCII5,SCII2	0.74	0.46	-1.12	0.66
9: SCII1,SCII3,SCII6,SCII2	1.04	0.30	-0.96	0.45

Table IV - 11 - CTA-PLS Results (Supply Chain Internal Integration – sample treads)

Supply Chain Supplier Integration	T Statistics (|O/STDEV|)	P Values	CI Low adj.	CI Up adj.
1: SCIS1,SCIS10,SCIS11,SCIS12	0.93	0.35	-2.23	1.13
2: SCIS1,SCIS10,SCIS12,SCIS11	0.85	0.40	-2.27	1.23
4: SCIS1,SCIS10,SCIS11,SCIS2	1.33	0.18	-0.93	0.34

Table IV - 12 - CTA-PLS Results (Supply Chain Supplier Integration – sample treads)

Customer Integration	T Statistics (|O/STDEV|)	P Values	CI Low adj.	CI Up adj.
4: SCIC1,SCIC10,SCIC11,SCIC3	0.30	0.76	-0.44	0.36
6: SCIC1,SCIC11,SCIC3,SCIC10	2.92	0.00	-2.52	0.03
7: SCIC1,SCIC10,SCIC11,SCIC4	1.73	0.08	-0.62	0.16

Table IV - 13 - CTA-PLS Results (Supply Chain Customer Integration – sample treads)

Thus, based on the results above, we also found statistical support that a reflective-reflective specification is appropriate to both Supply Chain Risk Management and Supply Chain Agility. Despite such results, it is important to emphasize that “CTA-PLS is no silver bullet and its results do not discharge researchers from closely thinking about the specification of measurement models.” (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017,p.96). Furthermore “researchers should make the formative vs. reflective decision based on sound theoretical considerations” (Wong, 2019, p.43).

4.3.6 - Low Order Construct Assessment

Model estimation delivers empirical measures of the relationship between the indicators and the constructs and between the constructs (Joe F. Hair et al., 2012).

The traditional criterion for internal consistency is Cronbach’s alpha, which provides an estimate of the reliability based on the mutual relationship of the observed indicator variables. “Due to Cronbach’s alpha’s limitations, it is technically more appropriate to apply a different measure of internal consistency reliability, referred to as composite reliability”. (Joseph F. Hair et al., 2017, p.127).

As a reference, the authors mentioned earlier suggest that values below 0.70 (or 0.6 in exploratory research) do not fulfill internal consistency. At the same time, values above 0.95 are not desirable because they indicate that all the indicator variables measure the same phenomenon and are therefore not likely to be a valid measure of the construct.

	Cronbach's Alpha	**Composite Reliability**
Demand Risks	**0,77**	**0,90**
Infrastuctural Risks	**0,85**	**0,90**
Operational Performance	**0,91**	**0,93**
Regulatory Risks	**0,84**	**0,92**
Supplier Risks	**0,85**	**0,89**
Supply Chain Agility	**0,91**	**0,93**
Supply Chain Riks Management	**0,93**	**0,95**
Supply Chain Internal Integration	**0,91**	**0,93**
Supply Chain Customer Integration	**0,92**	**0,93**

Supply Chain Supplier Integration	0,94	0,89
Supply Chain Robustness	0,94	0,96

Table IV - 14 - Internal consistency reliability

The next steps to assess the model consist of evaluating the convergent validity of reflective constructs. As oriented by (Joseph F. Hair et al., 2017) researchers should consider the outer loadings of the indicators and the average variance extracted (AVE).

A common rule of thumb is that the standardized outer loadings should be 0.708 or higher. For those values with values lower than the threshold proposed above, the author suggest that if it ranges on between 0.40 and 0.70 the indicator should be considered for removal from the scale only when deleting the indicator leads to an increase in the composite reliability (average variance extracted).

Constructs	Average Variance Extracted (AVE)
Demand Risks	0,57
Infrastuctural Risks	0,69
Operational Performance	0,57
Regulatory Risks	0,86
Supplier Risks	0,63
Supply Chain Agility	0,78
Supply Chain Riks Management	0,82
Supply Chain Internal Integration	0,59
Supply Chain Customer Integration	0,55
Supply Chain Supplier Integration	0,54
Supply Chain Robustness	0,85

Table IV - 15 - Average Variance Extracted (AVE) – Before Adjustments

A common rule of thumb is that the standardized outer loadings should be 0.708 or higher. For those values with values lower than the threshold proposed above, the author suggest that if it ranges on between 0.40 and 0.70 the indicator should be considered for removal from the scale only when deleting the indicator leads to an increase in the composite reliability (average variance extracted).

Indicator	Loadings	Indicator	Loadings
AGL 1	0,85	SCRI1	0,81
AGL2	0,88	SCRI2	0,76
AGL3	0,92	SCRI3	0,85
AGL4	0,87	SCRI4	0,90
MOP 1	0,71	SCRM 1	0,92
MOP 10	0,61	SCRM2 -	0,90
MOP 2	0,83	SCRM3	0,90
MOP 3	0,72	SCRM4	0,89
MOP 4	0,82	SCRR1	0,92
MOP 5	0,83	SCRR2	0,93
MOP 6	0,83	SCRS1	0,82
MOP 7	0,81	SCRS2	0,85
MOP 8	0,67	SCRS3	0,66
MOP 9	0,67	SCRS4	0,87

SCRD1	0,92	SCRS5	0,74
SCRD2	0,88		

Indicator	Loadings	Indicator	Loadings
SCIC1	0,67	SCIS1	0,82
SCIC2	0,72	SCIS2	0,70
SCIC3	0,77	SCIS3	0,74
SCIC4	0,77	SCIS4	0,31
SCIC5	0,80	SCIS5	0,41
SCIC6	0,77	SCIS6	0,41
SCIC7	0,83	SCIS7	0,87
SCIC8	0,70	SCIS8	0,86
SCIC9	0,74	SCIS9	0,86
SCIC10	0,70	SCIS10	0,84
SCIC11	0,67	SCIS11	0,85
SCII1	0,75	SCIS12	0,83
SCII2	0,75	ROB1	0,90
SCII3	0,77	ROB2	0,95
SCII4	0,80	ROB3	0,92
SCII5	0,80	ROB4	0,93
SCII6	0,76		
SCII7	0,79		
SCII8	0,68		
SCII9	0,84		

Table IV - 16 - Indicator Outer Loadings

Based on the above results, it is possible to visualize that that the Supplier Integration Construct to be refined with a reduced number of variables since some variables have Outer Loadings lower than 0.4 or very close to this threshold. Based on such assumptions the indicators SCIS 4, SCIS 5, SCIS 6, were excluded and the PLS Algorithm was run again producing positive effect on the model by increasing the value of AVE from 0,54 to 0,67.

Constructs	Average Variance Extracted (AVE)
Demand Risks	0,57
Infrastuctural Risks	0,69
Operational Performance	0,57
Regulatory Risks	0,86
Supplier Risks	0,63
Supply Chain Agility	0,78
Supply Chain Riks Management	0,82
Supply Chain Internal Integration	0,59
Supply Chain Customer Integration	0,55
Supply Chain Supplier Integration	0,67
Supply Chain Robustness	0,85

Table IV - 17 - Average Variance Extracted (AVE) – After Adjustment

The next step consist of discriminant validity following the parameters suggested by (Joe F. Hair et al., 2012). Discriminant validity is the extent to which a construct is truly distinct from other constructs by empirical standards. Thus, establishing discriminant validity implies that a construct is unique and captures phenomena not represented by other constructs in the model (Joseph F. Hair et al., 2017, p.131).

As point out by Henseler, J., Ringle, C. M., & Sarstedt (2014, p.116) "If discriminant validity is not established, constructs [have] an influence on the variation of more than just the observed variables to which they are theoretically related" and, as a consequence, "researchers can not be certain that results confirming hypothesized structural paths are real or whether they are a result of statistical discrepancies.(Farrell, 2010, p. 324)"

	Customer Integration	Demand Risk	Infrastuctura	Internal Integ	Operational I	Regulatory R	Robustness	Supplier Inte	Supplier Risks	Supply Chain	Supply Chain Riks
Customer Integration	**0,74**										
Demand Risks	-0,17	**0,90**									
Infrastuctural Risks	-0,21	0,47	**0,83**								
Internal Integration	0,63	-0,19	-0,34	**0,77**							
Operational Performance	0,43	-0,39	-0,49	0,55	**0,75**						
Regulatory Risks	-0,20	0,47	0,68	-0,24	-0,39	**0,93**					
Robustness	0,44	-0,16	-0,31	0,48	0,53	-0,20	**0,92**				
Supplier Integration	0,53	-0,02	-0,09	0,61	0,29	-0,13	0,42	**0,82**			
Supplier Risks	-0,31	0,59	0,66	-0,37	-0,61	0,65	-0,31	-0,17	**0,79**		
Supply Chain Agility	0,34	-0,03	-0,16	0,44	0,40	-0,14	0,61	0,28	-0,24	**0,88**	
Supply Chain Riks Management	0,57	-0,35	-0,36	0,69	0,61	-0,30	0,51	0,45	-0,52	0,46	0,91

Table IV - 18 - Discriminant validity - Fornell-Lacker Criteria

	Customer Int	Demand Risk	Infrastuctura	Internal Integ	Operational I	Regulatory R	Robustness	Supplier Inte	Supplier Risk	Supply Chain Agility
Customer Integration										
Demand Risks	0,21									
Infrastuctural Risks	0,24	0,56								
Internal Integration	0,67	0,22	0,38							
Operational Performance	0,45	0,44	0,54	0,58						
Regulatory Risks	0,24	0,57	0,80	0,27	0,43					
Robustness	0,46	0,18	0,34	0,51	0,57	0,22				
Supplier Integration	0,57	0,09	0,14	0,65	0,31	0,16	0,44			
Supplier Risks	0,34	0,72	0,77	0,41	0,67	0,77	0,34	0,19		
Supply Chain Agility	0,35	0,14	0,17	0,47	0,43	0,15	0,65	0,29	0,25	
Supply Chain Riks Manage	0,60	0,41	0,41	0,74	0,66	0,35	0,54	0,48	0,59	0,48

Table IV - 19 - Heterotrait-Monotrait Ratio (HTMT) Test

The results at table 19 support for the lower-order components' discriminant validity, because all HTMT values are below the conservative threshold of 0.85. (Franke & Sarstedt, 2019; Henseler et al., 2015; Voorhees et al., 2016). However, the discriminant validity between Demand Risks, Supplier Risks, Regulatory Risks and Infrastructural Risks both and their higher-order construct Supply Chain Risks was not assessed. According to Sarstedt et al., (2019, p.203), "violation of discriminant validity between these constructs is expected, because the measurement model of the higher-order component repeats the indicators of its lower-order components."

As suggested by (Sarstedt et al., 2019), the assessment of the lower-order components draws on the standard reliability and validity criteria for reflective measurement models as documented in the extant literature. Then, based on the results shown at tables 15 to 19 above, the Low Order Constructs of the research model met the convergent validity, internal consistency reliability, and discriminant validity as suggested by the literature

4.3.7 - High Order Construct Assessment

The repeated indicators approach was applied to establish the reflective-reflective relationship among Supply Chain Risks higher-order construct and is low-order constructs *Demand Risks, Supply Risks, Regulatory Risks and Infrastructural Risks. By applying such approach* all 13 indicators of the reflectively measured lower-order components are simultaneously assigned to the reflective measurement model of the higher-order construct.

"A reflective specification is appropriate when there is a more general, abstract construct that explains the correlations between the LOCs. Hence, there should be substantial correlations between the LOCs that—analogous to reflective measurement models—are assumed to be caused by the HOC. That is, the HOC is the spurious cause explaining the correlations between the LOCs.(Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017, p.43)

In order to verify the conditions suggested above by (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017) the correlations among the LOC were found to be relevant as show in the table below:

	Demand Risks	Infrastuctural Risks	Regulatory Risks	Supplier Risks
Demand Risks	1.000	0.467	0.469	0.599
Infrastuctural Risks	0.467	1.000	0.685	0.661
Regulatory Risks	0.469	0.685	1.000	0.649
Supplier Risks	0.599	0.661	0.649	1.000

Table IV - 20 - Latent Variable Correlations

The reliability and validity assessment of the higher-order construct *Supply Chain Risks* should be assessed taking into consideration its relationship with its lower-order components. The constructs *Demand Risks, Supply Risks, Regulatory Risks and Infrastructural Risks* are specifically interpreted as if they were indicators of the *Supply Chain Risks* construct. As a consequence, the (reflective) relationships between the *High Order* construct and its lower-order components, are interpreted as loading although they appear as path coefficients in the path model (Sarstedt et al., 2019).

The analysis produces loadings of 0,882 for *Demand Risks,* 0.911 for *Supplier Risks*, 0,788 for *Regulatory Risks* and 0,843 *Infrastructural Risks* for we thereby providing support for indicator reliability. By using these indicator loadings and the correlation between the constructs (0.665) as input, the higher-order construct'reliability and validity should be calculate out of Smart-PLS Software (manually) based on the equation suggested by (Sarstedt et al., 2019, p. 204).

The AVE is the mean of the higher-order construct's squared loadings for the relationships between the lower-order components and the higher-order component:

$$AVE = \frac{\left(\sum_{i=1}^{M} l_i^2\right)}{M},$$

where l_i represents the loading of the lower-order component *i* of a specific higher-order construct measured with *M* lower-order components ($i = 1,...,M$). For this example, the AVE is $(0.702^2 + 0.910^2 + 0{,}820^2 + 0{,}869^2)/4 = 0.69$, which is above the 0.5 threshold, therefore indicating convergent validity for *Supply Chain Risks* (Sarstedt et al., 2017).

The composite reliability is defined as

$$\rho_C = \frac{\left(\sum_{i=1}^{M} l_i\right)^2}{\left(\sum_{i=1}^{M} l_i\right)^2 + \sum_{i=1}^{M} var(e_i)},$$

where e_i is the measurement error of the lower-order component *i,* and $var(e_i)$ denotes the variance of the measurement error, which is defined as $1 - l_i$. Entering the for loading values yields the following:

Pc =$(0.702 + 0.910 + 0{,}820 + 0{,}869)^2 / (0.702 + 0.910 + 0{,}820 + 0{,}869) + (1- 0.702^2) + (1-0.910^2) + (1-0{,}820)^2 + (1- 0{,}869)^2 = 0{,}896$

Similarly, Cronbach's α is given by

$$Cronbach's\ \alpha = \frac{M \cdot \bar{r}}{(1 + (M-1) \cdot \bar{r})},$$

where r^{-} represents the average correlation between the lower order components. Since the higher-order construct Supply Chain Risks has four lower-order components (i.e., *M* = 4), the average correlation is equal to the correlation between the *Demand Risks, Supplier Risks, Regulatory Risks and Infrastructural Risks* construct scores (i.e., 0.647). Hence, Cronbach's alpha is given by

Cronbach's alpha, α = 4* 0,588/(1+(4-1)* 0,588 = 0,85

Overall, these results provide clear support for the higher-order construct's internal consistency reliability as all criteria (i.e., ρ_C, and Cronbach's α_A) are well above the commonly recommended threshold of 0.708 (Hair, Joe, Jr.; Sarstedt, Marko; Ringle, Christian M.; Gudergan, 2017)

4.3.8 - Structural Model Assessment

The assessment of the structural model should be performed based on the following steps: Collinearity among the latent variables, path coefficients; coefficient of determination R2, Effect Size f2, Blindfolding and predictive relevance Q2 and Effect Size q2

Collinearity arises when two indicators are highly correlated. Collinearity among latent variables is assessed through Variance Inflated Factor (VIF). VIF values above 5 indicate collinearity among the predictor constructs (Sarstedt, Ringle, & Hair, 2020, p 21). As shown in the table below, all model constructs have VIF values lower than the threshold suggested.

