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A FRAMEWORK FOR ASSESSING THE RISK OF THIRD-PARTY LOGISTICS WAREHOUSE OPERATORS IN THE CONSUMER GOODS INDUSTRY IN BRAZIL

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Tese de Doutorado apresentada ao Programa/Curso de Pós-Graduação *Stricto Sensu* em Engenharia de Produção e Sistemas do Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, CEFET/RJ, como parte dos requisitos necessários à obtenção do título de Doutor.

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ABSTRACT

A FRAMEWORK FOR ASSESSING THE RISK OF THIRD-PARTY LOGISTICS WAREHOUSE OPERATORS IN THE CONSUMER GOODS INDUSTRY IN BRAZIL

The outsourcing of logistics operations through third-party logistics providers (3PL) has been widely adopted by companies as a strategy to reduce costs and focus on their core activities. Traditionally, the main evaluation criteria for these service providers have been centered on cost and operational efficiency, due to their immediate impact on the contracting company's performance. However, recent incidents involving suppliers, such as labor non-compliance, bankruptcies, environmental disasters, and external crises (including pandemics, strikes, and natural disasters), have broadened the perception of risks associated with 3PL. While these types of risks are extensively documented in the literature and mainstream media when related to suppliers, they remain underexplored in the context of 3PL. Existing studies are mostly concentrated in China and India, with limited data reflecting the Brazilian reality. Considering this context, this thesis aims to develop a risk management framework for warehouse operations carried out by 3PL providers in Brazil, considering internal, external, operational, and sustainability-related risks. The research methodology includes a systematic literature review to map the global state of the art, followed by a case study conducted in a consumer goods company involving two third-party logistics providers. In this case study, supply chain experts were engaged to identify, categorize, assess, define mitigation strategies, and propose risk management indicators. The results indicate that although risk categories are found across different contexts, their root causes vary depending on the type of operation. The study revealed that managers tend to acknowledge operational and managerial risks but significantly underestimate social, labor, and financial risks. The proposed framework enables the assessment of the risk level posed by 3PL providers and supports decision-making processes, contributing to risk mitigation and helping managers measure and manage the risks associated with 3PL across different risk categories.

Keywords: Supply Chain Risk Management, Third-Party Logistics Risk Management, Warehouse Operations

RESUMO

A FRAMEWORK FOR ASSESSING THE RISK OF THIRD-PARTY LOGISTICS WAREHOUSE OPERATORS IN THE CONSUMER GOODS INDUSTRY IN BRAZIL

A terceirização de operações logísticas por meio de operadores logísticos terceirizados (3PL) tem sido adotada por empresas como estratégia para reduzir custos e focar em suas atividades principais. Tradicionalmente, os principais critérios de avaliação desses prestadores concentravam-se em aspectos de custo e eficiência operacional, devido ao impacto imediato sobre os resultados da empresa contratante. No entanto, incidentes recentes envolvendo fornecedores, como inadimplência trabalhista, falências, desastres ambientais e crises externas (pandemias, greves e eventos naturais), têm ampliado a percepção de risco também no contexto dos 3PL. Esses riscos extensamente mapeados pela literatura e na mídia tradicional quando relacionados a fornecedores, ainda são escassos quando se aborda 3PL. A literatura demonstra que esses estudos são concentrados em principalmente na China e Índia, porém ainda sem muitas informações quando se trata da realidade brasileira. Diante desse cenário, esta tese tem como objetivo desenvolver um framework para a gestão de riscos em operações de armazenagem realizadas por 3PL no Brasil, considerando riscos internos, externos, operacionais e sustentáveis. A metodologia empregada incluiu uma revisão sistemática da literatura mapeando o estado da arte no mundo e os resultados são introduzidos em um estudo de caso em uma empresa de bens de consumo, envolvendo dois operadores logísticos terceirizados, onde especialistas identificam, categorizam, avaliam, definem estratégias de mitigação e propõe indicadores para gerenciamento de riscos. Os resultados apontam que, embora as categorias de risco estejam presentes em diferentes contextos, suas causas variam conforme o tipo de operação. O estudo revelou que os gestores reconhecem os riscos operacionais e de gestão, mas subestimam significativamente os riscos sociais, trabalhistas e financeiros. O framework desenvolvido permite mensurar o nível de risco dos 3PL e oferece suporte à tomada de decisão, contribuindo para a mitigação dos riscos para que gestores possam mensurar o risco representado por 3PL nas diferentes categorias de risco.

Keywords: Supplier Chain Risk Management, Third-Party Logistics Risk Management, Warehouse operations.

SUMMARY

ABSTRACT 4

RESUMO 5

FIGURE INDEX 9

TABLE INDEX 10

CHART INDEX 11

LIST OF ABBREVIATIONS AND ACRONYMS 12

Introduction 13

General context 13
Motivation 15
Problem statement 17
Objectives 18
General Objective 18
Specific objectives (SO) 19
Thesis contribution 19
Research delimitation 20
Study Organization 21

1. Theoretical Background 23

1.1. Supply Chain Risk Management 23

1.2. Sustainable Supply Chain Risk Management 25

1.3. Supply Chain Resilience 27

1.4. Third-party logistics 28

1.5. Supply Chain Risk Management for Third-party logistics 29

1.6. Supply Chain Riks Management drivers for 3PL 33

2. Methodology 36

2.1. Conceptual Research Methodology 36

2.1.1. Systematic Literature Review 36

2.1.2. Formulation of research questions 37

2.1.3. Selection of databases 37
2.1.4. Definition of search terms 37
2.1.5. Article Selection 38
2.1.6. Identification of risks and relevant information from articles 38
2.1.7. Risk Assessment Data Collection 39
2.2. Applied Research Methodology 41
2.2.1. General Data collection 41
2.2.2. Define Research Questions 43
2.2.3. Risk Identification 44
2.2.4. Risk Assessment 44
2.2.5. Risk Mitigation 45
2.2.6. Risk Monitoring 46
2.3. Methodology for Third-Party Logistics Risk Assessment 46
2.3.1. Methodology for Calculating 3PL Risk Scores 47
2.3.2. Conducting 3PL Risk Assessments 49
2.3.3. Interpretation of Assessment Results 50
3. Conceptual Research: Systematic Literature Review of Third-Party Logistics Risk Management 51
3.1. Bibliometric data of articles 51
3.2. Characteristics of articles 53
3.3. 3PL Risk Identification 56
3.4. 3PL Risk Assessment 57
3.5. Validation and assessment of identified risks 58
3.6. Section Conclusion 62
4. Applied Research: Risk Management Framework for Third-Party Logistics Consumer Goods Warehouse Operators 63
4.1. Risk Identification 64
4.1.1. Identification of risk categories 66

4.1.2. Identification of specific risks causes 68
4.2. Risk Assessment 77
4.2.1. Categories Weights 77
4.2.2. Critical risks 78
4.3. Risk Mitigation 79
4.4. Risk Monitoring - KPIs 87
4.5. Section conclusion 91
5. Case Study: Assessment of Third-Party Logistics operators of consumer goods warehouses in Brazil 92
5.1. 3PL Assessment 92
5.2. Section Conclusion 95
6. General Discussion, Conclusion and Further Research 97
References 100
Appendices 111

FIGURE INDEX

Figure 1 - Thesis Delimitation 20
Figure 2 - Delimitation of the thesis sections. 21
Figure 3 - Supply Chain Risk Management cycle. 24
Figure 4 - Pillars of sustainability 26
Figure 5 - Risk Matrix used to define critical risks 45
Figure 6 - SCRM Framework for 3PL warehouse operators in the consumer goods 63
Figure 7 - 3PL1 risk assessment results 93
Figure 8 - 3PL2 risk assessment results 94
Figure 9 - 3PL1 risk with the weights defined in the methodology compared to the risk considering the highest weight in the Labor and Financial category 96
Figure 10 - 3PL2 risk with the weights defined in the methodology compared to the risk considering the highest weight in the Labor and Financial category 96

TABLE INDEX

Table 1 - Sustainable Supply Chain Resilience by Hsu et al. (2021) 28
Table 2 - Main risks to evaluate a 3PL according to Aguezzoul 31
Table 3 - Main risks to select a 3PL according to Singh; Gunasekaran and Kumar 32
Table 4 - Supply Chain Decision Makers 42
Table 5 - Technical Experts 42
Table 6 - A summary of methodological steps adopted in applied research 43
Table 7 - Example of 3PL scoring in risk assessment using defined methodology 48
Table 8 - 3PL risk classification based on 3PLRS result 49
Table 9 - Total of publications per journal 52
Table 10 - Number of articles by country where research is conducted 54
Table 11 - Number of articles by 3PL contractor's business segment 54
Table 12 - Quantity and percentage of articles by main activity performed by the 3PL .. 55
Table 13 - Risk categories identified in the SLR 56
Table 14 - Sustainable Supply Chain risks 65
Table 15 - Risk Categories Defined by SC Decision Makers for 3PL Warehouse Operators 67
Table 16 – EHS and Human risks 70
Table 17 – Labor and Financial relationship risks 72
Table 18 – Quality risks 73
Table 19 – Management risks 74
Table 20 - Operational risks for raw material warehouse, factory supply and finished product warehouse 75
Table 21 - Operational risks for finished product distribution center 76
Table 22 - Initial weights assigned by SC Decision Makers 78
Table 23 - Final weights assigned by SC Decision Makers 78
Table 24 - The critical risks of each 3PL category 79
Table 25 - Drivers for risk mitigation and improve resilience 80
Table 26 - Mitigation actions required for EHS and Human risks 81
Table 27 - Mitigation actions required for Labor and Financial relationship risks 83
Table 28 - Mitigation actions required for Quality risks 84
Table 29 - Mitigation actions required for Management risks 85
Table 30 - Mitigation actions required for Operational risks 86
Table 31 - KPIs defined for risk monitoring 90

CHART INDEX

Chart 1 - Publications from SLR pear year 52
Chart 2 - Percentage of SCRM stage covered by SLR articles 53
Chart 3 - Position and type of function of professionals 59
Chart 4 - Total number of people who responded to the questionnaire by segment 60
Chart 5 – Median Risk Ratings According to Non-Specialists 61
Chart 6 - Median Risk Ratings According-Specialists 61

LIST OF ABBREVIATIONS AND ACRONYMS

3PL – Third-Party Logistics

3PLRS – 3PL Risk Score

4PL – Fourth-Party Logistics

AHP - Analytic Hierarchy Process

B2B – Business to Business

B2C – Business to Costumer

CRS – Category Risk Score

EHS - Environment, health and safety

ESG - Environmental, social, and governance

KPI - Key Performance Indicator

MCDM – Multi Criteria Decision Making

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyzes

RQ – Research Question

SC – Supply Chain

SCM – Supply Chain Management

SCRes – Supply Chain Resilience

SCRM – Supply Chain Risk Management

SLA – Service Level Agreement

SLR – Systematic Literature Review

SO – Specific Objectives

SSCM – Sustainable Supply Chain Management

SSCRM – Sustainable Supply Chain Risk Management

STR - String

TBL – Triple Bottom Line

TPL – Third-Party Logistics

TQ – Thesis Question

UK – United Kingdom

USA – United States of America

wi – Weight

Introduction

General context

In an increasingly interconnected and competitive global landscape, the advent of Industry 4.0 has driven significant advancements while simultaneously imposing tighter margins and shorter deadlines on organizations. As a result, senior management is required to make faster decisions, the consequences of which often have a profound impact on business operations. Given this reality, decision-makers must enhance their strategic focus and leverage an increasing volume of information and analytical tools to support effective management and decision-making.

In response to these challenges, organizations are progressively concentrating on their core business activities while opting to outsource logistics functions, such as warehousing, distribution center management, and overall logistics operations, to specialized third-party service providers (OSORIO GÓMEZ et al., 2017). This strategic shift has led to the widespread adoption of Third-Party Logistics (3PL) providers, which assume responsibility for various logistical activities on behalf of client organizations. While outsourcing logistics to 3PL providers offers several operational advantages such as cost reduction (RAUT et al., 2016) and expertise in logistics (TSANG et al., 2017).

During the 2000s, the outsourcing of logistics activities emerged as a prominent market trend. Initially, this practice was primarily perceived as a strategy to reduce costs (KMIECIK, 2022; WU, 2012) and enable firms to concentrate on their core business operations (ABBASI et al., 2024; AKHTAR, 2023). Early concerns regarding logistics outsourcing were largely centered on operational performance factors, such as on-time delivery and the service level (ABBAS; AL-BAZI; PALADE, 2018; JAZAIRY; LENHARDT; VON HAARTMAN, 2017; OSORIO GÓMEZ; GARCIA; MANOTAS, 2018.; WANG; CHILDERHOUSE; ABARESHI, 2024).

However, recent global events have shifted the focus of concern in logistics outsourcing. The COVID-19 pandemic (ASHRAF et al., 2022; BLOM; NIEMANN, 2022; BUTT, 2022) and military conflicts, such as the ongoing war between Russia and Ukraine (ABDELAAZIZ et al., 2022; LIADZE et al., 2022), have exposed vulnerabilities in supply chains, leading to significant disruptions. Consequently, these challenges have become a subject of extensive study among both researchers and industry practitioners. In addition

to identifying and mitigating various types of risks, supply chain stakeholders must now prioritize efforts to recognize and address vulnerabilities (MEYER et al., 2019).

Supply Chain Management (SCM) encompasses the entire supply chain, from product development and material selection to supplier management, logistics operations, final delivery to end users, and reverse logistics. This process involves multiple stakeholders, including suppliers, manufacturers, transporters, customers, distributors, and Third-Party Logistics providers (TANG, 2006; VISHNU; SRIDHARAN; KUMAR, 2019).

Within this context, Supply Chain Risk Management (SCRM) has emerged as a critical field of study that considers the supply chain as a set of multifunctional business processes. SCRM enables managers to identify, evaluate, and mitigate risks that affect the entire supply chain (SENNA et al., 2020). Initially, risk management in the supply chain focused primarily on internal risks affecting operational outcomes and the performance of supply chain actors. However, in recent years, the scope of SCRM has expanded to include uncertainties and vulnerabilities external to organizations (SILVA et al., 2020). Additionally, when a company implements risk management actions in an isolated manner, these actions are not effective and can generate other risks (SENNA et al., 2022).

Despite the growing body of literature on sustainable supply chain risk management, studies specifically focused on risk management in 3PL operations prior to the COVID-19 pandemic were still limited (OSORIO GÓMEZ et al., 2017; RAUT; KUMAR, 2018). Given that outsourcing logistics functions to 3PL providers is a widespread strategy among firms, it is crucial to ensure that these providers operate efficiently and sustainably to prevent external risks from impacting on the organization's activities and reputation.

Sustainability in supply chain management is typically analyzed through the triple bottom line framework, which considers three key pillars: environmental, social, and financial sustainability (ELKINGTON, 1998). In recent years, supply chain managers have recognized the importance of assessing not only their own sustainability practices but also those of all entities within the supply chain, including 3PL providers. This has led to the emergence of a specialized field known as Sustainable Supply Chain Risk Management (SSCRM) (BAI et al., 2019).

A failure to integrate sustainability into outsourced logistics operations can lead to severe operational disruptions, financial losses, and reputational damage. Several recent cases illustrate the consequences of unsustainable in suppliers. As part of the supply chain, the use of a 3PL could also be susceptible to these threats and impact its contracting company.

- Cocoa Industry: A global chocolate manufacturer faced significant backlash after reports revealed that its suppliers were using child labor. In response, major organizations in the Brazilian cocoa industry introduced sustainability certification seals to assure consumers of ethical sourcing (BORDA et al., 2021).
- Toy Industry: In 2007, toy manufacturer Mattel recalled its products after discovering excessive lead levels in the paint used by a subcontractor (WEIDENHAMER, 2009).
- Automotive Industry (Brazil, 2024): The automobile company BYD was accused of hiring a third-party company for factory construction in Camaçari-BA, where 163 workers were found in conditions analogous to slavery (AUTOESPORTE, 2024).
- Wine Industry (Brazil, 2023): An outsourced labor company supplying workers to wineries in Rio Grande do Sul was found to be exploiting workers under inhumane conditions. As a result, the companies that hired these outsourced workers were sued and faced consumer boycotts (O GLOBO, 2023).
- Event Industry (Lollapalooza, Brazil): In 2023, five workers from an outsourced logistics company responsible for stage assembly at the Lollapalooza festival in São Paulo were rescued from unsafe and exploitative working conditions. In a similar case in 2019, a subcontractor hired for the event was found to have employed homeless individuals for wages far below legal standards (BRIGATTI, 2023).

These incidents caused by suppliers of large companies have been widely reported both in academic studies and in mainstream media. However, when it comes to third-party logistics providers (3PL), information is more limited. Nevertheless, such cases serve as a warning to contracting firms, as they have been held accountable, facing legal penalties, financial losses, and reputational damage, which could also apply if the incident were caused by a 3PL.

Given the numerous recent scandals involving segments of the supply chain (suppliers), and in contrast, the limited number of studies addressing these risks in the context of 3PL, this thesis aims to examine whether such risks are also present in the use of 3PL and how they can be managed. Furthermore, it seeks to develop a procedure or framework to guide managers in effectively conducting this risk management.

Motivation

In recent years, the outsourcing of logistics operations has expanded significantly,

allowing organizations to focus on their core business while delegating complex logistics processes to specialized 3PL. Despite the operational benefits that outsourcing offers, organizations tend to focus primarily on the operational management of logistics providers while neglecting or subjectively handling other critical sustainability factors within the supply chain.

Managing sustainability risks in outsourced logistics operations becomes even more challenging due to the highly fragmented nature of the 3PL market. Unlike industries dominated by a few large players, logistics outsourcing in Brazil is widely dispersed. According to ABOL – Associação Brasileira de Operadores Logísticos (2023), the five largest logistics providers account for only 10% of the total market revenue, indicating a high level of decentralization.

The inability to effectively manage 3PL providers from a sustainability perspective can have severe social, environmental, and economic consequences. Recent cases of outsourced companies engaging in exploitative labor practices have caused irreparable harm to individuals and communities (AUTOESPORTE, 2024; BORDA et al., 2021; O GLOBO, 2023). Furthermore, even when legal responsibility formally lies with the 3PL, contracting companies and their executives are frequently held accountable by public opinion, regulatory bodies, and the media. Legal liability, reputational damage, and consumer backlash are common consequences of such incidents, emphasizing the need for a structured and proactive risk management approach.

This thesis proposes a comprehensive risk management framework designed to minimize these risks and, consequently and protecting some stakeholders and parts such as:

- Workers, by mitigating some risks related to labor conditions and human rights.
- Society, by preventing labor exploitation and unethical business practices.
- The environment, by mitigating some risks of environmental and unsustainable logistics practices.
- The contracting company, by reducing legal, operational, and reputational exposure.
- The 3PL provider itself, by identifying potential risks and implementing mitigation strategies, key performance indicators (KPIs), and service level agreements (SLAs) to ensure sustainable operations (VAN DER WALT; NIEMANN; MEYER, 2021).

This thesis introduces a comprehensive risk management model for 3PL sustainability assessment, addressing not only operational performance but also social,

environmental, and financial sustainability. The proposed model enables organizations to:

- Evaluate and continuously monitor risks associated with each logistics provider, whether at an individual or aggregate level.
- Implement proactive risk mitigation strategies, from reactive measures following a supply chain breakdown or reputational crisis.
- Proposing long-term compliance with sustainability standards, protecting corporate reputation while improving overall supply chain resilience by implementation of mitigation strategies.

The need to assess the sustainability of logistics outsourcing stems from concerns not only about supply chain efficiency and business reputation but also about worker welfare, environmental preservation, and corporate social responsibility. Economic progress must be aligned with social well-being and environmental stewardship, reinforcing the importance of integrating sustainability into supply chain decision-making.

Organizations that prioritize sustainable Third-Party Logistics providers may be less vulnerable to a wide range of risks, including:

- Operational risks, such as supply chain disruptions and delivery failures.
- Financial risks, including the bankruptcy or financial instability of a 3PL provider.
- Social and environmental scandals, which can lead to regulatory scrutiny and reputational damage.
- Regulatory and legal risks arising from non-compliance with labor, environmental, and commercial regulations.

By adopting sustainable 3PL management practices, organizations can enhance their competitive advantage while fostering a win-win partnership with logistics providers (RATH et al., 2024).

Problem statement

Despite the well-documented operational risks associated with outsourcing storage operations, 3PL managers continue to face challenges in effectively controlling external risks. The lack of clarity in evaluating 3PL resilience can result in severe consequences, including operational disruptions, reputational damage, financial losses for contractors, and potentially irreversible harm to the environment, society, and individuals involved in 3PL-contractor relationships.

Managers require access to both qualitative and quantitative information to make informed decisions on contracts, contract extensions, incentive payments, risk

contingency planning, and, when necessary, interventions or contract terminations with 3PLs that pose significant sustainability risks. This thesis therefore seeks to answer the following question:

TQ: Is it possible for a framework or structured procedure to support supply chain managers in management risks of third-party logistics (3PL) in finish goods warehouses, located in Brazil?

The first phase of this research aims to answer the following key questions:

RQ1. What are the main risks identified in the literature concerning 3PL usage and what are the main methods to identify risks?

RQ2. In which countries and industries have these studies been conducted?

RQ3. Of the risks identified in the literature, which are applicable to the reality of Brazil?

This information makes it possible to point out theoretical trends in the main works for those involved in SCRM (SANTOS et al., 2020).

The second phase of this research focuses on developing a risk management framework to support decision-makers from multinational consumer goods company in:

RQ4. What are the types of risk and their specific causes in the operation of consumer goods warehouses by logistics contractors in Brazil?

RQ5. How critical is each category and each risk cause for case study?

RQ6. What are the strategies and drivers that should be implemented by the 3PL to mitigate risks?

RQ7. What are the critical indicators that must be monitored by the contractor and the 3PL?

Following the validation of this framework, it was applied within a multinational consumer goods company. The study also captured managerial perceptions of the framework's effectiveness and whether its results aligned with their subjective assessment of 3PL-related risks. Finally, the study presents the last question.

RQ8. What level of risk does each 3PL have when evaluated by the framework created in this research?

Objectives

General Objective (GO)

GO. Develop a Supply Chain Risk Management framework to manage the risk of

Third-Party Logistics warehouse operators in the consumer goods sector in Brazil.

Specific objectives (SO)

SO1. Identify the main risks related to Third-Party Logistics through a systematic literature review and the main methods of risk identification and assessment.

SO2. Identify the main segments and countries in which 3PL risk management studies were identified and evaluated.

SO3: Verify whether the risks identified in the systematic literature review are relevant for Brazil's reality.

SO4: Identify, the main risks related to the outsourcing of warehouse operations in Brazilian finish goods companies.

SO5: Conduct a risk assessment of identified risks.

SO6: Identify the mitigation strategies and drivers that the 3PL should implement for each identified risk.

SO7: Define KPIs for periodic risk monitoring.

SO8: Classify the 3PL by the level of risk represented

Thesis contribution

This thesis is divided into two major contributions: i) Theoretical and ii) Empirical.

i) This thesis provides identification of Third-Party Logistics Risk Management risks and main methods to risk identification and assessment.
ii) This thesis provides an applied framework for a SCRM for 3PL. The conceptual framework also consists of risk audit forms and mitigation strategy frameworks. The framework is validated through assessments with two Third-Party Logistics companies operating warehouses in the consumer goods sector in Brazil. The framework, if well applied, will reduce several 3PL risks, such as the use of labor and conditions outside those specified by law, without adequate technical knowledge, greater respect for the environment and use of resources, less chance of being caught off guard by bankruptcy or financial difficulties of the 3PL, among other risks.

Research delimitation

The applied research is limited to creating a monitoring tool for part of 3PL logistics operators by the manufacturer. The manufacturer's supply chain can be seen in the Figure 1, with the main actors in the supply chain highlighting the position of the 3PL that were evaluated in this research.

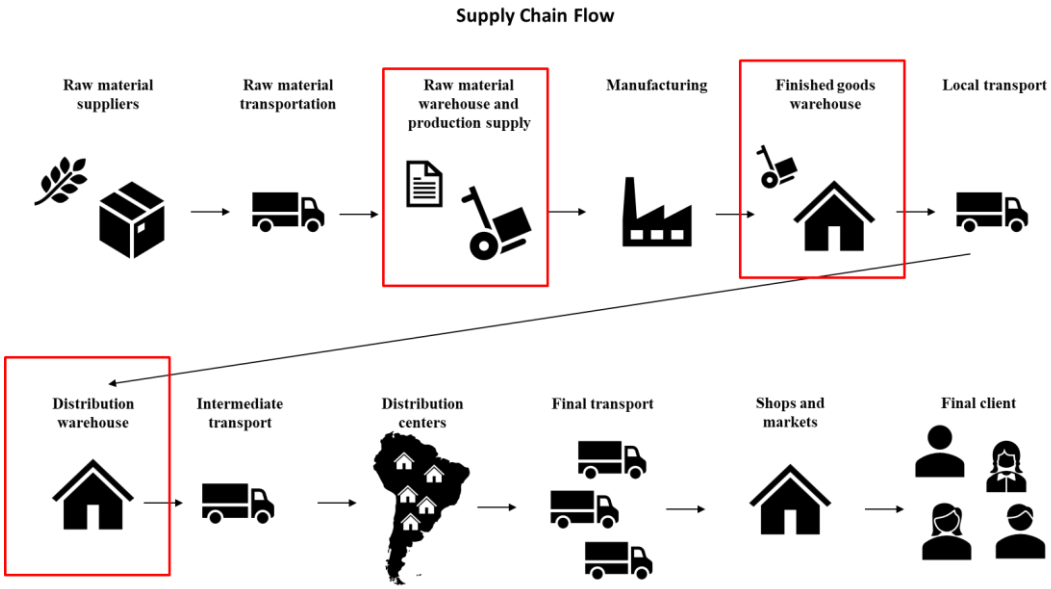


Figure 1 - Thesis Delimitation
Source: Author

The study is limited to evaluating the 3PLs that execute the operations marked in a red box. A 3PL performs both raw material storage, production supply and finished product storage operations. This 3PL is a large logistics operator based in Germany and operates in more than 220 countries and territories. In this study, this 3PL will be called “3PL1”. The 3PL that carries out the storage operation in the primary distribution center is a Brazilian 3PL, headquartered in the city of the manufacturer where the study was carried out and with a local operation and in contrast to the 3PL1 is a privately held company and managed by a family. In this study, this 3PL will be called "3PL2". The selection of these activities for the case study is justified by the fact that warehousing operations for raw materials and finished products at the factory and the first distribution center constitute the largest operations, involving the highest levels of investment and the most significant impact from the 3PL.

Study Organization

This thesis was developed throughout the doctoral research process through an extensive review of academic literature, including articles, books, and industry reports, as well as news articles and insights from practitioners. Additionally, interviews with supply chain executives and on-site visits to a consumer goods manufacturing facility and its Third-Party Logistics operated distribution centers provided valuable empirical insights into real world logistics operations.

The subsequent sections of this thesis outline the methodological approach and framework for assessing and monitoring 3PL-related risks. Figure 2 presents a structured overview of the key sections of this thesis, detailing the main topics covered in each phase of the research process.

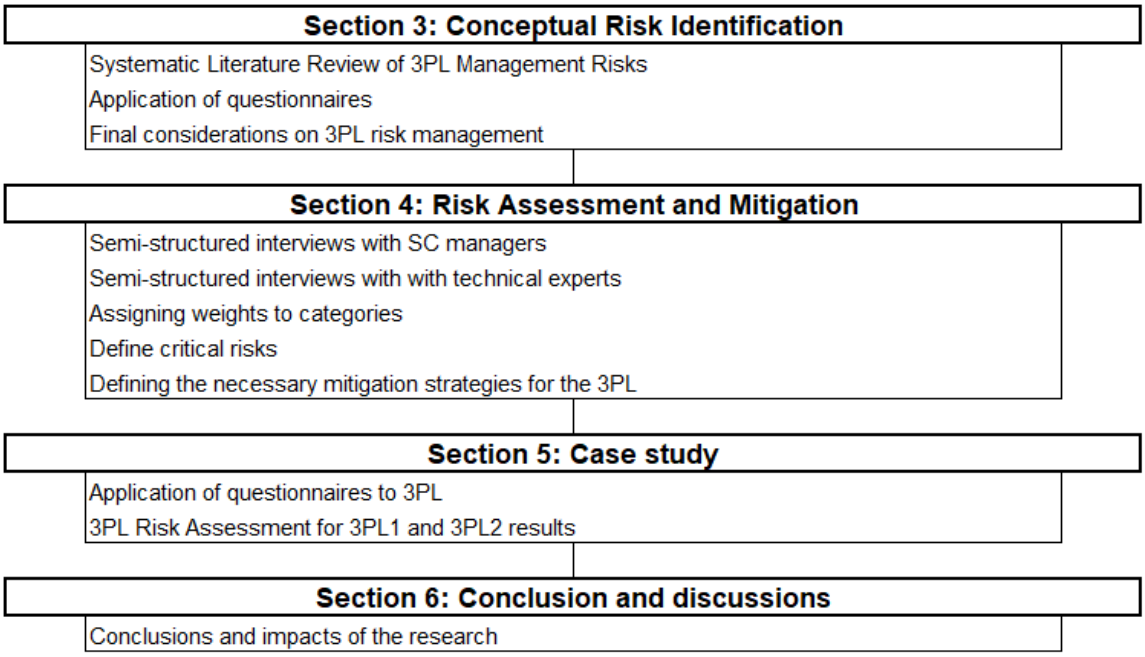


Figure 2 - Delimitation of the thesis sections.
Source: Author

Section 3 presents the results of 3PL risk identification, derived from a Systematic Literature Review (SLR). This section outlines the primary methods for risk identification and assessment found in the literature. To contextualize the findings within the Brazilian logistics sector, a questionnaire was distributed to analysts, engineers, specialists, and managers in Brazil. The responses provide insights into how professionals perceive and evaluate the risks identified in the SLR, in this section. This Section concludes the specific objective SO1, SO2, and SO3.

