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How Supply Chain Disruptions Affect Logistics Performance

A Mixed-method Analysis using LPI and industry Insights

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ABSTRACT:

This study examines the impacts of supply chain disruptions on logistics performance in the context of increasing global instability caused by pandemics, geopolitical tensions, transport bottlenecks, and labor shortages. The research is designed to help gain insight into the impact of disruptions on logistics systems and warehouse operations, and to develop solutions to enhance resilience and continuity of operations.

The research method used was mixed method research which involved quantitative and qualitative analysis. In 2018 and 2023, a quantitative component was used, based on the Logistics Performance Index (LPI) data from the World Bank for 134 countries and GDP per capita data. To analyze the data, statistical methods such as descriptive statistics, paired samples t-test, correlation analysis and regression analysis were performed by SPSS. The qualitative part involved five semi-structured interviews with professionals from organisations working in the manufacturing, logistics, transport co-ordination and energy related fields from Finland.

The results indicate that the dimensions of logistics performance (infrastructure, logistics competence and tracking and tracing) have become better from 2018 to 2023. Timeliness, however, was somewhat low, suggesting more delays during the disruption period. The regression and correlation analysis showed that GDP per capita was still positively correlated with logistics performance, but its correlation decreased slightly in 2023. These were corroborated by qualitative results which included delays, insufficient materials, congestion, warehouse capacity issues, and coordination problems.

The study finds that although logistics capacity has a definite way to improve in the long-term, short-term performance is extremely sensitive to disruptions. The results underline the need of resilience measures like supplier diversification, forecasting, communication and digital visibility to boost warehouse and logistics performance.

KEYWORDS: (Supply Chain Disruptions, Global Supply Chains, Warehouse and Logistics, Logistics Performance Index, Resilience, Pandemics and Geopolitical).

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List of Abbreviations

Short form	Full form
CAPA	**C**orrective **A**ction and **P**reventive **A**ction
COVID-19	**CO**rona**VI**rus **D**isease of 20**19**
GDPpc	**G**ross **D**omestic **P**roduct **p**er **c**apita
ICT	**I**nformation and **C**ommunication **T**echnology
LPI	**L**ogistics **P**erformance **I**ndex
OECD	**Organization** for **E**conomic **C**o-operation and **D**evelopment
SCM	**S**upply **C**hain **M**anagement
SPSS	**S**tatistical **P**ackage for the **S**ocial **S**ciences
SME	**S**mall and **M**edium-sized **E**nterprise
USA	**U**nited **S**tates of **A**merica

1 Introduction

1.1 Background of the study

The global supply chains are becoming more complex, interdependent and prone to various disruptions due to globalization, technological interdependency and the quest to achieve operational efficiency. Although these changes have helped companies to streamline their costs and increase market access, they have also increased systemic vulnerabilities with a breakdown in one part of the supply chain potentially cascading quickly down the various levels of the supply chain (Chowdhury et al., 2021; Hung et al., 2026; Queiroz et al., 2022). The COVID-19 pandemic became a stress test to demonstrate the extent to which contemporary supply chains are based on integrated logistic networks, the regularity of transportation flows, and the reliability of operations in warehouses. The closures of borders, shortages of labor and bottlenecks in transportation turned out to be unprecedented pressure on the logistics, proving that the impact of disruptions can quickly evolve into a systemic crisis in the activities of the entire world (Agyemang & Irannezhad, 2025; Kali et al., 2025; Smith & Fatorachian, 2023).

One of the most evident effects of the pandemic was observed in the sphere of logistics and warehousing activities, where the abrupt changes in demand and presence of imbalances in inventory as well as delays in transportation affected material flows in the industries. Companies that had been used to stable logistics cycles were left in dire need, with heavy traffic jams, and lower services (Mohammed et al., 2025; MOON & CHAE, 2024; Rashid et al., 2024). These obstacles demonstrated the strategic relevance of logistics performance metrics (including infrastructure quality, customs performance, reliability of shipments, and tracking), in ensuring continuity in case of crisis (Fritz, 2022; Hasan et al., 2025; Sharawi et al., 2025). As the disruptions approached, the capacity of warehouses to accommodate uncertainty, rearrange inventory and assist recovery became more and more crucial, which highlights the necessity to understand the impact of disruptions on the performance of warehouses and logistics in more depth (Kencono et al., 2025; Sharawi et al., 2025).

In addition to the pandemic, there have also been geopolitical strains, climate-related incidents and economic unpredictability that have also changed the global supply chain landscape. The case of the Russia-Ukraine conflict, in particular, caused a major disruption in the automotive and manufacturing supply chains, which proves that geopolitical shocks can negatively impact the performance of the supply chain and financial stability in a very short time (Kim et al., 2025). Equally, weather-related disruptions like floods, excessive snow and storms have been causing continuous inconveniences to transportation systems, lowering the effectiveness of logistics and making operations more expensive (Touloumidis et al., 2025). These shocks reveal the increasing demand of adaptive logistics systems that have the capacity to absorb shocks and ensure continuity in its operations despite the volatile conditions (López et al., 2025; Yang et al., 2024).