	Operational Performance	Supply Chain Robustness
Customer Integration	1.86	1.86
Internal Integration	2.71	2.67
Supplier Integration	1.74	1.70
Supply Chain Agility	1.33	1.32
Supply Chain Riks Management	2.52	2.24
Supply Chain Risks	1.34	

Table IV - 21 - VIF values (Latents Variables)

"The strength and significance of the path coefficients is evaluate regarding the relationships (structural paths) hypothesized between the constructs. Similar to the assessment of formative indicator weights, the significance assessment builds on bootstrapping standard errors as a basis for calculating t and p values of path coefficients" (Sarstedt et al., 2017, p.22).

	Operational Performance	Supply Chain Robustness
Customer Integration	0.05	0.10
Internal Integration	0.19	0.00
Supplier Integration	-0.07	0.14
Supply Chain Agility	0.14	0.46
Supply Chain Riks Management	0.28	0.22
Supply Chain Risks	-0.38	

Table IV - 22 - Path coefficients

The path coefficients are significant if the T-statistics is larger than 1.96 and the p-value lower than 0,05 (Sarstedt et al., 2017). Using such parameters we analyze the structural model by using bootstrapping, to obtain better statistical fit and check the statistical significance of the obtained coefficients, a structural model was estimated based on bootstrapping with 5000 subsamples as suggested by (Wong, 2019)

Hypotheses	Original Sample (O)	Sample Mean (M)	T Statistics (|O/STDEV|)	P Values	Result
Customer Integration -> Operational Performance	0.05	0.06	0.53	0.59	non-significant
Customer Integration -> Supply Chain Robustness	0.10	0.10	1.12	0.26	non-significant
Internal Integration -> Operational Performance	0.19	0.18	1.58	0.11	non-significant
Internal Integration -> Supply Chain Robustness	0.00	0.01	0.02	0.99	non-significant
Moderating Effect 1 -> Operational Performance	0.14	0.14	2.41	0.02**	significant
Moderating Effect 2 -> Supply Chain Robustness	0.14	0.14	2.08	0.04**	significant
Supplier Integration -> Operational Performance	-0.07	-0.07	0.99	0.32	non-significant
Supplier Integration -> Supply Chain Robustness	0.14	0.14	1.96	0.05***	significant
Supply Chain Agility -> Operational Performance	0.14	0.15	1.95	0.05***	significant
Supply Chain Agility -> Supply Chain Robustness	0.46	0.46	6.03	0.00*	significant
Supply Chain Riks Management -> Operational Performance	0.28	0.27	3.12	0.00*	significant
Supply Chain Riks Management -> Supply Chain Robustness	0.22	0.21	2.31	0.02**	significant
Supply Chain Risks -> Operational Performance	-0.38	-0.38	5.49	0.00*	significant

Table IV - 23 - T-Statistics - Boostrapping

*** significant at 0.000**
****significant at <0.05**
*****significant at<0.10**

The multiple correlation coefficient R2, also known as the coefficient of determination, is defined as the proportion of variance explained by the regression model. Thus, its results can be seen as a measure of predicting the dependent variable from the independent variables (Nagelkerke, 1991). The coefficient of determination, R2, is 0.532 for the Operational Performance endogenous latent variable. The coefficient of determination, R2, is 0.527 for the Operational Performance and 0.473 for Robustness which are endogenous latent variables of interest at the present research. This means that the developed model explain around 53 % of the variance in Operational Performance and 47% in Supply Chain Robustness.

In addition to evaluating the R2 values of all endogenous constructs, the change in the R2 value when a specific predictor construct is omitted from the model can be used to assess whether the omitted construct has a substantive impact on the endogenous constructs. This measure refers to the $f2$ effect size (Sarstedt, Ringle, & Hair, 2020, p 21).

As a guideline, $f2$ values of 0.02, 0.15, and 0.35, respectively, represent small, medium, and large effects of an exogenous latent variable. Effect size values of less than 0.02 indicate that there is no effect. (Sarstedt, Ringle, & Hair, 2020, p 21).

Based on the results in table 26, we analyze the effect size of the relationship that were found significant (see table 25). Supply Chain Agility and Supply Chain Risk Management has a small effect on operational performance, whereas Supply Chain Risks produce medium effects. In regards to Supply Chain Robustness, we observe a large effect of Supply Chain Agility and a small effect of Supply Chain Risks Management and Supplier Integration.

	Operational Performance	Supply Chain Robustness
Customer Integration	0.00	0.01
Internal Integration	0.03	0.00
Supplier Integration	0.01	0.02
Supply Chain Agility	0.03	0.32
Supply Chain Riks Management	0.07	0.04
Supply Chain Risks	0.23	

Table IV - 24 - Effect Size f2

The Q2 value builds on the blindfolding procedure, as proposed by (Joseph F. Hair et al., 2017, p. 202). "in addition to evaluating the magnitude of the R^2 values as a criterion of predictive accuracy, researchers should also examine Stone-Geisser's Q^2 value (Geisser, 1974; Stone, 1974). This measure "can only be partly considered a measure of out-of-sample prediction, because the sample structure remains largely intact in its computation." (Sarstedt, M., Ringle, C. M., & Hair, 2017, p.21)

The resulting Q^2 values larger than zero indicate that the exogenous constructs have predictive relevance for the endogenous constructs under consideration. "As a rule of thumb, Q2 values larger than zero for a particular endogenous construct indicate that the path model's predictive accuracy is acceptable for this particular construct (Sarstedt, Ringle, & Hair, 2020, p 22)".

As proposed by (Joseph F. Hair et al., 2017), the following rule of thumb allows to interpret the Q^2 results (based on the cross-validated redundancy):
- $0.02 \leq Q^2 < 0.15$: weak predictive power
- $0.15 \leq Q^2 < 0.35$: moderate predictive power
- $Q^2 \geq 0.35$: strong predictive power

Thus, our model renders a moderate predictive power concerning Operational Performance and a strong predictive power in regards to Supply Chain Robustness, as can seen at Table 26 below:

	SSO	SSE	Q^2 (=1-SSE/SSO)
Operational Performance	1.650.000	1.176.22	0.29
Supply Chain Robustness	660.000	394.13	0.40

Table IV - 25 - Blindfolding and predictive relevance Q2

Analogous to the f2 effect size, researchers can also analyze the q2 effect size, which indicates the change in the Q2 value when a specified exogenous construct is omitted from the model. As a relative measure of predictive relevance, "q2 values of 0.02, 0.15, and 0.35 indicate that an exogenous construct has a small, medium, or large predictive relevance, respectively, for a certain endogenous construct" (Joseph F. Hair et al., 2017, p. 208). Such calculation is based on the following equation:

Operational Performance:

$q^2 = [Q^2(included) - Q^2(excluded)] / 1 - Q^2(included)$

q^2 (Supply Chain Agility) = (0,29-0,26)/1-0,29 = 0,03/0,71 = 0,04

q^2 (Supply Chain Risk Management) = 0,29 – 0,25/ 1-0,29 = 0,04.0,71 = 0,05

q^2 (Supply Chain Risks) = 0,29 – 0,22/ 1-0,29 = 0,09

Robustness:

$q^2 = [Q^2(included) - Q^2(excluded)] / 1 - Q^2(included)$

q^2 (Supply Chain Agility) = (0,40-0,26)/1-0,40 = 0,14/0,6 = 0,46

q^2 (Supply Chain Risk Management) = 0,40 – 0,38/ 1-0,40 = 0,02/0,6 = 0,03

q^2 (Supplier Integration) = (0,40 – 0,40)/1-0,40 = 0.00

4.3.9 - Moderation analysis

"A moderation effect is a causal model that postulates ''when'' or ''for whom'' an inde- pendent variable most strongly (or weakly) causes a dependent variable (Baron and Kenny 1986; Frazier et al. 2004; Kraemer et al. 2002). In essence, a moderator modifies the strength or direction (i.e., positive or negative) of a causal relationship" (Wu & Zumbo, 2008, p.370)

Moderation is characterized as a condition in which a third variable interferes in the relationship between a dependent variable and an independent one. From the influence of the moderator, the strength and direction of the effect generated by the predictor variable in the output variable can be changed. (Sarstedt, M., Ringle, C. M., & Hair, 2017)

From such assumptions, we further explore the relationship between Supply Chain Agility and Supply Chain Robustness. We introduce supply chain risk management as moderator variable that can be assumed to positively influence the relationship above. That is, for industries with better practices of risk management in place, there may higher positive impact of Supply Chain Agility and Supply Chain Robustness as can be seen in Figure 3.

The interaction term has a positive effect on Operational Performance (0.137), whereas the simple effect of Supply Chain Agility on Supply Chain Robustness is 0.463. Next, we assess whether the interaction term is significant. For this purpose, we run the bootstrapping procedure. The analysis yields a p-value of 0.04. Then, we can consider it significant. Thus, the relationship between Supply Chain Agility on and Supply Chain Robustness increases by the size of the interaction term (0.463+0.137), equal to 0.60.

Finally, last step addresses in the moderator's f2. effect size. According to (Joseph F. Hair et al., 2017) highlights that in the case of moderation analysis Kenny (2016) proposes that 0.005, 0.01, and 0.025 constitute more realistic standards for small, medium, and large effect sizes than the tradicional values of 0.02, 0.15, and 0.35 represent small, medium, and large effect sizes, respectively proposed by Cohen (1988). The interaction term f2 effect size has a value of 0,04, which represents a large effect of moderator effect.

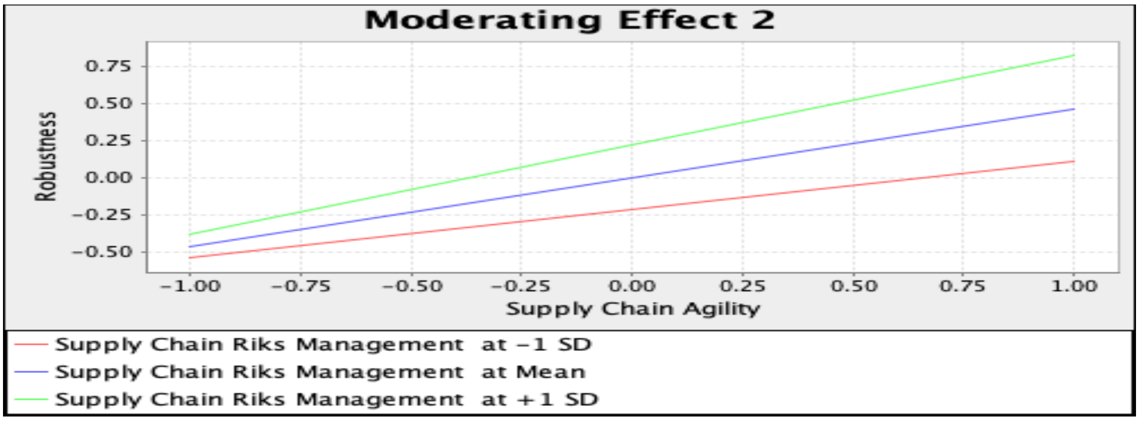

Figure IV - 3 - Slope Analysis

4.3.10 – Mediation analysis

As per Wu and Zu (2008), which cited (Muller, Judd, & Yzerbyt, p. 852, 2005) , a mediational analysis attempts to ‘‘identify the intermediary process that leads from the independent variable to the dependent variable’’.

Being more specific, in a simple mediational model, the independent variable is presumed to cause the mediator, and in turn, the mediator causes the dependent variable. For this reason, a mediation effect is also termed an indirect effect, surrogate effect, intermediates effect, or intervening effect (Wu and Zu, 2008, MacKinnon, Lockwood, Hoffman and Sheets, 2002).

In this study, mediation Analysis was performed to assess the mediating role of Supply Chain Risk Management on the linkage between Supplier Integration, Internal Integration and Customer Integration with Operational Performance. We follow the decision tree criteria proposed by Zhao, Lynch, & Chen (2010), as exposed below:

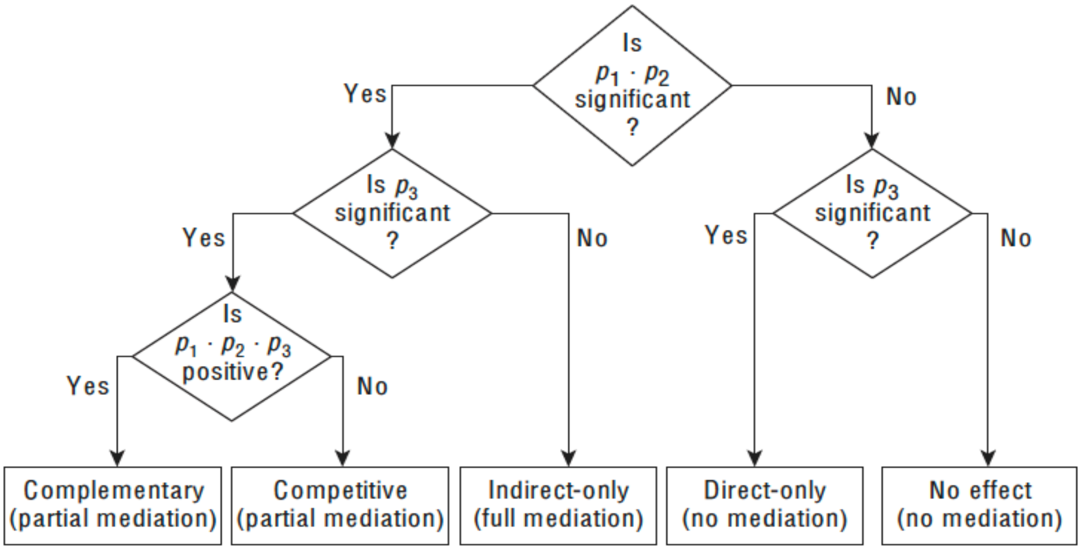

Figure IV - 4 Mediation Decision Tree extract from (Joseph F. Hair et al., 2017, p. 249)

The results of our calculations (see table 26) revealed the following mediation patterns in our model:

	Indirect Effect		Direct Effect		
	T Statistics	P Values	T Statistics	P Values	Results
Customer Integration -> Supply Chain Riks Management -> Operational Performance	2.06	0.04	0.52	0.60	Full Mediation
Internal Integration -> Supply Chain Riks Management -> Operational Performance	2.68	0.01	1.57	0.12	Full Mediation
Supplier Integration -> Supply Chain Riks Management -> Operational Performance	0.02	0.99	0.99	0.32	No Mediation

Table IV - 26 - Mediation results

Finally, taking into consideration the results of both the measurement and the structural model, we reach the following results for the proposed hypotheses:

H1: Supply Chain Risks negatively impacts Operational Performance – Chapter 2	Supported
H2: Supply Chain Risks Management positively impacts Operational Performance - Chapter 3	Supported
H3: Supply Chain Agility positively impacts Operational Performance - Chapter 3	Supported
H4: Supply Chain Risks Management positively moderates the relationship Supply Chain Agility and Operational Performance. Chapter 3	Supported
H5: Supplier Integration positively impacts Operational Performance	Not Supported
H6: Internal Integration positively impacts Operational Performance	Not Supported
H7: Customer Integration positively impacts Operational Performance	Not Supported
H8: Supply Chain Risks Management mediates the relationship among Supplier Integration and Operational Performance	Not Supported
H9: Supply Chain Risks Management mediates the relationship among Internal Integration and Operational Performance	Supported
H10: Supply Chain Risks Management mediates the relationship among Customer Integration and Operational Performance	Supported
H11: Supplier Integration positively impacts Robustness	Supported
H12: Internal Integration positively impacts Robustness	Not Supported
H13: Customer Integration positively impacts Robustness	Not Supported
H14: Supply Chain Risk Management positively impacts Supply Chain Robustness.	Supported
H15: Supply Chain Agility positively impacts Supply Chain Robustness.	Supported
H16: Supply Chain Risks Management positively moderates the relationship Supply Chain Agility and Robustness.	Supported

Table IV - 27 - Hypotheses Results

4.3.11 – Relevant changes observed in the improved model.