Section 4 introduces an applied study aimed at developing a comprehensive 3PL

risk management framework, covering risk identification, assessment, mitigation, and monitoring. The study focuses on 3PL providers managing warehouses for a consumer goods company in Brazil. The results were obtained through semi-structured interviews with supply chain managers from the case study company. Following risk identification, critical risks were determined based on interviews with technical experts. The section concludes with a detailed framework for risk mitigation strategies, outlining the necessary actions for a 3PL to be classified as resilient for a given risk, as well as the definition of key performance indicators (KPIs) for ongoing risk monitoring. This section concludes the General Objective of this doctoral thesis and concludes the specific objectives SO4, SO5, SO6, and SO7.

Section 5 presents the evaluation results of two 3PL providers, based on a case study conducted in a consumer goods company in Brazil. This section begins with the validation of the questionnaire, which was applied to the 3PLs, followed by an explanation of the scoring and classification criteria used to assess the 3PLs based on their responses and supporting evidence for each risk identified. The results include the risk classifications of the 3PL providers, along with insights from managers and technical experts of the case study company. Additionally, the perceptions of key personnel from the 3PLs are examined, providing a comprehensive evaluation of the risk management framework's applicability in real-world logistics operations. This section validates the General Objective and completes the SO8 specific objective.

1. Theoretical Background

This chapter conducts a review of the literature on Sustainable Supply Chain Risk Management and the management of Third-Party Logistics. We look for the main identified risks, methods for assessing risks, mitigation strategies and methods for monitoring risks.

1.1. Supply Chain Risk Management

Supply Chain Risk Management is a specialized area within supply chain management that focuses on identifying, assessing, mitigating, and monitoring risks that may disrupt the flow of materials, information, and capital within supply chains. Risks in this context refer to factors that can cause operational disruptions, create vulnerabilities for organizations, or lead to undesirable consequences, as exemplified by the COVID-19 pandemic (VISHNU et al., 2021).

A key characteristic that differentiates SCRM from other risk management disciplines is its approach to uncertainty. Unlike conventional risk management, which often seeks to eliminate uncertainty, SCRM acknowledges uncertainty as an inherent aspect of risk. Consequently, qualitative risk assessments are commonly employed, often complemented by tools that convert qualitative analyses into quantitative insights for more structured decision-making (DANG et al., 2022; HSU et al., 2022a).

In recent years, there has been a significant increase in academic research on SCRM, largely due to unforeseen events that have severely impacted global supply chains. The COVID-19 pandemic is one such example that exposed systemic vulnerabilities in global logistics networks (KHOKHAR et al., 2022). Similarly, natural disasters have frequently disrupted supply chains, prompting further research on disaster resilience strategies (XU; LIU, 2017). In Brazil, an additional concern is cargo theft, a persistent issue that generates substantial annual losses for the local economy, as documented in industry reports (DAPP, 2018). Supply Chain Risk Management can be divided into four steps which are risk identification, risk assessment, risk mitigation and risk monitoring, being a continuous cycle (VISHNU; SRIDHARAN; KUMAR, 2019) shown in Figure 3:



Figure 3 - Supply Chain Risk Management cycle.
Source: Author

Risk identification involves a variety of risks, including economic risks, internal management issues, infrastructure challenges, fluctuations in consumer demand, and environmental and political pressures (SEURING; MÜLLER, 2008). Proper risk identification and classification are essential for supply chain managers to accurately assess risks (HSU et al., 2021; MUNNY et al., 2019). Common methods for identifying risks include consulting expert opinions, conducting literature reviews, brainstorming, and sharing information (HERNADEWITA; SALEH, 2020). While certain risks are commonly found across supply chains, organizations must internally identify risks specific to their operations, leveraging expert knowledge within the company and benchmarking against industry leaders (BLACKHURST; SCHEIBE; JOHNSON, 2008).

Risk assessment is crucial because the risk identification stage often uncovers a large number of potential risks. The complexity of supply chains directly influences the number of risks involved; therefore, efforts must focus on significant risks, while less critical risks require fewer resources. Risk assessment determines the impact of each risk on the supply chain and prioritizes them accordingly. Some widely used risk assessment methods include the Analytic Hierarchy Process (AHP) (SAATY, 1980), Failure Mode and Effects Analysis (FMEA), Fuzzy Logic (ZADEH, 1978), and expert group evaluations within the supply chain (CHAPMAN, 1998; HERNADEWITA; SALEH, 2020; RADIVOJEVIĆ; GAJOVIĆ, 2014; ZAIDI; HASAN, 2022)

Even when risks are identified and assessed, eliminating them from the supply

chain is impossible. However, agents can mitigate these risks by reducing their impact. Consequently, risk mitigation is often the top priority for supply chain decision-makers (RAJESH, 2020b). Decision-makers aim to eliminate or reduce risks by analyzing risk factors. One possible approach to achieving this is expanding the number of contractual partners, and diversifying products and components within the supply chain (DIABAT; GOVINDAN; PANICKER, 2012). One of the most well-known examples of successful risk mitigation is Sony's response to a fire at the Philips plant in New Mexico, which was one of its main suppliers of mobile phone components. Sony promptly diversified its supplier base for product modules, significantly reducing the impact of the disruption. In contrast, Ericsson, another Philips customer, suffered far greater losses due to its lack of supplier diversification (NORRMAN; JANSSON, 2004).

The final stage of the SCRM cycle is risk monitoring, which is essential for all previous stages of the process. The increasing complexity of supply chains and globalization means that risks can emerge or evolve rapidly, often due to external factors in different parts of the world. Supply chain actors must continuously document risks, maintaining a historical database to ensure preparedness and avoid unexpected disruptions. Additionally, purchasing and manufacturing managers should collaborate closely and synchronize critical risk factors to enhance responsiveness (SURARAKSA; SHIN, 2019). However, monitoring methods must remain simple and easy to implement, as they need to become an integral part of daily supply chain operations (BLACKHURST; SCHEIBE; JOHNSON, 2008).

1.2. Sustainable Supply Chain Risk Management

Literature reviews aiming to identify risks in 3PL operations highlight risks that are internal to the 3PL from both operational and financial perspectives. However, recent events indicate that social and environmental risks related to suppliers have also become significant concerns for manufacturing companies in Brazil.

The lack of social responsibility among contracting companies is one of the most overlooked aspects of supply chain management (FERNANDO et al., 2022). Failing to address social sustainability in supplier management can result in severe reputational damage for the contracting company. One of the most well-known cases of corporate image damage caused by poor social responsibility practices in the supply chain is the chocolate industry scandal, where suppliers engaged in child labor, corruption of local

authorities, and child trafficking during cocoa production in Ghana and Ivory Coast. This resulted in legal sanctions against Nestlé in the United States (BAI; QUAYSON; SARKIS, 2022).

Sustainable Supply Chain Management (SSCM) refers to the process of managing the flow of information, raw materials, and finished products throughout the supply chain while considering economic, environmental, and social attributes (BAI et al., 2019; GOVINDAN; MANGLA; LUTHRA, 2017). These three attributes form the foundation of the Triple Bottom Line framework, which was first introduced by Elkington in 1998. The concept of TBL emerged in response to increasing government regulations, societal expectations, and consumer demands, which pressured organizations to adopt sustainability-driven business practices (ELKINGTON, 1998).

As illustrated in Figure 4, although the three pillars of TBL, economic, environmental, and social sustainability, are distinct, they are interconnected. Their applications and implications influence one another, ultimately shaping the sustainability of the entire supply chain (SILVA; SCHALTEGGER, 2019).

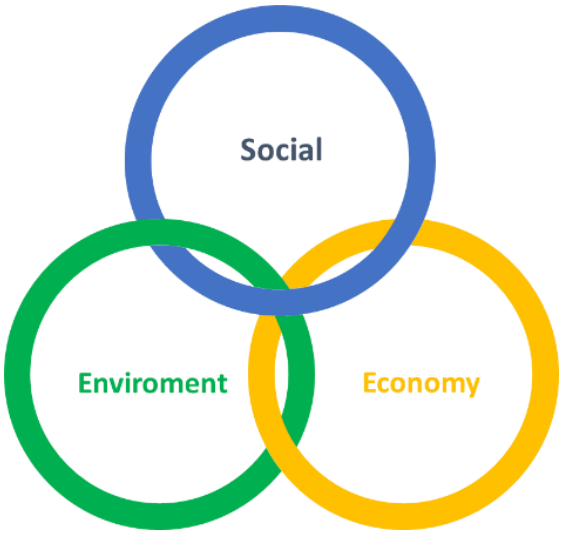


Figure 4 - Pillars of sustainability.

Source: Author

The risks associated with the TBL are often subjective and influenced by the perceptions of consumers and stakeholders. Therefore, when conducting Sustainable Supply Chain Risk Management with suppliers, uncertainties must be taken into account. Effective SSCRM is essential to ensure that companies do not suffer financial or

reputational damage due to unsustainable practices within their supply chain (JUETTNER et al., 2020).

Although few studies specifically identify sustainability risks in 3PL management, it can be inferred that many of these risks are similar to those encountered in supplier management and other aspects of the supply chain. For instance, if a company prioritizes fair labor practices for its own employees, it is naturally expected that its logistics contractors uphold the same level of diligence when managing their workforce.

1.3. Supply Chain Resilience

In the supply chain context, as supply chains become more complex, enhancing resilience to mitigate sustainable disruption risks has become increasingly important (HSU et al., 2021). The concept of supply chain resilience refers to the ability of the supply chain to withstand disruptions, react to negative effects, and return to its natural state after an undesirable event, or even to anticipate such events (HSU et al., 2022a). The COVID-19 pandemic highlighted the low resilience of supply chains to external shocks, as evidenced by widespread supply disruptions, job losses, and significant negative socio-economic impacts worldwide (SILVA et al., 2021).

The importance of supply chain resilience has gained increasing attention, leading to the development of various tools to assist managers in strengthening their supply chains. These tools include Multi-Criteria Decision Support Methods (HSU et al., 2021; MOHAMMED et al., 2019), Quality Function Deployment (HSU et al., 2022a), the implementation of key performance indicators (SINGH; SONI; BADHOTIYA, 2019), and digitalization (MICHEL-VILLARREAL et al., 2021)

Two primary methods were identified to improve supply chain resilience. The first involves restoring previous performance levels at a viable cost to the business, while the second focuses on reducing the severity and occurrence of threats through preventive actions and mitigation strategies. The latter is considered more effective since preventive measures implemented in advance result in less disruption and lower costs for organizations (HAIMES, 2006). In contrast, companies that rely on reactive resilience strategies, such as emergency responses or last-minute stock adjustments, tend to experience greater disruptions and higher operational costs (THUN; HOENIG, 2011). If managers focus solely on reducing costs and increasing efficiency without ensuring resilience, they are likely to create vulnerabilities within the supply chain (SHUAI; WANG;

ZHAO, 2011).

The main attributes that define supply chain resilience, as outlined by Hsu et al. (2021), are presented in Table 1. These attributes enable managers to implement strategies that enhance resilience, whether by restoring supply chain performance after a disruption or by proactively reducing the likelihood and severity of interruptions.

Table 1 - Sustainable Supply Chain Resilience by Hsu et al. (2021)

Resilience capacity	Definition
Agility	Agility refers to the ability to act quickly in response to market and consumer variations.
Flexibility	Flexibility is the capability of a firm to respond to long-term or fundamental changes in the supply chain and market environment by adjusting the configuration of the supply chain.
Redundancy	To act in a way that keeps redundancy of capacity and items, so that during market variations, it is possible to utilize the backup without operations being compromised.
Capacity	As a general business term, capacity in supply chain management refers to an entity's capability to generate output over a Capacity predetermined period.
Efficiency	Efficiency concerns the ability to produce results with the least use of resources possible, with quality and within the stipulated deadline.
Competence	Ability to respond effectively and efficiently to changes and variations in demand, withstanding turbulence.
Visibility	Transparency and the ability to visualize events and deadlines, sharing information that supports managers and technicians.
Adaptability	Adaptability is the ability of an organization to make changes in its operations to meet challenges or seize opportunities.
Anticipation	The ability to identify potential future events or situations. Supply chain and operations managers should anticipate interruptions and prepare the supply chain for any anticipated and unexpected changes in the environment.

Source: Hsu et. al (2021)

The risk mitigation stage in SCRM seeks to reinforce resilience, through actions that can mitigate or prevent the materialization of risks.

1.4. Third-party logistics

Logistics outsourcing has become an increasingly prominent trend since the 2000s. Companies whose core business is not logistics often choose to outsource these operations to specialized service providers. In addition to reducing operational costs due to the expertise of outsourced companies, logistics outsourcing offers several expected benefits, including greater flexibility, improved quality, reduced waiting times, better warehouse organization, and enhanced labor efficiency, ultimately contributing to a more sustainable logistics operation (ABBASI et al., 2024; MINASHKINA; HAPPONEN, 2023; SU et al., 2024).

Third-party logistics can perform a wide range of logistics activities, from loading and unloading finished products or raw materials to transporting inputs or products from suppliers to factories (WANG; CHILDERHOUSE; ABARESHI, 2024). Their responsibilities extend to managing the transportation of goods from factories to distribution centers, retailers, and end customers, as well as handling internal factory supply logistics, warehousing, and inventory management (MINASHKINA; HAPPONEN, 2023; WU, 2012). Additionally, reverse logistics, which involves the management of returned goods, recycling, and disposal processes, is also a key function of 3PLs (LI; CHEN, 2022; TAVANA et al., 2021). The specialization of logistics operations has become increasingly crucial with the rise of internet-driven commerce, which has facilitated greater consumer access to information, an expanded variety of available products, and shorter product life cycles and delivery times (WU, 2012)..

Since the core principles of logistics activities are shared across most industrial and commercial sectors, 3PLs can operate in diverse sectors, including e-commerce (ASHRAF et al., 2022), the chemical industry (ZARBAKHSHNIA; KARIMI, 2024), the pharmaceutical sector (MOREIRA; RODRIGUES, 2023), construction (EKESKÄR; RUDBERG, 2022), food and beverages (OYEDIJO et al., 2022), oil and gas (ETOKUDOH; BOOLAKY; GUNGAPHUL, 2017), and automotive manufacturing (WAGENAAR; FRAGKOS; ZUIDWIJK, 2021). In addition to these more common industries, 3PLs may also operate in specialized segments that require them to adapt their logistics strategies and operations. Examples include the halal industry, where compliance with specific religious and quality standards is required (NOORLIZA, 2020), and the pharmaceutical and food industries, where temperature-controlled logistics are essential for preserving perishable products (TSANG et al., 2017). Furthermore, some logistics providers operate as subcontracted entities under Fourth-Party Logistics (4PL) providers, which specialize in strategic planning and coordination of logistics operations across multiple service providers (WANG et al., 2022).

1.5. Supply Chain Risk Management for Third-party logistics

Over the years, supply chain risk management has gained increasing relevance, particularly following global events that have caused severe disruptions and economic shutdowns, such as the COVID-19 pandemic (MAJUMDAR; SINHA; GOVINDAN, 2021). In the context of Brazil’s supply chain, the management of Third-Party Logistics has become even more critical as organizations increasingly seek to contract logistics

operators with specialized expertise. In recent years, local risks have posed significant challenges to supply chains in Brazil. Among these obstacles are truck driver strikes resulting from political decisions and election outcomes, cargo theft, operational difficulties in regions controlled by militias and drug trafficking, and poor road conditions.

The increasing reliance on 3PL services necessitates a deeper understanding of how to effectively manage these providers, supporting managers in identifying the main risks, evaluating their impact, defining mitigation strategies, and establishing robust monitoring mechanisms for outsourced logistics operations. The relationship between the contracting company and the 3PL provider must be mutually beneficial, enhancing the efficiency and effectiveness of logistics operations while ensuring that costs remain manageable for the contractor and that the 3PL remains financially viable. This relationship should be based on cooperation, information sharing, and a commitment to the well-being of employees, whether they belong to the contractor or the 3PL (PREMKUMAR; GOPINATH; MATEEN, 2021). When 3PL providers prioritize sustainability factors alongside internal performance metrics, there is a notable improvement in transportation planning, inventory management, cost reduction in warehousing, and overall operational performance (RAUT et al., 2016). These benefits have led to a significant expansion in 3PL adoption, with approximately 60% of Fortune 500 companies in the United States reporting at least one contract with a 3PL provider, further fueling the growth of the logistics outsourcing market.

Despite the advantages, 3PL providers vary significantly in terms of capabilities and service offerings, which raises concerns among supply chain stakeholders when outsourcing logistics operations. These concerns include defining selection criteria, evaluating 3PL performance before and during the contract period, and monitoring the results delivered by the 3PL (AGUEZZOUL, 2014) . One of the primary tools used to assess the risks associated with 3PL contracting is the definition and continuous monitoring of operational and sustainability key performance indicators (KPIs). To assist decision-makers, multi-criteria decision support methods are frequently employed to help prioritize risks (ROY; PAMUČAR; KAR, 2020). Additionally, systematic literature reviews play a crucial role in identifying sustainability-related risks affecting 3PL operations. Aguezzoul, in his systematic review, compiled a list of 3PL risks, which are presented in Table 2 (AGUEZZOUL, 2014). Similarly, in Table 3, Singh et al. identified ten key criteria or risks commonly considered during 3PL selection and performance monitoring (SINGH; GUNASEKARAN; KUMAR, 2018).

Table 2 - Main risks to evaluate a 3PL according to Aguezzoul

Risk	**Definition**
Cost	It refers to the total cost of logistics outsourcing. Its related attributes include price, cost reduction, low-cost distribution, expected leasing cost, operation cost, warehousing cost, and cost savings.
Relationship	It includes shared risks and rewards, ensuring cooperation between the user and the 3PL. It also helps in controlling the 3PL opportunistic behavior. Reliability, truth, dependence, alliance, compatibility, reciprocity are among its attributes.
Services	It is related to attributes such as breadth of services, characterization / specialization of services, variety of available services, pre- sale/post-sale customer services, and value-added services.
Quality	Quality of the 3PL includes many aspects such as, commitment to continuous improvement, SQAS/ISO standards environment issues, and risk management.
Information and equipment system	It corresponds to physical equipment and an information system that has a 3PL to facilitate communication and execution of logistics operations of its customers. It is related to attributes such as tracking/tracing, technology capabilities, information accessibility, availability of computer network, informatization level, technical capability, materials.
Flexibility	Ability to adapt to changing customers' requirements and circumstances. Its attributes include ability to meet future requirements, capacity to accommodate and grow the client's business, system flexibility index, responsiveness to target market or service requests.
Delivery	It is represented by attributes such as: time, on-time performance, on time shipment and deliveries, delivery speed, accuracy of transit/delivery time, shipment delivery, and on- time
Professionalism	3PL exhibits sound knowledge of services and displays punctuality in the way they interact and present to the customers. Characterized by attributes such as expertise, competence, and experience.
Financial position	The sound financial performance of the 3PL ensures continuity of service and regular upgrading of the equipment and services, which are used in logistics operations.
Location	It is related to attributes such as distribution coverage, geographical specialization and coverage, international scope, market coverage, shipment destinations, and distance.
Reputation	It refers to the opinion of the customers about how good the 3PL is in satisfying their needs. This is more relevant in the initial screening of 3PL.

Source: AGUEZZOUL (2014)

Table 3 - Main risks to select a 3PL according to Singh; Gunasekaran and Kumar

Risk	Definition
Costs	It refers to the total cost of logistics focusing on warehouse operations and transportation (like fleet). Its related attributes include price, cost reduction, low-cost distribution, expected leasing cost, operation cost, warehousing cost, and cost savings.
Logistic/Warehousing facilities	It refers to the internal infrastructure of the 3PL and the facilities for operating and communication. Like tracking/tracing, technology capabilities, information accessibility, availability of computer network, informatization level, technical/engineering capability, materials handling equipment, and information security.
Customer service and reliability	Refers to the ability to communicate with the customer, respond quickly to demands, share information, act proactively and act quickly to make necessary corrections.
Network management	Network management refers to two related concepts. First is the process of configuring, monitoring, and managing the performance of a network. Second is the platform that IT and NetOps teams use to complete these ongoing tasks.
Material handling capabilities	Ability to manage stocks, move materials internally, supply distribution lines, load, and unload fleets, handling raw materials, finished products and operating machinery such as forklifts and freight lifts.
Quality control and inspection	Quality of the 3PL includes many aspects such as, commitment to continuous improvement, SQAS/ISO standards environment issues, and risk management ensuring the integrity and conformity of material and processes.
Automation of process	Level of process automation, such as number of AGVs, automatic separators, and number of automated processes that reduce employee wear and tear and reduce the possibility of human error.
Innovation chain process	Related to the ability to innovate in the logistics process, implementing continuous improvement and bringing novel solutions to the business in a win-win relationship.
Tracking and tracing	Related to IT's ability to monitor and track processes and products in real time, speed of information and reliability of 3pl management and tracking systems.
Flexibility of process	Flexibility to adjust your process through changes such as reducing or increasing demand for activities, changing operations with reduced deadlines, adjusting your operational capacity quickly and efficiently.

Source: (SINGH, R. K.; GUNASEKARAN; KUMAR, 2018)

It is observed that the risks listed in the two systematic reviews speak practically of the same risks for both monitoring and selection of 3PLs, with some small differences in the nomenclatures and definitions given by the authors. However, there is great concern about the costs of 3PL, the operation of warehouses, transport, infrastructure and facilities, flexibility capacity, and real-time management and tracking systems. It can be concluded that these are fundamental criteria for 3PL management.

1.6. Supply Chain Riks Management drivers for 3PL

Although risk identification and assessment form the foundation of supply chain risk management, risk mitigation is an essential practice that all organizations should implement to strengthen their resilience (SENNA VIEIRA, 2019). Mitigation strategies can generally be identified through literature reviews (MOREIRA; RODRIGUES, 2023) or interviews with industry experts (OYEDIJO et al., 2022). Various types of mitigation strategies are reported in the literature, with some drivers being external to organizations and others being internal.

Among the external drivers cited in the literature are investment in human resources, industry development, technological advancements, energy and security infrastructure, regulatory bodies, and workforce training and knowledge development. Additionally, internal factors such as internal evaluation and orientation adjustments, joint meetings, flexibility, collaborative problem-solving, strategic selection processes, and investment in innovation and development play a crucial role in mitigating risks (OYEDIJO et al., 2022).

Drivers play a crucial role in fostering a strong relationship between the third-party logistics provider and the contractor, as well as in enhancing supply chain resilience. Flexibility is particularly important, as it enables the supply chain to absorb disruptions caused by risk events through effective response strategies (SENNA VIEIRA, 2019). When applied to production, flexibility allows for adjustments in production volume, helping to reduce costs and increase speed (KASIM et al., 2020). In general, the ability to adapt and scale operations is what differentiates a local 3PL from a national or global 3PL (WANG; JIE; ABARESHI, 2018). Consequently, flexibility serves as a competitive advantage, benefiting 3PL providers that can adapt efficiently to dynamic market conditions (SU et al., 2024).

Communication is defined as the formal and informal exchange of meaningful and

timely information between firms and is recognized as a key factor in performance improvement, especially during the early stages of partnerships (JAZAIRY; LENHARDT; VON HAARTMAN, 2017). Recent literature, particularly applied studies in China, highlights the importance of collaboration through guanxi, a Chinese term referring to a network of personal and professional relationships (CHU et al., 2019; CHU; HOU; WANG, 2021). Effective communication is essential for building trust between the 3PL and the contractor, ensuring that information is shared accurately and promptly to support informed decision-making (JAZAIRY; LENHARDT; VON HAARTMAN, 2017).

Standardization of services across customers and suppliers helps companies maintain a balance between in-house production and outsourcing, facilitating better adaptation to changes in the global environment (MOREIRA; RODRIGUES, 2023). A lack of standardization results in weaker operational control within 3PL activities, making them more vulnerable to disruptions and inefficiencies, Certifications such as ISO 9001 guarantee the standardization of processes and consequently a better quality of the service or product (DE SIQUEIRA et al., 2024).

Labor knowledge and technical expertise are also fundamental drivers for mitigating risks, particularly those related to human error and low performance. In practice, leveraging managers' experience and knowledge provides a comprehensive understanding of complex situations, enabling the development of effective problem-solving strategies (DIABAT; KHODAVERDI; OLFAT, 2013). Knowledge transfer between organizations and employees is crucial for ensuring that necessary activities are carried out efficiently. To facilitate this, training programs must be implemented, requiring financial and time investments from the 3PL (OYEDIJO et al., 2022).

Technology adoption serves as a key driver for improving operational performance and planning, thereby mitigating risks related to operational inefficiencies and performance inconsistencies (ALI et al., 2023; WAN; YUAN; LAI, 2019). The implementation of Industry 4.0 technologies, such as the Internet of Things (IoT) (TSANG et al., 2017) and blockchain (AGRAWAL et al., 2021; LI; FENG; XU, 2023; SHOAIB; LIM; WANG, 2020), has further enhanced supply chain visibility, security, and efficiency.

Environmental, Social, and Governance (ESG) principles represent a sustainable and structured development framework, integrating economic, environmental, social, and governance considerations into corporate strategy (MOREIRA; RODRIGUES, 2023). ESG aligns with Triple Bottom Line parameters, and companies that implement ESG policies tend to operate more sustainably.

Cost reduction is another critical factor in ensuring the financial sustainability of

3PL operations. The financial aspect is an integral part of TBL, as a sustainable supply chain must be financially viable to mitigate the risk of bankruptcy (RATH et al., 2024). A culture of cost reduction benefits both the 3PL and the contractor, as it enhances operational efficiency while allowing the contracting company to focus on its core business activities (ABBASI et al., 2024).

To mitigate risks, contracting companies can adopt diversification strategies, such as engaging multiple 3PL providers and continuously evaluating suppliers. These strategies help address risks related to bankruptcy, communication failures, and low service reliability in outsourced logistics operations (DIABAT; GOVINDAN; PANICKER, 2012).

2. Methodology

The methodology is divided into three main sections. Section 2.1 outlines the conceptual research methodology, which aims to identify the primary risks associated with 3PL management through a Systematic Literature Review. It details the steps involved in data collection, classification, and risk assessment.

Section 2.2 describes the applied research methodology, focusing on a case study to identify and assess risk groups and specific risks related to outsourced logistics companies that operate warehouses for a consumer goods company. Additionally, it identifies the necessary mitigation strategies and defines Key Performance Indicators (KPIs) for risk monitoring.

Section 2.3 explains the methodology for evaluating two 3PL companies operating warehouses for the consumer goods company in the case study. It details the assessment and classification method used to evaluate the 3PLs in terms of risk.

2.1. Conceptual Research Methodology

The conceptual research aims to explore the state of the art in supply chain risk management as it applies to third-party logistics companies and to capture diverse perspectives. To accomplish this, a systematic literature review is initially conducted to address research objective SO1 and SO2. Additionally, to gain insights specific to Brazil, questionnaires are distributed to supply chain and logistics managers and specialists in the region to address SO3. Detailed methodological procedures are provided in the subsequent sections.

2.1.1. Systematic Literature Review

To examine the state of the art in 3PL risk management, this thesis adopts a SLR. SLR is a scientific, replicable, transparent, and rigorous methodology (TIWARI, 2021) that applies inclusion and exclusion criteria to address research questions (LYNGDOH et al., 2021). Additionally, it helps organize existing publications on a given topic, identify research gaps, and outline future research agendas (KARIMI TAKALO; SAYYADI

TOORANLOO; SHAHABALDINI PARIZI, 2021). Moreover, SLR is widely adopted across various research fields and segments (SANTOS et al., 2020; SENNA et al., 2024).

2.1.2. Formulation of research questions

The first stage of the methodology consists of expressing in research questions (RQ) the scope of the articles we wish to find that are in line with the research objectives.

RQ1. What are the main risks identified in the literature concerning 3PL usage and what are the main methods to identify risks?

RQ2. In which countries and industries have these studies been conducted?

RQ3. Of the risks identified in the literature, which are applicable to the reality of different segments in Brazil?

2.1.3. Selection of databases

The database chosen for the search was the Scopus database. Scopus is the largest database in the world with different peer-reviewed publications such as Emerald, Science Direct, Springer, Taylor & Francis and other important databases that were used in the literature review.

2.1.4. Definition of search terms

To answer the questions raised in the research, it is necessary to understand the state of the art in risk management applied to 3PL, so the following expressions were defined to be combined. (STR1) Third-Party Logistics or 3PL or TPL. (STR2) Risk Management. We chose to use term risk management instead of Supply Chain Risk Management because some authors might not have used the full term, but the study could be a SCRM study. STR1 was searched in the abstract of the publications be cause we were looking for studies focused on 3PL. STR2 was searched in any part of the publications, not limited to the abstract so as not to limit the number of publications.

2.1.5. Article Selection

The selection of articles followed the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (MOHER et al., 2015). While PRISMA is primarily used in healthcare systematic literature reviews (SLRs), it is also widely applied in industrial engineering research, including studies on supply chain risks (GOULART et al., 2023; SANTOS et al., 2023; SENNA et al., 2021)

Articles were excluded based on specific criteria. Conference papers, notes, book chapters, editorial notes, and reports were not considered. Only articles published in English were included in the review. Additionally, studies unrelated to 3PL risk management were excluded, and duplicate entries were removed after reviewing the abstracts.