Due to increased vulnerability of supply chains, the importance of the performance measurement tools has surfaced. The Logistics Performance Index (LPI) is a recent initiative by the World Bank that has become one of the main tools to assess the capacity of national logistics, providing an understanding of the quality of infrastructure, competence of services and tracking systems (World Bank, 2023). In recent literature, it is stressed that the logistics performance is not merely an operational measure, but a strategic factor of the resilience, competitiveness, and sustainability (Cheng et al., 2024; Joshi & Sharma, 2022; Lücker et al., 2025; Sy, 2025). Studies also indicate that the core in global logistics performance are logistics service competence, quality of infrastructure, and tracking, which impact the responsiveness of countries and firms to disruptions (Hasan et al., 2025; Sharawi et al., 2025).

There has been also a massive change in warehousing systems that have been influenced by automation, digitalization and the development of Warehousing 5.0. The improved capabilities of the warehouse, with the help of advanced technologies (human-robot cooperation, real-time monitoring, and multi-criteria performance evaluation), have allowed achieving more flexibility and resilience (Hackius, 2022; Sharawi et al., 2025). Nonetheless, as automation is enhanced, new risks emerge such as cyberattacks, system crashes and challenges in human-machine interactions, which must be mitigated by solid risk management approaches to maintain continuity of operations (Rodríguez-García et al., 2026). The changes

underscore the two-sidedness of technological change in warehousing with respect to providing more performance and increasing vulnerability.

The growing number and intensity of disruptions have led researchers to review the conventional supply chain designs and resiliency models. Studies indicate that any of the steps of the supply chain, including sourcing and production, warehousing and distribution can be disrupted, and the impact of these disruptions can be cascading and difficult to manage (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). Redundancy, agility, collaboration, and digital transformation have become the most necessary strategies to implement resiliency measures to counter these effects (El Baz & Ruel, 2021; Hosseini Shekarabi et al., 2025; Kencono et al., 2025). A viable supply chain model, in particular, places resilience as a core competency which allows supply chains to respond to both the short-term shocks and long-term structural changes (Ivanov, 2022, 2024).

However, even with the mentioned progress, the effects of disruptions on the performance of logistics and warehouses are under-researched. Although many studies have explored the resilience strategies, less of them have managed to give an in-depth analysis of the effects of disruptions on the logistics performance indicators or the operations of warehouses in practice (Gesese & Singh, 2025; Pang et al., 2025). This gap is especially important considering the key role of logistics and warehousing in ensuring the stability of the flow, contributing to recovery, and helping firms to endure uncertainty (Rushton et al., 2022; K. Shahzad & Imran, 2021).

In this respect, the study of impacts of supply chain disruptions on logistics and performance of warehouses has gained more importance to scholars and practitioners. Since companies are in a world where volatility, uncertainty, complexity, and ambiguity are inherent, knowledge about the effects of disruptions on operations is critical in developing robust logistics systems and enhancing decision-making during times of pressure (Farrukh & Sajjad, 2025; Kencono et al., 2025). This paper adds to this expanding field of knowledge by exploring effects of disruptions on logistics and warehouse performance using the latest studies and world performance indicators to offer a detailed review of the issues and opportunities that await the contemporary supply chains.

1.2 Importance of Warehouse and Logistics Performance in Disruptions

The logistics performance and warehouse are the operational backbone of the contemporary supply chains, which make sure that materials, products and information flow efficiently through global networks. These functions are particularly crucial during disruptions, since they define how well firms can continue, absorb shocks, and recover disruptions in their operations (Banomyong et al., 2024; Hung et al., 2026; Queiroz et al., 2022). Warehouses serve as stabilizing buffers to control inventory variability, overcome delays, and facilitate the continuity of production processes, so their performance is a key factor in resilience in case of crisis (Rushton et al., 2022; Sharawi et al., 2025). Logistics performance, in its turn, refers to the extended capabilities like reliability of transportation, efficiency of customs, quality of infrastructure, and tracking system, which affect the pace of supply chain activities, their visibility, and reliability (Hasan et al., 2025; World Bank, 2023).

Disruptions can be in the form of delays, scarcity or capacity, which put a great strain on the activities of the warehouses to absorb upstream and downstream volatility (Hung et al., 2026; Kali et al., 2025). An example is during the COVID-19 pandemic, when companies in all industries experienced acute shortages of materials, disruption of transportation, and unstable delivery time, requiring warehouses to handle changing inventory levels, prioritize, and adjust to changing demand patterns (Agyemang & Irannezhad, 2025; MOON & CHAE, 2024). These issues emphasized the significance of flexibility, visibility, and coordination in warehouses to ensure operations remain at the expected level when faced with stress (Kencono et al., 2025; Rashid et al., 2024). Likewise, logistics performance is the key factor that can help identify the ability of supply chains to react to disruption in a timely and efficient manner, as effective customs administration, a robust transportation network, and effective tracking systems also allow companies to overcome uncertainty to preserve service levels (Cheng et al., 2024; Sharawi et al., 2025).