The improvement made in the model produced changesin regards to the significance of the effect of Supply Chain Agility on Operational Performance (H3) since it shifts from a p-value of 0.02 (see Chapter 3) to 0.05 (see table 23). Then, observing the threshold of 0.05, H3 would become a non-significant relationship. Nevertheless, by assuming a less conservative significance level of 0.1, the significance level remains supported.

4.4 – NECESSARY CONDITION ANALYSIS (NCA) - MODEL REFINEMENT

As discussed previously, the second research question proposed in this research is the following: Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary conditions, to a certain degree, to achieve relatively higher Operational Performance in the context of Brazilian industries?".

The research methods applied so far did not allow us to explore such a question, and, consequently, it remains unanswered to the investigation performed up to this moment. In fact, as stressed out by Tho (2018, p. 323), the question of "what level of each capability serving as a necessary condition for a wanted level of performance has been largely ignored in the literature." Then, at this point, we shift our analysis to a necessity logic perspective of the model through the application of Necessary Condition Analysis in the complement of PLS-SEM.

Researchers may utilize Necessary Condition Analysis to identify the level that a necessary condition must achieve to ensure a certain level of an outcome of interest; in other words, through Necessary Condition Analysis, we can establish an understanding of the necessary causes that must be in place to guarantee an outcome or a certain level of it. Differently, from a sufficiency perspective, we may find that a specific factor is sufficient to achieve certain results, but it may be not necessary since another factor may compensate for its absence (Richter et al., 2020)

Based on the observation above, we can assume that due to the necessary logic nature of the second question proposed in our research, the application of PLS-SEM is not suitable since such a method is adequate to measure the average net effect (mean-based) and the significance of the relationships from a sufficiency perspective only.

According to Dul, Hak, Goertz, & Voss (2010, p.1173), "Necessary condition hypotheses are important types of hypotheses that are common in many fields including Operations Management." Based on the literature, historically, scholars have reported different variables as "necessary conditions" but with no appropriate quantitative methodological approach to support such calls (Dul, Hak, Goertz, & Voss, 2010).

As suggested by the authors above, necessary conditions are usually written without using the word "necessary" but instead use the following types of formulations:: X is needed for Y; X is critical for Y; X is crucial for Y; X is essential for Y; X is indispensable for Y; X is a prerequisite for Y; X is a requirement for Y; X is a pre-condition for Y; X allows Y; there must be X to have Y, and Y requires.

In the field of Supply Chain and Dynamic Capabilities research, previous studies have reported the role of different dynamic capabilities (here understood as different types of Supply Chain Strategy) as necessary conditions to achieve a higher relative competitive advantage, success and outperform rivals, but with no consistent analytical approach to support such a call. Different examples of such statements can be seen in table 28.

Factor	Outcome	Statement	Source
Supply Chain Risks Management	Sucess	"Supply chain risk management is critical for the success of organizations in the petroleum industry."	(Lambaino et al., 2018, p.380)
Supply Chain Risks Management	Operational Performance	"….operational performance requires that the risks and uncertainty inherent in each subsystem must be identified and analyzed:	(Green & Stafford Smith, 1975, p.182)
Supply Chain Agility	Sucess	"Supply chain agility is essential for the success of all entities in the supply chain network."	(Darmawan & Maulida, 2021, p.93)
Supply Chain Agility	Superior Competitive condition	"Supply chain agility allows firms to establish a superior competitive position by responding quickly and effectively to market volatility and other uncertainties"	(Zhu & Gao, 2021, p.168)
Supply Chain Agility	Superior Value	"Supply Chain Agility allows companies to create superior value for customers as a response to their demand requirement"	(Müller, Hoberg, & Fransoo, 2021, p,6)
Supply Chain Agility	Competitive Advantage	"Supply chain agility is critical for increasing competitive advantage".	(Anggraeni & Wibowo, 2021, p.19)
Supply Chain Agility	Firm Performance	"Supply chain agility is crucial for the firm performance"	(Ezgi Şahin, Murat Çemberci, Mustafa Emre Civelek, & Nagehan Uca, 2017, p.339)
Supply Chain Agility	Competitiveness	"Supply chain, agility is necessary for competitiveness"	(Iskanius & Helaakoski, 2009, p.371)
Supply Chain Agility	Customer expectations	"Supply chain agility is needed to meet customer expectations."	(Gligor, Holcomb, Maloni, & Davis-Sramek, 2019, p.252)
Supply Chain Integration	Service performance Information flow Generates profit, Effective and Efficient decision value-added benefits	"Enterprise supply chain integration is needed to ensure an enterprise achieves a certain level of service performance, have a discernible information flow, generates profit, and creates an effective and efficient decision in order to provide maximum value-added benefits to customers and suppliers."	(Rudyanto, Soemarni, Pramono, & Purwanto, 2020, p.865)
Supply Chain Integration	Customer demands	Supply chain integration is needed for satisfying customer demands	(Makhdoom, Anjum, Kashif, & Riaz, 2016)
Supply Chain Integration	Competitive advantage	"…it is necessary to choose a specific degree of supply integration (=resource access)	(Sembritzki & Glas, 2015, p.110)

		to realize competitive advantage”.	
Supply Chain Integration	Success	“…the following were identified as critical success factors in the industry: Supply Chain Integration”	(Gloria & Talavera, 2015, p.54)
Supply Chain Integration	Performance of the supply chain	“But a growing body of literature on operations management has suggested that a high degree of supply chain integration is needed to improve the performance of the supply chain”	(Saha & Sarmah, 2013, p.193)
Supply Chain Integration	Performance	“In the retail industry where products have varying shelf lives, the importance of supply chain integration is critical for performance and survival in a competitive business environment.”	(Edward & Bray, 2015, p.42)
Supply Chain Integration	Performance	“Supply chain integration is critical in creating competitive advantage and improving organizational performance. Therefore, it is necessary to synchronize planning with other organizations.”	(Perdana, Ciptono, & Setiawan, 2018, p.1822)
Supply Chain Integration	Operational Performance	“The essence of improving operational performance requires that the supply chain be linked together in an information supply chain…”	(Ahlawat & Martinez, 2016, p.57)
Resources	Supply Chain Robustness	“increasing robustness requires the allocation of scarce resources.”	(Wieland & Wallenburg, 2012, p.897)
Dynamic capabilities	Competitive Advantage	“Dynamic capabilities are necessary, but not sufficient, conditions for competitive advantage”	(Eisenhardt & Martin, 2000, p.1106).
Dynamic capabilities	Competitive advantage	“Dynamic capabilities are necessary in turbulent contexts”	(Castiaux, 2012, p.3)
Dynamic capabilities	Organizational Performance	“Dynamic capabilities are necessary but not sufficient on their own. Sensing, seizing, and reconfiguring capabilities are peripheral to organizational performance, as their cause-effect associations with performance are weak”	(Jantunen, Tarkiainen, Chari, & Oghazi, 2018, p.5).

Table IV - 28 - Examples of “Necessary conditions” reported in the literature

Then, Necessary Condition Analysis was developed by Jan Dul, in 2016, to enable researchers to "test or induce hypotheses examining the necessary but not sufficient contributions of various organizational determinants (e.g., events, characteristics, resources, efforts) to various outcomes (e.g., individual job attitudes, firm performance)" (Dul, 2016, p. 11),

Necessary Condition Analysis development was promoted motivated to the author's views that research in organizational science heavily relies on sufficiency data analysis to evaluate the phenomenon of interest even though the hypotheses statement indicates a necessity nature type of relationship.

Since the introduction of Necessary Condition Analysis, this statistical technique has been increasingly used for testing necessary conditional assumptions in the social sciences. Figure 5 shows the evolution of its cumulative application, from 2016 to 2020.

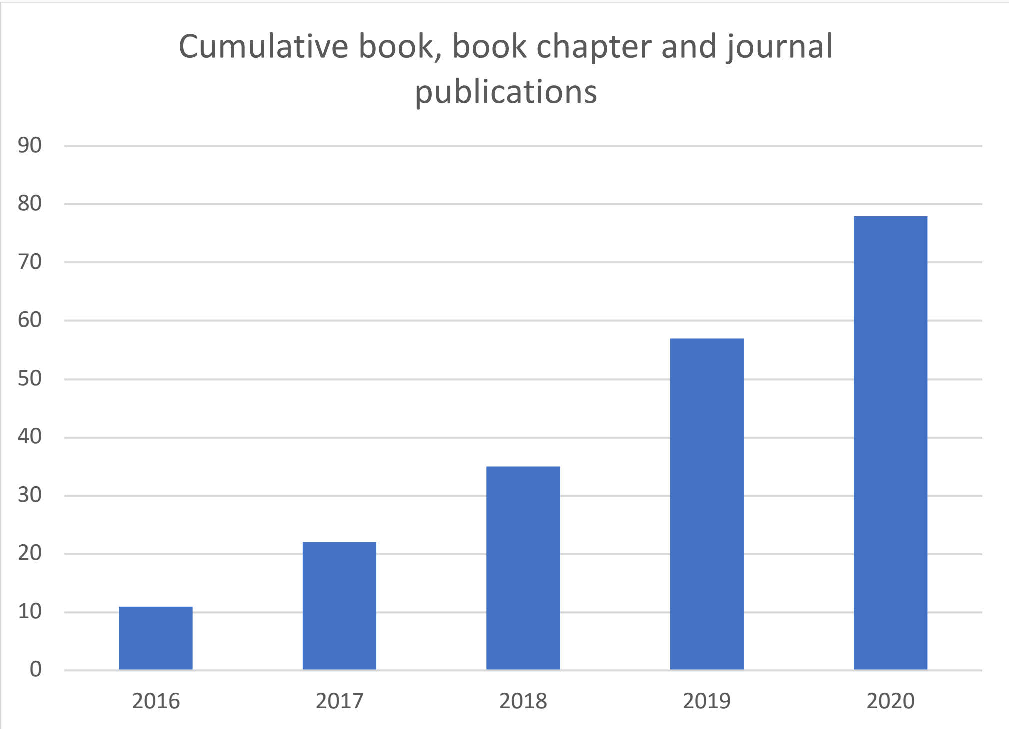

Figure IV - 5 - – NCA Publications in the last 5 years (80 publications) - source: (Dul, 2021)

In the study, by applying Necessary Condition Analysis analytical approach, we will perform an analysis from a different angle regarding the ongoing discussion in the field of Supply Chain Management about the nature of the relationship among different Dynamic Capabilities (understood here as Supply Chain Strategies) and Organization Performance (here measured as Operational Performance and Supply Chain Robustness). As suggested by (Goertz 2016, p.857), "If the practice and recognition of necessary-condition hypothesizing become more widespread, a richer and more detailed dialogue will no doubt develop."

Dul (2016) highlights that when applying Necessary Condition Analysis, researchers may deal with variables may that assume just two levels (e.g., absent/present), in which an "in kind" analysis is suitable and variables with more than two levels, where an "in degree" analysis is more appropriated. The "in degree" perspective enables propositions like which level of the variable "A" is necessary for the outcome "B."

In our case, due to the nature of our second research question, we formulated "in degree" necessity hypotheses, as presented in Tables 32 and 33. By exploring these hypotheses, we seek to understand at which level Internal Integration, Supplier

Integration, Customer Integration, Supply Chain Agility, Supply Chain Risks Management must be in place in all sufficient combinations to ensure that these combinations will generate relatively higher Operational Performance and Supply Chain Robustness.

Necessary Conditions Hypothesis		
H1: Internal Integration	+ ➔+	Operational Performance
H2: Supplier Integration	+ ➔+	Operational Performance
H3: Customer Integration	+ ➔+	Operational Performance
H4: Supply Chain Agility	+ ➔+	Operational Performance
H5: Supply Chain Risks Management	+ ➔+	Operational Performance

Table IV - 29 - Necessary Conditions for Operational Performance (in degree)

Necessary Conditions Hypothesis		
H1: Internal Integration	+ ➔+	Supply Chain Robustness
H2: Supplier Integration	+ ➔+	Supply Chain Robustness
H3: Customer Integration	+ ➔+	Supply Chain Robustness
H4: Supply Chain Agility	+ ➔+	Supply Chain Robustness
H5: Supply Chain Risks Management	+ ➔+	Supply Chain Robustness

Table IV - 30 - Necessary Conditions for Supply Chain Robustness (in degree)

4.4.1 - Data Analysis with Necessary Condition Analysis

Dul (2016) suggests two data analysis approaches named 'contingency table approach' (qualitative) and the scatter plot approach' (quantitative); both approaches are composed of 6 steps. Based on the nature of our data, we will adopt the scatter plot approach. As highlighted by Dul (2016, p.4) "The scatter plot approach can be useful when you have a dataset with X and Y scores that have a large number of levels (more than five) and when the scores are numbers, for example in a large N study."

The scatter plot approach steps are the following ones: (1) make the scatter plot; (2) identify the empty space; (3)draw the ceiling line; (4) quantify the NCA parameters; (5) evaluate the NCA parameters; (6) Formulate the conclusion.

As discussed previously, Necessary Condition Analysis will be applied in combination with PLS-SEM. According to Richter et al. (2020), such a type of analysis must observe particular procedures. For instance, since our conceptual model has reflective constructs, to conduct the analysis, we have to export the latent variables scores from PLS-SEM to import it to RStudio. The primary use of R in NCA Analysis is to calculate the NCA tests parameters (effect size, scope and ceiling zone, and p-values).

Our model has two exogenous constructs (Operational Performance and Supply Chain Robustness). For this reason, we will have to execute two Necessary Condition Analysis using all the exogenous constructs (Supplier Integration, Internal Integration, Customer Integration, Supply Chain Risk Management, and Supply Chain Agility).