At the end of the selection process, from the total of 119 articles retrieved through the search and accessible via the Scopus database, 67 freely accessible articles were identified as relevant and aligned with the objectives of this thesis.

2.1.6. Identification of risks and relevant information from articles

After reviewing the abstracts and eliminating articles that did not focus on 3PL risk management, the remaining articles were read in full of the primary objective of identifying risks associated with 3PL management. Additional relevant data were also collected, including the annual evolution of publications, the journals with the highest number of relevant studies, the number of articles per country where the research was conducted, the most frequently studied industry segments, the activities performed by 3PLs, and the main methods used for risk identification, assessment, and modeling.

The data were organized using a Microsoft Excel® spreadsheet. First, the specific risks identified in each article were recorded. Then, through a conceptual assessment, the risks were grouped into broader categories. These risk categories were later validated through a questionnaire, as described in Section 2.1.7, using questionnaires administered to professionals in Brazil.

2.1.7. Risk Assessment Data Collection

At the conclusion of the SLR, the identified risks were grouped, defined, and subsequently evaluated using a questionnaire. The questionnaire was created using Google Forms® and distributed via LinkedIn®, a professional social network owned by Microsoft®, to professionals from various industry segments working in Brazil. Since the target audience consists of Portuguese speakers, the questionnaire was conducted in Portuguese.

The questionnaire begins with two open-ended questions, following an optional identification section, aimed at determining the respondent's job position and industry segment. The remaining questions are closed-ended, designed to assess whether the respondent has knowledge of supply chain management and outsourced logistics. If the respondent indicates a lack of relevant knowledge, their subsequent responses are disregarded. Finally, professionals are asked to evaluate the criticality of the risks identified in the SLR using the Likert scale from 1 to 5 (LIKERT, 1932).

The first part of the questionnaire, translated into English, consists of the following questions (Q) and corresponding answer options (A) for closed-ended questions.

Q1: (Optional Question) What is your name?
Q2: What is your current or last job position?
Q3: What segment of the company do you currently work in or last worked in? (e.g., food, steel, oil and gas, automotive)
Q4: Do you work, or have you worked in logistics/supply chain, or have you had any interaction with this discipline?

A1: Yes, I work in Logistics / Supply Chain
A2: Yes, I have/was involved with Logistics / Supply Chain
A3: No

Q5: Have you had interaction or knowledge in your work of outsourced logistics activities, what activity is performed by the Third-Party Logistics (3PL)?

A1: Transport
A2: Warehouse operation
A3: Factory supply
A4: Logistics planning
A5: Multiple activities
A6: I had no interaction or knowledge with logistics activities by 3PLs

The second part of the questionnaire consists of assessments from 1 to 5 on the Likert scale for the types of risk identified in the SLR, below is the second part of the questionnaire translated into English.

Risk Assessment: Considering the probability of occurrence and the impact of the risk for the organization that hired a 3PL, classify the types of risk below on a critical scale ranging from 1 (extremely low criticality) to 5 (extreme criticality).

Q6: Financial risks (e.g., increased operating costs, 3PL failure, lack of management and governance, low competitiveness).

Q7: Operational risks (e.g., late deliveries, wrong deliveries, non-deliveries, lack of organization in warehouses, failure to meet demands).

Q8: Management risks (e.g., failure to comply with management requirements, lack of monitoring of KPIs and action plans, poor resource planning, lack of FIFO/FEFO).

Q9: Personnel risks (e.g., human errors in operations due to lack of technical knowledge or discipline, lack of collaboration and communication by 3PL employees).

Q10: Quality risks (e.g., damage to products due to failure to meet requirements and damage caused by carelessness in transportation and scheduling).

Q11: Low flexibility risks (e.g., lack of capacity to make operations and planning more flexible during demand variations, crises, and disruptions).

Q12: Technological and facilities risks (e.g. low level of equipment and systems, cyber-attacks, data leaks, system failure).

Q13: Due diligence and compliance risks (failure to comply with ethics, labor laws, legislation, reputational damage due to lawsuits and media exposure).

Q14: Environmental risks (e.g., CO2 emissions, poor waste management, pollution caused by the 3PL and natural disasters (floods, landslides, droughts, pests) or man-made disasters (fires, fuel spills, release of toxic products).

Q15: Occupational health and safety risks (e.g., occurrence of accidents, injuries to workers, health crises such as outbreaks of COVID-19, conjunctivitis, psychological illnesses among outsourced workers).

The last question is an open question asking whether any type of risk is absent from the questionnaire and, if so, what its score would be on the Likert scale.

Q16: Do you want to add any other type of risk not mentioned? How would you rate it from 1 to 5?

A:

2.2. Applied Research Methodology

This section outlines the methodological procedures for the applied research presented in this thesis. The research aims to develop a framework incorporating a Supply Chain Risk Management methodology for Third-Party Logistics providers that operate warehouses for a consumer goods company in Brazil.

This section details the methodology for data collection, risk identification, assessment, mitigation strategies, and the definition of key performance indicators (KPIs) for risk monitoring. These steps contribute to achieving the general objective of this doctoral thesis while fulfilling the specific objectives SO4, SO5, SO6, and SO7.

2.2.1. General Data collection

This section of the research focuses on supply chain decision-makers and technical experts, who play a key role in identifying, assessing, mitigating, and defining 3PL's KPIs for risk monitoring in the case study. These groups provided insights through semi-structured interviews. To avoid redundancy in the following sections, as the same groups are interviewed at different stages with distinct objectives, this section defines the professionals in each group. In subsequent sections, only the group names will be used to refer to the interviewees.

The supply chain decision-makers are described in Table 4, while the technical experts are detailed in Table 5. All supply chain managers included in the study are employees of the consumer goods company that served as the case study subject.

Consultant 1 is the Supply Chain Director of a major retail company in Brazil, which operates over 1,250 stores and more than 20 distribution centers across the country. The company also has a strong presence in e-commerce. Previously, this consultant worked for an e-commerce company based in Uruguay, which operates in more than 18 countries and is the leading e-commerce platform in Latin America. Consultant 2 holds a director position at a global beverage company, which is the largest beer producer in the world. Consultant 3 works for a business management consulting firm that operates in Brazil and internationally, specializing in supply chain consulting.

The length of experience refers to the total time each professional has worked in

the supply chain industry, rather than the duration of their tenure at their current company or position.

Table 4 - Supply Chain Decision Makers

Function	Segment	SC experience
Vice President of SC	Finish Goods (Case study company)	> 25 years
SC Director 1	Finish Goods (Case study company)	20 years
SC Director 2	Finish Goods (Case study company)	10 years
SC Manager 1	Finish Goods (Case study company)	10 years
SC Manager 2	Finish Goods (Case study company)	8 years
SC Consultant 1	Retail and E-Commerce	> 20 years
SC Consultant 2	Beverages	> 20 years
SC Consultant 3	Consulting	12 years

Source: Author

Table 5 - Technical Experts

Function	Function experience
Operations Coordinator 1	5 years
Operations Coordinator 2	5 years
Supply Chain Engineer	5 years
Supply Chain Analyst 1	3 years
Supply Chain Analyst 2	2 years
Quality Manager	9 years
Quality Coordinator	5 years
Quality Analyst	3 years
Environmental, Health and Safety Manager	10 years
Environmental, Social and Governance Manager	6 years
EHS Technician 1	12 years
EHS Technician 2	5 years
ESG Analyst	3 years
Security Manager	16 years
Due diligence Manager	10 years
Financial Manager	9 years
Labor Relations Manager	9 years
Labor Relations Coordinator	6 years

Source: Author

The data collection method used in this research is semi-structured interviews. SLR identified this as the most used approach for risk identification in applied studies, as each industry segment has its own specific characteristics. A generalized questionnaire would likely fail to capture the unique risks associated with the business under study.

Table 6 presents an overview of the semi-structured interviews conducted during this research, along with the groups involved in each interview phase.

Table 6 - A summary of methodological steps adopted in applied research

Main Objective	Marks	Involved parts
Risk Identification	Group of risks	SC Decision Makers
	Causes of risks	Technical experts
Risk Assessment	Risk category weights	SC Decision Makers
	Define critical risks	Technical experts
Risk Mitigation	Mitigation strategies	Technical experts
Risk Monitoring	KPIs definition	Technical experts
	KPIs validation	SC Decision Makers

Source: Author

After the complete cycle of interviews with the SC Decision Makers and Technical Experts, the group of SC Decision Makers and Technical Experts from the same risk category were brought together and brainstorming was carried out together to conclude each stage of the methodology so that in the end the results presented were obtained by consensus.

2.2.2. Define Research Questions

This research is applied to enable the consumer goods company to effectively manage its third-party logistics providers (3PLs) responsible for operating its primary warehouses. One 3PL manages the warehouse for receiving and storing raw materials, supplies raw materials to the factory, operates the finished product warehouse, and handles product loading for shipment. The second 3PL is responsible for managing a distribution hub, where it receives products from the factory, stores them, and loads them for distribution to other distribution centers across Brazil.

To facilitate 3PL management, this research aims to address the following research questions (RQ).

RQ4. What are the types of risk and their specific causes in the operation of consumer goods warehouses by logistics contractors in Brazil?

RQ5. How critical is each category and each risk cause?

RQ6. What are the strategies and drivers that should be implemented by the 3PL to mitigate risks?

RQ7. What are the critical indicators that must be monitored by the contractor and the 3PL?

2.2.3. Risk Identification

After identifying the risk categories through the SLR, they were presented to supply chain (SC) decision-makers prior to a semi-structured interview. The interview was conducted collectively with all the agents involved described in Table 4 and lasted three hours via the Microsoft Teams® application. Following the interview, a brainstorming session was conducted.

The brainstorming session focused on three key questions, allowing interviewees to express their opinions freely. However, the results were obtained through consensus during the brainstorming session. The first question aimed to determine whether the risks presented were relevant to the company-3PL relationship. The second question explored whether any risk category had been overlooked, and the third sought to identify which risk categories should be applied in this research.

Once the risk categories were defined by the SC decision-makers, additional semi-structured interviews were conducted individually with technical experts specializing in each defined risk category. These interviews lasted two hours each. During these sessions, technical experts were asked to identify risks relevant to their area of expertise and to list the causes and threats that generate risks for either the 3PL or the contractor. Additionally, technical experts were required to describe each threat or cause in detail, ensuring that, in the later mitigation stage, all involved parties would clearly understand where and how to take action to mitigate the identified risks.

2.2.4. Risk Assessment

Through fuzzy logic, SC Decision Makers assigned, in consensus during a one-hour interview, weights according to the criticality and relevance of each risk category. Following the guidelines proposed by Blackhurst; Scheibe and Johnson (2008), the sum of the weights (w_i) for each risk category (i) must be 100% according to equation 1. Within each category, the experts identified the risks that they considered critical. In this research, critical risks are the ones that have a high likelihood of significantly impacting the organization.

The decision regarding the weight assignment was made through a brainstorming

process, taking into account the organization's current context. Decision-makers were guided to assign greater weight to the risk category with the highest level of criticality (probability × impact) and to also consider the visibility of each risk

$$\sum wi = 1 \quad (1)$$

Technical Experts then define which specific risks are classified as critical. Critical risks are defined by Risk Matrix in Figure 5. This matrix considers the probability of the event and the impact of non-containment or risk mitigation for the organization. The purpose of this matrix is to assist in the definition of critical risks. The matrix has two axes: probability of the risk, which starts from a rare probability of occurrence to an almost certain probability of occurrence, and the risk impact axis, measuring the impact on the organization caused by the occurrence of the risk, starting from a minor to a catastrophic impact. In this methodology, the critical risks are the ones with a “high” or “catastrophic” impact and with a “certain” or “likely” probability of occurrence, as shown in the grey cells in Figure 5.

		Impact			
		Minor	Marginal	High	Catastrophic
Frequency	Certain			Critical risk	Critical risk
	Likely			Critical risk	Critical risk
	Possible				Critical risk
	Unlikely				
	Rare				

Figure 5 - Risk Matrix used to define critical risks
Source: Author

2.2.5. Risk Mitigation

With the specific risks identified and assessed by the technical experts, the next stage of the research involves defining the strategies needed to mitigate these risks. The technical experts were asked the following questions (Q) for each identified risk:

Q1.What risk mitigation or elimination strategy, driver, or KPI should the 3PL implement to mitigate this risk?

Q2. How can you assess whether the 3PL has mitigated this risk, whether it has been partially mitigated, or whether it remains unaddressed by the 3PL?

Q3. What evidence should the 3PL present to demonstrate that this risk has been

mitigated?

For each risk category, a Table was created in Microsoft Excel, listing the risks and their corresponding mitigation requirements. The technical experts provided a set of criteria to determine whether a 3PL is compliant, partially compliant, or non-compliant with the mitigation requirements.

2.2.6. Risk Monitoring

After completing the three stages of risk management (risk identification, assessment, and mitigation) technical experts were tasked with defining the key performance indicators (KPIs) necessary for monitoring 3PL risks. To ensure a structured approach, the following questions were posed to the technical experts:

Q1. Which KPIs should be measured for 3PL risk monitoring?

Q2. How frequently should each KPI be monitored?

The technical experts were given one week to provide their responses. Once the answers were compiled, the data was presented to the SC decision-makers, who, through consensus, were responsible for approving or rejecting the KPIs defined in the previous stage. This step ensured that the selected KPIs aligned with the organization's strategic objectives and risk management framework.

2.3. Methodology for Third-Party Logistics Risk Assessment

This section presents the methodology used in the case study conducted for this thesis. Based on the data collected through applied research, a structured 3PL risk assessment method was developed. This method is built upon a questionnaire that incorporates the identified risks, category weights, and defined mitigation strategies.

To ensure a comprehensive evaluation, this section is divided into three parts. Section 2.3.1 outlines the methodology for developing the quantitative-qualitative assessment framework for 3PL evaluation. Section 2.3.2 details the methodology used to prepare and conduct the 3PL assessments, and Section 2.3.3 explains the methodology for analyzing results and the qualitative classification of 3PL risks.

2.3.1. Methodology for Calculating 3PL Risk Scores

The methodology is created to answer the following research question:

RQ8. What level of risk does each 3PL have when evaluated by the framework created in this research?

The methodology then seeks to create a descending scoring system to classify the 3PL risk and achieve the specific objective SO8. The 3PL score ranges from 0 to 100, where 0 represents maximum risk and 100 the minimum risk.

Following the risk identification, assessment, and mitigation phases, an audit methodology was developed in collaboration with supply chain (SC) managers to systematically monitor 3PL risks. This audit employs a scoring system known as the Category Risk Score (CRS), with an illustrative example provided in Table 7.

The purpose of this assessment is to evaluate the vulnerability of the 3PL to each specific risk identified in the applied research. For each risk, the evaluation determines whether the corresponding driver, KPI, or mitigation strategy has been implemented by the 3PL. The final risk level is calculated based on the 3PL's resistance to the identified risks, as reflected in the CRS score.

As described in the previous section, the audit team assesses the level of compliance for each risk. To calculate the CRS, the number of risks in each category is classified as compliant, partially compliant, or non-compliant. In Table 7, for instance, 10 risks were identified as compliant in Category A, while 2 risks in Category C were considered partially compliant, the categories established will be detailed in Section 4.1.1 of this thesis.. The scoring system assigns:

- 100 points for compliant risks,
- 50 points for partially compliant risks, and
- 0 points for non-compliant risks.

The CRS for each category is then determined by calculating the average score of the identified risks. For example, in Category A, the CRS is 95.5, calculated as [(10 × 100) + (1 × 50) + (0 × 0)] ÷ 11, where 11 is the total number of risks assessed in that category.

Table 7 - Example of 3PL scoring in risk assessment using defined methodology

	Category A	Category B	Category C
Weights (w_i)	0.3	0.3	0.4
Compliant (100 points)	10	5	14
Partially (50 points)	1	3	2
Non-compliant (0 points)	0	2	1
Critical risk non-compliant (0 points)	0	1	0
CRS_i	95.5	0	88.2

Source: Author

When a critical risk is classified as non-compliant, the CRS for that risk category is automatically set to zero. This reflects the significant impact that failing to contain or mitigate a critical risk would have on the contractor's operations. For example, in the illustrative case presented in Table 7, Category B has a CRS of zero because the 3PL has one non-compliant critical risk. This scoring system ensures that higher CRS values indicate greater preparedness, meaning the 3PL is more capable of mitigating or eliminating risks within a particular category.

Using the CRS, contractors can evaluate whether a 3PL poses a minor or major risk to their organization. To quantify the overall 3PL risk level, the 3PL Risk Score (3PLRS) is calculated, as defined in Equation (01).

$$3PLRS = \sum_i CRS_i * w_i \quad (01)$$

The 3PLRS is determined by summing the CRS values for each category CRS_i multiplied by the respective weights (wi) assigned to each risk category (i) during the risk assessment phase.

For example, in the illustrative case of Table 7, the 3PLRS is calculated as:

3PLRS=63.9

This value provides contractors with a numerical representation of the 3PL's overall risk level, facilitating data-driven decision-making when selecting and monitoring logistics providers.

3PLRS serves as a quantitative measure of the risk level associated with a 3PL within the sustainable supply chain. A higher 3PLRS indicates a lower risk, meaning the 3PL is better prepared to manage and mitigate risks effectively. Conversely, a lower 3PLRS suggests a higher risk, signaling that the 3PL requires immediate attention.

When a 3PL receives a low 3PLRS, supply chain managers must promptly demand the implementation of mitigation strategies and repeat the audit cycle to reassess the

provider’s risk management capabilities. To facilitate decision-making, a 3PLRS scale is proposed in Table 8, which classifies 3PLs based on their quantitative risk assessment.

In the example provided in Table 7, the 3PLRS of 63.9 falls under the "critical" risk level as defined in Table 8. This classification highlights the urgent need for intervention, requiring the contractor to enforce corrective actions and enhance risk mitigation measures to ensure supply chain resilience.

Table 8 - 3PL risk classification based on 3PLRS result

3PL Risk Score	Risk Level
98 <= 3PLRS	Extremely low
94 <= 3PLRS < 98	Very low
90 <= 3PLRS < 94	Low
80 <= 3PLRS < 90	Moderate risk
75 <= 3PLRS < 80	Considerable
70 <= 3PLRS < 75	High risk
3PLRS < 70	Critical

Source: Author

The methodology is applied to two third-party logistics (3PL) providers, with the results presented in Section 5 of this thesis, along with the respective discussions."

2.3.2. Conducting 3PL Risk Assessments

With the assessment methodology established, the two 3PLs were given questionnaires containing the identified risks, approved mitigation strategies, category weights, and required evidence to demonstrate risk mitigation. The assessments were scheduled two weeks in advance, allowing the 3PLs sufficient time to gather and prepare the necessary evidence.

To ensure accuracy and reliability, the technical experts were instructed to conduct on-site assessments at each 3PL facility. Each expert evaluated risks within their specific area of expertise, ensuring a comprehensive assessment. The assessments took place in designated rooms within the warehouses, but assessors periodically visited operational areas to physically verify compliance with specific risk mitigation requirements.

The assessment of 3PL1 was conducted over two days, with eight hours of evaluation on the first day and four hours on the second. In contrast, the assessment of 3PL2 was completed in a single day, lasting eight hours in total. Upon completion of the assessments, the results were consolidated by category and entered the evaluation model

to determine the final risk classification of each 3PL.

2.3.3. Interpretation of Assessment Results

The final ranking of third-party logistics providers after the assessment serves as a foundation for evaluating the degree of risk associated with each provider and identifying key areas for improvement. At the conclusion of the supply chain decision-making process, SC decision-makers excluding external consultants, collaboratively determine, through consensus, the necessary actions and timelines for 3PLs to implement risk mitigation measures and make the required adjustments to improve compliance.

Additionally, the results provide an opportunity for a critical analysis of the developed framework, assessing whether the research questions were effectively addressed and whether the outcomes align with expected objectives and overall research validity.

3. Conceptual Research: Systematic Literature Review of Third-Party Logistics Risk Management

This section presents the results obtained from the Systematic Literature Review on Supply Chain Risk Management, with a specific focus on 3PL risk management. The literature search was conducted using two search strings defined in the methodology: STR1, which included the terms "Third-Party Logistics", "Third Party Logistics", "3PL", or "TPL", and STR2, which included the term "Risk Management".

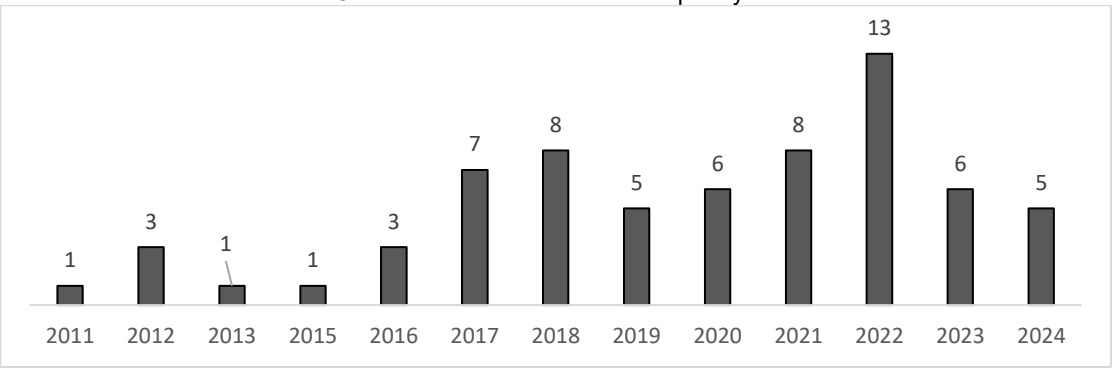
Using these search strings, a query in the Scopus database returned 117 English-language articles from completed publications. After analyzing the abstracts, 42 articles were discarded for not focusing on 3PLs, not addressing risk management, or lacking relevance to 3PL risks within the supply chain context. Additionally, 8 more articles were excluded due to restricted access, either because they were not open-access or were unavailable through the authors' institutional access.

The results, graphs and tables obtained as results and presented in this section were published as an article entitled “A Systematic Literature Review on Supply Chain Risk Management in 3PL Operations: Risk Identification and Assessment” (DE SIQUEIRA; VIEIRA; SANTOS, 2025).

3.1. Bibliometric data of articles

Of the 67 articles, an increase in publications was observed in recent years with the maximum number of publications in 2022 when supply chains were still facing the consequences of the coronavirus pandemic, as can be seen in the Chart 1.

Chart 1 - Publications from SLR pear year



Source: (DE SIQUEIRA; VIEIRA; SANTOS, 2025)

Of the articles analyzed, 52 (77.6%) are applied studies, which include analyses or empirical data specific to a company, sector or region, aimed at practical application. The other 15 articles (22.4%) are conceptual studies that expand conceptual models created and are based on literature reviews and are not the result of direct application. The superiority of applied studies may indicate that the topic is of great relevance to companies since they participate in these studies in search of solutions in their supply chain where a 3PL is involved.

In total, 50 different journals published the 67 articles evaluated, therefore it can be seen that 3PL risk management is relevant for journals in general linked to the areas of logistics, management, industrial engineering and sustainability. Table 9 shows the journals with at least two publications that were part of this SLR.

Table 9 - Total of publications per journal

Journal	Total of articles
Sustainability (Switzerland)	4
Benchmarking	4
Journal of Business Research	3
International Journal of Logistics Research and Applications	3
Journal of Transport and Supply Chain Management	2
Supply Chain Management	2
Mathematical Problems in Engineering	2
International Journal of Logistics Management	2
Industrial Management and Data Systems	2
Journal of Enterprise Information Management	2
Transportation Research Part E: Logistics and Transportation	2

Source: (DE SIQUEIRA; VIEIRA; SANTOS, 2025)

It is observed that two journals stand out with 4 publications each, Sustainability

from the publisher MDPI, which is a journal focused on sustainability, and Benchmarking from the publisher Emerald, which is a journal focused on operations management.

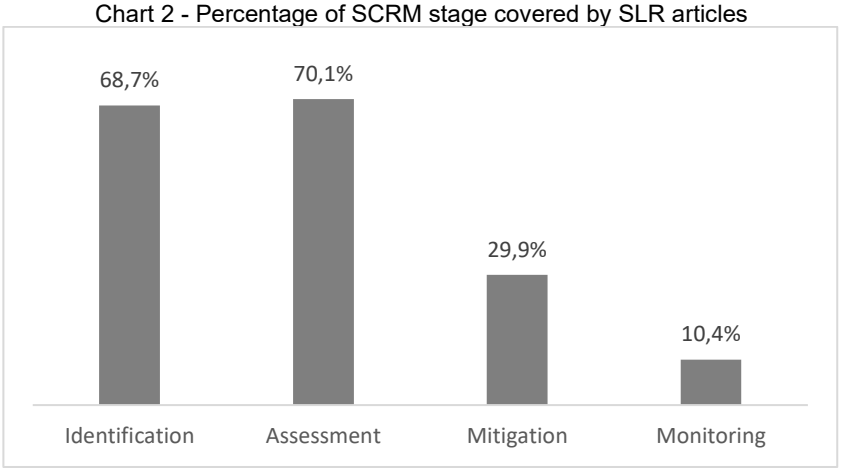
3.2. Characteristics of articles

During the evaluation of the articles, the research identified which SCRM stages were addressed: risk identification, assessment, mitigation, and monitoring. Some articles covered more than one stage, such as both risk identification and assessment. The percentage of articles addressing each stage is illustrated in Chart 2.

The majority of the articles focused on the risk identification (68.7%) and risk assessment (70.1%) stages. However, the absence of risk identification in some articles should not be misinterpreted as the non-existence of risks. Risks were mentioned in 100% of the articles, though they had often been identified in a prior stage before being discussed in the study.

The risk mitigation stage was covered in 29.9% of the articles, while the risk monitoring stage was the least studied, appearing in only 10.4% of the articles. Notably, no article examined all four SCRM stages comprehensively, highlighting a gap in the literature regarding the integration of risk management processes in 3PL operations.

Chart 2 - Percentage of SCRM stage covered by SLR articles



Source: (DE SIQUEIRA; VIEIRA; SANTOS, 2025)

The country with the highest number of 3PL-related studies in Systematic Literature Review publications is China, with 15 studies (22.4%) focused on 3PL operations. Additionally, there were 11 articles (16.4%) in which the study location was not specified or covered more than three different locations. Most of these unspecified

studies were literature reviews or conceptual articles that analyzed multiple 3PLs and were categorized as not location-specific.

The majority of the articles examined 3PLs in emerging economies. When excluding unspecified studies or those covering multiple countries, 42 articles (62.7%) focused on at least one emerging country, compared to 16 articles (23.9%) that studied developed countries. Studies that analyzed 3PLs operating in up to two different countries were counted separately in each respective country.

Table 10 presents an overview of countries with at least two published studies on 3PL risk management.

Table 10 - Number of articles by country where research is conducted

Country studied	Total of articles	%
China	15	22.4%
Not Specified/Global	11	16.4%
India	6	9.0%
South Africa	5	7.5%
Sweden	4	6.0%
Nigeria	3	4.5%
USA	3	4.5%
.UK	3	4.5%
Thailand	2	3.0%
Hong Kong	2	3.0%
Iran	2	3.0%
Malaysia	2	3.0%
Brazil	2	3.0%

Source: (DE SIQUEIRA; VIEIRA; SANTOS, 2025)

The companies analyzed in the reviewed articles operate in various industry segments. However, 25 articles (37.3%) did not specify the segments studied, as they focused on 3PL performance across multiple sectors rather than a single industry.

Among the articles that explicitly identified industry segments, 10.4% broadly categorized their focus as industrial or manufacturing. The pharmaceutical industry and Fourth-Party Logistics (4PL) operations were each covered in five articles (7.5%), followed by the food industry with four studies (6.0%). Additionally, three articles (4.5%) examined 3PL performance in the automobile industry and e-commerce sector, respectively.

Table 11 presents an overview of industry segments that were analyzed in at least two published studies.

Table 11 - Number of articles by 3PL contractor's business segment

Segment	Total of articles	%
Not Specified / General	25	37.3%

Industrial / Manufacturer	7	10.4%
4PL (Logistics)	5	7.5%
Pharmaceutical	5	7.5%
Food / beverages	4	6.0%
Automotive	3	4.5%
e-commerce	3	4.5%
Oil and gas	2	3.0%
Chemical industry	2	3.0%
Retailer	2	3.0%
Construction	2	3.0%

Source: (DE SIQUEIRA; VIEIRA; SANTOS, 2025)

The wide range of industry segments covered in the reviewed articles suggests that 3PL risk management is not confined to a specific sector but rather represents a global concern. The diverse nature of 3PL activities highlights the importance of risk management strategies across multiple operational areas.

When analyzing the primary functions of 3PLs, the research found that 32 articles (47.8%) focus on 3PLs that perform multiple activities, such as transportation, loading/unloading, warehouse management, and logistics coordination. In comparison, 22 articles (32.8%) specifically address transportation-related risks, while 8 articles (11.9%) examine risks associated with warehouse operations and storage site management. In smaller proportions, 3 articles focus on reverse logistics, and 2 articles explore logistics management by 3PL providers. Table 12.presents a detailed breakdown of 3PL activities and the number of studies focusing on each function.

Table 12 - Quantity and percentage of articles by main activity performed by the 3PL

3PL activity	Total of articles	%
Multiple	32	47.8%
Transport	22	32.8%
Warehouse or Area operation and management	8	11.9%
Logistic Management	3	4.5%
Reversal Logistic	2	3.0%

Source: (DE SIQUEIRA; VIEIRA; SANTOS, 2025)

This information highlights that most publications perceive 3PL providers as playing multiple roles within supply chains, engaging in various functions due to the broader, more generalist focus of the studies. When research seeks to analyze specific challenges in 3PL performance, transportation emerges as the most studied activity, followed, though to a lesser extent, by warehouse operations and storage management. The SLR also reveals a smaller number of studies dedicated to logistics management by 3PL providers and reverse logistics, indicating potential gaps in research coverage for

these specific areas.

3.3. 3PL Risk Identification

The most common method for identifying risks related to 3PLs is through semi-structured interviews, either alone or in combination with other approaches. A total of 38 articles (56.7%) employed semi-structured interviews for this purpose, followed by questionnaires in 18 articles (26.9%) and literature reviews in 16 articles (23.9%). Additionally, 10 articles (14.9%) identified risks internally, using information previously collected by the studied organizations or through internal observations.

Across the analyzed articles, various risks were identified. To facilitate data organization and analysis, this research grouped these risks into eleven categories, defined subjectively based on thematic similarities. The type of risk and its citation percentage are detailed in Table 13

Table 13 - Risk categories identified in the SLR

Risk Category	% of articles	Description
Financial	74.6%	Related to the costs of outsourcing operations, risks of bankruptcy and financial difficulties of the 3PL, contractual risks, lack of governance, and low competitiveness.
Operational	67.2%	Risks of delays or non-delivery of operations, risks inherent to transportation operations, logistics management, warehouse management, deliveries and receipts, and failure to meet customer requirements.
Management	53.7%	Risks caused by poor management of the 3PL in its activities, such as the absence of non-compliance with standards, absence of KPIs, poor management of available resources, absence of action plans to correct or improve processes.
Workforce	50.7%	Risks caused by the lack of knowledge and technical training of the workforce, lack of collaboration and communication and cultural shock among employees.
Quality	47.8%	Related to damages during or loss of products during 3PL activities such as transportation and packing or due to poor storage.
Flexibility	47.8%	Flexibility is essential to mitigate periods of disruption and crises in the supply chain; the lack of flexibility leads to prolonged disruption and greater losses in times of crisis.
Technology and facilities	44.8%	Flexibility is essential to mitigate periods of disruption and crises in the supply chain; the lack of flexibility leads to prolonged disruption and greater losses in times of crisis.
Due diligence and compliance	43.3%	Risks stemming from the 3PL's failure to comply with ethical standards and compliance requirements, as well as reputational risks caused by non-compliance with laws and social impact regulations.
Environmental	32.8%	General environmental risks, such as pollution and waste emissions, as well as risks from natural disasters like floods, earthquakes, tsunamis, and climate change.

Local	22.4%	Risks such as conflicts, wars, terrorism, organized crime, local legislation, political instability, and strikes.
Health and Safety	19.4%	Workplace safety risks that may result in fatalities, accidents with or without leave, ergonomic injuries, psychological illnesses, and contaminations, such as coronavirus.

Source: Author

The SLR reveals that most studies on 3PL risks historically focus on financial, operational, management, quality, and flexibility aspects. Financial risks are primarily related to operational costs, while a smaller portion of research examines issues such as bankruptcy risk and poor governance, both of which directly impact supply chain sustainability. A recent shift in focus towards sustainability is observed, with financial, environmental, and social concerns being discussed, although the latter two receive less attention.

Emerging technologies have introduced a growing concern regarding cyberattacks and data breaches, highlighting vulnerabilities in digital operations. Compliance risks are mainly linked to ethics and adherence to internal regulations, both by the 3PL and the contracting company. Environmental and local risks remain less frequently explored in the literature, while health and safety risks, previously underemphasized, have gained importance in recent years due to the COVID-19 pandemic.

3.4. 3PL Risk Assessment

Of the 67 articles, 46 performed risk assessment. The research agrees that the most used method to assess risks are multicriteria decision-making methods, of the 46 articles 17 (37%) used some Multicriteria Decision Maker (MCDM) methods, such as the Analytic Hierarchy Process (AHP) (ORJI; U-DOMINIC, 2024; RAHMAN et al., 2019; SHAKOURLOO; KAZEMI; JAVAD, 2016; SHANKER; SHARMA; BARVE, 2022; XU; LIU, 2017). Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (KAHRAMAN et al., 2022; SHANKER; SHARMA; BARVE, 2021; YAN et al., 2020), codes with Fuzzy logic (SHANKER; SHARMA; BARVE, 2021; ZARBAKHSHNIA; KARIMI, 2024), Stepwise Weight Assessment Ratio Analysis (SWARA) (MAVI; GOH; ZARBAKHSHNIA, 2017; SREMAC et al., 2018; ZARBAKHSHNIA; KARIMI, 2024), Best Worst Method (BWM) (ZARBAKHSHNIA; KARIMI, 2024) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) (GOVINDAN; CHAUDHURI, 2016). This demonstrates that risk management can be viewed as a multicriteria analysis situation with multiple decision

possibilities.

Other methods cited are qualitative expert analyses and Structural Equation Modeling (SEM) (BUNTHONGSANG; THAWORNSUJARITKUL; SILPCHARU, 2022; BUTT, 2022) in 6 articles (13.0%) each. Qualitative analyses are based on expert opinion to assess risks in certain characteristics while SEM models the identified risks and data and indicates which ones have the greatest impacts. Other articles present different methods for evaluation with less than one citation.

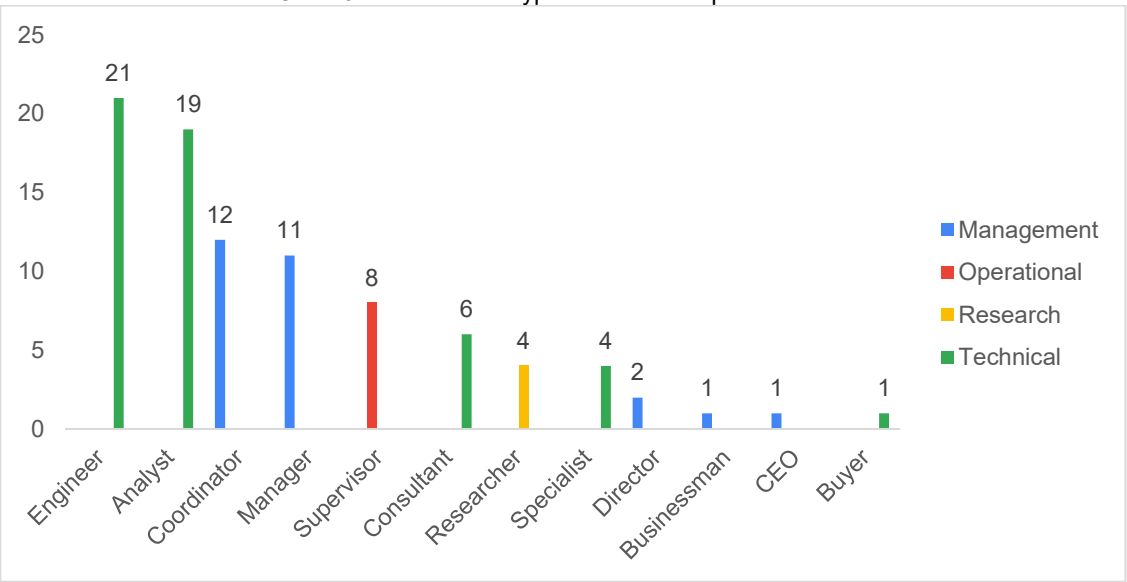
3.5. Validation and assessment of identified risks

The risk categories identified in the SLR were validated and assessed through a questionnaire distributed via Google Forms. All categories were included except for the location category, as the research focused on 3PLs operating in predefined locations determined by their contractors.

A total of 123 individuals responded to the questionnaire, but 33 were excluded as they did not work or had interactions with the supply chain or 3PL sector. Ultimately, 90 responses were validated and used for this research. Among them, 33 participants were experts in supply chain and logistics, while 53 were actively involved in these fields.

Chart 3 illustrates the job roles and functions of the respondents whose answers were validated. The majority of responses came from individuals in technical roles, accounting for 51 (56.7%) professionals, including 21 engineers, 19 analysts, 6 consultants, 4 specialists, and 1 buyer. Management roles comprised the second-largest group, with 27 professionals (30%), including 12 coordinators, 11 managers, 2 directors, 1 CEO, and 1 business owner. Operational roles accounted for 6 responses (6.7%) from operational supervisors, while 4 (4.4%) research professors also participated.

Chart 3 - Position and type of function of professionals



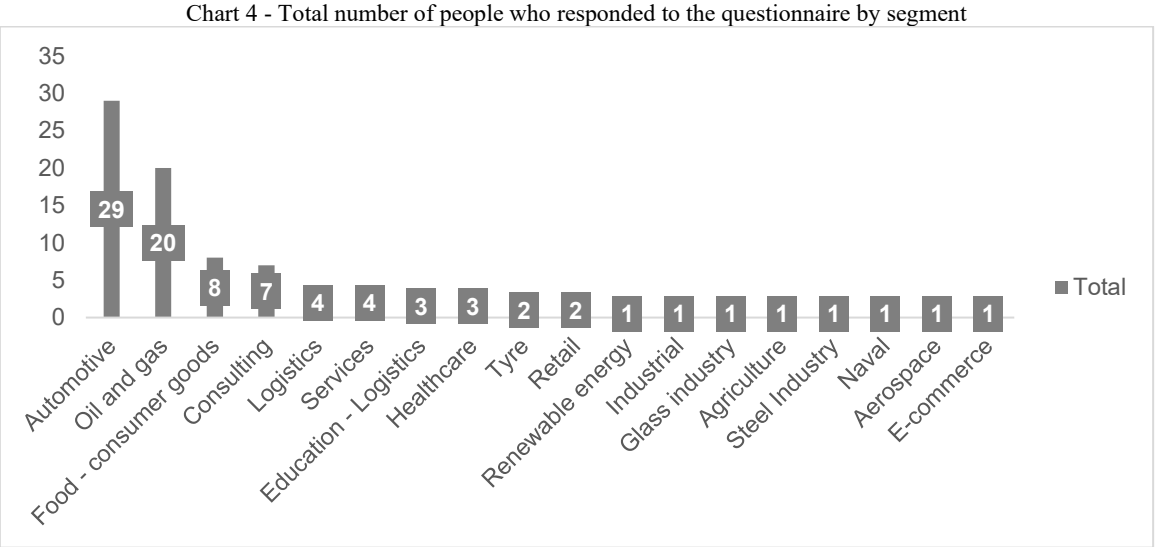
Source: Author

In addition to the variety of positions and functions represented in the questionnaire, the professionals also came from diverse industry segments. Chart 4 presents the distribution of respondents by industry in descending order.

The automotive sector had the highest number of respondents, with 29 (32.2%) professionals, followed by the oil and gas sector with 20 (22.2%). These industries are particularly strong in Brazil, especially in the regions of Rio de Janeiro and São Paulo. The automotive industry has numerous factories in the metropolitan region of São Paulo and the southern part of Rio de Janeiro, while the oil and gas sector are prominent in the capital of Rio de Janeiro and along the coastal region.

Other industries with significant representation included the food and consumer goods sector with 8 respondents, consulting with 7, logistics and services with 4 each, and education, healthcare, and pharmaceuticals with 3 each. The tire and retail industries had 2 respondents each, while the renewable energy, industrial, glass, agriculture, steel, naval, aerospace, and e-commerce sectors each had a single respondent.

Chart 4 - Total number of people who responded to the questionnaire by segment

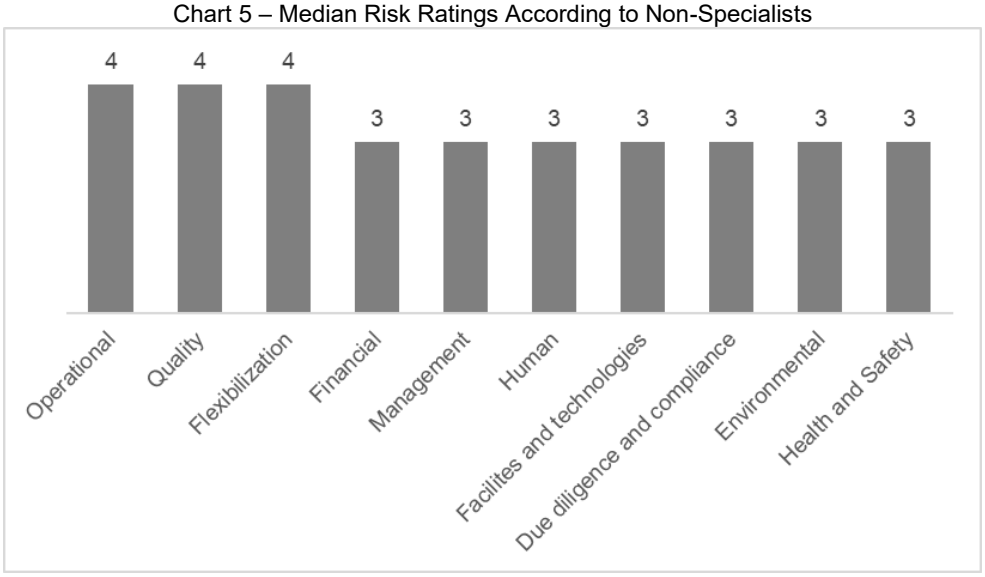


Source: Author

When answering Q16 about whether any type of risk was missing from the questionnaire, only two respondents suggested adding new factors. The first comment did not introduce a new risk category but rather highlighted a specific aspect of human risk: the demotivation of 3PL employees due to salary discrepancies between 3PL workers and contractor employees performing similar functions. The second comment mentioned the risk of confidentiality loss, but this concern was already covered under technological and compliance risks, which address data leakage both through digital breaches and human actions.

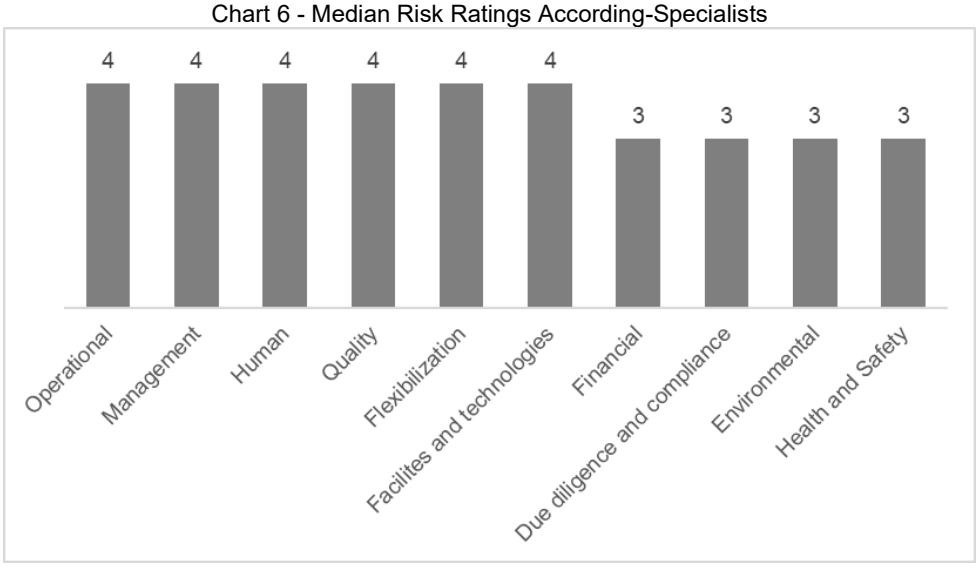
Regarding the classification of risk criticality using the Likert scale, two analyses were conducted based on the median of the responses. The first analysis included responses from professionals who interact with 3PLs but are not specialists in the subject, as presented in Chart 5. The second analysis considered only the responses of logistics specialists, as shown in Chart 6.

Chart 5 – Median Risk Ratings According to Non-Specialists



Source: Author

Chart 6 - Median Risk Ratings According-Specialists



Source: Author

The opinions provided by non-specialists identified operational risks, risks related to the quality of the handled product, and the ability to adapt activities as the three most critical risks. These responses suggest that the perspective of non-specialists may tend to prioritize risks with immediate impact and high visibility

When the opinions of specialists are considered, a greater balance among the different types of risks is observed. In addition to the three risks identified by non-specialists, specialists also highlighted human, managerial, and facilities and technology-related risks. These risks are more subjective and reflect a more strategic and long-term perspective. However, low-visibility risks, such as financial risks of the 3PL, due diligence,

compliance and social risks, environmental risks, and occupational health and safety risks were rated as less critical compared to more operational risks with immediate impact.

3.6. Section Conclusion

The study showed that 3PL risk management is maturing, most of the risks identified and assessed are related to financial, operational and management performance, and there is research addressing environmental and social risks. However, these types of risks are addressed in a generic way, leaving a gap in identifying and assessing these risks in different industries and in different countries.

The research showed that the most used ways to identify risks are semi-structured interviews with experts and managers. Each understood that part of the peculiarity is that each industry has its own risks and assesses the impacts in its own way. The peculiarity is that each industry has its own risks and assesses the impacts in its own way. And the most used way to assess risks is MCDM methods, these methods have the characteristic of transforming qualitative assessments into quantitative ones and indicating decision makers items for prioritization and recommending decisions. However, the classification into risk groups conducted by this research allows managers and experts to think in a more targeted way to identify and assess risks within their organizations and for researchers to expand this research by applying it to specific industries and locations.

In the questionnaire to validate the types of risk that were identified in the SLR, there were no significant responses, so it can be concluded that the risk classifications are quite comprehensive. The lack of variation in the risk assessment, with the risk categories ranging from 2.9 to 3.8, allows us to conclude that in the view of those involved there is no risk category that is significantly more critical than the others. The criticality may vary according to location, segment, 3PL fragility, and criteria external to the organizations.

4. Applied Research: Risk Management Framework for Third-Party Logistics Consumer Goods Warehouse Operators

This research applied to a consumer goods company in Brazil sought to build a framework for risk management of 3PL warehouse operations based on the four SCRM steps described by Vishnu; Sridharan; and Kumar (2019), risk identification, risk assessment, risk mitigation and risk monitoring. This section describes the results found for each of these steps, which were described in the methodological section of this thesis.

The steps created in the SCRM framework for 3PLs can be seen in Figure 6. The 4 steps of the Model have their phases described on the side, where each number represents the subsection within that Section 4. The only exception is the last activity within Risk Monitoring, which is the assessment of the 3PLs to measure their resilience to the proposed model. This part of the study has its results presented throughout Section 5 of this thesis.

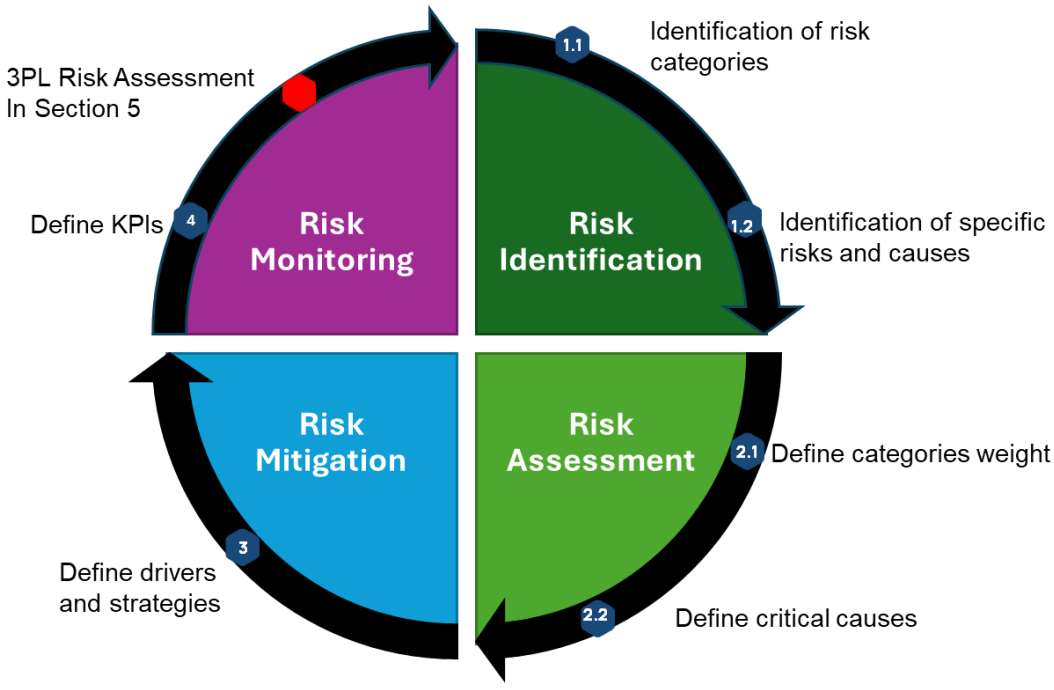


Figure 6 - SCRM Framework for 3PL warehouse operators in the consumer goods
Source: Author

4.1. Risk Identification

This risk identification section is divided into two parts. The first presents the classification of the risk categories of the study applied after the interview and brainstorming with the SC Decision Makers. The second part presents the specific causes generating the risks of the categories defined by the Technical Experts.

Previously, the results obtained in the SLR were presented to the interviewed agents so that they could identify the risk categories, and, in addition, sustainability risk categories is expressed in Table 14 which were identified in another literature review.

Table 14 - Sustainable Supply Chain risks

Risk	Definition	Source
Occupational safety and health	It is a multidisciplinary field concerned with the safety, health, and welfare of people at work (EHS)	(BAI et al., 2019; GIANNAKIS et al., 2020; KUMAR et al., 2022; STROUMPOULIS; KOPANAKI, 2022; SUDUSINGHE; SEURING, 2020)
Environmental governance	includes policy, rules and norms that govern human behavior, and it also addresses who makes decisions,	(KHOKHAR et al., 2022; RAJESH, 2020a; SILVA et al., 2021)
Waste Management	Reduction at origin or source reduction is the objective of a set of policies and strategies to reduce the number of raw materials or by-products, thus reducing the need to explore natural resources.	(JAIN et al., 2022; MACHADO; SCAVARDA; VACCARO, 2014; MASTOS et al., 2020)
Pandemics and epidemics	Biological risks such as covid-19, pandemics, and epidemics such as flu, viruses, conjunctivitis, and others that can paralyze the workforce	(KHOKHAR et al., 2022; RATHVIBOON; TABUCANON; SIVAKUMAR, 2013; SHARMA et al., 2022; YAZDANI; GONZALEZ; CHATTERJEE, 2019)
Compliance with labor legislation	Risk related to non-compliance with labor legislation by a member of the supply chain, including child labor and conditions like slavery, non-payment of employee rights.	(JUETTNER et al., 2020a;KUMAR, Anup et al., 2022a;ROSTAMZADEH et al., 2018a;SEURING, 2014;SILVA, S.; SCHALTEGGER, 2019a
Diversity, inclusion and combating discrimination	Risks to exclusive practices within organizations, lack of diversity and discrimination, causing discomfort among people, in addition to generating risks of legal proceedings due to these practices and negative exposure	(KUMAR et al., 2022; KUMAR; A, 2020; MUNNY et al., 2019; SUDUSINGHE; SEURING, 2020)
Workforce Engagement and Development	Refers to the risk of a drop in team performance and morale due to a lack of training and recognition of workers, making them less engaged, less productive, and unhappy with their work	(HSU et al., 2022a; KUMAR et al., 2022; KUSI-SARPONG et al., 2021; MUNNY et al., 2019; SUDUSINGHE; SEURING, 2020)
Financial health	Financial ability to honor its commitments and guarantee the continuity of its operations, without the need for leverage, rescue, and lower risk of bankruptcy due to lack of financial resources.	(DANG et al., 2022; HSU et al., 2022a; HSU; HWANG; CHIU, 2021; KHOKHAR et al., 2022; SHANKER; SHARMA; BARVE, 2022; STROUMPOULIS; KOPANAKI, 2022)
Bribery and corruption	Related to the acceptance of bribes and corruption from members of the organization, whether in relation to private or government entities, which may cause legal punishments and image and financial damage.	(TAJBAKHSH; HASSINI, 2015; JUETTNER et al., 2020; MUNNY et al., 2019; SILVA; SCHALTEGGER, 2019)
Information security and data protection	Refers to the risk of managing information and data sensitive to the business, organization, and stakeholders. The data can be financial, relating to a new product, development or even personal.	(HSU et al., 2021, 2022a, 2022b; KUSI-SARPONG et al., 2021; SATO; TSE; TAN, 2020)
Inventory management and asset security	It refers to the risk that poor inventory and asset management can generate financially in the supply chain. It is related to the financial pillar of TBL.	(EROL; AR; PEKER, 2022; HSU et al., 2022b; KUMAR et al., 2022; ROSTAMZADEH et al., 2018; ZHANG; SONG, 2022)

Source: Author

4.1.1. Identification of risk categories

During the semi-structured risk identification interview, SC decision makers and consultants openly discussed which risk categories should be considered. They were presented to categories shown in Table 13 however, they were allowed to group or separate categories based on the group's collective judgment. Some observations and comments before deciding on the risk categories were relevant to this research.

"Cooperation and communication are not a problem; we always help the 3PL and the 3PL also helps us even if it is not within their contractual scope. In fact, our goal is to have a more professional relationship where all non-contractual and informal collaborations are formalized and included in a contract." SC Director .1

"We hold daily meetings with 3PLs to discuss operations. We have well-defined and structured KPIs. We require action plans for deviations and monitor them in daily meetings. Operational risks are part of the business." SC Manager 1

"The costs with the 3PL are lower than when we were doing the operation ourselves. This does not make it a significant risk. However, a few years ago, we had to make advance payments to help a 3PL that was in precarious financial condition. If this 3PL went bankrupt, our operations would be affected. This is a risk that we want to include in the model." SC Manager 1

"We focus a lot on operational risks, but we do not monitor the health and safety conditions of outsourced employees at a strategic level, except for specific audits of our safety areas. On the environmental side, we have recycling and waste management campaigns, but we do not measure the engagement of the 3PL. Since these risks are handled internally by the same department, they must be grouped together." SC Director 1.

"Product quality is essential for our customers. As it is a product with organic components, it is susceptible to biological attacks such as fungi and insects. Storage conditions are critical, and the quality department works very hard to ensure, with the 3PL, the quality of our raw material and especially of our final product." SC Manager 2.

"The social side and well-being of the worker is important to us because there was recently a crisis of absenteeism in the 3PL and a high turnover, this harmed the internal climate of the company and absenteeism, and turnover caused a drop in the quality of the service provided." SC Manager 1.

"We have a company that provides due diligence and investigation services with 3PL, because in our view labor risks are the most critical, the risks may be smaller because 3PLs have to deliver and demonstrate these legal and purchasing documents monthly to continue operating, however we never measure the quality of this outsourced company that performs due diligence, we will keep it as a risk category even to measure the effectiveness of our strategy" Vice President of SC

The decision makers chose to cluster the risks into five categories as can be seen in Table 15. The first category is Environmental, Health, and Safety (EHS) and Human category. This category includes risks of work accidents, environmental risks, biological risks such as infectious diseases and the human aspects that permeate the relationship with the 3PL. The second category was named labor and financial relationships, it covers legal risks, such as compliance with labor legislation, leakage of personal data, ethical and legal behavior, and the financial consistency of the 3PL company. For this category, there was greater debate as to whether the financial risks should be separated, but as they are handled by the same company and department that performs due diligence, the VP of Supply Chain decided to group them in the same category and the others reached a consensus. The third category is called Quality. Risks related to this category include risks to product quality arising from 3PL processes, such as storage, handling, shipping, correct packaging, and compliance with good quality standards. The fourth category was called management, which includes the risks of low flexibility, the use of outdated digital systems and machinery, the response time to crises and disruptions, and the increased cost and unsustainability of operations. The last category is called Operational Risks and covers risks arising from operations, meeting deadlines, and quality in service execution. In general, this category covers the risks of operational non-delivery of what is expected.

Despite the nomenclature and definitions of each risk category, it was concluded that the categories often overlap, for example, digital systems risks are present in three different categories, such as in the labor and financial relationship category in the form of data leaks, in the management category as a tool for operation planning and data control, and impacts the operational category, potentially causing delays and errors in processes.

Table 15 - Risk Categories Defined by SC Decision Makers for 3PL Warehouse Operators

Category	**Description**
EHS and Human	Risks with internal or external effects of environmental or physical occupational or process incidents or accidents, with physical or economic damage.
Labor and Financial relationship	Risks of media or financial exposure, due to non-compliance with labor obligations, non-compliance with ethics and legal practices and financial risks caused by bankruptcy or cash flow problems of the 3PL.
Quality	Quality risks of operations, materials and products. Failure to meet acceptable standards and suitability for use by the external customer, contracting customer.
Management	Risks of not responding to fluctuations in production and demand, contractual adjustments, lack of flexibility and responses to external threats to the business and lack of technical knowledge.
Operational	Risks of not delivering the contracted services at the level desired by the contractor, such as deliveries within the deadline and with the expected quality.

Source: Author

The number of categories was smaller than that identified in the SLR, however some risk categories were grouped within it to reduce the number of alternatives when carrying out the assessment. One of the SC Decision Makers justified this decision by saying:

"The idea is to continuously and internally monitor these risks. If we have many categories, the assessment will be more complex. We will group them into five or six categories." SC Director 2.

The EHS and Human category groups the categories of environmental risk, health and safety, and human factors. The Labor and Financial category, in addition to grouping these two risk categories, groups together due diligence and compliance risks. These two categories of risk are considered non-operational, as their effects do not directly influence operational outcomes, but they may adversely affect the reputation of both the 3PL provider and the manufacturer among stakeholders and the media, as well as lead to potential legal consequences. The Management category groups together management, flexibility, technological and facilities risks

4.1.2. Identification of specific risks causes

Specific causes of risks were identified with the Technical Experts in semi-structured interviews, for each risk category the following specific risks causes are in the Table 16, Table 17, Table 18, Table 19, Table 20, and Table 21. The operational risk category was subdivided into two, as according to the operational Technical Experts the risks are different depending on the 3PL activity.