Step 1and 2: Make the scatter plot and Draw the ceiling line

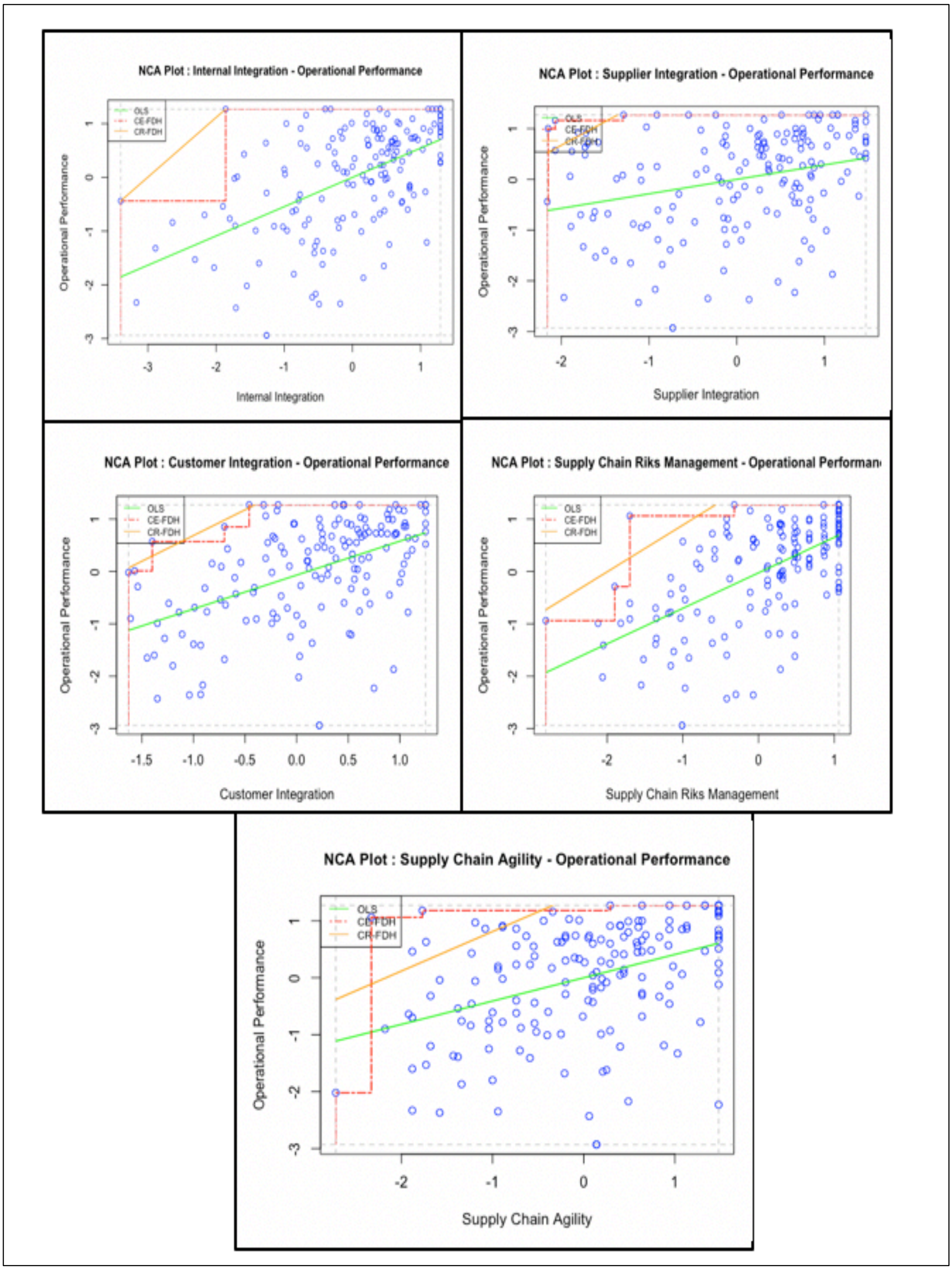

Figure IV - 6 - Necessary Condition Analysis Step 1 and 2 (Operational Performance)

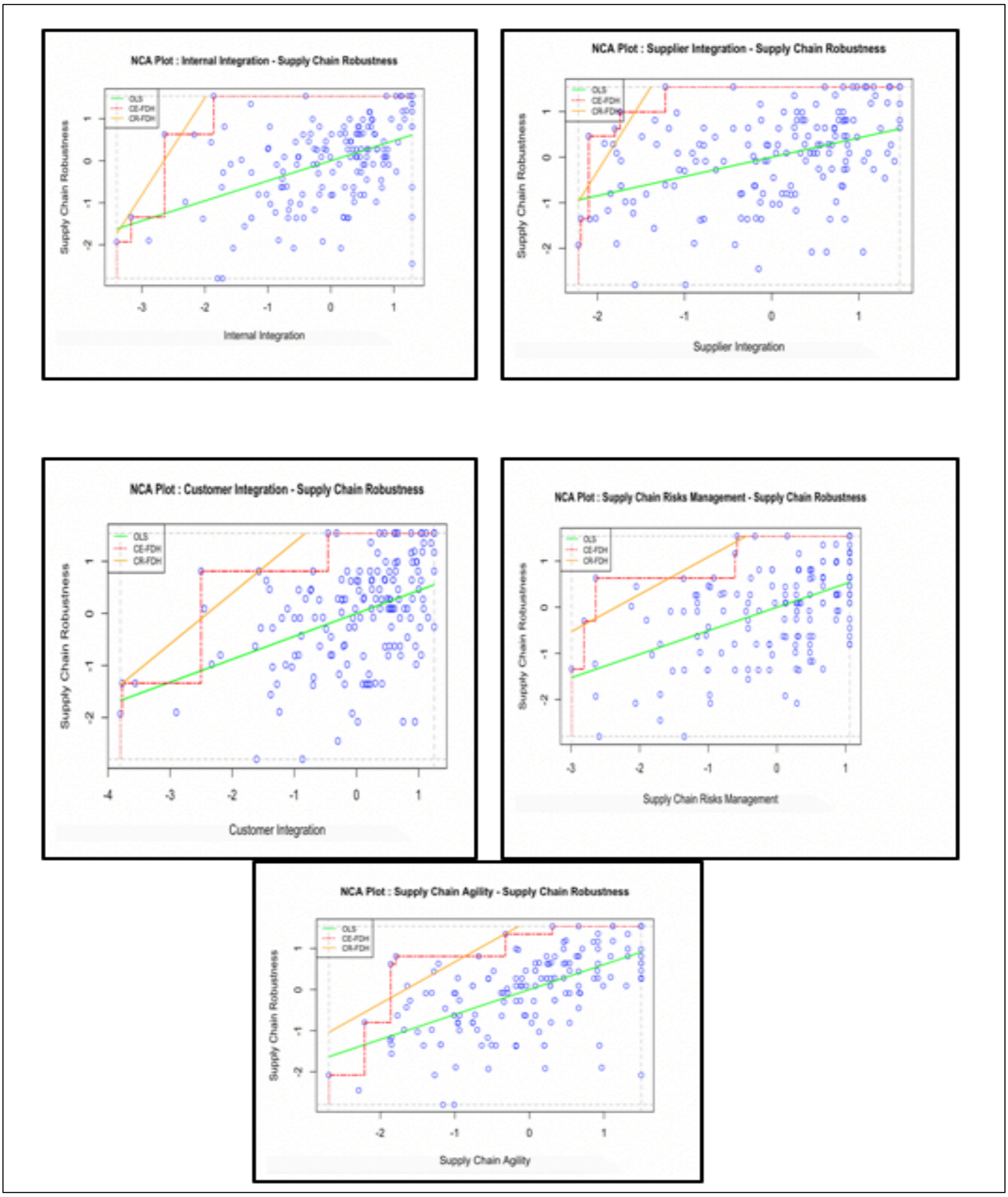

Figure IV - 7 - Necessary Condition Analysis Step 1 and 2 (Supply Chain Robustness)

Step 3: Quantify the Necessary Condition Analysis parameters

```
--------------------------------------------------------------
NCA Parameters : Internal Integration - Operational Performar
--------------------------------------------------------------

Number of observations 165
Scope                  19.74
Xmin                   -3.40
Xmax                    1.29
Ymin                   -2.94
Ymax                    1.27

                  ce_fdh  cr_fdh
Ceiling zone       2.633   1.317
Effect size        0.133   0.067
# above            0       0
c-accuracy       100%    100%
Fit              100%     50.0%
p-value            0.011   0.175
p-accuracy         0.002   0.007

Slope                      1.110
Intercept                  3.335
Abs. ineff.       17.111  17.111
Rel. ineff.       86.663  86.663
Condition ineff.  67.164  67.164
```

```
--------------------------------------------------------------
NCA Parameters : Supplier Integration - Operational Performan
--------------------------------------------------------------

Number of observations 165
Scope                  15.53
Xmin                   -2.22
Xmax                    1.47
Ymin                   -2.94
Ymax                    1.27

                  ce_fdh cr_fdh
Ceiling zone       0.174  0.347
Effect size        0.011  0.022
# above            0      4
c-accuracy       100%    97.6%
Fit              100%     0.6%
p-value            0.534  0.188
p-accuracy         0.010  0.008

Slope                     0.857
Intercept                 2.401
Abs. ineff.       13.825 14.841
Rel. ineff.       88.993 95.534
```

```
--------------------------------------------------------------
NCA Parameters : Customer Integration - Operational Performanc
--------------------------------------------------------------

Number of observations 165
Scope                  21.26
Xmin                   -3.80
Xmax                    1.25
Ymin                   -2.94
Ymax                    1.27

                  ce_fdh cr_fdh
Ceiling zone       0.965  1.402
Effect size        0.045  0.066
# above            0      2
c-accuracy       100%    98.8%
Fit              100%    54.7%
p-value            0.389  0.211
p-accuracy         0.010  0.008

Slope                     0.313
Intercept                 1.522
Abs. ineff.       15.549 18.456
Rel. ineff.       73.136 86.810
Condition ineff   33.861 40.722
```

```
--------------------------------------------------------------
NCA Parameters : Supply Chain Riks Management - Operational Performan
--------------------------------------------------------------

Number of observations 165
Scope                  17.05
Xmin                   -2.99
Xmax                    1.06
Ymin                   -2.94
Ymax                    1.27

                  ce_fdh cr_fdh
Ceiling zone       2.888  2.899
Effect size        0.169  0.170
# above            0      6
c-accuracy       100%    96.4%
Fit              100%    99.6%
p-value            0.000  0.000
p-accuracy         0.000  0.000

Slope                     1.116
Intercept                 2.064
Abs. ineff.        7.439 11.253
Rel. ineff.       43.626 65.995
Condition ineff.  34.074 43.728
Outcome ineff.    14.489 39.571
```

```
--------------------------------------------------------------
NCA Parameters : Supply Chain Agility - Operational Performan
--------------------------------------------------------------

Number of observations 165
Scope                  17.64
Xmin                   -2.69
Xmax                    1.50
Ymin                   -2.94
Ymax                    1.27

                  ce_fdh cr_fdh
Ceiling zone       1.608  1.937
Effect size        0.091  0.110
# above            0      8
c-accuracy       100%    95.2%
Fit              100%    79.6%
p-value            0.087  0.006
p-accuracy         0.006  0.002

Slope                     0.697
Intercept                 1.502
Abs. ineff.        7.836 13.766
Rel. ineff.       44.420 78.038
```

Figure IV - 8 - Necessary Condition Analysis Parameters (Operational Performance)

NCA Parameters : Internal Integration - Supply Chain Robustne

Number of observations	165	
Scope	20.35	
Xmin	-3.40	
Xmax	1.29	
Ymin	-2.80	
Ymax	1.54	
	ce_fdh	cr_fdh
Ceiling zone	3.034	2.323
Effect size	0.149	0.114
# above	0	1
c-accuracy	100%	99.4%
Fit	100%	76.6%
p-value	0.018	0.045
p-accuracy	0.003	0.004
Slope		2.310
Intercept		6.117
Abs. ineff.	15.011	15.708
Rel. ineff.	73.746	77.174
Condition ineff.	67.164	69.759

NCA Parameters : Supplier Integration - Supply Chain Robustne

Number of observations	165	
Scope	16.01	
Xmin	-2.22	
Xmax	1.47	
Ymin	-2.80	
Ymax	1.54	
	ce_fdh	cr_fdh
Ceiling zone	1.029	1.049
Effect size	0.064	0.065
# above	0	5
c-accuracy	100%	97.0%
Fit	100%	98.1%
p-value	0.006	0.006
p-accuracy	0.002	0.002
Slope		3.017
Intercept		5.723
Abs. ineff.	12.545	13.917
Rel. ineff.	78.332	86.900
Condition ineff.	72.900	77.403

NCA Parameters : Customer Integration - Supply Chain Robustne

Number of observations	165	
Scope	21.92	
Xmin	-3.80	
Xmax	1.25	
Ymin	-2.80	
Ymax	1.54	
	ce_fdh	cr_fdh
Ceiling zone	5.251	4.335
Effect size	0.240	0.198
# above	0	4
c-accuracy	100%	97.6%
Fit	100%	82.6%
p-value	0.000	0.000
p-accuracy	0.000	0.000
Slope		0.978
Intercept		2.344
Abs. ineff.	10.327	13.247
Rel. ineff.	47.120	60.443
Condition ineff.	33.861	41.038

NCA Parameters : Supply Chain Risks Management - Supply Chain Robustne

Number of observations	165	
Scope	17.58	
Xmin	-2.99	
Xmax	1.06	
Ymin	-2.80	
Ymax	1.54	
	ce_fdh	cr_fdh
Ceiling zone	2.690	2.629
Effect size	0.153	0.150
# above	0	4
c-accuracy	100%	97.6%
Fit	100%	97.7%
p-value	0.000	0.000
p-accuracy	0.000	0.000
Slope		0.811
Intercept		1.900
Abs. ineff.	10.636	12.320
Rel. ineff.	60.512	70.090
Condition ineff.	40.494	37.143
Outcome ineff.	33.641	52.416

NCA Parameters : Supply Chain Agility - Supply Chain Robustne

Number of observations	165	
Scope	18.18	
Xmin	-2.69	
Xmax	1.50	
Ymin	-2.80	
Ymax	1.54	
	ce_fdh	cr_fdh
Ceiling zone	3.814	3.285
Effect size	0.210	0.181
# above	0	5
c-accuracy	100%	97.0%
Fit	100%	86.1%
p-value	0.000	0.000
p-accuracy	0.000	0.000
Slope		1.013
Intercept		1.686
Abs. ineff.	7.325	11.615
Rel. ineff.	40.279	63.872
Condition ineff.	28.401	39.229

Figure IV - 9 - Necessary Condition Analysis Parameters (Supply Chain Robustness)

Step 4 and 5: Evaluate the Necessary Condition Analysis parameters; Formulate the conclusion.

An essential parameter in the context of Necessary Condition Analysis consists of the effect size “d”. As defined by Dul, van der Laan, & Kuik (2020. p.385), “the necessity effect size (d) is the size of the empty space above the ceiling as a fraction of the total space where cases are observed or could be observed given by the minimum and maximum empirical or theoretical values of X and Y (scope).”

The “d”effect size has values between 0 and 1. Based on Dul (2016) proposition the following interpretation should be made in regards to such variable:

- $0 < d < 0.1$ - ‘small effect’,
- $0.1 \leq d < 0.3$ -‘medium effect’,
- $0.3 \leq d < 0.5$ - ‘large effect’;
- $d \geq 0.5$ a ‘very large effect’.

Evaluating the ceiling line allows the analysis of whether the outcome is constrained or bounded by a specific condition. The area delimited from the line to the upper left corner of the scatter plot is understood as the empty zone. The larger the size of such a space, the more X constrains Y. (Dul, 2016)

Dul (2016) defines two different ceiling lines as follows: Ceiling Envelopment – Free Disposal Hull (CE-FDH) and Ceiling Regression – Free Disposal Hull (CR-FDH). The CE-FDH is usually applied for discrete or data with a few levels and the CR-FDH for continuous or practically continuous data. Thus, due to the nature of our data, we will apply CR-FDH as the reference to evaluate the Necessary Condition Analysis parameters.