"There are many activities in common, but we have a 3PL that works receiving and storing raw materials in addition to having to supply the factory, and at the end it stores and loads the product. The other 3PL only receives, stores and loads the finished product, so the difference is that a 3PL works with raw materials and supplies the factory."

Due to the number of potential risks cited in different categories, the causes were numbered by two sequences of numbers. The first number represents the risk category in which the cause is located, while the second number is continuous and is only used to provide continuity and identification. For example, the risk of fire in facilities is numbered as 1.22, meaning it is a risk in the first risk category (Environmental, Health, Safety and Human), being the twenty-second in that category. The only exception is in the operational risk category, which is subdivided into two and has three numbers in sequence. As with the others, the first number, "5", indicates that it is the operational risk category; the second

number, if it is “1”, indicates that it is a risk related to raw material warehouses, products and factory supply operations; if it is “2”, it indicates that it is a risk related to the warehouse f the finished product distribution center.

Table 16 – EHS and Human risks

Cause of Risk	Description
1.1 Lack of management in accidents	Risk of not reporting accidents to the contractor, resulting in failure to carry out investigations, identify causes, create action plans and follow-up, creating the possibility of accidents repeating themselves.
1.2 Lack of training for accident prevention	Lack of knowledge or engagement of 3PL employees to prevent accidents and identify potential safety risks at facilities.
1.3 Safety individual equipment management	Risk of lack of or inadequate use of individual protective equipment, inadequate use or use of equipment inappropriate for specific activity.
1.4 Subcontractors' safety management	Risk arising from the lack of control and fair treatment in the management of health and safety by the 3PL in relation to the subcontracted workforce in the operation.
1.5 Internal layout	Risks caused by the layout of the warehouses themselves, such as lack of signage for elevated loads, forklift crossings, sharp corners, grouping of machines or materials.
1.6 Internal changes	Risk arising from internal changes made by the 3PL, changing the standards known and executed by employees.
1.7 Lack of monitoring to prevent accidents	Risks arising from the lack of audits, walks and on-site verification of conditions favorable to the occurrence of accidents.
1.8 Failure or absence of safety devices	Risk of lack of safety devices in operations equipment. For example, poka-yokes, safety padlocks, ropes and emergency buttons.
1.9 Lifting equipment	Risk of using lifting equipment, lack of maintenance, correct dimensioning of the load capacity and mechanical and electrical components of this equipment
1.10 Forklift traffic signs	Risk of traffic signs for trucks and forklifts inside and around warehouses, generating the possibility of collisions and run overs.
1.11 Lack of Signage in the areas	Risk of inadequate signage, such as signs indicating risks, intersections, and failure to signpost safety areas.
1.12 Technical standards (NR)	Personal Risk of carrying out activities by professionals who are not trained in the appropriate regulatory standards, in Portuguese NR, such as NR 10 – work with electricity, NR 11 – transportation, storage and handling.
1.13 non-observation of near accident	Risk due to failure to observe and report events that almost caused an accident, preventing management from being carried out properly.
1.14 Non-disclosure of EHS practices	Caused by the low dissemination of EHS practices, it can generate disengagement in the prevention of accidents, illnesses and environmental incidents.
1.15 Lack of EHS training	Caused by lack of employee training matrix in environmental, health and safety practices, causing a risk of an increase in the incident rate due to failures resulting from poor training
1.16 Unqualified forklift drivers	Risk of using loading and transport equipment by employees who are not trained and qualified for such activity.
1.17 Diseases, pandemics, and epidemics	Risk of contamination by contagious diseases among 3PL and contractor employees, such as conjunctivitis, COVID, viruses.
1.18 Occupational health of employees	Risk related to diseases in the individual and the lack of campaigns for prevention and detection, such as mental, psychological and biological diseases.
1.19 Bad ergonomics	Poor ergonomic conditions for employees, causing physical damage due to repetitive strain, poor posture, excessive lifting

1.20 Handling hazardous materials	Risks arise from the handling of biological or chemical materials during receipt, unpacking, storage, movement and packaging.
1.21 Lack of material categorization	This results from the lack of categorization of the type of material and the employee's knowledge of what type of material he handles.
1.22 Fire in installations	Risk of fires in warehouses, due to the use of machinery and flammable materials that can spread fires.
1.23 Lack of emergency actions	This is a result of the 3PL's lack of preparation and procedures to act in case of emergencies, such as fires, chemical leaks and the need to abandon the area.
1.24 Lack of environmental practices	Resulting from the lack of management and knowledge of good environmental practices, which can generate waste and contamination.
1.25 Poor environmental assessment	Poor assessment of environmental risks by the 3PL, without correct knowledge of the impacts and consequences that its actions can cause to the local environment.
1.26 Waste management	Risk of poor management of waste from operations such as packaging, boxes, raw materials, chemical products for storage.

Source: Author

Table 17 – Labor and Financial relationship risks

Cause of Risk	Description
2.1 Failure to comply with Legal working hours	Excessive working hours, working hours outside those permitted by Brazilian law, or working hours not recorded in accordance with law.
2.2 Absenteeism	Absences of 3PL employees, reducing the workforce, leading to burnout and demotivation, etc.
2.3 Turnover	Excessive turnover of employees for several reasons reduces the quality and loss of knowledge of the 3PL.
2.4 Internal discrimination	Discrimination by the 3PL in relation to the employee, whether based on belief, race, sexuality, place of origin, political orientation, etc.
2.5 Labor legislation	Risks arising from non-compliance with labor rules beyond the legal working hours, such as legal payment of wages and additional payments, taxes and benefits.
2.6 Individual performance	Risk of the 3PL not individually evaluating the employee, not correcting or promoting the employee, when necessary, which could lead to dissatisfaction.
2.7 Labor documentation management	Lack of control by the 3PL over the documentation and evidence of its employees.
2.8 Lack of registration for risk manager	Lack of registration and sending materials to another third-party that carries out due diligence to mitigate risks.
2.9 Financial health	Risk of bankruptcy or reduced operational capacity due to lack of cash flow and other financial problems.
2.10 Operational costs	Lack of control and increased operating costs, putting the sustainability of the continuity of the operation at risk.
2.11 Bribery and corruption	Bribery or corruption for contract renewals, targeted purchases, and other questionable choices.
2.12 Theft and deviations	Theft and diversion of products or materials from the contractor by 3PL employees.
2.13 Lack of compliance channel	Lack of an internal 3PL compliance channel to report acts such as discrimination, bribery, theft, harassment.
2.14 Employees subcontracted	Risk of unfairness in the labor relations of 3PL employees with subcontracted employees, the risk of exposure is the same even if it is a subcontract.
2.15 Data protection	Risk of leakage of economic-strategic, personal, labor data, or any other type of data, whether from the contractor, 3PL or subcontractors, of an individual or legal entity.
2.16 Lack of claims management	Risk of loss of invoices and damaged volumes (loss of material due to expiration, route deviation, theft, fire, contamination) which may generate financial losses.
2.17 Lack of Allowance management	Risk caused by the absence of allowance management that can generate losses of material, products and consequently financial losses.
2.18 Lack of transparency in risks	Lack of communication or attempt to “hide” risks and deviations of personnel or finances, or of any kind.
2.19 Incapacitated employees	Lack of technical-operational knowledge, or collective or personal misconduct by 3PL employees, whether operational or administrative.
2.20 Conflict of interests	Risk of non-communication or that the 3PL takes some action that is detrimental to the contractor due to any possible conflict of interest.
2.21 Asset security	Risks related to internal security of warehouses, lack of cameras, surveillance, or other factors that generate the risk of internal or external theft.

Source: Author

Table 18 – Quality risks

Cause of Risk	Description
3.1 Lack of Quality Standards	Risks of non-conformities and losses arising from the 3PL not following the International Organization for Standardization 9001 (ISO-9001) standard.
3.2 Lack of Quality management system	Lack or insufficiency of the 3PL quality management system, both operational and administrative
3.3 Lack of Quality criteria	Lack or insufficiency of clarity in quality standards for 3PL operations, such as receiving, storing, handling, packaging and loading of product or raw material.
3.4 Lack of Quality disclosure	There is no knowledge of quality standards and guidelines among company employees, whether operational or administrative.
3.5 Poor identification of defects.	It creates the risk of non-proprietary products or raw materials not being rejected in the process due to a lack of evaluation standards, carelessness, or any other failure by the 3PL.
3.6 Poor non-conformity treatment	Risk of recurrence of quality problems due to lack of, or poor investigation and treatment of, deviations.
3.7 Poor of PDCA implementation	Risk of recurrence of quality problems due to lack of, or poor investigation and treatment of, deviations.
3.8 Lack of Quality visual management	Risk of quality problems due to lack of publicity and visual aids that display acceptable and unacceptable conditions of the product or raw material.
3.9 Poor incoming inspection	Quality risks generated by the 3PL not carrying out the inspection of the product or raw material receipt. Even if the 3PL is not the generator, it must inspect the receipt.
3.10 Contaminants	The quality risk is due to the presence of biological, chemical or physical contaminants in products due to poor handling or storage.
3.11 Lack of Customer complaint handling	Quality risks are due to failure to monitor and resolve customer complaints, whether the contractor or a distribution center.
3.12 Lack of 5S evaluation	Quality risks due to non-compliance with the 5S standard within the facilities where the 3PL operates.
3.13 Lack of improvements follow up	Quality risks due to failure to monitor 5S corrective actions or other improvements made in the 3PL's area of operation.
3.14 Lack of Continuous improvement	Quality risks due to the absence of actions and continuous improvement plans by the 3PL technical and operational team.
3.15 Poor accountability	Under sizing or oversizing of quality losses due to lack of control and recording of items lost due to inadequate quality.

Source: Author

Table 19 – Management risks

Cause of Risk	Description
4.1 Poor KPI management	Risks of poor operational, tactical or strategic results due to poor management and control of KPI metrics and results by the 3PL.
4.2 Poor ERP software	3PL operational risks due to non-use or use of low-quality Enterprise Resource Planning (ERP) software.
4.3 Poor communication	Risks caused by the absence of poor communication between the 3PL and the contracting company.
4.4 Poor response to external risks	Risk of not monitoring, planning and structuring the 3PL in relation to risks external to the organization (strikes, policies, etc.).
4.5 Demand fluctuations	Risk of fluctuations in demand and changes in production volume (increase or decrease) and the 3PL not being able to keep up with these variations.
4.6 Low Productivity	Risk of a drop in productivity in the medium and long term, with a lack of plans for continuous improvement and mutual gains.
4.7 Lack of contractual flexibility.	Risk of low 3PL flexibility: there are contractual changes resulting from the contractor's planning, such as an increase or reduction in production volume.
4.8 Product and material expiration control	Risk of loss of product or raw material due to poor inventory management and consequent expiration of the material or product.
4.9 Lack of technical expertise	Lack of organizational technical knowledge in warehouse management activities.
4.10 Lack of standardization of activities	Risks due to lack of standard and repeatability of activities and processes.
4.11 Poor order management	Risk of errors due to poor management by the 3PL regarding orders placed (which product mix to send, which material to store, etc.).
4.12 Poor inventory capacity management	Risks of poor inventory management, such as excess or lack of materials, lack of space, placement of material in an inappropriate location, etc.
4.13 Poor organization of stocks	Poor organization of stocks, such as frequently used materials in hard-to-reach locations, delay in accessing important materials, etc.
4.14 Poor stock withdrawals control	Risk of losses due to absence or lack of control over stock outputs, not knowing the quantity of material or errors in output.
4.15 Absence or inadequate inventory	Risk of losses due to non-performance or inadequate periodic performance of stock inventories.
4.16 Storage of inhibited or blocked items	Risk of using unsuitable products or materials, due to the absence or incorrect use of blocking non-conforming materials, without segregating them from other materials.

Source: Author

Table 20 - Operational risks for raw material warehouse, factory supply and finished product warehouse

Cause of Risk	Description
5.1.1 Poor inbound planning	Risks of poor inbound planning because of not prioritizing special loads and the team being unprepared for the type of load that will be worked on.
5.1.2 Missing inbound time	Loss of productivity and volume due to failure to comply with the scheduled inbound time, aggravated by the 3PL's lack of control and measurement of inbound time.
5.1.3 Poor receipt validation	Failure to observe damage to cargo or notification of lack of material due to failure to validate and check the cargo received.
5.1.4 Poor systematic receipt	Risk of loss of material, or excess material request, or loss of control of material and products due to failure to register receipt in the material and product management system.
5.1.5 Factory supply errors	Errors in incorrect or incomplete supply or some other problem during the supply of raw materials and materials to the factory, which may paralyze the factory's production.
5.1.6 Poor OTIF management	Risk of non-compliance with On Time in Full delivery, i.e., materials delivered on time and correctly due to lack of control and monitoring.
5.1.7 Lack supply management	Risk caused by not monitoring the stock index in real time with shipping orders made by the factory.
5.1.8 Lack of Off-system supply plan	Risk of downtime or delayed delivery in the event of a factory supply system outage if the 3PL does not have a plan to act and ensure emergency supply.
5.1.9 Poor Internal returns	Risk of loss of inventory control when the factory requests an item to be returned to stock due to loss of consumed value.
5.1.10 Material movement	Risk of material loss due to lack of control over material movement or production delays due to failure to locate or incorrect movement of material.
5.1.11 Poor Production record	Risk of loss or excess ordering of material caused by failure to monitor daily production volumes, both planned and actual.
5.1.12 Poor Reversal management	Risk of loss of products or materials due to poor execution of reverse logistics, that is, when the factory or distribution center sends the product back due to some need.
5.1.13 SKU non availability	Risk of not sending a product due to lack of available SKUs caused by the lack of control and verification of SKU availability by the 3PL.
5.1.14 Poor Billing management	Risk of delays and loading errors due to poor execution by the 3PL of the billing records that are issued daily.
5.1.15 Poor Availability validation	Poor or lack of daily validates whether products are available for billing in the 3PL x manufacturer interface and whether communication is effective.
5.1.16 Poor loading	Errors and delays in loading trucks due to lack of planning and poor execution of the activity by the 3PL.
5.1.17 Poor documentation management	Risk of incorrect shipments, loss of control, non-shipment of cargo caused by shipping errors and document control by the 3PL.
5.1.18 Poor loading validation	Risk of shortages, excess quantities, or incorrect SKUs at the customer or distribution centers due to discrepancies in what was loaded and what the shipping documentation.
5.1.19 Fill rate management	Risk of increasing the cost of the operation due to failure to use the maximum load volume on the trucks, requesting more vehicles than necessary.
5.1.20 Poor special shipments	Risk of operational errors in special shipments, such as items for export directly to ports and railways.

Source: Author

Table 21 - Operational risks for finished product distribution center

Cause of Risk	Description
5.2.1 Poor inbound planning	Same as risk 5.1.1
5.2.2 Missing inbound time	Same as risk 5.1.2
5.2.3 Poor Receipt validation	Same as risk 5.1.3
5.2.4 Systematic receipt	Same as risk 5.1.4
5.2.5 SKU non availability	Same as risk 5.1.13
5.2.6 Poor Billing management	Same as risk 5.1.14
5.2.7 Poor Loading	Same as risk 5.1.15
5.2.8 Poor documentation management	Same as risk 5.1.16
5.2.9 Poor loading validation	Same as risk 5.1.17
5.2.10 Poor fill rate management	Same as risk 5.1.18
5.2.11 Poor Productivity	Same as risk 5.1.19
5.2.12 Poor execution of special shipments	Same as risk 5.1.20

Source: Author

4.2. Risk Assessment

In this section, the SC Decision Makers defined the importance weights of the risk categories, and the Technical Experts defined which risks are classified as critical.

4.2.1. Categories Weights

The SC Decision Makers and consultants at this stage, after brainstorming, defined by consensus the weights for each risk category. The defined weights will be applied considering the current needs of the company in the case study scenario and the broader contextual circumstances at this time. It is recommended that these weights be reviewed periodically. The first decision on weights, as shown in the Table 22, shows the first definition that was established with the highest weight in the “Labor and Financial Relationship” category. However, during the continuation of the Brainstorming, it was decided to reduce the weight of this category because the SC Decision Makers believe that this category is well covered, since a large part of the risk causes are mitigated by a third party that performs the Due diligence of the 3PL. The final decision reduced the weight of the Labor and Financial Relationship category to 10%, while the category that gained the highest weight was EHS and Human Risks. The justification was given by one of the agents in the statement as can be seen in Table 23.

“On a daily basis, we focus a lot on operations and delivery volume and productivity. I am concerned that this could increase the chances of occupational accidents within our warehouses, which is why safety is the most concerning item and one that I want to give more visibility to.” SC Director 1.

The “Labor and Financial Relationship” category received the lowest weight from decision makers at the end of second judgment, as they judged its probability of occurrence to be low, given that the 3PLs establish a comprehensive mitigation strategy as requested on their contracts. Furthermore, the decision-makers did not identify significant differences in the risk level in the other categories and hence, they decided to keep equal weights.

Table 22 - Initial weights assigned by SC Decision Makers

Category	Weight
EHS and Human	20%
Labor and Financial relationship	30%
Quality	20%
Management	10%
Operational	20%

Source: Author

Table 23 - Final weights assigned by SC Decision Makers

Category	Weight
EHS and Human	30%
Labor and Financial relationship	10%
Quality	20%
Management	20%
Operational	20%

Source: Author

4.2.2. Critical risks

Considering the Risk Matrix depicted in Figure 5, the Technical Experts defined the critical risks within their specialty category. A total of 15 risks were deemed critical for 3PL1 and 13 for 3PL2, as presented in Table 24. Most of the risks are common for the two 3PLs with an exception to the “Operational” risks. For instance, there are three critical risks for both 3PL1 and 3PL2 in the “EHS and Human” category: work accidents, lack of monitoring strategies to prevent accidents, and emergency actions. Similarly, three critical risks are considered in the “Labor and Financial relationship” category: non-compliance with legal working hours, absenteeism, and non-compliance with labor legislation. The critical risks in the “Quality” category are the quality criteria adopted by the 3PLs, non-conformity treatment, and contaminant control. In the “Management” category, the critical risks are 3PL Key Performance Indicators (KPI) management, inventory capacity management, and inventory management. The “Warehouse operation” critical risks identified for 3PL1 are inbound planning, On-Time in Full (OTIF) management, and production supply management, whereas, for 3PL2, the critical risk is the inbound planning of the finished goods.

At the beginning of the interview process, the labor risks were expected to be classified as critical as they could severely impact the contractor’s reputation. However, most critical risks are operational as they can cause financial impacts through assembly line shutdowns. In addition, if the finished products are contaminated, they can cause

immediate financial and reputational impacts when they reach the retail stores and end customers.

Table 24 - The critical risks of each 3PL category

Risk Category	Risks
EHS and Human	1) Work accidents 2) Lack of monitoring strategies to prevent accidents 3) Emergency actions
Labor and Financial relationship	1) Non-compliance with legal working hours 2) Absenteeism 3) Non-compliance with labor legislation
Quality	1) Quality criteria adopted by 3PLs 2) Non-conformity treatment 3) Contaminant control
Management	1) 3PL KPI management 2) Inventory capacity management 3) Inventory management
Operational (1)	1) Inbound planning 2) OTIF management 3) Production Supply management
Operational (2)	1) Inbound planning of the finished goods

Source: Author

The classification of absenteeism as a critical risk is a major surprise. According to the experts, absenteeism has a strong impact on productivity and on product quality, provoking other risks such as the presence of contaminants and production supply. Therefore, due to a potential cascading event, the absenteeism of workers is a critical risk in the “Labor and Financial relationship” category.

4.3. Risk Mitigation

The definition of mitigation strategies to each one of the identified risks is available in the supplementary material. Most of the mitigation strategies defined by the experts are rooted on regulatory standards for each type of risk, such as ISO 9001, ISO 9004, ISO 14001, Brazilian Standard NR-10 (Working with electricity), and the Brazilian Standard NR-17 (Ergonomics). Furthermore, legal requirements and good practices identified by experts on benchmarking studies performed throughout their careers were adopted to define the more appropriate mitigation strategies. A review of the literature identified the main mitigation strategies that were presented to the interviewees prior to the interviews and are expressed in the Table 25:

Table 25 - Drivers for risk mitigation and improve resilience

Driver	Source
Flexibility	(ALI et al., 2023; ORJI; U-DOMINIC, 2024; VITORINO RAZZERA; MACHADO, 2018; ZARBAKHSHNIA; KARIMI, 2024)
Communication	(CHU et al., 2019; CHU; HOU; WANG, 2021; HOFENK et al., 2011; RAHMAN et al., 2019; SU et al., 2024; YUAN et al., 2018)
Standardization	(BALI; GÜMÜŞ; KAYA, 2013; LIN; LIN; YEH, 2016; PREMKUMAR; GOPINATH; MATEEN, 2021; WANG; JIE; ABARESHI, 2018)
Work force knowledge	(DIABAT et al., 2013; DIABAT; KHODAVERDI; OLFAT, 2013; DUBEY et al., 2018; MEYER et al., 2019; OYEDIJO et al., 2022)
Technologies	(ALI et al., 2023; LI; FENG; XU, 2023; OYEDIJO et al., 2022; WAN; YUAN; LAI, 2019)
ESG and Sustainability	(CENTOBELLI; CERCHIONE; ESPOSITO, 2017; MOREIRA; RODRIGUES, 2023; YAZDANI et al., 2017)
Cost reduction	(BI et al., 2023; HONG et al., 2021; RATH et al., 2024; SU et al., 2024)

Source: Author

In general, Technical Experts understand that mitigation strategies should not be complex. However, they require the 3PL to be disciplined and to monitor the risks constantly. Some exceptions are in the mitigation of “Management” risks, in which experts and decision-makers agree that the execution of mitigation strategies is challenging due to fluctuations in product demand and the standardization of operations and productivity. So, the 3PL needs to prove previous experiences when dealing with these types of risk, since the decision-makers and experts emphasized the need for feasible mitigation strategies.

The greatest challenge identified by experts and decision-makers in the risk monitoring phase is the subjectivity of the 3PL evaluation, especially when considering the 3PL’s ability to execute the mitigation strategies in which they are partially compliant. The judgment on whether the 3PL needs some adjustments to its mitigation strategy and thus is judged partially compliant, or when the 3PL is not suitable for that strategy, ends up being a subjective matter. Thus, the decision-makers and experts highlighted that different results can be expected from different auditors, and consequently, the monitoring periods should be expected to vary. The mitigation strategies can be seen in Table 26, Table 27, Table 28, Table 29, and Table 30.

Table 26 - Mitigation actions required for EHS and Human risks

Risk nº	Mitigation requirement
1.1	100% of all accidents/incidents reported within 24 hours, with a complete investigation and structured and completed action plans. Goals are being achieved, and PDCA (Plan, Do, Check, Act) is in effect.
1.2	100% of employees trained, and all possess knowledge of the accident and incident reporting process.
1.3	Clear rules for the use of Personal Protective Equipment (PPE) in all activities, PPE in good condition; PPE records updated and signed with a periodic replacement schedule. Minimum stock.
1.4	100% of subcontractors trained annually, and all possess knowledge of the use, storage, and conservation of Personal Protective Equipment (PPE); 100% are using PPE.
1.5	Organized, standardized, clean, sanitized, and disciplined environment. Physical evidence of conducting DDS (Daily Safety Sessions), training, and 5S (Sort, set in order, Shine, Standardize, Sustain) and slip, trip, and fall campaigns.
1.6	Environment, Health, and Safety (EHS) is an integral part of all new projects. Projects adhere to EHS guidelines and required permits.
1.7	List of critical behaviors, action plan in force. Daily Environment, Health, and Safety (EHS) messages from leadership, meetings start with the EHS theme. Safety inspections are conducted. Complete risk assessments
1.8	Quarterly verification of safety devices. Complete mapping of critical routes, updated and reviewed action plans.
1.9	Inspections are documented daily, equipment is immediately taken out of service in case of non-compliance, and there is a plan for preventive and corrective maintenance.
1.10	Comprehensive traffic plan established and posted within the workspace with a unit layout and appropriate signage along the demarcation of specific parts of the plan (routes, speed limits, height limits, equipment risks, convex mirrors, etc.).
1.11	Separation of vehicles and pedestrians in the loading and unloading area. Inside the warehouse, separation of forklifts, pallet trucks, and pedestrians, with physical barriers, pedestrian protection at intersections, and where necessary. Pedestrian crossings were needed. Vehicles loaded and unloaded in designated areas, drivers waiting in a safe area, wheel chocks or keys removed from the ignition
1.12	Workers are trained in the Regulatory Standards (NRs) for specific activities such as working at heights, lifting loads, working with electricity, etc. and knowing the safety standards, demonstrating through interviews
1.13	Unsafe conditions are reported through near miss notifications, recorded near miss's trigger action plans that result in timely resolution of items
1.14	EHS policy displayed in the unit, employees relate the policy to their activities. Well-planned campaigns to raise situational awareness. Visual management tables updated with EHS information.
1.15	Well-developed and implemented training matrix by function and training corresponding to the function. Induction with 100% of employees who begin activities in the unit, including sporadic ones.
1.16	The 3PL demonstrates that it has forklift license management control and 100% of drivers have a license and are up to date
1.17	The 3PL carries out preventive campaigns for worker well-being and health (e.g. vaccination against Covid, suicide prevention, combating breast cancer and prostate cancer, etc.).
1.18	The 3PL has an occupational health certificate management system and employees have their certificates up to date.
1.19	Complete risk assessment, compliant training, structured and completed action plans for improving ergonomics conditions.
1.20	When handling and storing materials, the Risk assessment and/or Ergonomic Report (NR17) are reviewed annually, action plan is applied to comply NR 11.
1.21	100% of employees are trained annually and all have knowledge of safe material handling and ergonomics.

1.22	Are fire prevention and protection systems and strategies in place and maintained? (Storage of flammable materials, cleaning, sprinklers, extinguishers, fire hydrants, etc.).
1.23	Updated emergency plan and semi-annual simulation. Emergency signage according to design, exits and emergency equipment unlocked. Emergency equipment (hydrants, pumps, extinguishers, alarms, etc.) inspected monthly. Valid Brigade training and sizing of the number of Brigade members accordingly.
1.24	The 3PL has an environmental risk assessment system and management system such as ISO 14001 and applies environmental risk assessment.
1.25	The 3PL presents a definition of environmental performance goals. Definition of accident reduction and environmental performance goals. Maintain records and controls available at the unit for possible inspection by regulatory bodies or external and internal audits.
1.26	ESG agenda with action plans in place and targets for electricity use, water use, waste management and CO2 emissions in place. Prove waste disposal and promote recycling.

Source: Author

Table 27 - Mitigation actions required for Labor and Financial relationship risks

Risk nº	Mitigation requirement
2.1	Working hours and time records are shared with the manufacturer and the records are within the labor regime in force in the country
2.2	Absenteeism is controlled and information is shared with the manufacturer and is within established SLA levels
2.3	Turnover is controlled and shared with the manufacturer and analyzes and reasons for turnover are presented, and the levels are within the established SLA
2.4	The 3PL presents a plan to combat discrimination among its employees with defined goals and objectives
2.5	Labor debts and payments are shared with the manufacturer and there are no non-conformities or delays and the 3PL is registered with the risk management company
2.6	There is a formal assessment of individual performance and the possibility of professional development within the 3PL, through a formalized assessment plan.
2.7	All documentation required by legislation is in accordance with current legislation and has been evaluated by experts
2.8	The 3PL has an active representative defined for all shifts and the channel with the 3PL team that is internal to the manufacturer is functional and adequate
2.9	Financial statements are shared when requested and are issued annually, reporting cash flow, EBITDA, etc.
2.10	Operating costs are detailed and described in the invoices issued and delivered to the manufacturer.
2.11	There is an anti-bribery and corruption training program and 100% of employees are trained in anti-bribery and corruption
2.12	There is monitoring of theft and internal deviations and employees demonstrate knowledge of security procedures and the consequences
2.13	The compliance system is disclosed to employees and the communication channels are anonymous and spread throughout the workplace.
2.14	When outsourcing occurs, it is justified and notified in advance, stating which company is contracted and must undergo prior approval from the manufacturer.
2.15	The 3PL has a data protection program following the guidelines of the General Data Protection Law (LGPD), the IT team is trained and specialized in data protection, employees who have access to sensitive data are trained and evaluated in LGPD
2.16	The 3PL validates information about invoices and accident volumes, holds daily meetings, checks the recovered cargo and correctly communicates the information to the injured party.
2.17	Manages allowance, employees take due care and understand allowance concepts and meet required SLA levels.
2.18	The 3PL has an up-to-date registration with the risk manager, including operational, administrative and outsourced audiences.
2.19	The 3PL checks the system to see if there are unfit employees, there are no unfit employees and if there are, action plans have been created with treatments carried out within a maximum of 30 days and the information is shared with the manufacturer.
2.20	The 3PL has internal processes capable of identifying situations that constitute a potential conflict of interest and reporting them to the manufacturer
2.21	Results from safety monitoring, critical behaviors, and audit action tracking are integrated into the routine review process to drive accountability for performance, improve quality, and guide root cause actions.