In addition to the assessment of the effect size, (Dul, van der Laan, et al., 2020) also propose as a parameter to assess the evidence against the null hypothesis an “approximate permutation test.” which produces an estimate of the exact p-value to protect researchers from making Type 1 errors and drawing false-positive conclusions.

In sum, a hypothesis is supported in the scope of Necessary Condition Analysis if The literature effect size is at least equal to 0.1 and the p-value is below 0.05.

Based on the calculation of Necessary Condition Analysis’ parameters (see figure 7), we found that, among the five proposed Dynamic Capabilities, only Supply Chain Risk Management and Supply Chain Agility are meaningful ($d \geq 0.1$) and significant ($p< 0.05$) necessary conditions for Operational Performance. In contrast, Integration, Customer Integration, and Supplier Integration are non-necessary conditions to achieve relatively higher Operational Performance.

In regards to Supply Chain Robustness, Necessary Condition Analysis’ parameters (see figure 8) indicates that Internal Integration, Customer Integration, Supply Chain Risk Management, and Supply Chain Agility are meaningful ($d \geq 0.1$) and significant ($p< 0.05$) necessary conditions for Supply Chain Robustness. Conversely, only Supplier Integration is a non-necessary condition to enable Supply Chain Robustness.

4.4.2 - Bottleneck Analysis

In addition to the evaluation of the effect sizes and their significance, we also developed bottleneck tables. The bottleneck table shows which level of the condition (X) is necessary for which level of the outcome (Y) and can be interpreted as follows: “for a given value of outcome Y the table shows the necessary levels (minimum required levels) of the conditions”. (Dul, 2016, p.69)

Y and X values can be expressed as percentages of maximum, actual values, or percentiles. (Dul, 2016) In our case, we chose the percentage range for Y and X (see figure 9). In such an approach, 0 represents the minimum value of Y and X, and 100 represents the maximum value of Y and X. “The X and Y values displayed in the bottleneck table are percentages of the range of X and Y, respectively"(Breet, van Rhee, & Dul, 2018, p.6). The bottleneck tables for Operational Performance and Supply Chain Robustness can be seen in Figures 9.

```
---------------------------------------------------
Bottleneck CR-FDH (cutoff = 0)
Y Operational Performance       (percentage.range)
1 Supply Chain Riks Management  (percentage.range)
2 Supply Chain Agility          (percentage.range)
---------------------------------------------------
Y        1    2
0        NN   NN
10       NN   NN
20       NN   NN
30       NN   NN
40       0.4  NN
50       9.7  NN
60       19.0 NN
70       28.3 13.0
80       37.6 27.4
90       47.0 41.8
100      56.3 56.2
```

```
---------------------------------------------------
Bottleneck CR-FDH (cutoff = 0)
Y Supply Chain Robustness        (percentage.range)
1 Internal Integration           (percentage.range)
2 Customer Integration           (percentage.range)
3 Supply Chain Risks Management  (percentage.range)
4 Supply Chain Agility           (percentage.range)
---------------------------------------------------
Y        1    2    3    4
0        NN   NN   NN   NN
10       NN   NN   NN   NN
20       NN   NN   NN   NN
30       2.2  NN   NN   NN
40       6.2  6.2  NN   NN
50       10.2 15.0 NN   9.7
60       14.2 23.8 10.0 19.9
70       18.2 32.6 23.2 30.1
80       22.2 41.4 36.4 40.3
90       26.2 50.2 49.6 50.5
100      30.2 59.0 62.9 60.8
```

Figure IV - 10 - Bottleneck Table (Operational Performance and Supply Chain Robustness)

At tables 31 and 32, the combined results from both logic and necessity perspective are presented:

	PLS-SEM - Significance Analysis			Necessary Condition Analysis		
Hypotheses	Path coefficients	P Values	Sufficiency	Effect size (d-value)	P-value	Necessary Condition
Customer Integration -> Operational Performance	0.05	0.59	NOT fulfilled	0.066	0.211	NOT fulfilled
Supplier Integration -> Operational Performance	- 0.07	0.32	NOT fulfilled	0.022	0.188	NOT fulfilled
Internal Integration -> Operational Performance	0.19	0.11	NOT fulfilled	0.067	0.175	NOT fulfilled
Supply Chain Agility -> Operational Performance	0.14	0.05***	Fulfilled	0.110	0.006	Fulfilled
Supply Chain Riks Management -> Operational Performance	0.28	0.00*	Fulfilled	0.170	0.000	Fulfilled

Table IV - 31 - Necessity and Sufficiency results - Operational Performance

*** significant at 0.000**
****significant at <0.05**
*****significant at<0.10**

	PLS-SEM - Significance Analysis	Necessary Condition Analysis (Cr-fdh)

Hypotheses	Path coefficients	P Values	Sufficiency	Effect size (d-value)	P-value	Necessary Condition
Customer Integration -> Supply Chain Robustness	0.10	0.26	NOT fulfilled	0.198	0.000	Fulfilled
Supplier Integration -> Supply Chain Robustness	0.14	0.05	Fulfilled	0.065	0.006	Not Fulfilled
Internal Integration -> Supply Chain Robustness	0.00	0.99	NOT fulfilled	0.114	0.045	Fulfilled
Supply Chain Agility -> Supply Chain Robustness	0.46	0.00*	Fulfilled	0.150	0.006	Fulfilled
Supply Chain Riks Management -> Supply Chain Robustness	0.22	0.02**	Fulfilled	0.181	0.000	Fulfilled

Table IV - 32 - Necessity and Sufficiency results - Supply Chain Robustness

*** significant at 0.000**
****significant at <0.05**
*****significant at<0.10**

4.4.3 - Conceptual Model from Necessary Condition perspective

Based on the result above, at the figure 12 we present our conceptual framework based only the Necessary Conditions (NC).

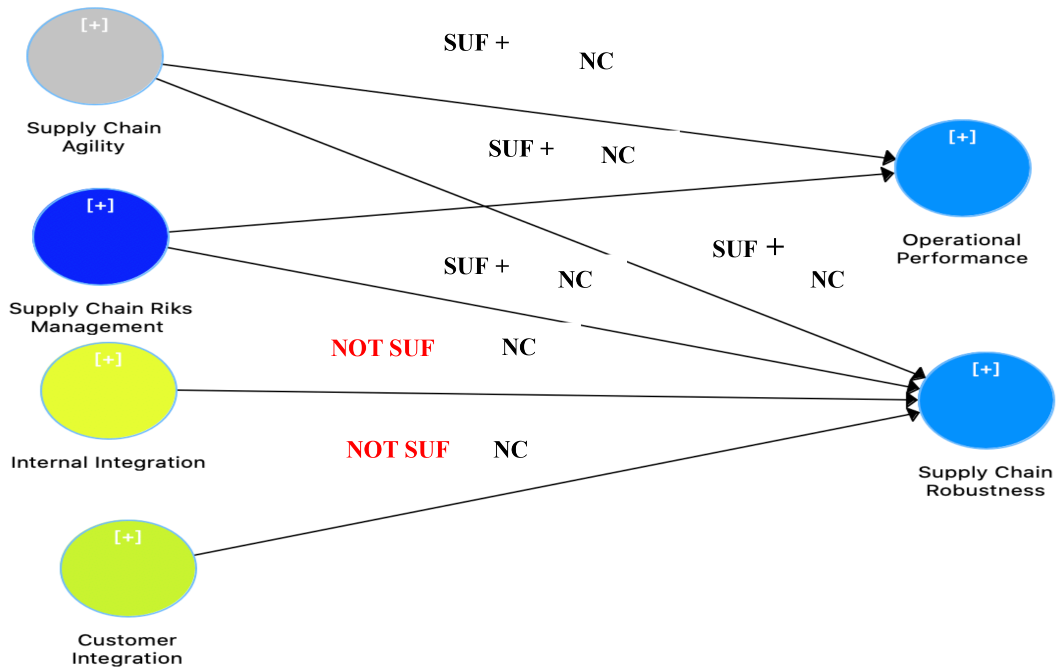

Figure IV - 11 - Conceptual Model Refinement

4.5 – DISCUSSIONS AND IMPLICATIONS FOR RESEARCH AND PRACTICE

The present investigation aims to evaluate and distinguish the influence of a different set of dynamic capabilities (Supply Chain Management Strategies) on Operational Performance and Supply Chain Robustness, considering both sufficiency logic and necessity logic view.

In this chapter, to attend the aim above mentioned, we focus on answering the following research questions:

- How do Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration influence Operational Performance and Supply Chain Robustness in the Manufacturing companies in Brazil
- Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary conditions, to a certain degree, to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".
- Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary, to a certain degree, and significant condition to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

The first question includes two relationships already assessed in the previous chapter. The influence of both Supply Chain Risk Management and Supply Chain Agility on Operational Performance. Then, before discussing and presenting the news findings, it is crucial to mention any observed changes concerning chapter 3.

In this regard, as presented in item 4.4.11, the relationship among Supply Chain Risk Management remained significant. The only relevant changes consist of the significance level (p-value) of the effect of Supply Chain Agility on Operational Performance (H3) since this value shifted from a p-value of 0.02 (see Chapter 3) to 0.05 (see table 25). Then, observing the threshold of 0.05, our hypothesis H3 would become a nonsignificant relationship. Nevertheless, by assuming a less conservative significant level of 0.1, the hypothesis would remain supported. Concerning the results of other hypotheses previously evaluated, there is no change in our findings.

Now, we turn our attention to evaluate the behavior of the three new Dynamic Capabilities that were included in the conceptual model (Supplier, Internal, and Customer Integration). The results available in table 24 shows that all three dimensions of Supply Chain Integration do not impact Operational Performance either positively or negatively. In the context of Brazilian industries, this result is an empirical finding that provisionally falsifies the hypotheses that Supply Chain Integration generates higher Operational Performance.

For instance, our finding contrasts with previous studies in which a positive and significant relationship between Supply Chain Integration and Operational Performance was supported. Scholars like Feng et al. (2017); Frohlich & Westbrook (2001); Huo & Wang (2014); Jajja, Chatha, & Farooq (2018); Vanpoucke et al. (2014); and Vickery et al. (2013) and other studies available at Appendix B have supported such a view.

The absence of a significant relationship between integration and performance found in our research is aligned with Khan & Wisner (2019), who found such a condition in a study performed with 257 companies in Pakistan. Swink et al. (2007), using data from a variety of manufacturing industries, also found no relationship between customer integration and supplier integration with manufacturing competitive capabilities like cost efficiency, quality, delivery, process flexibility, and new product flexibility, which in our study are being considered as operational performance measures.

The study of (Boon-itt & Wong, 2011), performed with 151 participants in the Thai automotive industry supply chain, is another empirical investigation that generates empirical findings supporting no significant relationship among one of the dimensions of Supply Chain integration (customer integration) and Performance (delivery performance).

The investigations of Wiengarten, Pagell, Ahmed, & Gimenez (2014); Danese & Romano (2011); Lu et al., 2018) Danese, Romano, & Romano,(2013); Koufteros, Vonderembse, & Jayaram,(2005); Sezen (2008); Devaraj et al. (2007)); Parente, Baack, & Hahn (2011) and Huo et al., (2014) and Schoenherr & Swink (2012) are others examples of studies that found either negative, insignificant or mixed results. The meta-analysis performed by (Leuschner et al., 2013) also supports such a view. For further information, see Appendix B.

The mixed findings reported in the literature about the relationship of Supply Chain Integration and Performance motived us to hypothesized and assess the role of Supply Chain Risk Management as a potential mediator. The results, available in table 27, indicate that Supply Chain Risk Management fully mediates both Customer and Internal Supply Chain Integration. In contrast, no mediation was found in the case of Supplier Integration.

Our results about the mediation role are aligned, for instance, with Kauppi et al., (2016) suggestion that the combined use of external integration in association with risk management generates higher operational performance within riskier countries.

The results concerning the mediation function of Supply Chain Risk Management among integration and performance, in the context of Brazilian Industries, builds on and diverge in some aspects with Munir's et al. (2020) research that investigated the phenomenon using data from manufacturing companies located in Europe, Asia, North, and South America

According to their research, Supply Chain Risk Management partially mediates the relationship between Internal Integration and Operational Performance. In contrast, our results show a full mediation pattern. Regarding Supplier Integration, Munir et al. (2020) findings support full mediation, whereas we found no mediation. Concerning Customer Integration, both investigations are aligned with empirical evidence of full mediation.

Based on our findings, we can learn that the positive and significant effect of Internal Integration and Customer Integration on performance through Supply Chain Management as a mediator means that the ability of organizations integrate among internal functions as well as with major customers enables organizations capabilities related to Riks Management and, consequently, positively affects the Operational Performance.

The second endogenous variable of this study consists of Supply Chain Robustness. After the influence of the three dimensions of integration on Supply Chain Robustness, our results show that only Supplier Integration has a significant effect. These findings refine Zhuo et al. (2021) research, where Supply Chain Integration was positively related to supply chain robustness. In our investigation, we were able to understand such phenomenon in further detail by evaluating each dimension of integration separately and identifying that among the three dimensions, only Supplier Integration proved to be significant to foster greater Supply Chain Robustness.

Regarding the relationship between Supply Chain Risk Management and Supply Chain Robustness, our results show a positive and significant relationship among those variables. This finding encounters convergence, for instance, with the researches of El Baz & Ruel (2021), Durach et al. (2014), Wieland & Marcus Wallenburg (2012). Thus, our study supports the proposition that Supply Chain Risk management activities and their processes like identification, assessment, and controlling of risks are essential to enable supply chains to withstand disruption and continue operating.

The two last interactions evaluated in our research were the direct impact of Supply Chain Agility upon Supply Chain Robustness and the possible moderator role of Supply Chain Risk Management within such a relationship. Our results indicate both a positive and significant impact of agility upon the robustness and a positive and significant moderation role played by risk management.

In contrast to the traditional that consider agility and robustness opposite strategies, being the former a reactive approach and the latter a proactive, as proposed for instance by Purvis, Spall, Naim, & Spiegler, 2016; Durach, Wieland, & Machuca (2014) and; Wieland & Wallenburg (2012), in our research, Supply Chain Agility was hypothesized as an enabler of robustness. Our research findings provisionally support such a theoretical perspective that understood agility as precedent action that contributes to increasing Supply Chain Robustness.

Our finding is aligned with Stockmann et al. (2021, p.5), who states that "a robust production system also has to be agile in order to maneuver itself through substantial changes without instability and without a drop of its performance." Wieland & Durach (2021) and X. Zhang & Wang (2011) also understand agility as a precedent of robustness.

From a practical perspective, our results show that organizations with greater supply chain agility also enrich their levels of robustness. From this proposed perspective, we start to see that robustness relies on resistance or avoidance and the reactive capacity of the system.

Finally, the positive moderation provided by supply chain risk management in between supply chain agility and robustness contributes to the current discussion about the existence of potential moderator factors between the associations of supply chain agility and firms' performance as proposed by (Nazempour et al., 2018).

Since we have not found in the literature, to the date, other studies which have empirically investigated the impact of agility on robustness as well as the role of supply chain risk management as a potential moderator on such a relationship, our findings open a venue to other researchers to explore this phenomenon further to assess if such behavior is also present at different business contexts.

As suggested by Sarstedt & Danks (2021, p.4), "Researchers evaluate their models' explanatory power based on F-type metrics and the R2 (Cohen, 1988), followed by an assessment of the model coefficients in terms of their significance, direction, and size".

Thus, based on the statistical results, we can assess the explanatory power of our model. The coefficient of determination of results indicates that our exogenous variables have a moderate, in sample, predictive power, which explains almost 53% of the variance for Operational Performance and 47% for Supply Chain Robustness.

The effect size ($f2$ values) results available in table 25 conveys that Supply Chain Agility and Supply Chain Risks Management have a small effect on operational performance. In contrast, Supply Chain Risks Management and Supply Chain Risks produce medium effects. In terms of the impact on Supply Chain Robustness, Supplier Integration and Supply Chain Risk Management produces small effect whereas Supply Chain Agility has medium influence.

In Chapter 3, concerning the relationship between Supply Chain Risks and Operational Performance, we observed that f2's value changed from 0.57 (large effect) to 0.24 (medium effect) due to the inclusion of Supply Chain Risk Management and Supply Chain Agility. In this chapter, we did not detect the same pattern due to the inclusion of the three dimensions of integration since the f2 also remained the same (0.23). From these results, we may conclude about the role of risks management and agility in producing positive impacts on performance and then alleviating the adverse effects produced by Supply Chain Risks by improving Operational Performance. Still, the same conditions do not apply to all three dimensions of Supply Chain Integration, as proposed initially.

In terms of predictive relevance of our model (out of sample), the blindfolding procedure results (Stone-Geisser's Q^2 value) of 0.288 indicate that together Supply Chain Risks, Supply Chain Risks Management, and Supply Chain Agility have predictive relevance for the Operational Performance at a moderate level. In regards to Supply Chain Robustness, the Q^2 value of 0.40 indicate that the Supplier Integration, Supply Chain Risks Management, and Supply Chain Agility have strong predictive relevance. It is vital to notice that this measure "can only be partly considered a measure of out-of-sample prediction because the sample structure remains largely intact in its computation." (Sarstedt, M., Ringle, C. M., & Hair, 2017, p.21).

Thus, in terms of the Dynamic Capability theory perspective, we found empirical evidence to identify the supply chain strategies that positively support companies in sensing risks, seizing and adapting their processes and resources towards better Performance. Based on that, we fulfill the first aim of this research by distinguishing the influence of a different set of dynamic capabilities on Operational Performance and Supply Chain Robustness, considering the sufficiency logic.

At this moment of the discussion, we start to address the second research question. We shift attention to incorporate the results obtained from the assessment of our conceptual model from the necessity logic perspective. The motivation for such complementary analysis relies on the purpose to further understand the relationship of Dynamic Capabilities and Performance dimension not only from average net effect and significant logic perspective.

The Necessary Condition Analysis in regards to Operational Performance indicates that out of five Dynamic Capabilities, only Supply Chain Agility and Supply Chain Risk Management are necessary conditions, to a certain degree, to achieve relative higher levels of Operational Performance since Supplier Integration, Customer Integration and Internal Integration were not proven to be indispensable based on the necessity logic.

In sum, the Necessary Condition Analysis allows us to conclude that Supply Chain risk Management and Supply Chain agility are dynamic capabilities that must be in place, to a certain degree, to enable companies to reach relatively higher Operational Performance. Based on the bottleneck analysis (see figure 9), we can visualize the necessary threshold (minimum required levels) of those necessary conditions. For instance, 56,3% Supply chain Risks Management and 56.2% Supply Agility must be present simultaneously to allow industries to reach relative operational performance at maximum level. Furthermore, to be a below-average industry, a minimum level of 40% of Supply Chain Risks Management activities and processes are required.

The Necessary Condition Analysis concerning the level of Supply Chain Robustness shows that Customer integration, Internal integration, Supply Chain Agility, and Supply Chain Risk Management are necessary conditions to a certain degree. Thus, we can conclude that to reach high levels of Supply Chain Robustness, all four necessary conditions, as mentioned above, need to be in place to a certain degree. In contrast, Supplier Integration did not fulfill such a condition.

The bottleneck analysis of the Supply Chain Robustness also generates valuable results. From the results (see figure 9), we can visualize the necessary levels (minimum required levels) of the necessary conditions to a desire outcome. For instance, to have Supply Chain Robustness at the maximum level, Internal Integration must be present at

30.2%, Customer Integration at 59%,, Supply chain Risks Management at 62.9%, and Supply Agility 60.8%, concurrently.

The results also show that Internal Integration (10.2%), Customer Integration (15%), and Supply Agility (9.7%), as necessary conditions, must be present to enable an average level of Supply Chain Robustness (at the level of 50%). In other words, industries with the absence of minimal levels of processes and practices related to those dynamic capabilities will be bound to have a below-average ability to face internal and external disruption and keep operations running, meet customer demand, keep their performance target.

Our analysis support us to provide a clear answer to the second research question proposed in this study. Based on the Necessary Condition Analysis results (see tables 32 and 33), the following Supply Chain Strategies are necessary, in certain, degree to achieve relatively higher Operational Performance and Supply Chain Robustness.

	Operational Performance	Supply Chain Robustness
Necessary Conditions	4. Supply Chain Risk Management 5. Supply Chain Agility	1 Supply Chain Agility 2 Supply Chain Risk Management 3 Customer Integration 4 Internal Integration

Table IV - 33 - Necessary Conditions to Operational Peformance and Supply Chain Robustness

The third and last research problem suggested concerns evaluating if Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary, to a certain degree, and significant condition to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

The response to such a question requires combining both PLS-SEM and Necessary Condition Analysis results explicitly presented in tables 32 and 33, which are organized and summarized in table 35.

	Operational Performance	Supply Chain Robustness
Significant determinant and necessary condition	Supply Chain Risk Management and Supply Chain Agility	Supply Chain Agility Supply Chain Risk Management
Significant determinant but no necessary condition	XXXXXXX	Supplier Integration
Nonsignificant determinant but a necessary condition	XXXXXXX	Customer Integration Internal Integration
Nonsignificant determinant/ no necessary condition	Internal, Customer, and Supplier	

Table IV - 34 - Combined PLS-SEM and Necessary Condition Analysis results

Richter et al., (2020) paper provide prescriptions to interpreting hypothesis from significance and necessity in a combined manner. Following such guidance in the next paragraph, we provide our scientific and managerial conclusions.

In the case of dynamic capabilities that are significant and necessary (e.g., Supply Chain Risk Management and Supply Chain Agility concerning both Operational Performance and Supply Chain Robustness), an increase in the presence of the predictor will augment the outcome.

Concerning significant dynamic capabilities that have not been proved necessary conditions (e.g., the relationship among Supplier Integration and Supply Chain Robustness), increasing such the predictor will improve the outcome. Nevertheless, no minimum level of the Supplier Integration is needed for Supply Chain Robustness to manifest at any level

Lastly, in the scenarios where the exogenous construct is not a significant determinant but a necessary condition, a certain level of the exogenous construct is necessary for the outcome to manifest. However, a further increase is not recommended, as it will not increase the result any further. This scenario was found in the case of Customer Integration and Internal Integration with Supply Chain Robustness From that perspective, we can learn, for instance, that industries should prioritize customer integration over internal integration since the minimal level of the former is 59% against 30.2% to achieve the high level of robustness.

Furthermore, the combined use of Necessary Condition Analysis and PLS-SEM also allows us to expand our diagnostic. The results showing that Supply Chain Risk Management and Supply Chain Agility are necessary dynamic capabilities for the operational performance to manifest at certain levels, may orient and motivate industries to choose and prioritize it over all other dynamic capabilities tested in our model (internal, supplier, and customer integration) since the absence of those supply chain strategies blocks Operational Performance in such a degree.

The same interpretation applies to Supply Chain Robustness. The following dynamic capabilities: Internal Integration, Customer Integration, Supply chain Risks Management, and Supply Agility should be in place to guarantee robustness at a certain level. In contrast, the absence of Supplier Integration will not constrain it.

Based on the arguments above, we found scientific evidence to accomplish the second aim of this research evaluating and distinguishing the influence of a different set of dynamic capabilities on Operational Performance and Supply Chain Robustness, considering the necessity logic perspective.

Finally, considering our combined analysis from sufficiency and necessity logic, we were able to refine our conceptual model to turn it more parsimonious (see figure 10), which contributes to managers and practitioners defining and prioritizing their actions and the allocations of the scarce resources of all kind.

4.6 – CONCLUSION

In this chapter, we explored the impact of Supply Chain Risks, Supply Chain Risk Management, Supply Chain Agility, and Supply Chain Integration upon Operational Performance and Supply Chain Robustness, at the level of a manufacturing plant, in the specific context of the Brazilian business environment

This research pursued expanding the frontier of the current knowledge of supply chain management to enrich the discussion about such phenomena and topics at critical developmental stages. The analysis was conducted by further improving the model under investigation since chapter 2.

Section 4.3 presents a literature review about the new elements introduced in our model (Supply Chain Integration and Supply Chain Robustness) and complimentary details concerning the Dynamic Capability Theory to justify and build a comprehensive conceptual framework explanation. The main definitions of the variables mentioned above, the empirical studies available in the literature, and the studies performed in Brazil were detailed to enrich the discussion.

Section 4.4 covers the data collection method, the sample demographics, the research design, the structural equation model complete statistical analysis results. Section 4.5 covers the application of Necessary Condition Analysis and the results obtained from such an analytical, statistical technique. In section 4.6, we analyze the empirical results from both the theoretical and managerial lenses, discussing the implications of the findings for both academics and managers.

The present investigation aimed to empirically evaluate and distinguish the influence of a different set of dynamic capabilities (Supply Chain Management Strategies) on Operational Performance and Supply Chain Robustness, considering both sufficiency logic and necessity logic.

From such aims, we seek to achieve the following objectives:

– to evaluate the influence of Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration on Operational Performance, and Supply Chain Robustness of Manufacturing companies in Brazil

– to evaluate if Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration are necessary conditions to Operational Performance and Supply Chain Robustness in the context of Manufacturing companies in Brazil

- to evaluate if Supply Chain Agility, Supply Chain Risk Management, Supplier Integration, Internal Integration, Customer Integration are necessary and significant conditions to Operational Performance and Supply Chain Robustness in the context of Manufacturing companies in Brazil

In sum, after conducting the work, we found empirical evidence to fulfill the research aims and objectives proposed above. For instance, concerning Operational Performance, the results demonstrate that Supply Chain Risks Management and Supply Chain Agility may support companies in the process of sensing and seizing risks and opportunities; and adapting their processes and structures towards better results. In contrast, our findings indicate that all three dimensions of Supply Chain Integration did not meet such a criterion. Nevertheless, it is vital to note that Customer and Internal Integration became significant through the mediation role of Supply Chain Risks Management.

Concerning the Supply Chain Robustness performance dimension, Supply Chain Risk management, Supply Chain Agility, and Supplier Integration have proven to be significant dynamic capabilities to sensing risks, seizing and adapting their processes and structures. In contrast, Customer and Internal Integration shown no significant effect. Our empirical findings provisionally support the contemporary theoretical perspective that understood agility as a precedent supply chain strategy to foster Supply Chain Robustness. Furthermore, the role of Supply Chain Risk Management as a moderator between Supply Chain Agility and Supply Chain Robustness is another relevant contribution of the present study.

In sum, the validation of the proposed conceptual framework through PLS-SEM application extends the existing literature on Dynamic Capabilities theory. It provides a comprehensive empirical analysis and evidence about how different supply chain management strategies behave in a Brazilian industry's business environment from a significant logical perspective.

Based on the Necessary Condition Analysis (NCA) application in the complement of PLS-SEM, we further refine our analysis by applying contemporary and different perspectives of how to approach problems in Social Science. The Necessary Condition Analysis application allowed us to evaluate our proposed conceptual model from a necessity logic view to identifying the critical predictors that when absent, the desired outcome is constrained, in our case, to a certain degree.

The analysis from the necessity logic view allowed us to shift our attention from ‘average trends’ to the logic of ‘the required level’ of the dynamic capabilities under investigation. This approach fits our purposes since historically dynamic capabilities have been reported as necessary but with no appropriate quantitative method to support such calls. Then, our work contributes to reducing such a methodological gap.

The Necessary Condition Analysis results allowed us to distinguish between Dynamic Capabilities that must be present from those that only contributes positively but is not crucial. Thus, based on such a view, we found two necessary conditions (e.g., Supply Chain Riks Management and Supply Chain Agility) to achieve relatively higher Operational Performance and three essential conditions (e.g., Supply Chain Riks Management, Supply Chain Agility, and Supplier Integration) to enable Supply Chain Robustness

It is essential to acknowledge that this research also has significant limitations as follows: the study took into consideration only the Brazilian industries segment; the study does not cover service industries; our sample comprises 52% small and medium industries and 48% of larger firms based on sales volume parameters.

According to the author's views, these limitations are acceptable. We chose Brazilian industries due to the distinguishing characteristics compared to other environments where the studies about dynamic capabilities in Supply Chains have been executed. The limited number of scientific researches dedicated to this environment is another motivating factor. The manufacturing plant was selected as the unit of analysis in this research. Thus, due to this reason, no service industries were considered. Finally, the sample profile of mix size companies does not conflict with the general purpose of this study.

This study provides original managerial insights to Brazilian Industries and Supply Chain and Operations Management Professionals by providing empirical evidence to support organizations to deal with defining, deploying, and developing strategies among Supply Chain Integration (internal, supplier, and customer), Supply Chain Agility, and Supply Chain Risk Management, in the context of Brazilian industries, to achieve relatively higher Operational Performance and Supply Chain Robustness.

Based on the antecedent research and the gaps identified in the existing literature (empirical, populational, methodological, and theoretical), the results produced to contribute to improving the understanding and predictability of critical latent contextual and managerial variables' effects on Brazilian industries performance. In sum, in practical terms, we found evidence to distinguish among different supply chain strategies those that industries must necessarily focus on investing in improving performance in response to the negative impacts generated by various sources of supply chain risks.

We understood that there are still vast opportunities for further research concerning the phenomena proposed here. For example, the following areas could be offered and investigated as a continuity of the present study:

- What are some of the other potential supply chain strategies which can be configured, at the firm level of analysis, as other essential capabilities for improving Operational Performance and Supply Chain Robustness?.
- Does Supply Chain Agility, Supply Chain Risk Management, and Supplier Integration are necessary conditions, to a certain degree, to Supply Chain Robustness in different business contexts.?.
- Does Supply Chain Risk Management and Supply Chain Agility are necessary conditions to Operational Performance in different business contexts.?.

Additionally to the questions raised above, further investigation can be deployed based on the principles of the triangulation method to refine the generalized results obtained from the quantitative methods with the complementary application of qualitative methods among a few and specific industries, for example.

The value and originality of this research derive from different aspects. This work is one of the first quantitative studies dedicated to develop and test a conceptual model, which explored a wide range of Supply Chain Strategies (Supply Chain Risks, Supply Chain Risks Management, Supply Chain Agility, Internal Integration, Supplier Integration, and Customer Integration) upon Operational Performance and Supply Chain Robustness.

Secondly, to the best of our knowledge, our research focused on the business environment (Brazilian Manufacturing Industries) and a field (Supply Chain Management) that lacks further empirical investigation concerning the manifestation of Dynamic Capabilities Theory assumptions in practice. Thus, our research efforts contributed to reducing such an empirical and population gap.