Source: Author

Table 28 - Mitigation actions required for Quality risks

Risk nº	Mitigation requirement
3.1	The 3PL has current and updated QMS certifications (ISO 9001 and ISO 9004).
3.2	The 3PL carries out internal audits of its quality management system (QMS), non-conformities and implemented treatments are monitored until closure.
3.3	It has a quality manual, approved by the manufacturer, for operation, highlighting what quality is and what the quality criteria are for inputs/products handled in 3PL activities and the conditions of use, blocking, rework and disposal.
3.4	Frequent training is carried out with operators, and they can identify the quality criteria in the products and inputs handled in the warehouses.
3.5	The 3PL must detect faults in operated products and have a procedure for reporting faults and defects, which when identified are immediately communicated to the manufacturer.
3.6	The 3PL issues a daily quality report and accounts for deviations occurring during the process such as dents, folds, and other damage to products, in addition to holding a daily meeting to address the issue and propose countermeasures for deviations and meets the SLA level defined for the company. quality.
3.7	The 3PL correctly applies the PDCA methodology to resolve anomalies presented in its processes, seeking to achieve excellence in quality.
3.8	Quality indicators are available in plain sight, employees understand the metrics of each indicator and what needs to be done to achieve the goals.
3.9	Inspections are carried out on products received from the previous stage of the process using checklists. Non-conformities are reported, and management follows to receive non-conforming products.
3.10	The 3PL performs product contaminant control, traps are placed at key points to collect samples of pests and contaminants from the product and raw material, the traps are monitored weekly, and countermeasures are taken if infestations are identified.
3.11	Complaints from subsequent customers are controlled, reported, investigated and action plans are carried out when the 3PL's responsibility for the product defect identified by the Business to Business (B2B) or Business to Customer (B2C) customer is proven, and the action plans are shared with the manufacturer's quality team.
3.12	5S audit walks are carried out by the 3PL at least once a month, non-conformity items are opened requiring action with a defined deadline.
3.13	5S action plans are completed and monitored in meetings, actions are not overdue or forgotten, ensuring system governance.
3.14	There is a plan and a system for collecting suggestions from employees, the best ideas are evaluated, and the creators are recognized by the 3PL and are highlighted.
3.15	Losses due to lack of quality, whether in storage or handling of items, are accounted for and action plans are opened for appropriate treatment, and the SLA is within the defined parameters.

Source: Author

Table 29 - Mitigation actions required for Management risks

Risk nº	Mitigation requirement
4.1	The 3PL defines, controls and monitors KPIs at the strategic, tactical and operational levels, the KPIs are deployed and are in accordance with the strategic vision of the business.
4.2	The 3PL has an ERP system (SAP for example) and uses it to carry out routine management and measure the resources needed for each activity.
4.3	There is formal and registered communication with the planning, primary, production and other areas involved in the process, with communication and response deadlines defined and met.
4.4	The 3PL has external risk assessment governance (e.g., strikes, fuel increases, truck driver stoppages, environmental crises, disruptions in the supply chain), and for the mapped external risks there is a defined mitigation strategy.
4.5	Demand is monitored and the resources required for activities are managed, with flexibility plans in case of changes in the manufacturer's planning, such as a decrease or increase in demand.
4.6	Productivity indicators are controlled and monitored for each activity; a productivity gain plan is presented for an annual increase defined in SLA.
4.7	There is a management system and containment plan in case any specific changes occur in planning so that the 3PL can absorb these changes, whether increasing or decreasing its operations and work team.
4.8	The validity of stock items is monitored, stock items older than 60 days are accounted for and reported daily as well as expired items, action plans are required.
4.9	The 3PL controls and monitors items that are close to expiration and prioritizes their use using the FIFO or FEFFO system or as directed by the manufacturer.
4.10	The production and administrative processes are mapped by the 3PL and there are work instructions available in the area or in the system duly signed by those responsible and the employees involved in the process have access to the work instructions.
4.11	Orders placed by the customer (the customer is understood as the subsequent stage) are checked in stocks and invoiced by the 3PL with accuracy and forecast.
4.12	Stock levels are monitored in warehouses and stocks at the limit of their capacity are informed in meetings and generate action plans to reduce levels.
4.13	Stock items have the correct position and the 3PL records the positions correctly in the system. Not occupying corridor areas and in safe conditions, critical items can be tracked using bar code or QR code scanning software.
4.14	FIFO and FEFO are monitored by the ERP system and production requests are met based on what is requested and in the best condition.
4.15	Stock is controlled through inventory monthly. The 3PL manages the accuracy of the physical position of the raw material with what is in the system ensuring that there is no movement of cargo through barcode or QR code reading.
4.16	The 3PL stores inhibited items and blocked items in the indicated locations and informed them of the stock condition in the ERP system. When assigned by quality, does the 3PL update the status of inhibited items as blocked or for return to current stock? Blocked materials or products have their movement blocked to ensure that they will not be used in processes until quality is released.

Source: Author

Table 30 - Mitigation actions required for Operational risks

Risk nº	Mitigation requirement
5.1.1	Inbound planning for receiving raw materials is carried out daily and discussed in daily meetings with the team. Urgent loads are prioritized.
5.1.2	The 3PL controls the time that each trailer spends inbound for unloading, the time from arrival to the end of unloading is accounted for with established goals. For inbound times above the target, action plans are opened with effective actions by the 3PL.
5.1.3	The 3PL carries out a checklist for every receipt made and files them, the loads are checked and deviations and damage to the load are reported in the checklist and reported to the manufacturer.
5.1.4	The products received are cataloged in the ERP system and physically positioned in the location indicated in the system.
5.1.5	The 3PL manages the supply material mix without any errors in planning and the operator checks the material through bar code or QR code control.
5.1.6	The 3PL manages the movement for factory supply to meet the OTIF and opens action plans for non-conformities.
5.1.7	The 3PL monitors stocks and makes deliveries, requesting material to avoid impacts on the production line.
5.1.8	When requested to perform an offline supply, the 3PL immediately notifies the manufacturer via email or some other formal means that is recorded.
5.1.9	When requested, the 3PL immediately removes excess material from the factory and weighs the material, ensuring the accuracy of what was returned for 100% of the load.
5.1.10	The 3PL carries out unloading and loading using the necessary equipment, such as pallet jacks, forklifts, complying with safety and ergonomics notes, executing within the estimated time.
5.1.11	The 3PL guarantees accuracy in consolidating the volume produced on the day, validates whether the indicated volumes are in accordance with the production reported by the modules and validates whether the analyst has consolidated the production data.
5.1.12	Management is carried out for export items that will go directly from the factory to airports/ports, the items are entered into the system and written off, inversions are controlled and there are action plans for each non-conformity.
5.1.13	Checks the number of SKUs available in the system to supply the distribution center and exports to avoid SKU shortage problems, this is done daily and weekly with the planning team and controls critical items and meets the FIFO and FEFO to meet the necessities.
5.1.14	The 3PL validates daily whether there was a delay in starting the loading list release process, after releasing the day's shipment planning. Furthermore, it also checks whether 100% of the products were processed and whether there were differences in the separation in relation to the notes.
5.1.15	The 3PL controls the loading time of each trailer that arrives at the warehouse, the total time for supply is calculated and there are actions to correct non-conformities.
5.1.16	Daily checks whether the necessary documentation for shipping was printed (invoices) and whether the separations were carried out in accordance with the separation.
5.1.17	During loading, the 3PL must ensure that 100% of what was loaded is what is in the documentation for each loading when it was carried out. Action plans must be opened for each divergence and the items treated and checklists completed daily.
5.1.18	The 3PL manages the trailer fill rate with each shipment to the distribution center so that the trailer space is filled in the best possible way, improving utilization.
5.1.19	The 3PL must monitor the times and quantity of man hour placed for each operation it performs and show progress and action plans to reduce man hour
5.1.20	Management is carried out for export items that will go directly from the factory to airports/ports, the items are entered into the system and written off, inversions are controlled and there are action plans for each incident.

Source: Author

For operational risks related to the operation of the finished products warehouse at the distribution center, the necessary mitigation strategies are the same as for equivalent risks that are within the operational risks presented in Table 30.

4.4. Risk Monitoring - KPIs

This section presents the results of the KPIs defined in this applied research. During brainstorming, the Technical Experts defined which 3PL KPIs should be monitored. The largest number of KPIs refers to operational KPIs because, as they affect the contractor more quickly and almost immediately in the short term, they are the most sensitive and were already monitored previously. The other KPIs demonstrate recent concerns about the safety and health of 3PL employees, ensuring compliance with labor standards by 3PL employees and subcontractors, and the financial sustainability of the operation.

For the brainstorming session, the Technical Experts were instructed not to set goals and deadlines for achieving the KPIs, but only to list essential indicators to monitor the 3PL and ensure the sustainability of the relationship between the two. At this point, the level of reporting of the KPI (operational, tactical or strategic) was not defined, but all necessary KPIs were listed.

To define occupational safety monitoring, two KPIs were defined. The first is the number of accidents. At first there was a doubt as to whether the KPI to be measured would be the number of accidents in absolute quantity or in rate per man hour worked. A consensus was reached that the absolute number is the best alternative since warehouse operations are small and the number of accidents is small, if it were in rate, it could cause difficulty in understanding by the 3PL and the workers, for this KPI as The lower the result, the better the 3PL performance. The second safety KPI is the number of near accidents, this is a KPI that identifies unsafe conditions in the area operated by the 3PL, the fewer unsafe conditions the lower the probability of an accident occurring so that the 3PL has time to act to reduce the number of near accidents, that is, this KPI is a preventive KPI while the number of accidents KPI is a reactive KPI.

To monitor health and the environment, three KPIs were proposed. The adherence to health campaigns KPI monitors the number of 3PL employees who adhere to preventive health campaigns, such as vaccination campaigns against coronavirus, flu or other specific vaccination campaigns, measures the amount of adherence to preventive health

campaigns as an achievement physical and psychological examinations. The recycling rate KPI monitors the percentage of items used by the 3PL that are recycled in relation to total waste, while the untreated waste KPI measures the amount of waste discarded by the 3PL in kilograms.

For labor and legal conditions, five KPIs were defined. The first KPI is Rate of outside legal working hours, which measures the percentage of 3PL workers who are within the legal working hours, without exceeding the working hours authorized by current Brazilian legislation. The second is Number of labor lawsuits which measures the number of labor lawsuits filed by 3PL workers who operated in the evaluated warehouses. A low percentage of workers outside the legal working hours reduces the probability of labor lawsuits, therefore KPIs are preventive, and the others are reactive. Absenteeism is an indicator that measures the percentage of absences in operations, it is a critical indicator as it results in loss of performance and operational quality, in addition to increasing fatigue, discontent and increased overtime, the 3PL must act to minimize absenteeism. The Labor Liabilities indicator measures the financial obligations or legal responsibilities that the 3PL may have in labor matters such as divisions, processes, fines and compensation. A high labor liability results in a risk to the sustainability of the 3PL, generating financial and image damage. The last indicator is the Subcontracted Employee Rate, which measures the percentage of workers who are not directly hired by the 3PL but subcontracted by another company. A high number of subcontractors puts at risk monitoring and ensuring that all legal and labor obligations are being met.

Two KPIs were defined to monitor financial sustainability. The first measures the cost of the operation. This KPI is the actual financial value that the operation costs 3PL and should be compared with the planned cost. An excessive cost puts the sustainability of the 3PL at risk. A cost aligned with the planned cost shows the opportunity for improvements and the creation of a win-win partnership to reduce costs. The second KPI is the 3PL's Cash Balance. This financial indicator shows the amount in reais that the 3PL has in its cash. A small cash balance generates more risks of non-payment and a 3PL bankruptcy and is therefore important to monitor.

Five KPIs were defined to monitor quality. The contaminant count indicator is a reactive indicator that monitors the number of fungi and insects present in boxes of raw materials or finished products. The Defective Item Rate KPI measures the percentage of damaged items in relation to the total number of items. These defects can be dents, tears, or other dirt. The allowance indicator converts losses and deviations due to quality or loss of items in warehouses into financial value. The Customer complaint indicator measures

the number of customer complaints to warehouses, whether due to defects or shipping errors by the 3PL. These customers are business-to-business, such as distribution centers or retail companies. The last indicator, shipping errors rate, measures the percentage of shipping errors, comparing what was shipped and what was requested.

Four KPIs were defined for the management category. The first, Stock Occupancy Rate, monitors the inventory occupancy rate, and is a preventive KPI to avoid a lack of space for allocating new materials. The second, Shelf-Life Rate, monitors the management of the validity of products and materials. It is a KPI that checks the percentage of losses due to expired items in relation to the total quantity of items. The 3PL must first use the materials with the shortest expiration date. The third KPI monitors position accuracy. The item must be physically in the same place where it is indicated in the system and must be quickly located. The last KPI, Volume Accuracy, monitors the volume of items in stock by the 3PL compared to the volume recorded in the system. If the results are the same or close, this represents good 3PL management.

As it is a category that is already monitored and has the highest probability of occurrence of risks, the operational category has the largest number of KPIs, with a total of five. The OTIF (On Time in Full) indicator monitors the deadline and quality of deliveries, indicating items delivered on time and as requested. Volume of Production measures the quantity in absolute values of production carried out, such as receipts, storage, factory supplies and loading. The Productivity indicator uses data from Volume of Production, parameterized by the number of man-hours used in the activities. The Fill Rate indicator seeks to monitor the use of loads, evaluating the volume of cargo carried out in relation to the maximum capacity of receiving cargo of the vehicles used for transportation. And the last indicator, Number of Delayed Loads, measures in absolute terms the number of vehicles with late departures from the 3PL's operating areas. Vehicle delays can generate fines through the carriers used in the supply chain.

All KPIs defined in this section can be seen in Table 31.

Table 31 - KPIs defined for risk monitoring

Category	KPI	Description
EHS and Human	No of Accidents	Number of occupational accidents.
	No of near accidents	Identified number of near misses
	Adherence to health campaigns	Percentage of employees who joined health campaigns.
	Recycling rate	Percentage of waste that went to recycling.
	Untreated waste	Kilograms of items discarded without treatment.
Labor and Financial	Rate of outside legal working hours	Percentage of employees working over the legal working hours.
	Number of labor lawsuits	Number of labor lawsuits responded to by the 3PL.
	Absenteeism	Percentage of 3PL employees missing.
	Labor liabilities	Value of the 3PL's labor liabilities.
	Rate of subcontracted employees	Percentage of employees who are subcontracted by the 3PL.
	Cost of operation	Difference between the actual cost of the operation and the planned cost.
	Cash balance	3PL cash flow to guarantee payments and operations.
Quality	No. of contaminations	Number of biological contaminants detected in the material and product.
	Defective Item Rate	Percentage of items with defects due to storage or handling.
	Allowance	Value in R$ for items lost due to inadequate quality.
	Customer Complaint	Number of customer complaints directed at 3PL activity.
	Shipping errors rate	Percentage of errors during shipping of products and material.
Management	Stock occupancy rate	Percentage of occupied storage areas.
	Shelf-life rate	Rate of expired items in warehouses.
	Positioning accuracy	Percentage of items in the right place according to the system.
	Volume accuracy	Percentage of items in the right place according to the system.
Operational	OTIF	Percentage of orders delivered on time and complete / total orders
	Volume of production	Number of receipts, storages and shipments carried out.
	Productivity	Production volume divided by Man Hours.
	Adherence to planning	Percentage of activities executed / activities planned.
	Fill Rate	Percentage of total boxes placed on the truck / maximum of boxes
	Number of delayed loads	The number of trucks delayed due to late loading or unloading.

Source: Author

4.5. Section conclusion

The research identified specific risks of outsourcing warehouse operations by a consumer goods company. It can be concluded that although operational risks vary according to the segment and type of business, other risks such as EHS, labor, financial, human, legal, quality and management risks may be common in different segments and operations. The similarities should be maintained in the different types, with the difference being in the criticality of the risk, probability and effect may be greater or lesser depending on the segment, activity, type of 3PL and location where the operation is carried out, an example is the risk of absenteeism which was not identified in the conceptual research and in the applied research was classified as a critical risk.

By identifying and assessing the criticality of each risk category and specific risks, both the contracting company and the 3PL can focus their greatest efforts on the most critical risks. With the mitigation strategies defined, the 3PL can implement the strategies, drivers and KPIs to mitigate the risks and increase the resilience of its operation. With increased resilience in addition to faster and lower-cost response or prevention of the risk from materializing, the 3PL and the contracting company are less likely to suffer disruptions, financial impacts and impacts on their reputation, whether due to operational problems, external problems, or problems with employees such as accidents and non-compliance with labor obligations.

5. Case Study: Assessment of Third-Party Logistics operators of consumer goods warehouses in Brazil

5.1. 3PL Assessment

To carry out the risk assessment of the 3PL, the specific risks identified in Section 4.1.2 of this thesis were verified whether the necessary mitigation strategies for each risk, described in Section 4.3, were implemented. For the 3PL, in the operational risk category, risks 5.1.10 (Material movement), 5.1.11 (Poor production record) and 5.1.15 (Poor availability validation) are verified twice for 3PL1 because they are risks evaluated in the two different warehouses that this 3PL operates, the factory warehouse with raw materials and the finished products warehouse after leaving the factory. Therefore, for 3PL1 in the operational risk category, 23 risks are assessed.

The 3PL risk assessment results are depicted in Figure 7 and Figure 8 for the 3PL1 and 3PL2, respectively. Over the course of two days, the experts were in contact with 3PL representatives and assessed whether the 3PLs were compliant with the risks in each category. In this study, none of the 3PLs had a non-compliance assessment for a critical risk, and thus, there was no risk category with a CRS of zero.

Figure 7 presents the assessment results of 3PL1, and as can be seen, a total of 24 risks in the “EHS and Human” category was identified as compliant, implying that this category has most compliant risks. Conversely, the category “Quality” has the lowest number of compliant risks (i.e., 11 risks). Furthermore, “Labor and Financial” has the highest number of non-compliant risks. The CRS values of 3PL1 range from 76.2 to 96.2, with the category with the highest CRS being “EHS and Human” and the one with the lowest “Labor and Financial”.

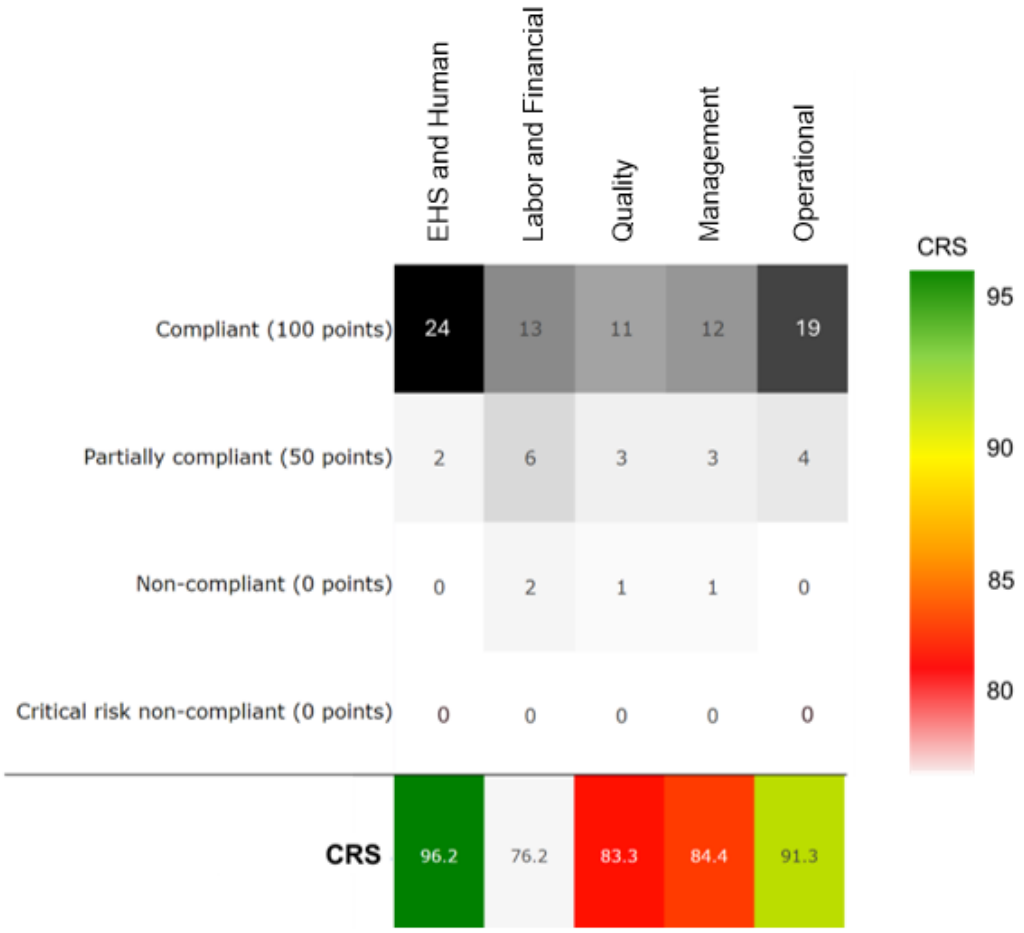


Figure 7 - 3PL1 risk assessment results
Source: Author

The 3PLRS of 3PL1 are given by the weighted average of the categories' scores. Hence, the score of 3PL1 is calculated as (0.3 x 96.2) + (0.1 x 76.2) + (0.2 x 83.3) + (0.2 x 84.4) + (0.2 x 91.3), resulting in a score of 88.3. According to Table 8, this 3PL1 is assumed to pose a moderate risk to its contractor. Notwithstanding, the score of 88.3 is close to being considered a low risk. Thus, the 3PL must demonstrate its capacity to adjust and execute additional mitigation strategies to the partially compliant or non-compliant risks.

The results of the assessment for the 3PL2 are depicted in Figure 8. Like the 3PL1, the categories "EHS and Human" and "Quality" have a higher and lower number of compliant risks, respectively. The category with the highest number of non-compliant risks is "Quality" with 5 risks. Compared to 3PL1, 3PL2 has a higher number of non-compliant risks (i.e., 12 risks) as opposed to 4 risks. The total points obtained by 3PL2 is calculated as (0.3 x 88.5) + (0.1 x 69.0) + (0.2 x 56.7) + (0.2 x 78.1) + (0.2 x 84.6), resulting in a score

of 77.3. This score is in the risk level “Considerable” in Table 8. Hence, the 3PL2 poses a considerable risk for the supply chain, and therefore, the monitoring phase must focus on the categories “Quality” and “Labor and Financial”, which have the lowest CRSs.

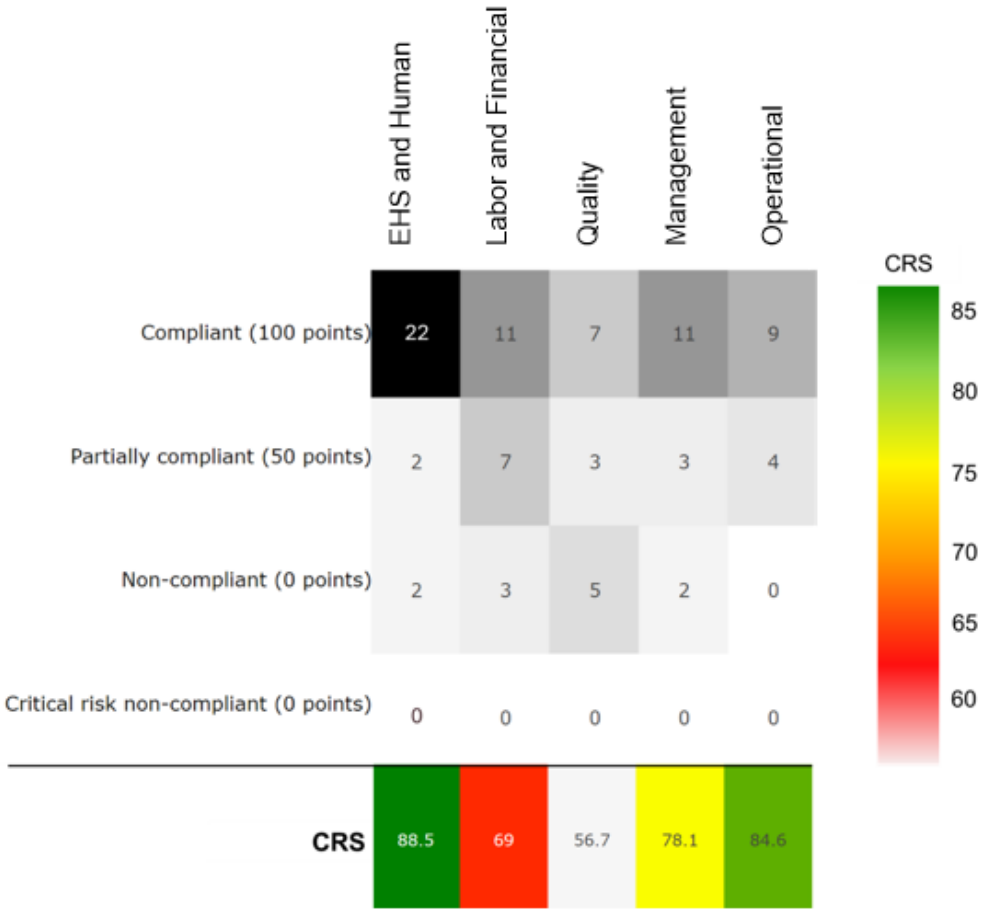


Figure 8 - 3PL2 risk assessment results
Source: Author

The results presented in Figure 7 and Figure 8 confirm some of the biases and trends pointed out by the decision-makers during the interviews. The “EHS and Human” category, which received the highest weight, is the category in which the 3PL1 and 3PL2 achieved the best results. This outcome reassured parties involved in the SSC, as the manufacturer and the 3PLs are aligned in their concern and prioritization of mitigating “EHS and Human” risks.

The scores in “Quality,” “Management,” and “Operations” are also as expected. Since the 3PL1 is an international provider with more expertise in the business, they were expected to have a higher $3PLRS$. As mentioned in Section 3.5, the 3PL2 is a family-owned company and has a lower $3PLRS$, which was anticipated in the categories of

“Management”. A result to be highlighted is that its “Quality” CRS was much lower than expected, with five risks identified as unmapped and without a mitigation strategy. This result raised concerns among the decision-makers, who immediately decided to implement action plans to improven the 3PL quality. Hence, they assigned a quality expert to assist and ensure the improvement of 3PL2 in this category.

The “Labor and Financial” category presents a negative result for 3PL1 and 3PL2. This category received the lowest weights from the decision-makers, as they assumed that these risks were being mitigated by another company responsible for managing these risks and periodically checking the mitigation proof of evidence. However, while it was found that critical risks were indeed mapped and had mitigation strategies in place, non-critical risks were not mapped and lacked the required mitigation strategies. Hence, this methodological approach helped in the identification of these 3PLs’ major drawbacks.

5.2. Section Conclusion

After the conclusion of the study, the decision-makers asked us to change the weights assigned to the categories in future studies. They provided feedback that future studies should separate the “Labor and Financial” category into two distinct categories: “Financial” and “Labor” According to them, there is a major desire to focus on labor issues involving other social factors that go beyond what was mapped following the Brazilian legislation.

Another perception of the SC Decision Makers that was changed was in relation to the performance of the outsourced company that provides due diligence services for evaluating 3PLs. The initial perception was that this company was sufficient to mitigate labor risks, and a higher score was expected, especially from 3PL1. However, this did not occur, which led the SC Decision Makers to change the weights again for the initial idea. Figure 9 shows the comparison of the 3PL1 risk measured by the weights defined in the assessment with the result of being a moderate risk 3PL compared to the first suggestion of weights for the risk categories, where the Labor and Financial category has a weight of 30%, the comparison shows that the 3PL1 risk changes from moderate to considerable. The most worrying situation is with 3PL2 if the weights were changed. Figure 10 shows that 3PL2, which had considerable risk in the assessment, is now considered a 3PL with critical risk.

Risk Category	Weight (1)	3PL1RS	Risk Classification	Weight (2)	3PL1RS	Risk Classification
EHS and Human	30%	88.3	Moderate Risk	20%	76.3	Considerable Risk
Labor and Financial	10%			30%		
Quality	20%			20%		
Management	20%			10%		
Operational	20%			10%		

Figure 9 - 3PL1 risk with the weights defined in the methodology compared to the risk considering the highest weight in the Labor and Financial category
Source: Author

Risk Category	Weight (1)	3PL2RS	Risk Classification	Weight (2)	3PL2RS	Risk Classification
EHS and Human	30%	77.3	Considerable Risk	20%	**66.0**	**Critical Risk**
Labor and Financial	10%			30%		
Quality	20%			20%		
Management	20%			10%		
Operational	20%			10%		

Figure 10 - 3PL2 risk with the weights defined in the methodology compared to the risk considering the highest weight in the Labor and Financial category
Source: Author

The assessment allowed 3PLs to identify their critical vulnerabilities and, together with the contractor, implement mitigation strategies and drivers in the short term to increase their resilience in the short term. In the long term, the assessment model can be used for the 3PL's variable remuneration, as well as a trigger for the application of bonuses or penalties and as a guide for contract extension or termination.

As an immediate outcome, following the implementation of the framework, the organization, in collaboration with the 3PL providers, developed action plans to implement mitigation strategies and reduce the level of risk associated with each 3PL. Positive impacts were observed in the 3PLs' approaches to the prevention of occupational and environmental accidents, in the quality of communication between the parties, and in a heightened sense of transparency within the relationships.

6. General Discussion, Conclusion and Further Research

The general objective of this research was developing a Supply Chain Risk Management framework to manage the risk of Third-Party Logistics warehouse operators in the consumer goods sector in Brazil, including operational, management, health and safety and triple bottom line risks. The general objective was concluded in Section 4 of this thesis. With the support of the SLR presented in Section 3, the main categories of common risks for 3PL management were identified and in Section 4, experts identified the specific risks and contributing causes for 3PLs that operate warehouses in a consumer goods industry in Brazil, carried out the assessment of the risk categories and the assessment of the specific causes using the risk matrix, classifying the critical risks. The experts defined strategies, KPIs and drivers for risk mitigation and finally identified the KPIs that should be continuously monitored to mitigate and monitor risks. Section 5 contributes with an assessment of two 3PLs that should be performed periodically so that the 3PLs can be monitored. Therefore, this thesis fulfilled the objective of creating a framework that goes through the four stages of SCRM, risk identification, risk assessment, risk mitigation, and risk monitoring.