Thirdly, this research contributes to academia by proposing and testing 16 different hypotheses, which allowed us to confront our findings against pre-established antecedent research hypotheses in a field with evidence gaps (contradictory results).

Finally, this research also enriches the scientific debate in the field of Supply Chain Management through the combined application of PLS-SEM and Necessary Condition Analysis to explore the impact of different strategies on organizational performance. These approaches contribute to reducing the current methodological gap (characterized when research topics have been mainly explored using a particular or common method). Our findings brought new knowledge and opened the venue for further discussions aboutthe importance of understanding both significance and the necessity when exploring enablers and outcomes.

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APPENDIX A – CONSTRUCTS ITEMS

SUPPLY CHAIN RISKS MEASURES

Instructions:
- Questions regarding Supply Chain Risk Measures starts with the letters "SCR"
- To what extent has your firm in the past 3 years experienced a negative impact in supply chain management due to…. (1 not at all– 7 to a very large extent)

Demand side risks measurements	1	2	3	4	5	6	7
SCR-D1 Unanticipated or very volatile demand							
SCR-D2 Insufficient or distorted information from your customer about orders or demand quantities							

Supply side risks measurements	1	2	3	4	5	6	7
SCR-S1 Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity)							
SCR-S2 Supplier quality problems							
SCR-S3 Sudden demise of a supplier (e.g., due to bankruptcy)							
SCR-S4 Poor logistics performance of logistics service providers							
SCR-S5 Capacity fluctuations or shortages on the supply markets							

Regulatory, legal and bureaucratic risks	1	2	3	4	5	6	7
SCR-R1 Changes in the political environment due to the introduction of new laws, stipulations, etc.							
SCR-R2 Administrative barriers for the setup or operation of supply chains (e.g., authorizations).							

Infrastructural risks	1	2	3	4	5	6	7
SCR-I1 Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents).							
SCR-I2 Perturbation or breakdown of intemal IT infrastructure (e.g., caused by computer viruses, software bugs).							
SCR-I3 Loss of own production capacity due to technical reasons (e.g., machine deterioration).							

SCR-I4 Perturbation or breakdown of external IT infrastructure.							

Catastrophic risks	1	2	3	4	5	6	7
SCR-C1 Political instability, war, civil unrest or other sociopolitical crises.							
SCR-C2 Diseases or epidemics (e.g., SARS, Foot and Mouth Disease).							
SCR-C3 Natural disasters (e.g., earthquake, flooding, extreme climate, tsunami).							
SCR-C4 International terror attacks (e.g., 2005 London or 2004 Madrid terror attacks).							

Table IV - 35 - Supply Chain Risks - Retrieved from (Wagner & Bode, 2008a)

SUPPLY CHAIN AGILITY– MEASURES

- Questions regarding Agility starts with the letters "AGL"
- Please indicate the speed of reaction with which your company can engage in the following activities should changes occur (1 – slow; 7 – fast):

Agility measurements	1	2	3	4	5	6	7
AGL 1 - Adapt manufacturing leadtimes.							
AGL 2 - Adapt level of customer service.							
AGL 3 - Adapt delivery reliability.							
AGL 4 - Adapt responsiveness to changing market needs.							

Table IV - 36 - Supply Chain Agility - Retrieved from Wieland & Wallenburg (2012)

SUPPLY CHAIN RISK MANAGEMENT – MEASURES

- Questions regarding Supply Chain Risk Management starts with the letters "SCRM"
- In order to counter disruptions of the material flow along our supply chain (both inbound and outbound), the following measures are taken (1 – strongly disagree; 7 – strongly agree):

Supply chain risk management measurements	1	2	3	4	5	6	7
SCRM 1 - Systematic identification of sources for such disruptions.							
SCRM 2 - Assessment of both own risks and risks of important suppliers and customers.							
SCRM 3 - Assigned persons responsible for the management of such risks.							
SCRM 4 - Continuous monitoring of developments that might promote such disruptions.							

Table IV - 37 - Supply Chain Risk Management - Retrieved from Wieland & Wallenburg (2012)

OPERATIONAL PERFORMANCE MEASURES

Instructions:

- Questions regarding Operational Performance Measures starts with the letters "MOP"
- Indicate your evaluation for each variable based on the following question: How does your company perform compared with your major competitors (1-much worse; 7-much better)?

Operational Performance measurements	1	2	3	4	5	6	7
MOP 1 Overall product quality							
MOP 2 Customer service level							
MOP 3 Pre-sale customer service							
MOP 4 Product Support							
MOP 5 Responsiveness to customer							
MOP 6 Delivery Speed							
MOP 7 Delivery Dependability							
MOP 8 Volume flexibility							
MOP 9 Product Mix flexibility							
MOP 10 New product Flexibility							

Table IV - 38 - Operational Performance - Retrieved from ((Huo et al., 2014)

SUPPLY CHAIN INTEGRATION MANAGEMENT – MEASURES

- Questions regarding Customer Integration starts with the letters "SCI-C"
- Please indicate the extent of integration or information sharing between your organization and your major customer in the following areas (1 = not at all; 7 = extensive).

Customer integration measurements	1	2	3	4	5	6	7
SCI-C1 - The level of linkage with our major customer through information networks.							
SCI-C2 - The level of computerization for our major customer's ordering.							
SCI-C3 - The level of sharing of market information from our major customer.							
SCI-C4 - The level of communication with our major customer.							
SCI-C5 - The establishment of quick ordering systems with our major customer.							
SCI-C6 - Follow-up with our major customer for feedback.							
SCI-C7 - The frequency of period contacts with our major customer.							
SCI-C8 - Our major customer shares Point of Sales (POS) information with us.							
SCI-C9 - Our major customer shares demand forecast with us.							

SCI-C10 - We share our available inventory with our major customer.							
SCI-C11 - We share our production plan with our major customer.							

Table IV - 39 - Customer Integration - Retrieved from (Flynn et al., 2010b)

- Questions regarding Supplier Integration starts with the letters "SCI-S"
- Please indicate the extent of integration or information sharing between your organization and your major supplier in the following areas (1 = not at all; 7 = extensive).

Supplier Integration measurements	**1**	**2**	**3**	**4**	**5**	**6**	**7**
SCI-S1 - The level of information exchange with our major supplier through information networks							
SCI-S2 - The establishment of quick ordering systems with our major supplier.							
SCI-S3 - The level of strategic partnership with our major supplier.							
SCI-S4 - Stable procurement through network with our major supplier.							
SCI-S5 - The participation level of our major supplier in the process of procurement and production							
SCI-S6 - The participation level of our major supplier in the design stage.							
SCI-S7 - Our major supplier shares their production schedule with us.							
SCI-S8 - Our major supplier shares their production capacity with us.							
SCI-S9 - Our major supplier shares available inventory with us.							
SCI-S10 - We share our production plans with our major supplier.							
SCI-S11 - We share our demand forecasts with our major supplier.							
SCI-S12 - We share our inventory levels with our major supplier.							
SCI-S13 - We help our major supplier to improve its process to better meet our needs.							

Table IV - 40 - Supplier Integration - Retrieved from Flynn et al. (2010a)

- Questions regarding Integration Integration starts with the letters "SCI-S"
- Please indicate the degree of integration in the following areas (1 = not at all; 7 = extensive).

Internal integration measurements	1	2	3	4	5	6	7
SCI-S1 - Data integration among internal functions.							
SCI-S2 - Enterprise application integration among internal functions.							
SCI-S3 - Integrative inventory management.							
SCI-S4 - Real-time searching of the level of inventory.							
SCI-S5- Real-time searching of logistics-related operating data.							
SCI-S6 - The utilization of periodic interdepartmental meetings among internal functions.							
SCI-S7 - The use of cross functional teams in process improvement.							
SCI-S7 - The use of cross functional teams in new product development.							
SCI-S9 - Real-time integration and connection among all internal functions from raw material management through production, shipping, and sales.							

Table IV - 41 - Internal Integration - Retrieved from Flynn et al., (2010a)

SUPPLY CHAIN ROBUSTNESS MEASURES
- Questions regarding Robustness starts with the letters "ROB"
- Supply chain robustness is defined as the ability of the supply chain to maintain its function despite internal or external disruptions
- Please indicate the ability of which your company has to maintain its function despite internal or external disruptions assessing the sentences below (1 = strongly disagree and 7 = strongly agree)

Supply chain robustness measurements	1	2	3	4	5	6	7
ROB1 Operations would be able to continue							
ROB2 We would still be able to meet customer demand							
ROB3 Performance would not deviate significantly from targets							
ROB4 The supply chain would still be able to carry out its regular functions							

Table IV - 42 - Supply Chain Robustness Measurements - Retrieved from Brandon-Jones et al (2014)

APPENDIX B - Previous empirical study about Impact of Supply Chain Integration on Operational Performance

Authors	Context	Supply Chain Integration Dimensions	Performance Measures	Main Findings
(Y. Cheng et al., 2016)	606 plants from Europe, Asia, North America and South America	Internal and External Integration	Quality, Flexibility, Delivery and service	External integration affects positively operational performance. Internal integration produces no effect is not.
(Schoenherr & Swink, 2012)	403 supply chain professionals	Customer integration Supplier integration Internal integration	Quality performance Delivery performance Flexibility performance Cost performance	External Integration positively impacts delivery and flexibility performance positively. The presence of internal intregation strength the relationship above. No support was found concerning quality cost performance
(Wiengarten et al., 2014)	435 manufacturing industries from different countries (including 27 from Brazil)	Supplier and Customer	Cost, Flexibility and Delivery	Plants located in countries with relatively low levels of logistical capabilities benefit more from external integration efforts in comparison with Plants situated in countries with superior logistical capabilities
(Chavez, Yu, Gimenez, Fynes, & Wiengarten, 2015)	228 manufacturing companies in the Republic of Ireland	Customer Integration	Quality,Delivery, flexibility and Cost	The positive impact of customer integration on quality, delivery and flexibility partially mediated by information quality The effect of customer integration on cost reduction is fully mediated by information quality
(Wiengarten & Longoni, 2015)	90 Manufacturing Plants in India	Customer and Supplier	Cost, quality, delivery and flexibility, environmental and social performance	Supply Chain Integration including customers and suppliers positively impact on performance.

(Danese & Romano, 2011)	200 manufacturing plants (Different countries)	Customer and Supplier	Unit cost of manufacturing inventory turnover Balanced Capacities In process inventory	No support was found concerning the positive impact of customer integration on efficiency. Low level of supplier integration make customer integration reduce efficiency .
(Danese & Bortolotti, 2014)	317 manufacturing plants from 10 different countries	Internal integration Supplier involvement Customer Supply Chain Planning	Quality, delivery, flexibility and efficiency	Non-adopters of Internal Integration, Supplier Involvement Customer Involvement and Supply Chain Planning practices perform worse than full adopters, in terms of quality, delivery, flexibility and efficiency.
(Lu et al., 2018a)	357 manu-facturing companies from China Automotive sector	Supply chain integration	Time, flexibility and service	The relationship between the supply chain integration and operational performance is 'nonlinear' and is moderated by market uncertainty.
(Bae, 2017)	208 Korean firms in China.	Supply chain integration	Cost and Service	Supply chain integration has a positive effect on operational performance

(Feng et al., 2017)	126 automobile manufacturers in China	Supply chain integration	flexibility, delivery, quality and cost	Guanxi positively impacts Supply Chain Integration Supply chain integration has a positive effect on operational performance.
(Ding, Lu, & Fan, 2017)	357 automotive supply chains,	customer, internal and supplier integration	flexibility, delivery, quality	Demand Uncertainty moderate positively the relationship among supplier integration/customer integration and Operational Performance Demand Uncertainty did not moderate the relationship among Internal integration and Operational Performance.
(Kauppi et al., 2016)	Data from the 6th International Manufacturing Strategy Survey on 21 countries,	Customer Supplier	cost, quality, flexibility, delivery, and customer service	Supplier and customer integration are positively related to operational performance
(Danese et al., 2013)	Data from the third round of the high performance manufacturing (HPM) project	Customer	Efficiency Performance	Customer integration alone is not positively related to Efficiency Performance
(Flynn et al., 2010a)	617 Industries in China and Hong Kong	customer, internal and supplier integration	quality, flexibility, delivery, and customer service	Internal and customer integration have greater influence on Performance in comparison with supplier integration
(Frohlich & Westbrook, 2002)	Data from the 1998 round of the International Manufacturing	Customer and Supplier integration	Marketplace, Productivity and Non-productivity	The higher the suppliers and customers integration the stronger the effect on performance

	Strategy Survey (IMSS)			
(Boon-itt & Wong, 2011)	151 participants in the Thai automotive industry supply chain	customer, internal and supplier integration	Delivery performance	Internal and supplier integration, but not customer integration, were positively associated with customer delivery performance
(Germain & Iyer, 2006)	538 Member of the Council of Supply Chain Management Professionals Manufacturing List	Downstream and internal integration	Logistic Performance (Delivery lead-times; Inventory turnover rates and on time deliveries to customers)	Downstream and internal integration improve performance.

(Koufteros et al., 2005)	244 manufacturing firm (US)	External Integration	Innovation performance and quality performance.	Internal and external integration positively influence product innovation and quality
(Iyer, Germain, & Claycomb, 2009)	914 manufacturing firms (US)	B2B e-commerce supply chain integration	Financial, market, and operational performance	B2B supply chain integration positively influence operational, financial and market performance. The higher the product turbulence and demand unpredictability the lower the influence of
(Sanders & Premus, 2005)	245 U.S. manufacturing firms.	Internal Integration	cost improvement relative product quality improvement new product introduction time relative delivery speed improvement	Internal Integration positively impacts perfomance
(Sezen, 2008)	125 manufacturing firms in Turkey	Supplier and Customer	Flexibility performance Resource performance Output performance	No significant relationship found
(Villena, Gomez-Mejia, & Revilla, 2009)	133 Spanish firms	Supply chain integration	Higher productivity, shorter lead time, improved quality, and better service levels.	Supply chain integration positively influences operational performance

(Devaraj et al., 2007)	120 US Manufacturers	Customer and Supplier Integration	Cost, quality, flexibility, and delivery	Supplier integration positively impact cost, quality, flexibility, and delivery performance. Customer integration has no significant effect and performance.
(Parente et al., 2011b)	111 Brazilian automobile suppliers	Supplier Integration	New Product Innovation	Supplier Integration produces negative effect on new product Innovation.

(Huo et al., 2014)	604 Chinese manufacturer	Internal, Process and Product Integration	Overall product quality Customer service level Pre-sale customer service Product supports Responsiveness to customers Delivery speed Delivery dependability Volume flexibility Product mix flexibility New product flexibility	Internal and Process Integration positively impacts Performance Product Integration has no significant effect

Table IV - 43 - Supply Chain Integration and Operational Performance Adapted and improved from Ataseven & Nair, (2017); Huo et al., (2014); Tarifa-Fernandez & De Burgos-Jiménez (2017)

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CHAPTER 5

THESIS CONCLUSION

This dissertation was developed in the Supply Chain Management research area, which is still a very new area compared to other disciplines in the social sciences. Our study was structured around the following main pillars: first evaluating and identifying the influence of Supply Chain Risks and Contingencies on the Operational Performance of Manufacturing companies in Brazil. Secondly, from significance and necessary condition analysis perspectives, we evaluated and distinguished the influence of a different set of supply chain strategies, Operational Performance, and Supply Chain Robustness.

In many situations, the downgrade in performance is attributed as a natural consequence of the impacts arising from environmental factors as such disruptions due to supply, demand, legal, infrastructural issues, etc. In this context, the influence of different structural factors and organizational variables such as sources of complexity (internal, upstream, and downstream), the size of the company, and the strategy executed as a basis for competitive advantage (price or differentiation) are also characterized, based on common sense, as ingredients that make the business environment more exposed to the adverse effects of risks. However, such notes, from a theoretical point of view, require scientific validation.

Then, as demonstrated in our study, different researchers have tried to explore empirically the consequences derived from other dimensions of risks and their sources on Operational Performance. Nevertheless, the perimeter of studies geographically and the number of available studies are still limited and presents conflicting findings.

We also note that specifically in Brazil, a few researchers explored the theme risks in the context of the supply chain, whereas in the world, the empirical studies were concentrated in Europe and Asia. From a scientific point of view, these observations were characterized in our research using a taxonomy available for scientific gaps as empirical and populational types of gaps.

Based on Contingency Theory lenses and motivated by the relevance of the theme from the point of view of its impact on the daily lives of companies and by the existence of latent scientific gaps, we decided to unfold, in chapter 2 of this thesis, unprecedented research focusing on empirically investigate the impact of Supply Chain Risks on Operational Performance of Brazilian industries.

The scientific effort was performed to enable us to address three central questions, as follows:

How does Overall Supply Chain Risks influence Operational Performance?

What dimensions and sources of risks have a relatively higher negative impact on Operational Performance?

What are the contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage that influence the relationship between Supply Chain Risks and operational performance?

This article contributes to the academic world by answering the questions above through a quantitative study of a phenomenon of great interest. We structure our analysis and diagnostics in 4 layers, as exposes follows:

In the first layer, we explored the overall impact of Supply Chain Risks on the Operational Performance of Brazilian industries, and our results provide statistical support about the negative influence of Supply Chain Risks and Operational Performance.

In the second layer, we assess how each dimension (Supply, Demand, Regulatory, legal and bureaucratic risks, and infrastructure risks) affects performance to answer question number 2 proposed in this research. Based on our analysis and results, we were able to distinguish and provide a relative hierarchy concerning four distinct dimensions of Supply Chain Risks in terms of their frequency of occurrence in the daily lives of organizations, as well as concerning the size of the adverse effects that can be generated in the operational performance of companies, when the sources of risk of each dimension are present.

In sum, our results convey that in terms of relative negative predictive relevance, or total negative effects, upon Operational Performance, the following risk dimensions can be classified in the following order: Infrastructural; Supplier; Regulatory, legal, and bureaucratic risks; and Demand.

Regarding the frequency that organizations experience any event related to the dimensions above, our results demonstrate that Demand risks are the most frequent ones, followed by Supplier risks; Regulatory, legal, and bureaucratic risks, and Infrastructural.

By evaluating the above dimensions in combination, it is possible, for example, to conclude that despite the risks associated with demand being more influential, the negative effects on operational performance are manifested in a lower magnitude, for instance, than the impacts generated by infrastructure risks, which, on the other hand, are less frequent.

In the second layer, our investigation further refined the information inside each risk dimension assessing from importance (total effects when present) and performance (rate of frequency) perspectives, 13 different sources of risks. Based on our analysis, the top 5 events of risks experienced in terms its frequency of occurrence are the following ones in decreasing order: unanticipated and very volatile demand; Capacity fluctuations or shortage on the Supply Markets; Insufficient or distorted information from customers about orders or demand quantities; Supplier quality problems.

In terms of the negative effect produced on Performance, when presented, the following risk sources are the top 5 according to our results in decreasing order: Perturbation or Breakdown of external IT infrastructure, Downtime, or loss of own production capacity due to local disruptions (e.g. strike); Perturbation or Breakdown of internal IT infrastructure and Perturbation or Breakdown of internal IT infrastructure.

Such analysis offers scientists and market professionals detailed knowledge about the specific events that cause disruptions in supply chains. Consequently, it allows the definition and prioritization concerning the main events to monitor and be avoided or mitigated. Our investigation offers interesting results concerning our third and last research objective, which consists of identifying contingencies among Supply Chain Complexity sources, Firm Size, and Strategies for Competitive Advantage that influence the relationship between Supply Chain Risks and operational performance.

In the fourth layer, after analyzing the contingent role of 12 variables related to supply complexity (upstream, internal, and downstream) firm size and its strategy to competitive advantage, we concluded that only three of the contingencies analyzed to increase the negative effect risks on performance. From our observations, we learned that contingencies like product life cycle, number of distinct products, long supplier lead time have a contingent impact on the relationship between Overall Supply Chain and

Operational Performance. Those contingencies are classified, respectively, as Downstream, Manufacturing Internal, and Upstream complexity drivers.

Interestingly, we found no contingent influence, in the relationship between Overall Supply Chain Risk and Operational Performance, concerning the other contingencies as such: the number of suppliers and globalization of the supply base (upstream complexity drivers); the number of customers, the Heterogeneity in customer needs and the demand variability (Downstream complexity drivers); and the number of parts (Internal manufacturing complexity drivers).

We consider the findings above valuable since they can support organizations' important step towards gaining a better understanding of the consequences of Supply Chain Risks and Supply Chain Complexity and its negative consequences on Operational Performance.

Academically, our research effort enrich the discussion about the relationship between Supply Chain Risk and Operational Performance and provide new knowledge about such a subject since we were able to confront our results against previous research and add new conclusions about the topic under discussion as presented in detail in this study

Based on the work developed and presented in Chapter 2, we have fulfilled the first aim proposed in our thesis, which consists of evaluating and identifying the influence of Supply Chain Risks and contingencies on the Operational Performance of Manufacturing companies in Brazil.

Following the research, we focused on empirically evaluating the influence that some strategies deployed in the scope of the chains can exert on the operational performance of companies, in our case, the industry.

Thus, based on perspectives derived from the Dynamic Capabilities Theory, we incorporated into the conceptual model explored in chapter two strategies widely applied by industries today and that have been receiving significant attention from the scientific community.

First, we conceptualize that the deployment of risk management in supply chains should be understood as a dynamic capability that needs to be deployed to allow companies to sense and seize information related to the different dimensions and sources of risks. Additionally, we assume that companies should organize and deploy Supply Chain Agility to react quickly and adapt to critical aspects of the operation.

In Chapter 3, we guide our investigation considering the following main research questions

- How do Supply Chain Risk Management and Supply Chain Agility influence the Operational Performance of Manufacturing companies in Brazil?
- Which Supply Chain Strategy is more relevant in terms of its relevance and performance to increase the Operational Performance of Manufacturing companies in Brazil?

In regards to the first question, we found empirical evidence that strategies like Supply Chain Risk management and Supply Chain Agility may support companies in the process of sensing risks, seizing and adapting their processes and resources towards better operational performance. The positive moderation role produced by Supply Chain Risk Management in between the relationship of Supply Chain Agility and Operational Performance is another important scientific finding that opens up a meaningful discussion about factors that may amplify the positive effects of agility on operational performance.

Regarding the second research question explored in this article, we found that Supply Chain Risk Management has greater positive predictive relevance (total effects) concerning Supply Chain Agility concerning the influence of such strategies on Operational Performance.

The execution of the IPMA also allows us to refine our understanding both in terms of the relative role among the latent variables and in between the indicators. Such analysis suggested a prevalence of Supply Risk Management actions over Supply Chain Agility.

In sum, in terms of managerial analysis, we found evidence that industries must focus on investing in risk management activities to identify, assess, control, and monitor possible risks. Our results also indicate that organizations may benefit, in terms of their Operational Performance, through investing in the capacity to fast react in terms of customer service, delivery reliability, responsiveness to changing market needs, and manufacturing lead times.

From a scientific perspective, in chapter 3, our investigation contributes to a field where there is limited empirical research on Supply Chain Risk Management and Supply Chain Agility on Operational Performance, especially in an almost unexplored business environment like Brazil.

Furthermore, the fact that our hypotheses were supported enriches the discussion into the literature since, to this date, there is only partial evidence, provided by a few studies, about the positive relationship between risk management and agility with performance in the field of Supply Chain Management.

In the last chapter, we continue with investigating the effects of supply chain strategies on the performance of Brazilian industries. With this purpose, we expanded the conceptual framework, including Supply Chain Integration, through its three dimensions (suppliers, internal, and customers), as another dynamic capacity capable of supporting organizations in the process of sensing and seizing information and events inherent to the dimensions and sources of risks, as well as helping companies in adapting and transforming themselves, when necessary.

In this chapter, we also take a greater perspective about organizational performance. Thus, as a complement to the investigation on the effects on the operational performance of companies, we included another dimension in the case, the Robustness of the supply chain. The primary motivation for assessing the degree of robustness derives from the fact that in an environment with many risks and complexities, companies must be able to deal with internal and external disruptions without significant impacts on their performance.

Finally, in this chapter, we also broaden the perspective on how to assess cause and effect relationships. Motivated by the view that many studies advocate that specific strategies are necessary and crucial to obtain certain results without actually properly evaluating such statements, we decided to apply the Necessary Condition Analysis in addition to the PLS-SEM and to allow us to assess which dynamic capabilities, when absent to a certain degree, in fact, will imply the absence of operational performance and robustness also to a certain degree.

Based on the above arguments, we aim to answer the following research questions:

- How do Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration influence Operational Performance and Supply Chain Robustness in the Manufacturing companies in Brazil
- Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary conditions, to a certain degree, to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

- Supply Chain Agility, Supply Chain Risk Management, and Supply Chain Integration are necessary, to a certain degree, and significant condition to achieve relatively higher Operational Performance and Supply Chain Robustness, in the context of Brazilian industries?".

In sum, after conducting the work in regards to the first question. The results demonstrate that Supply Chain Risks Management and Supply Chain Agility may support companies in sensing and seizing risks and opportunities and adapting their processes and structures towards better results in terms of Operational Performance. In contrast, our findings indicate that all three dimensions of Supply Chain Integration did not meet such a criterion. Nevertheless, it is vital to note that Customer and Internal Integration became significant through the mediation role of Supply Chain Risks Management.

Concerning the Supply Chain Robustness performance dimension, Supply Chain Risk management, Supply Chain Agility, and Supplier Integration have proven to be significant dynamic capabilities to sensing risks, seizing and adapting their processes and structures. In contrast, Customer and Internal Integration both have no significant effect. Our empirical findings provisionally support the contemporary theoretical perspective that understood agility as a precedent supply chain strategy to foster Supply Chain Robustness. Furthermore, the role of Supply Chain Risk Management as a moderator between Supply Chain Agility and Supply Chain Robustness is another relevant contribution of the present study.

In sum, the validation of the proposed conceptual framework through PLS-SEM application extends the existing literature on Dynamic Capabilities theory. It provides a comprehensive empirical analysis and evidence about how different supply chain management strategies behave in a Brazilian industry's business environment from a significant logical perspective.

Based on the Necessary Condition Analysis (NCA) application in the complement of PLS-SEM, we further refine our analysis by applying contemporary and different perspectives of how to approach problems in Social Science. The Necessary Condition Analysis application allowed us to evaluate our proposed conceptual model from a necessity logic view to identifying the critical predictors that when absent, the desired outcome is constrained, in our case, to a certain degree.

The analysis from the necessity logic view allowed us to shift our attention from 'average trends' to the logic of 'the required level' of the dynamic capabilities under investigation. This approach fits our purposes since historically dynamic capabilities have been reported as necessary but with no appropriate quantitative method to support such calls. Then, our work contributes to reducing such a methodological gap.

The Necessary Condition Analysis results allowed us to distinguish between Dynamic Capabilities that must be present from those that contribute positively but are not crucial. Thus, based on such a view, we found two necessary conditions (Supply Chain Riks Management and Supply Chain Agility) to achieve relatively higher Operational Performance and four necessary conditions to enable Supply Chain Robustness (e.g., Supply Chain Riks Management, Supply Chain Agility, Customer Integration and Internal Integration), in certain degree.

Based on the work developed and presented in Chapters 3 and 4, we have fulfilled the second aim proposed in our thesis, which consists of empirically evaluating and distinguishing the influence of a different set of dynamic capabilities on the performance of Manufacturing companies in Brazil.

It is essential to acknowledge that this research also has significant limitations as follows: the study took into consideration only the Brazilian industries segment; the study does not cover service industries; our sample comprises 52% small and medium industries and 48% of larger firms based on sales volume parameters.

According to the author's views, these limitations are acceptable. We chose Brazilian industries due to the distinguishing characteristics compared to other environments where the studies about dynamic capabilities in Supply Chains have been executed. The limited number of scientific researches dedicated to this environment is another motivating factor. The manufacturing plant was selected as the unit of analysis in this research. Thus, due to this reason, no service industries were considered. Finally, the sample profile of mix size companies does not conflict with the general purpose of this study.

In sum, we believe that this study provides concrete scientific and managerial insights to Brazilian Industries and Supply Chain and Operations Management Professionals by providing offering evidence using real data from Brazilian industries.

The value and originality of this research derive from different aspects. This work is one of the first quantitative studies dedicated to develop and test a conceptual model, which explored a wide range of Supply Chain Risks and Supply Chain Strategies (Supply Chain Risks, Supply Chain Risks Management, Supply Chain Agility, Internal Integration, Supplier Integration, and Customer Integration) upon Operational Performance and Supply Chain Robustness in the context of Brazilian Industries. Thus, our research efforts contributed to reducing such a populational scientific gap.

Secondly, to the best of our knowledge, our research focused on a field (Supply Chain Management that lacks further empirical and evidence foundation concerning the manifestation of Contingency and Dynamic Capabilities Theory assumptions in practice. Thus, our research efforts contributed to reducing such a scientific gaps.

Thirdly, the results produced to contribute to improving the understanding and predictability of critical latent contextual and managerial variables' effects on Brazilian industries performance.

Fourthly, this research contributes to academia by proposing and testing 16 different hypotheses, which allowed us to confront our findings against pre-established antecedent research hypotheses in a field with evidence gaps (contradictory results).

Finally, this research also enriches the scientific debate in Supply Chain Management through the combined application of PLS-SEM and Necessary Condition Analysis to explore the impact of different strategies on organizational performance. These approaches contribute to reducing the current methodological gap (characterized when research topics have been mainly explored using a particular or common method).

In sum, we truly believe that our efforts and findings brought new knowledge and opened the venue for further discussions about the importance of understanding both significance and the necessity when exploring enablers and outcomes.

Nevertheless, we also acknowledge that there are still vast opportunities for further research concerning the phenomena proposed here. For example, the following areas could be offered and investigated as a continuity of the present study:

- How the relationship between risk and performance behaves, particularly, in larger, medium, or small industries?
- How Supply Chain Risks influences performance over time?
- What are some of the other potential supply chain strategies which can be configured, at the firm level of analysis, like other essential capabilities for improving Operational Performance and Supply Chain Robustness?
- Does Supply Chain Agility, Supply Chain Risk Management, and Supplier Integration are necessary conditions, to a certain degree, to Supply Chain Robustness in different business contexts.?.

- Does Supply Chain Risk Management and Supply Chain Agility are necessary conditions to Operational Performance in different business contexts.?.

Additionally to the questions raised above, further investigation can be deployed based on the principles of the triangulation method to refine the generalized results obtained from the quantitative methods with the complementary application of qualitative methods among a few and specific industries, for example.

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