In comparing the results of the framework development, occupational health and safety risks for 3PL workers were given significant relevance within the context of 3PL management in the consumer goods sector in Brazil. In contrast, in the systematic literature review (SLR), only 19.4% of the 67 articles analyzed mentioned risks in this category. These risks may not be as relevant in a global context or may be underrepresented in literature. This thesis recommends, as a direction for future research, assessing the impact of health and safety risks on 3PL operations, distinguishing between emerging economies and established economies, in order to identify potential differences in the perception of such risks.

One confirmation provided by this thesis and addressed by the developed framework in alignment with the systematic literature review (SLR), is the relevance of financial risks (covered by 74.6% of the SLR articles), operational risks (67.2%), and risks related to 3PL management (53.7%). These three categories are the most frequently identified and assessed risks in global literature, and their inclusion in the framework reinforces their significance.

One of the findings of this thesis is the concern with absenteeism risk in the case study company. This risk was neither identified in the reviewed literature nor mentioned in

the survey conducted with professionals from different industries in Brazil. The need for a deeper investigation into absenteeism risk may represent a gap in the literature within the research segment studied and could serve as a potential area for future academic research and development.

Other future research opportunities that may arise from this thesis include the development of similar frameworks applied to different industry segments, such as the pharmaceutical industry, food industry, and industrial goods, as well as in different regions of Brazil and around the world. It is expected that some results will be similar, while others may differ depending on the specific context.

The research also reflects the relative stability of the Brazilian context, as political risks and natural disasters were neither addressed in this study nor spontaneously mentioned by the interviewees. This reality is likely to differ in regions affected by conflict or prone to natural disasters, opening up possibilities for future research focused on these types of risks."

The framework developed in this thesis fills the gap left by the absence of similar studies in Brazil, as few studies address all four stages of SCRM with including sustainability (TBL) and worker well-being. If the organizations apply the framework correctly applied by organizations and their managers take actions to mitigate identified risks, it brings benefits to the worker, the environment, the contracting company, and the 3PL itself, opening up possibilities for future research focused on these types of risks, representing the main contribution that this thesis offers to the field of Management.

For the worker and society, the actions will improve well-being at work through ergonomics, physical and psychological health services, increased workplace safety, access to training, and periodic performance evaluations, ensuring mental security. For the environment, the framework will reduce the probability of accidents and environmental incidents while optimizing the use of material resources.

For the contracting companies, the benefits include improved knowledge and interdisciplinary perspective for supply chain managers and 3PLs, greater interconnection between different areas, and the ability to proactively identify weaknesses in the 3PL that were previously hidden due to it is not being considered a priority.

For the 3PL the following benefits are realized. Improvement in internal documentation management so that they serve as evidence during assessments, lower probability of occupational, process or environmental accidents and incidents occurring within your facilities, lower risk of labor processes and improved communication and alignment of your objectives with your client, making the commercial relationship and the

supply chain more transparent.

As future opportunities for organizations, there is the possibility of conducting the same study in different industry segments, such as the automotive, oil and gas, and pharmaceutical sectors, among others. Another opportunity is the development of a similar framework for risk management in 3PLs that perform freight and transportation activities, adapting to local realities, industry characteristics, the nature of 3PL activities, and specific regional conditions.

In terms of applied opportunities, the case study company has replicated the methodology of this framework, expanded its scope and implemented it in other South American countries, such as Argentina, Chile, and Paraguay.

References

ABBAS, A.; AL-BAZI, A.; PALADE, V. A Constrained Fuzzy Knowledge-Based System for the Management of Container Yard Operations. **International Journal of Fuzzy Systems**, v. 20, n. 4, p. 1205–1223, 1 abr. 2018.

ABBASI, S. et al. A systematic literature review of logistics services outsourcing. **Heliyon**, v. 10, n. 13, 15 jul. 2024.

ABDELAAZIZ, B. et al. The Economic Implications of the War in Ukraine for Africa and Morocco. **Policy Center for the New South**, 2022.

ABOL – ASSOCIAÇÃO BRASILEIRA DE OPERADORES LOGÍSTICOS. **Perfil dos Operadores Logísticos 2022**. São Paulo:

AGRAWAL, T. K. et al. Blockchain-based framework for supply chain traceability: A case example of textile and clothing industry. **Computers and Industrial Engineering**, v. 154, n. May 2020, p. 107130, 2021.

AGUEZZOUL, A. Third-party logistics selection problem: A literature review on criteria and methods. **Omega (United Kingdom)**, v. 49, p. 69–78, 2014.

AKHTAR, M. Logistics Services Outsourcing Decision Making: a literature review and research agenda. **International Journal of Production Management and Engineering**, v. 11, n. 1, p. 73–88, 2023.

ALI, A. et al. Investigation of the drivers of logistics outsourcing in the United Kingdom's pharmaceutical manufacturing industry. **Multimodal Transportation**, v. 2, n. 1, 1 mar. 2023.

ASHRAF, M. H. et al. Is the US 3PL industry overcoming paradoxes amid the pandemic? **International Journal of Logistics Management**, v. 33, n. 4, p. 1269–1293, 17 out. 2022.

AUTOESPORTE. **BYD rescinde contrato com empresa denunciada por trabalho análogo à escravidão**. Disponível em: <https://autoesporte.globo.com/setor-automotivo/industria-automotiva/noticia/2024/12/byd-contrato-empresa-denuncia-trabalho-analogo-escravidao.ghtml>. Acesso em: 27 jan. 2025.

BAI, C. et al. Social sustainable supplier evaluation and selection: a group decision-support approach. **International Journal of Production Research**, v. 57, n. 22, p. 7046–7067, 2019.

BAI, C.; QUAYSON, M.; SARKIS, J. Analysis of Blockchain's enablers for improving sustainable supply chain transparency in Africa cocoa industry. **Journal of Cleaner Production**, v. 358, n. April, p. 131896, 2022.

BALI, Ö.; GÜMÜŞ, S.; KAYA, İ. A Multi-Period Decision Making Procedure based on Intuitionistic Fuzzy Sets for Selection Among Third-Party Logistics Providers. **Journal of Mult. Valued Logic & Soft Computing**, v. 0, p. 1–23, 2013.

BI, H. et al. The Meal Delivery Routing Problem in E-commerce Platforms under the Shared Logistics Mode. **Journal of Theoretical and Applied Electronic Commerce**

Research, v. 18, n. 4, p. 1799–1819, 1 dez. 2023.

BLACKHURST, J. V.; SCHEIBE, K. P.; JOHNSON, D. J. Supplier risk assessment and monitoring for the automotive industry. **International Journal of Physical Distribution and Logistics Management**, v. 38, n. 2, p. 143–165, 2008.

BLOM, T.; NIEMANN, W. Managing reputational risk during supply chain disruption recovery: A triadic logistics outsourcing perspective. **Journal of Transport and Supply Chain Management**, v. 16, 2022.

BORDA, A. et al. Addressing sustainable rural development with shared value: A peruvian model from the cacao industry. **Sustainability (Switzerland)**, v. 13, n. 14, p. 1–17, 2021.

BRIGATTI, F. Trabalhadores no Lollapalooza estavam em regime análogo ao escravo, segundo fiscalização. **Folha de São Paulo**, 23 mar. 2023.

BUNTHONGSANG, W.; THAWORNSUJARITKUL, T.; SILPCHARU, T. Guideline for Decision to Select use Third Party Logistics Service Provider (3PL) to Enhance Performance of Competitiveness in Industrial Business Sectors. **Res Militaris**, v. 12, 2022.

BUTT, A. S. Building resilience in retail supply chains: Lessons learned from COVID-19 and future pathways. **Benchmarking**, v. 29, n. 10, p. 3057–3078, 29 nov. 2022.

CENTOBELLI, P.; CERCHIONE, R.; ESPOSITO, E. Developing the WH2 framework for environmental sustainability in logistics service providers: A taxonomy of green initiatives. **Journal of Cleaner Production**, v. 165, p. 1063–1077, 2017.

CHAPMAN, R. J. The effectiveness of working group risk identification and assessment techniques. **International Journal of Project Management**, v. 16, n. 6, p. 333–343, 1998.

CHU, Z. et al. Managing interdependence: Using Guanxi to cope with supply chain dependency. **Journal of Business Research**, v. 103, p. 620–631, 1 out. 2019.

CHU, Z.; HOU, Y.; WANG, Y. Examining guanxi as an environmental-dependency-coping strategy in China: A 3PL provider's perspective. **International Journal of Logistics Research and Applications**, v. 24, n. 5, p. 511–529, 2021.

DANG, T.-T. et al. A Two-Stage Multi-Criteria Supplier Selection Model for Sustainable Automotive Supply Chain under Uncertainty. **Axioms**, v. 11, n. 5, p. 228, 2022.

DAPP, F. **Roubo De Carga: Panorama no estado do Rio de Janeiro**. Rio de Janeiro: 2018

DE SIQUEIRA, S. S. S.; VIEIRA, P. S.; SANTOS, A. C. DE S. G. DOS. A Systematic Literature Review on Supply Chain Risk Management in 3PL Operations: Risk Identification and Assessment. **Revista de Gestão Social e Ambiental**, v. 19, n. 2, p. e011067, 14 fev. 2025.

DIABAT, A. et al. Benchmarking the interactions among barriers in third-party logistics implementation: An ISM approach. **Benchmarking**, v. 20, n. 6, p. 805–824, 2013.

DIABAT, A.; GOVINDAN, K.; PANICKER, V. V. Supply chain risk management and its mitigation in a food industry. **International Journal of Production Research**, v. 50, n. 11, p. 3039–3050, 2012.

DIABAT, A.; KHODAVERDI, R.; OLFAT, L. An exploration of green supply chain practices and performances in an automotive industry. **International Journal of Advanced Manufacturing Technology**, v. 68, n. 1–4, p. 949–961, 2013.

DUBEY, R. et al. Skills needed in supply chain-human agency and social capital analysis in third party logistics. **Management Decision**, v. 56, n. 1, p. 143–159, 2018.

EKESKÄR, A.; RUDBERG, M. Third-party logistics in construction: perspectives from suppliers and transport service providers. **Production Planning and Control**, v. 33, n. 9–10, p. 831–846, 2022.

ELKINGTON, J. Accounting for the Triple Bottom Line. **Measuring Business Excellence**, v. 2, n. 3, p. 18–22, 1998.

EROL, I.; AR, I. M.; PEKER, I. Scrutinizing blockchain applicability in sustainable supply chains through an integrated fuzzy multi-criteria decision making framework. **Applied Soft Computing**, v. 116, p. 108331, 2022.

ETOKUDOH, E. P.; BOOLAKY, M.; GUNGAPHUL, M. Third party logistics outsourcing: An exploratory study of the oil and gas industry in Nigeria. **SAGE Open**, v. 7, n. 4, 1 out. 2017.

FERNANDO, Y. et al. Sustainable social supply chain practices and firm social performance: Framework and empirical evidence. **Sustainable Production and Consumption**, v. 32, p. 160–172, 2022.

GIANNAKIS, M. et al. Supplier sustainability performance evaluation using the analytic network process. **Journal of Cleaner Production**, v. 247, p. 119439, 2020.

GOULART, L. DA S. et al. BOOSTING THE CIRCULAR ECONOMY WITH OMNICHANNEL USING BLOCKCHAIN AND BEHAVIORAL INCENTIVE MECHANISMS: A BIBLIOMETRIC ANALYSIS. **Revista de Gestao Social e Ambiental**, v. 17, n. 2, 2023.

GOVINDAN, K.; CHAUDHURI, A. Interrelationships of risks faced by third party logistics service providers: A DEMATEL based approach. **Transportation Research Part E: Logistics and Transportation Review**, v. 90, p. 177–195, 1 jun. 2016.

GOVINDAN, K.; MANGLA, S. K.; LUTHRA, S. Prioritising indicators in improving supply chain performance using fuzzy AHP: insights from the case example of four Indian manufacturing companies. **Production Planning and Control**, v. 28, n. 6–8, p. 552–573, 11 jun. 2017.

HAIMES, Y. Y. **On the definition of vulnerabilities in measuring risks to infrastructures**. **Risk Analysis**, abr. 2006.

HERNADEWITA, H.; SALEH, B. I. Identifying tools and methods for risk identification and assessment in construction supply chain. **International Journal of Engineering,**

Transactions A: Basics, v. 33, n. 7, p. 1311–1320, 1 jul. 2020.

HOFENK, D. et al. The influence of contractual and relational factors on the effectiveness of third party logistics relationships. **Journal of Purchasing and Supply Management**, v. 17, n. 3, p. 167–175, set. 2011.

HONG, W. et al. Queuing theory-based optimization research on the multi-objective transportation problem of fourth party logistics. **Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture**, v. 235, n. 8, p. 1327–1337, 1 jun. 2021.

HSU, C. H. et al. Resilience-enhancing solution to mitigate risk for sustainable supply chain-an empirical study of elevator manufacturing. **Processes**, v. 9, n. 4, 1 abr. 2021.

HSU, C. H. et al. Applying Integrated QFD-MCDM Approach to Strengthen Supply Chain Agility for Mitigating Sustainable Risks. **Mathematics**, v. 10, n. 4, p. 1–41, 2022a.

HSU, C. H. et al. Deploying Big Data Enablers to Strengthen Supply Chain Resilience to Mitigate Sustainable Risks Based on Integrated HOQ-MCDM Framework. **Mathematics**, v. 10, n. 8, 1 abr. 2022b.

HSU, H. Y.; HWANG, M. H.; CHIU, Y. S. P. Development of a strategic framework for sustainable supply chain management. **AIMS Environmental Science**, v. 8, n. 6, p. 532–552, 2021.

JAIN, V. et al. Sustainability performance evaluation of the E-waste closed-loop supply chain with the SCOR model. **Waste Management**, v. 147, n. May, p. 36–47, 2022.

JAZAIRY, A.; LENHARDT, J.; VON HAARTMAN, R. Improving logistics performance in cross-border 3PL relationships. **International Journal of Logistics Research and Applications**, v. 20, n. 5, p. 491–513, 3 set. 2017.

JUETTNER, U. et al. Implementing supplier management strategies for supply chain sustainability risks in multinational companies. **TQM Journal**, v. 32, n. 5, p. 923–938, 2020.

KAHRAMAN, C. et al. Pharmaceutical 3PL supplier selection using interval-valued intuitionistic fuzzy TOPSIS. **Notes on Intuitionistic Fuzzy Sets**, v. 28, n. 3, p. 361–374, 2022.

KARIMI TAKALO, S.; SAYYADI TOORANLOO, H.; SHAHABALDINI PARIZI, Z. **Green innovation: A systematic literature review**. **Journal of Cleaner Production**Elsevier Ltd, , 10 jan. 2021.

KASIM, E. S. et al. Supply disruption risk mitigation: A case study of automotive company. **Polish Journal of Management Studies**, v. 22, n. 1, p. 247–262, 2020.

KHOKHAR, M. et al. Going green supply chain management during covid-19, assessing the best supplier selection criteria: A triple bottom line (tbl) approach. **Problemy Ekorozwoju**, v. 17, n. 1, p. 36–51, 2022.

KMIECIK, M. Logistics Coordination Based on Inventory Management and Transportation Planning by Third-Party Logistics (3PL). **Sustainability (Switzerland)**, v.

14, n. 13, 1 jul. 2022.

KUMAR, A. et al. Appropriation of sustainability priorities to gain strategic advantage in a supply chain. **International Journal of Productivity and Performance Management**, v. 71, n. 1, p. 125–155, 2022.

KUMAR, A.; A, R. An MCDM framework for assessment of social sustainability indicators of the freight transport industry under uncertainty. A multi-company perspective. **Journal of Enterprise Information Management**, v. 33, n. 5, p. 1023–1058, 2020.

KUSI-SARPONG, S. et al. Risks associated with the implementation of big data analytics in sustainable supply chains. **Omega (United Kingdom)**, v. 105, p. 102502, 2021.

LI, M.; FENG, J.; XU, S. X. Toward resilient cloud warehousing via a blockchain-enabled auction approach. **Frontiers of Engineering Management**, v. 10, n. 1, p. 20–38, 1 mar. 2023.

LI, R.; CHEN, X. Reverse Logistics Network Design under Disruption Risk for Third-Party Logistics Providers. **Sustainability (Switzerland)**, v. 14, n. 22, 1 nov. 2022.

LIADZE, I. et al. The Economic Costs of the Russia- Ukraine Conflict. n. March, 2022.

LIKERT, R. A technique for the measurement of attitudes. **Archives of psychology**, 1932.

LIN, Y. K.; LIN, J. J.; YEH, R. H. Coordinating a Service Supply Chain under Arms Offset Program's Intervention by Performance-Based Contracting. **Mathematical Problems in Engineering**, v. 2016, 2016.

LYNGDOH, T. et al. A systematic literature review of negative psychological states and behaviors in sales. **Journal of Business Research**, v. 122, p. 518–533, 1 jan. 2021.

MACHADO, C. M. L.; SCAVARDA, A.; VACCARO, G. Lean Healthcare Supply Chain Management: Minimizing Waste and Costs. **Independent Journal of Management & Production**, v. 5, n. 4, p. 1071–1088, 2014.

MAJUMDAR, A.; SINHA, S. K.; GOVINDAN, K. Prioritising risk mitigation strategies for environmentally sustainable clothing supply chains: Insights from selected organisational theories. **Sustainable Production and Consumption**, v. 28, p. 543–555, 1 out. 2021.

MASTOS, T. D. et al. Industry 4.0 sustainable supply chains: An application of an IoT enabled scrap metal management solution. **Journal of Cleaner Production**, v. 269, 2020.

MAVI, R. K.; GOH, M.; ZARBAKHSHNIA, N. Sustainable third-party reverse logistic provider selection with fuzzy SWARA and fuzzy MOORA in plastic industry. **International Journal of Advanced Manufacturing Technology**, v. 91, n. 5–8, p. 2401–2418, 1 jul. 2017.

MEYER, A. et al. An exploration of supply chain risk management in the South African third-party logistics industry. **Acta Commercii**, v. 19, n. 1, 2019.

MICHEL-VILLARREAL, R. et al. Resilience and digitalization in short food supply chains:

A case study approach. **Sustainability (Switzerland)**, v. 13, n. 11, p. 1–23, 2021.

MINASHKINA, D.; HAPPONEN, A. A systematic literature mapping of current academic research linking warehouse management systems to the third-party logistics context. **Acta Logistica**, v. 10, n. 2, p. 209–228, 1 jun. 2023.

MOHAMMED, A. et al. A hybrid MCDM-fuzzy multi-objective programming approach for a G-resilient supply chain network design. **Computers and Industrial Engineering**, v. 127, p. 297–312, 1 jan. 2019.

MOHER, D. et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. **Revista Espanola de Nutricion Humana y Dietetica**, v. 20, n. 2, p. 148–160, 2015.

MOREIRA, O. J.; RODRIGUES, M. C. M. Sourcing third party logistics service providers based on environmental, social and corporate governance: a case study. **Discover Sustainability**, v. 4, n. 1, 1 dez. 2023.

MUNNY, A. A. et al. Enablers of social sustainability in the supply chain: An example of footwear industry from an emerging economy. **Sustainable Production and Consumption**, v. 20, p. 230–242, 2019.

NOORLIZA, K. Resource-capability of halal logistics services, its extent and impact on performance. **Journal of Islamic Marketing**, v. 12, n. 4, p. 813–829, 2020.

NORRMAN, A.; JANSSON, U. Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. **International Journal of Physical Distribution and Logistics Management**, v. 34, n. 5, p. 434–456, 2004.

O GLOBO. **Trabalhadores resgatados em situação de escravidão no RS: o que se sabe e o que falta saber**. Disponível em: <https://g1.globo.com/rs/rio-grande-do-sul/noticia/2023/02/27/trabalhadores-resgatados-em-situacao-de-escravidao-no-rs-o-que-se-sabe-e-o-que-falta-saber.ghtml>. Acesso em: 12 maio. 2023.

ORJI, I. J.; U-DOMINIC, C. M. Modelling the conundrums to cyber-risks management in logistics firms for supply chain social sustainability. **Journal of Enterprise Information Management**, 16 out. 2024.

OSORIO GÓMEZ, J. C. et al. Decision support system for operational risk management in supply chain with 3PL providers. **Intelligent Systems Reference Library**, v. 120, p. 205–222, 2017.

OSORIO GOMES, J. C.; GARCIA, J. L.; MANOTAS, D. F. **AHP Topsis para la selección de proveedores considerando el riesgo asociado a la calidad**. Revista espacios, v. 39, n. 16, 2018.

OYEDIJO, A. et al. Restraining forces and drivers of supply chain collaboration: evidence from an emerging market. **Supply Chain Management**, v. 27, n. 3, p. 409–430, 30 mar. 2022.

PREMKUMAR, P.; GOPINATH, S.; MATEEN, A. Trends in third party logistics–the past, the present & the future. **International Journal of Logistics Research and Applications**, v. 24, n. 6, p. 551–580, 2021.

RADIVOJEVIĆ, G.; GAJOVIĆ, V. Supply chain risk modeling by AHP and Fuzzy AHP methods. **Journal of Risk Research**, v. 17, n. 3, p. 337–352, 16 mar. 2014.

RAHMAN, S. et al. An Investigation into critical challenges for multinational third-party logistics providers operating in China. **Journal of Business Research**, v. 103, p. 607–619, 1 out. 2019.

RAJESH, R. Sustainable supply chains in the Indian context: An integrative decision-making model. **Technology in Society**, v. 61, n. January, p. 101230, 2020a.

RAJESH, R. A grey-layered ANP based decision support model for analyzing strategies of resilience in electronic supply chains. **Engineering Applications of Artificial Intelligence**, v. 87, 1 jan. 2020b.

RATH, S. B. et al. Platform vs. 3PL financing: Strategic choice of lending model for an e-tailer under operational risk. **Transportation Research Part E: Logistics and Transportation Review**, v. 184, 1 abr. 2024.

RATHVIBOON, S.; TABUCANON, M. T.; SIVAKUMAR, M. A multiple-criteria decision-making model for evaluating sustainability of business enterprises. **International Journal of Industrial and Systems Engineering**, v. 14, n. 3, p. 315–332, 2013.

RAUT, R. et al. Benchmarking: An International Journal Sustainable Evaluation & Selection of potential Third Party Logistics providers (3PL): an Integrated MCDM Approach Sustainable Evaluation & Selection of potential Third Party Logistics providers (3PL): an Integrated. **Benchmarking: An International Journal**, v. 0, p. 1–32, 2016.

RAUT, R.; KUMAR, C. S. Sustainable evaluation and selection of potential third-party logistics (3PL) providers An integrated MCDM approach. 2018.

ROSTAMZADEH, R. et al. Evaluation of sustainable supply chain risk management using an integrated fuzzy TOPSIS- CRITIC approach. **Journal of Cleaner Production**, v. 175, p. 651–669, 20 fev. 2018.

ROY, J.; PAMUČAR, D.; KAR, S. Evaluation and selection of third-party logistics provider under sustainability perspectives: an interval valued fuzzy-rough approach. **Annals of Operations Research**, v. 293, n. 2, p. 669–714, 1 out. 2020.

SAATY, T. L. **The Analytic Hierarchy Process**. New York: McGraw-Hill, 1980.

SANTOS, A. C. D. S. G. D. et al. Measuring the current state-of-the-art in lean healthcare literature from the lenses of bibliometric indicators. **Benchmarking: An International Journal**, v. 30, p. 3508–3533, 2023.

SANTOS, A. C. DE S. G. DOS et al. The first evidence about conceptual vs analytical lean healthcare research studies. **Journal of Health Organization and Management**, v. 34, n. 7, p. 789–806, 2020.

SATO, Y.; TSE, Y. K.; TAN, K. H. Managers' risk perception of supply chain uncertainties. **Industrial Management and Data Systems**, v. 120, n. 9, p. 1617–1634, 2020.

SENNA, P. et al. Supply Chain Risk Management : a Bibliometric Analysis Considering Healthcare Supply Chains Gestão De Riscos Em Cadeias De Suprimentos : **Refas**, v. 6, n. 4, 2020.

SENNA, P. et al. A systematic literature review on supply chain risk management: is healthcare management a forsaken research field? **Benchmarking**, v. 28, n. 3, p. 926–956, 2021.

SENNA, P. et al. Healthcare supply chain risk management in Rio de Janeiro, Brazil: what is the current situation? **Work**, v. 72, n. 2, p. 511–527, 2022.

SENNA, P. et al. Supply chain risk management to achieve healthcare supply chain operational excellence: a fsQCA and PLS-SEM approach. **International Journal of Lean Six Sigma**, v. 15, n. 1, p. 177–200, 2024.

SENNA VIEIRA, P. **SUPPLY CHAIN RISK MANAGEMENT IN HEALTHCARE: IDENTIFICATION, ASSESSMENT AND MITIGATION**. Rio de Janeiro: Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, CEFET/RJ, jun. 2019.

SEURING, S. Putting sustainability into supply chain management. **Supply Chain Management**, v. 19, n. 3, p. 322–331, 2014.

SEURING, S.; MÜLLER, M. From a literature review to a conceptual framework for sustainable supply chain management. **Journal of Cleaner Production**, v. 16, n. 15, p. 1699–1710, 2008.

SHAKOURLOO, A.; KAZEMI, A.; JAVAD, M. O. M. A new model for more effective supplier selection and remanufacturing process in a closed-loop supply chain. **Applied Mathematical Modelling**, v. 40, n. 23–24, p. 9914–9931, 1 dez. 2016.

SHANKER, S.; SHARMA, H.; BARVE, A. Assessment of risks associated with third-party logistics in restaurant supply chain. **Benchmarking**, v. 28, n. 8, p. 2432–2464, 7 out. 2021.

SHANKER, S.; SHARMA, H.; BARVE, A. Analysing the critical success factors and the risks associated with third-party logistics in the food supply chain: a case of coffee industry. **Journal of Advances in Management Research**, v. 19, n. 2, p. 161–197, 1 abr. 2022.

SHARMA, M. et al. Developing a framework for enhancing survivability of sustainable supply chains during and post-COVID-19 pandemic. **International Journal of Logistics Research and Applications**, v. 25, n. 4–5, p. 433–453, 2022.

SHOAIB, M.; LIM, M. K.; WANG, C. An integrated framework to prioritize blockchain-based supply chain success factors. **Industrial Management and Data Systems**, v. 120, n. 11, p. 2103–2131, 2020.

SHUAI, Y.; WANG, X.; ZHAO, L. **Research on Measuring Method of Supply Chain Resilience Based on Biological Cell Elasticity Theory**. IEEE International Conference on Industrial Engineering and Engineering Management. **Anais**...IEEE, 2011.

SILVA, J. B. N. DA et al. Data mining and operations research techniques in Supply Chain Risk Management: A bibliometric study. **Brazilian Journal of Operations &**

Production Management, v. 17, n. 3, p. 1–14, 2020.

SILVA, M. E. et al. Managing micro and small enterprise supply chains: A multi-level approach to sustainability, resilience and regional development. **Journal of Cleaner Production**, v. 311, n. April, 2021.

SILVA, S.; SCHALTEGGER, S. Social assessment and management of conflict minerals: a systematic literature review. **Sustainability Accounting, Management and Policy Journal**, v. 10, n. 1, p. 157–182, 2019.

SIQUEIRA, S. S. S. et al. SELECTION OF TOOLING FOR EXTRUSION OF POLYAMIDE HOSES USING PROCESS CAPABILITY ANALYSIS. **Revista de Gestao Social e Ambiental**, v. 18, n. 3, 2024.

SINGH, C. S.; SONI, G.; BADHOTIYA, G. K. Performance indicators for supply chain resilience: review and conceptual framework. **Journal of Industrial Engineering International**, v. 15, n. s1, p. 105–117, 2019.

SINGH, R. K.; GUNASEKARAN, A.; KUMAR, P. Third party logistics (3PL) selection for cold chain management: a fuzzy AHP and fuzzy TOPSIS approach. **Annals of Operations Research**, v. 267, n. 1–2, p. 531–553, 1 ago. 2018.

SREMAC, S. et al. Evaluation of a third-party logistics (3PL) provider using a rough SWARA-WASPAS model based on a new rough dombi aggregator. **Symmetry**, v. 10, n. 8, 1 ago. 2018.

STROUMPOULIS, A.; KOPANAKI, E. Theoretical Perspectives on Sustainable Supply Chain Management and Digital Transformation: A Literature Review and a Conceptual Framework. **Sustainability (Switzerland)**, v. 14, n. 8, 2022.

SU, Q. et al. The Improvement of Logistics Management in China: A Study of the Risk Perspective. **Sustainability (Switzerland)**, v. 16, n. 15, 1 ago. 2024.

SUDUSINGHE, J. I.; SEURING, S. Social sustainability empowering the economic sustainability in the global apparel supply chain. **Sustainability (Switzerland)**, v. 12, n. 7, p. 1–18, 2020.

SURARAKSA, J.; SHIN, K. S. Comparative analysis of factors for supplier selection and monitoring: The case of the automotive industry in Thailand. **Sustainability (Switzerland)**, v. 11, n. 4, 14 fev. 2019.

TAJBAKHSH, A.; HASSINI, E. **Performance measurement of sustainable supply chains: A review and research questions.** International Journal of Productivity and Performance Management, v. 64, n. 6, p. 744-783, 2015.

TANG, C. S. Perspectives in supply chain risk management. **International Journal of Production Economics**, v. 103, n. 2, p. 451–488, 2006.

TAVANA, M. et al. An integrated fuzzy sustainable supplier evaluation and selection framework for green supply chains in reverse logistics. **Environmental Science and Pollution Research**, v. 28, n. 38, p. 53953–53982, 2021.

THUN, J. H.; HOENIG, D. An empirical analysis of supply chain risk management in the

German automotive industry. **International Journal of Production Economics**, v. 131, n. 1, p. 242–249, 2011.

TIWARI, S. Supply chain integration and Industry 4.0: a systematic literature review. **Benchmarking**; 2021.

TSANG, Y. P. et al. An IoT-based cargo monitoring system for enhancing operational effectiveness under a cold chain environment. **International Journal of Engineering Business Management**, v. 9, 22 dez. 2017.

VAN DER WALT, M.; NIEMANN, W.; MEYER, A. The role of personal relationships in supply chain risk information sharing: Perspectives from buyers and suppliers of logistics services. **South African Journal of Economic and Management Sciences**, v. 24, n. 1, 2021.

VISHNU, C. R. et al. Development of a reliable and flexible supply chain network design model: a genetic algorithm based approach. **International Journal of Production Research**, v. 59, n. 20, p. 6185–6209, 2021.

VISHNU, C. R.; SRIDHARAN, R.; KUMAR, P. N. R. Supply chain risk management: models and methods. **International Journal Management and Decision Making**, v. 18, n. 1, 2019.

VITORINO RAZZERA, A.; MACHADO, M. A. The role of TPLs in innovative logistics solutions in importation. **Innovation and Management Review**, v. 15, n. 1, p. 73–91, 6 jun. 2018.

WAGENAAR, J.; FRAGKOS, I.; ZUIDWIJK, R. Integrated planning for multimodal networks with disruptions and customer service requirements. **Transportation Science**, v. 55, n. 1, p. 196–221, 1 jan. 2021.

WAN, Q.; YUAN, Y.; LAI, F. Disentangling the driving factors of logistics outsourcing: a configurational perspective. **Journal of Enterprise Information Management**, v. 32, n. 6, p. 964–992, 1 out. 2019.

WANG, H. et al. Contract design for the fourth party logistics considering tardiness risk. **International Journal of Industrial Engineering Computations**, v. 13, n. 1, p. 13–30, 2022.

WANG, M.; CHILDERHOUSE, P.; ABARESHI, A. Global logistics and supply chain integration in the digital era: a focus on China's Belt and Road Initiative. **Journal of International Logistics and Trade**, v. 22, n. 2, p. 58–79, 2024.

WANG, M.; JIE, F.; ABARESHI, A**.** Improving logistics performance for one belt one road: a conceptual framework for supply chain risk management in Chinese third-party logistics providers. **International Journal of Agile Systems and Management**, v. 11, n. 4, p. 364-380, 2018.

WEIDENHAMER, J. D. Lead contamination of inexpensive seasonal and holiday products. **Science of the Total Environment**, v. 407, n. 7, p. 2447–2450, 15 mar. 2009.

WU, Y. A dual-response strategy for global logistics under uncertainty: A case study of a third-party logistics company. **International Transactions in Operational Research**, v.

19, n. 3, p. 397–419, maio 2012.

XU, X.; LIU, Y. Customer satisfaction of the third-party logistics enterprise based on AHP: A case study. **International Journal of Information Systems and Supply Chain Management**, v. 10, n. 1, p. 68–81, 1 jan. 2017.

YAN, X. et al. Integrated Data Mining and TOPSIS Entropy Weight Method to Evaluate Logistics Supply and Demand Efficiency of a 3PL Company. **Mathematical Problems in Engineering**, v. 2020, 2020.

YAZDANI, M. et al. A group decision making support system in logistics and supply chain management. **Expert Systems with Applications**, v. 88, p. 376–392, 1 dez. 2017.

YAZDANI, M.; GONZALEZ, E. D. R. S.; CHATTERJEE, P. A multi-criteria decision-making framework for agriculture supply chain risk management under a circular economy context. **Management Decision**, v. 59, n. 8, p. 1801–1826, 2019.

YUAN, Y. et al. The role of trust, commitment, and learning orientation on logistic service effectiveness. **Journal of Business Research**, v. 93, p. 37–50, 1 dez. 2018.

ZADEH, L. A. Fuzzy sets as a basis for a theory of possibility. **Fuzzy sets and systems**, v. 1, n. 1, p. 3–28, 1978.

ZAIDI, M.; HASAN, S. Supply Chain Risk Prioritization Using AHP and Framework Development: A Perspective of the Automotive Industry. **International Journal of Industrial Engineering and Management**, v. 13, n. 4, p. 283–293, 2022.

ZARBAKHSHNIA, N.; KARIMI, A. Enhancing third-party logistics providers partnerships: An approach through the D.L.A.R.C.S supply chain paradigm. **Resources, Conservation and Recycling**, v. 202, 1 jan. 2024.

ZHANG, F.; SONG, W. Computers & Industrial Engineering Sustainability risk assessment of blockchain adoption in sustainable supply chain: An integrated method. **Computers & Industrial Engineering**, v. 171, n. 37, p. 108378, 2022.

Appendices

Articles studied in the Systematic Literature Review

Title	Authors	Year	Source title
The Improvement of Logistics Management in China: A Study of the Risk Perspective	Su Q.; Shi Y.; Gao Y.; Arthanari T.; Wang M.	2024	Sustainability (Switzerland)
Modelling the conundrums to cyber-risks management in logistics firms for supply chain social sustainability	Orji I.J.; U-Dominic C.M.	2024	Journal of Enterprise Information Management
A systematic literature review of logistics services outsourcing	Abbasi S.; Sıcakyüz Ç.; Santibanez Gonzalez E.D.; Ghasemi P.	2024	Heliyon
The role of relationship commitment in managing logistics outsourcing in the digital economy	Shi R.; Yang B.; Chu Z.; Lai F.	2024	Industrial Management and Data Systems
Enhancing third-party logistics providers partnerships: An approach through the D.L.A.R.C.S supply chain paradigm	Zarbakhshnia N.; Karimi A.	2024	Resources, Conservation and Recycling
Logistics Services Outsourcing Decision Making: a literature review and research agenda	Akhtar M.	2023	International Journal of Production Management and Engineering
A systematic literature mapping of current academic research linking warehouse management systems to the third-party logistics context	Minashkina D.; Happonen A.	2023	Acta Logistica
Green-Resilient Supplier Selection and Order Allocation Under Disruption by Utilizing Conditional Value at Risk: Mixed Response Strategies	Taghavi S.M.; Ghezavati V.; Bidhandi H.M.; Al-e-Hashem S.M.J.M.	2023	Process Integration and Optimization for Sustainability
Sourcing third party logistics service providers based on environmental, social and corporate governance: a case study	Moreira O.J.; Rodrigues M.C.M.	2023	Discover Sustainability
Investigation of the drivers of logistics outsourcing in the United Kingdom's pharmaceutical manufacturing industry	Ali A.; Cao M.; Allen J.; Liu Q.; Ling Y.; Cheng L.	2023	Multimodal Transportation
Enhancing supply chain information sharing with third party logistics service providers	Valashiya M.C.; Luke R.	2023	International Journal of Logistics Management
Building resilience in retail supply chains: Lessons learned from COVID-19 and future pathways	Butt A.S.	2022	Benchmarking
Managing reputational risk during supply chain disruption recovery: A triadic logistics outsourcing perspective	Blom T.; Niemann W.	2022	Journal of Transport and Supply Chain Management
Pharmaceutical 3PL supplier selection using interval-valued intuitionistic fuzzy TOPSIS	Kahraman C.; Cebi S.; Onar S.C.; Öztayşi B.	2022	Notes on Intuitionistic Fuzzy Sets
Contract design for the fourth party logistics considering tardiness risk	Wang H.; Huang M.; Wang H.; Feng X.; Zhou Y.	2022	International Journal of Industrial Engineering Computations

Is the US 3PL industry overcoming paradoxes amid the pandemic?	Ashraf M.H.; Yalcin M.G.; Zhang J.; Ozpolat K.	2022	International Journal of Logistics Management
Analysing the critical success factors and the risks associated with third-party logistics in the food supply chain: a case of coffee industry	Shanker S.; Sharma H.; Barve A.	2022	Journal of Advances in Management Research
Third-party logistics in construction: perspectives from suppliers and transport service providers	Ekeskär A.; Rudberg M.	2022	Production Planning and Control
Logistics Coordination Based on Inventory Management and Transportation Planning by Third-Party Logistics (3PL)	Kmiecik M.	2022	Sustainability (Switzerland)
Guideline for Decision to Select use Third Party Logistics Service Provider (3PL) to Enhance Performance of Competitiveness in Industrial Business Sectors	Bunthongsang; Thawornsujaritkul; Silpcharu.	2022	Res Militaris
Challenges in extending sustainability across a transport supply chain	Forslund H.; Björklund M.; Svensson Ülgen V.	2022	Supply Chain Management
Strategic supply chain alignment: The role of third-party logistics service providers during disruption recovery	van der Westhuizen C.; Niemann W.	2022	Journal of Transport and Supply Chain Management
Restraining forces and drivers of supply chain collaboration: evidence from an emerging market	Oyedijo A.; Francois Koukpaki A.S.; Kusi-Sarpong S.; Alfarsi F.; Yang Y.	2022	Supply Chain Management
Reverse Logistics Network Design under Disruption Risk for Third-Party Logistics Providers	Li R.; Chen X.	2022	Sustainability (Switzerland)
Examining guanxi as an environmental-dependency-coping strategy in China: A 3PL provider's perspective	Chu Z.; Hou Y.; Wang Y.	2021	International Journal of Logistics Research and Applications
The role of personal relationships in supply chain risk information sharing: Perspectives from buyers and suppliers of logistics services	van der Walt M.; Niemann W.; Meyer A.	2021	South African Journal of Economic and Management Sciences
Risk management tools in the road transportation industry with mediation and moderation analysis	Ersoy P.; Tanyeri M.	2021	Logforum
Queuing theory-based optimization research on the multi-objective transportation problem of fourth party logistics	Hong W.; Xu Z.; Liu W.; Wu L.; Pu X.	2021	Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture
Integrated planning for multimodal networks with disruptions and customer service requirements	Wagenaar J.; Fragkos I.; Zuidwijk R.	2021	Transportation Science
Trends in third party logistics–the past, the present & the future	Premkumar P.; Gopinath S.; Mateen A.	2021	International Journal of Logistics Research and Applications
Assessment of risks associated with third-party logistics in restaurant supply chain	Shanker S.; Sharma H.; Barve A.	2021	Benchmarking
A two-stage auction mechanism for 3pl supplier selection under risk aversion	Lu F.; Bi H.; Hu Y.; Feng W.; Wang S.; Zhang X.	2021	Sustainability (Switzerland)
Logistics service outsourcing choices in a retailer-led supply chain	Lou Y.; Feng L.; He S.; He Z.; Zhao X.	2020	Transportation Research Part E: Logistics and Transportation Review
A framework for measuring customer loyalty for 3PL industry: a case of evolving market	Ahmed W.; Najmi A.; Kusi-Sarpong S.; Khan S.A.; Khushal A.; Quartey J	2020	Benchmarking

Integrated Data Mining and TOPSIS Entropy Weight Method to Evaluate Logistics Supply and Demand Efficiency of a 3PL Company	Yan X.; Gong J.; He J.; Zhang H.; Zhang C.; Liu Z.	2020	Mathematical Problems in Engineering
The strategic analysis of logistics service sharing in an e-commerce platform	Qin X.; Liu Z.; Tian L.	2020	Omega (United Kingdom)
Supply disruption risk mitigation: A case study of automotive company	Kasim, E. S., Daud, D., Said, J., Md Zin, N., & Kusrini, E.	2020	Polish Journal of Management Studies
Resource-capability of halal logistics services, its extent and impact on performance	Noorliza K.	2020	Journal of Islamic Marketing
An exploration of supply chain risk management in the South African third-party logistics industry	Meyer A.; Niemann W.; Uys G.; Beetge D.	2019	Acta Commercii
Disentangling the driving factors of logistics outsourcing: a configurational perspective	Wan Q.; Yuan Y.; Lai F.	2019	Journal of Enterprise Information Management
Managing interdependence: Using Guanxi to cope with supply chain dependency	Chu Z.; Wang Q.; Lai F.; Collins B.J.	2019	Journal of Business Research
Quality risk in logistics outsourcing: A fourth party logistics perspective	Huang M.; Tu J.; Chao X.; Jin D.	2019	European Journal of Operational Research
An Investigation into critical challenges for multinational third-party logistics providers operating in China	Rahman S.; Ahsan K.; Yang L.; Odgers J.	2019	Journal of Business Research
A fuzzy-based House of Risk assessment method for manufacturers in global supply chains	Ma H.-L.; Wong W.-H.C.	2018	Industrial Management and Data Systems
Improving logistics performance for one belt one road: A conceptual framework for supply chain risk management in Chinese third-party logistics providers	Wang M.; Jie F.; Abareshi A.	2018	International Journal of Agile Systems and Management
The role of trust, commitment, and learning orientation on logistic service effectiveness	Yuan Y.; Feng B.; Lai F.; Collins B.J.	2018	Journal of Business Research
Cold supply chain logistics: System optimization for real-time rerouting transportation solutions	Mejjaouli S.; Babiceanu R.F.	2018	Computers in Industry
A Constrained Fuzzy Knowledge-Based System for the Management of Container Yard Operations	Abbas A.; Al-Bazi A.; Palade V.	2018	International Journal of Fuzzy Systems
Skills needed in supply chain-human agency and social capital analysis in third party logistics	Dubey R.; Gunasekaran A.; Childe S.J.; Papadopoulos T.	2018	Management Decision
Evaluation of a third-party logistics (3PL) provider using a rough SWARA-WASPAS model based on a new rough dombi aggregator	Sremac S.; Stević Ž.; Pamučar D.; Arsić M.; Matić B.	2018	Symmetry
The role of TPLs in innovative logistics solutions in importation	Vitorino Razzera A.; Machado M.A.	2018	Innovation and Management Review
Third party logistics outsourcing: An exploratory study of the oil and gas industry in Nigeria	Etokudoh E.P.; Boolaky M.; Gungaphul M.	2017	SAGE Open
Improving logistics performance in cross-border 3PL relationships	Jazairy A.; Lenhardt J.; von Haartman R.	2017	International Journal of Logistics Research and Applications
An IoT-based cargo monitoring system for enhancing operational effectiveness under a cold chain environment	Tsang Y.P.; Choy K.L.; Wu C.H.; Ho G.T.S.; Lam H.Y.; Koo P.S.	2017	International Journal of Engineering Business Management

A group decision making support system in logistics and supply chain management	Yazdani M.; Zarate P.; Coulibaly A.; Zavadskas E.K.	2017	Expert Systems with Applications
Customer satisfaction of the third-party logistics enterprise based on AHP: A case study	Xu X.; Liu Y.	2017	International Journal of Information Systems and Supply Chain Management
Improving performance by coordinating a supply chain with third party logistics outsourcing under production disruption	Giri B.C.; Sarker B.R.	2017	Computers and Industrial Engineering
Sustainable third-party reverse logistic provider selection with fuzzy SWARA and fuzzy MOORA in plastic industry	Mavi R.K.; Goh M.; Zarbakhshnia N.	2017	International Journal of Advanced Manufacturing Technology
Coordinating a Service Supply Chain under Arms Offset Program's Intervention by Performance-Based Contracting	Lin Y.-K.; Lin J.-J.; Yeh R.-H.	2016	Mathematical Problems in Engineering
A new model for more effective supplier selection and remanufacturing process in a closed-loop supply chain	Shakourloo A.; Kazemi A.; Javad M.O.M.	2016	Applied Mathematical Modelling
Interrelationships of risks faced by third party logistics service providers: A DEMATEL based approach	Govindan K.; Chaudhuri A.	2016	Transportation Research Part E: Logistics and Transportation Review
A multi-period decision making procedure based on intuitionistic fuzzy sets for selection among third-party logistics providers	Bali O.; Gümüş S.; Kaya I.	2015	Journal of Multiple-Valued Logic and Soft Computing
Benchmarking the interactions among barriers in third-party logistics implementation: An ISM approach	Diabat A.; Khreishah A.; Kannan G.; Panikar V.; Gunasekaran A.	2013	Benchmarking
Evaluating reverse Third-Party logistics operations using a semi-fuzzy approach	Sharif A.M.; Irani Z.; Love P.E.D.; Kamal M.M.	2012	International Journal of Production Research
Legal analysis of a contract for advanced logistics services	Olander M.; Norrman A.	2012	International Journal of Physical Distribution and Logistics Management
A dual-response strategy for global logistics under uncertainty: A case study of a third-party logistics company	Wu Y.	2012	International Transactions in Operational Research
The influence of contractual and relational factors on the effectiveness of third-party logistics relationships	Hofenk D.; Schipper R.; Semeijn J.; Gelderman C.	2011	Journal of Purchasing and Supply Management

Answers to the questionnaire

Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
CEO e Engenheiro consultor	Manutenção industrial	Sim, tenho/tive envolvimento com Logística / Supply Chain	Operação de armazém	4	3	4	2	3	4	2	5	3	2
Pesquisador	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Planejamento da logística	5	4	4	4	3	3	4	4	5	5
Eng de qualidade	Óleo e gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	3	3	4	2	2	2	3	3	3	2
Analista de Negócios	Consultoria em Gestão	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	4	3	3	3	4	4	2	5	4	4
Coordenador de Operações	Óleo e Gás	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	4	3	4	4	2	1	4	5	4
Analista de Programação de materiais Pleno	Logística Automotiva	Sim trabalho(ei) em Logística / Supply Chain	Transporte	2	1	1	1	2	2	1	1	1	1
Engenheira de sistemas. Engenheira do Produto	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	3	5	5	5	5	5	5	4	4	5
Coordenador de Produção	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	3	5	4	3	2	2	3	4	4	4
Comprador	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	5	4	3	4	1	4	2	1	1	5
Gerente	Consultoria	Sim, tenho/tive envolvimento com Logística / Supply Chain	Não tive interação ou conhecimento com atividades logísticas feitas por empresas terceirizadas	3	4	5	2	3	2	3	2	2	2
Analista de Processos	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Não tive interação ou conhecimento com atividades logísticas feitas por empresas terceirizadas	4	4	3	3	4	3	3	4	2	2

Engenheira Fiscal de Contratos	óleo e gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	3	3	4	4	4	3	3	2	4
Engenheiro do Produto	Automotiva	Sim trabalho(ei) em Logística / Supply Chain	Operação de armazém	3	4	4	3	2	3	3	4	2	3
Professor	Logística	Sim trabalho(ei) em Logística / Supply Chain	Transporte	5	5	5	5	5	5	5	5	5	5
Gestor de tráfego pago	Infoprodutos	Sim, tenho/tive envolvimento com Logística / Supply Chain	Operação de armazém	2	3	3	4	2	4	1	4	3	4
Engenheira	Óleo e gás	Sim trabalho(ei) em Logística / Supply Chain	Transporte	5	4	3	4	2	3	5	3	5	5
GERENTE DE PRODUTOS DIGITAIS	VAREJO	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	2	4	2	2	4	4	4	2	2	2
Engenheiro	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	4	5	3	3	4	5	5	3	4	3
Assist. PCP	siderúrgica	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	5	5	5	5	5	3	5	5	5	5
Sourcing Specialist	Óleo e Gás	Sim trabalho(ei) em Logística / Supply Chain	Transporte	1	4	3	2	3	3	3	1	3	2
Coordenador de Engenharia de Material Handling	Automotiva	Sim trabalho(ei) em Logística / Supply Chain	Transporte	3	3	2	4	4	3	3	4	2	2
Engenheiro Industrial	Medico	Sim, tenho/tive envolvimento com Logística / Supply Chain	Abastecimento de fábrica	3	4	4	4	4	4	4	4	4	3
Gerente de Logística	automotiva	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	4	4	4	4	5	3	3	3	3
Business Development	Automotivo	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	3	3	3	3	3	3	3	3	3
Coordenador de Qualidade	Automotiva/Logística	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	2	3	3	2	1	4	2	3	3
Consultor	Alimentício	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	4	4	3	2	4	2	3	3	2	3
Analista de produto	Vidro	Sim, tenho/tive envolvimento com Logística / Supply Chain	Operação de armazém	3	3	4	4	3	4	4	5	4	3
Desk	Óleo e Gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	1	1	4	3	2	3	4	2	2	3
Empresário	Serviços	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	2	5	5	3	5	4	3	3	3	2
Engenheiro	óleo e gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Planejamento da logística	2	4	4	4	4	4	5	3	4	3
Analista de planejamento logistico	automotiva	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	5	5	5	5	4	4	4	5	4	5

Especialista de Pricing	Meios de pagamento	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	4	5	3	4	1	1	1	2	3
Chefe de projeto	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	5	4	4	4	4	3	4	5	5	5
Engenheiro de Performance	Óleo e gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	3	4	5	4	3	4	2	3	2	3
Consultant	Consultoria em Gestão	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	5	4	2	4	3	3	1	5	5
Engenheiro	Automobilística	Sim, tenho/tive envolvimento com Logística / Supply Chain	Não tive interação ou conhecimento com atividades logísticas feitas por empresas terceirizadas	4	5	3	3	5	5	4	3	3	3
Coordenador de logistica	Alimenticio	Sim trabalho(ei) em Logística / Supply Chain	Operação de armazém	3	4	5	3	3	2	2	5	2	4
Gerente de Operações	Agro - Bioinsumos	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	4	1	3	3	4	1	1	1	1
Analista de Engenharia	Óleo e Gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	3	4	2	3	3	4	2	1	2	2
Supervisor de Planejamento e Demanda	Alimenticio / bebidas	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	4	3	4	3	4	4	3	3	3
Operação de armazém	Logística	Sim trabalho(ei) em Logística / Supply Chain	Não tive interação ou conhecimento com atividades logísticas feitas por empresas terceirizadas	4	5	5	4	4	4	4	4	4	4
Team Leader	Automotivo	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	3	4	3	4	4	2	2	5	2	3
Analista de Logística	automotiva	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	4	3	4	3	4	4	4	2	2
Condutor de Processos e Inovação	Logística Integrada	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	2	3	3	4	2	4	3	1	1	2

Consultor Lean Manufaturing & Maintenance	Indústria Farmacêtica	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	1	1	1	2	1	2	2	2	2	2
Assistente de Qualidade	Automotivo	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	1	4	3	3	2	1	2	1	1	1
Analista de Logística PL	Automotiva	Sim trabalho(ei) em Logística / Supply Chain	Transporte	3	5	5	4	5	4	3	4	3	3
Engenheiro de Produto	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	4	2	3	3	3	2	4	5	4	4
Engenheira de Processos	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	3	4	3	3	4	2	4	4	4	4
Supervisor de Treinamento	Automotivo	Sim trabalho(ei) em Logística / Supply Chain	Transporte	5	3	4	4	4	2	1	5	5	5
Coordenação	Frota	Sim trabalho(ei) em Logística / Supply Chain	Operação de armazém	1	3	4	3	2	3	3	1	2	1
Coordenador de Qualidade	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Abastecimento de fábrica	3	3	3	3	3	3	3	4	2	3
Professor	Educação	Sim, tenho/tive envolvimento com Logística / Supply Chain	Abastecimento de fábrica	2	4	3	2	3	4	4	3	1	2
Supervisor de logística	Pneus	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	5	4	4	5	3	1	2	1	3
Supervisor de Logística	Alimentício	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	5	4	3	3	2	5	4	4	2	1
Gerente de Projetos	Óleo e Gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	3	5	4	5	5	3	5	3	5	5
Gerente de Operações	Farmacêutica	Sim, tenho/tive envolvimento com Logística / Supply Chain	Não tive interação ou conhecimento com atividades logísticas feitas por empresas terceirizadas	2	2	4	3	3	5	4	4	3	3
Analista de planejamento logístico	Óleos lubrificantes _ Shell	Sim trabalho(ei) em Logística / Supply Chain	Operação de armazém	3	4	4	4	2	3	1	1	1	1
Analista de Negócios	Tecnologia	Sim trabalho(ei) em Logística / Supply Chain	Transporte	3	4	4	3	3	3	4	3	3	4
Gerente supply chain	Automativa, pneus	Sim trabalho(ei) em Logística / Supply Chain	Operação de armazém	2	3	4	4	3	3	2	3	2	3

Analista	Gerenciamento de projetos	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	5	5	5	3	3	2	4	2	2
Supervisora de Produção	Alimentício	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	4	3	2	4	4	2	2	2	2
Engenheira	Automotiva	Sim trabalho(ei) em Logística / Supply Chain	Planejamento da logística	2	2	2	2	2	2	2	2	2	2
Coordenador de Sustentabilidade Ambiental	Alimentício	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	4	4	2	3	5	4	4	3	4	4
Diretor de O&G	O&G	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	1	5	2	2	5	4	1	5	5	3
Gerente de Planejamento e Logística	Distribuição de combustível	Sim trabalho(ei) em Logística / Supply Chain	Transporte	5	5	4	3	4	2	2	3	5	3
Ergonomista	automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Abastecimento de fábrica	4	4	3	4	3	4	4	2	1	4
supervisor de QA	logistica	Sim, tenho/tive envolvimento com Logística / Supply Chain	Operação de armazém	4	4	2	3	3	4	3	4	3	4
Analista de processos	Automotiva	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	2	2	2	3	2	3	3	1	3
Analista de Suprimentks	Aerospacial	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	4	2	4	4	2	3	4	5	2	2
Analista do Produto	Linha amarela	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	2	4	3	4	1	1	4	4	2	2
Analista de Sistemas	Energia solar	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	3	3	2	2	2	4	2	2	2	3
Engenheiro de Qualidade	Oleo e Gas	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	3	4	4	3	5	4	4	5	4	3
Engenheira de Logística	Automotivo	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	4	4	3	3	3	2	3	2	3	2
Engenheiro Mecânico Júnior	Óleo e gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	2	4	3	2	2	2	2	2	2	2
Consultora de Recrutamento e Seleção	Consultoria/ Serviços	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	3	3	3	4	2	3	4	4	4
Engenheira de Projetos de Umbilicais	Óleo e Gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Operação de armazém	3	5	4	4	5	3	3	3	3	3
Engenheiro de Performance	Óleo & Gás I	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	3	3	3	4	4	3	2	4	2	4
Gerente de Projetos	Automotivo pesado	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	4	4	3	4	5	4	5	4	4	1
Coordenador de PCP	Logística Ferroviária	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	4	5	4	4	4	3	3	5	4	4

Engenheira	Gestão de contatos	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	2	4	3	3	4	3	2	1	1	3
Professor	Educação	Sim, tenho/tive envolvimento com Logística / Supply Chain	Planejamento da logística	3	4	5	5	4	4	4	5	5	5
Diretor comercial	Óleo e gás	Sim, tenho/tive envolvimento com Logística / Supply Chain	Não tive interação ou conhecimento com	4	4	4	4	4	3	3	3	3	4
Engenheiro logístico	Automotivo	Sim, tenho/tive envolvimento com Logística / Supply Chain	Transporte	2	4	3	3	4	4	4	4	3	3
Engenheira	Bens de Consumo	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	3	5	3	5	5	2	2	3	2	5
Analista de Sourcing II	Óleo e gás	Sim trabalho(ei) em Logística / Supply Chain	Transporte	4	5	3	4	3	4	5	4	3	4
Coordenador	Óleo e gás	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	4	4	4	4	3	2	1	5	5	5
Diretor de Treinamentos / Consultoria	Alimentício, Siderurgia, Aeroespacial e defesas, automotiva	Sim trabalho(ei) em Logística / Supply Chain	Multiplas atividades	4	4	4	4	3	3	4	3	3	5
Coordenador de Segurança Corporativa	Tabaco	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	3	3	2	2	3	4	4	4	3	3
Consultor	Varejo Moda	Sim, tenho/tive envolvimento com Logística / Supply Chain	Multiplas atividades	4	4	4	3	2	5	3	3	3	2

Interview guidance with SC Decision Makers for Risk Identification

Q1 – Of the risks identified in the Literature, which are relevant to the organization?
Q2 – Of the risks identified in the Literature, did you miss any other risk category?
Q3 – Of the risks identified in the Literature, do any of them not apply to your business?
Q4 – How do you want to categorize the risks? Do you want to open or group any categories?

Brainstorming guidance with SC Decision Makers for Risk identification

Q1 – Of the risks identified in the previous interviews, which are relevant to the relationship with 3PL?
Q2 – Were any risk categories not presented and should be included?
Q3 – Validate by consensus which risk categories will be used in this research.

Interview and brainstorming guidance with Technical Experts for Risk Identification

Q1 – What are the specific risks that you already monitor for 3PLs?
Q2 – What risks are not monitored and should be included in the 3PL risk list?
Q3 – Identify in a list all the risks and potential risk causes that we should map to perform 3PL risk management.

Interview and brainstorming guidance with Technical Experts for Risk Mitigation

Q1 – For each risk you previously identified, is there a KPI that should be monitored or implemented?

Q2 – For each risk you previously identified, is there a driver that should be implemented by the 3PL?

Q3 – For each risk you previously identified, is there an elimination or mitigation strategy to be implemented?

Q4 – Using the previous table of identified risks, list what the 3PL needs to do to mitigate that risk.

Q5 – Describe what the 3PL needs to prove to confirm that the risk is mitigated.

Q6 – Describe what the 3PL needs to prove for the risk to be partially mitigated, that is, to prove that mitigation exists, but is incomplete.

Communication form with the 3PL before the Assessment with roles and responsibilities