The intervention also reveals vulnerabilities in logistics systems, including overdependence on one supplier, poor infrastructure, or a lack of digital abilities (Hosseini Shekarabi et al., 2025;

Laari et al., 2024; A. Shahzad & Irfan, 2024). These weak spots can enhance the consequences of disruptions, resulting in long delays, high costs, and customer dissatisfaction (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). This has prompted the better performance of warehouses and logistics to be strategic priority of firms aiming to make the environment increasingly volatile more resilient and competitive (Kencono et al., 2025; Lücker et al., 2025). Digitalization, automation, and high-level analytics have been found to enhance the logistics capacity and help companies to foresee disruptions, streamline their activities, and recuperate faster after shocks (K. Shahzad & Imran, 2021; Sharawi et al., 2025).

The significance of logistics performance can be also seen in its high correlation with the economic development, as well as with the global competitiveness. The greater the logistics performance of countries, the higher the efficiency of their trade, the higher the economic growth rate, and the resiliency to global disruptions (Cheng et al., 2024; Hasan et al., 2025). This highlights the bigger societal, economic consequences of logistics performance, especially during global crises, which discontinue supply chains and endanger economic stability (Agyemang & Irannezhad, 2025; OECD, 2020). Due to increasing frequency and severity of disruptions, it is crucial to understand their impact on the performance of warehouses and logistics to create effective measures to make organizations and the country more resilient to them (Banomyong et al., 2024; Hosseini Shekarabi et al., 2025).

1.3 Research Gap

Even though recent scholars have made a great progress in terms of knowledge about supply chain disruptions, there is still a lot of missing information about their direct and operational effects on the warehouse and logistics performance. The modern literature is largely dedicated to the higher-level frameworks of resilience, the mitigation of risks at the strategic level, and theoretical models with a need to rely on agility, redundancy, collaboration, and digital transformation as the primary enabling factors related to resilience (Hosseini Shekarabi et al., 2025; Kencono et al., 2025). Although these studies can provide excellent theoretical understanding, they frequently fail to consider the practical implications of the disruptions on the logistics and warehouse operations, including inventory disequilibrium, capacity overload,

decreased throughput, and performance decline, which are essential in ensuring continuity in case of a crisis (Rushton et al., 2022; Sharawi et al., 2025).

The second gap is related to a lack of integration of the macro-level logistics performance indicators with disruption-oriented research. The LPI has been commonly established as an indicator of analysing the national logistics performance, but limited literature is available on the impact of global disruptions on the elements of the LPI over time or the changes in logistics performance as indicators of the global instability in supply chains (Hasan et al., 2025; Sharawi et al., 2025). Current studies are inclined to be one-dimensional in relation to LPI, perceiving it as a fixed indicator instead of the dynamic one, which will be able to reflect the impact of pandemics, geopolitical shocks, or climate-related events (Agyemang & Irannezhad, 2025; Cheng et al., 2024). Specifically, this is a gap that is especially important due to the growing use of LPI to determine the level of logistics resilience and national competitiveness (Lücker et al., 2025; World Bank, 2023).

A third gap comes because of the division between qualitative information about the experience of disruption at a firm level and macro-level logistics performance studies. Although qualitative research describes the strategies of firms in shortages, transportation delays, and operational uncertainty (Balicevac Al Ismail et al., 2026; Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024), they are not typically related to the general trends in the logistics performance or the issues in warehouses. Consequently, the literature does not have a holistic picture of the simultaneous impact of disruptions on both micro-level operations in the warehouse and macro-level logistics (Hosseini Shekarabi et al., 2025; Kencono et al., 2025). Such disintegration restricts the creation of unified frameworks that capture the entire range of the impacts of disruption along the supply chain layers.

Considering these gaps, it is evident that research studies are necessary involving how supply chain disruptions affect the performance of warehouses, logistics, by combining the latest empirical evidence with the global performance measures. This study fulfils this requirement by selecting the operational implications of disruptions as a special concern and providing a thorough analysis that links micro-level problems in the supply chain of the warehouse and a

macro-level performance of the logistics based on trends. In this way, the research adds to the more comprehensive and complex view of the vulnerabilities and resilience processes that determine contemporary supply chains in the context of increased volatility.

1.4 Research Method and Study Objective

This study aims to examine the effects of supply chain disruption on warehouse and logistics performance, especially in terms of the insights into their operational impacts and the strategies to increase resilience. The research design of the study will be a mixed-methods research design incorporating both quantitative analysis and qualitative insights. The quantitative aspect is based on the performance indicators on the global scale, especially the LPI, and the modern empirical research to analyse the impact of disruptions on the logistics results at the macro level (Hasan et al., 2025; Hung et al., 2026). The study offers a fact-based viewpoint on the effects of disruptions on the efficiency of logistics in different nations by examining trends and relationships between the elements of logistics performance and general economic indicators.

The qualitative part involves semi-structured interviews with logistics and supply chain experts of several companies. Such interviews give practical information on the experience of disruptions in warehouses, production systems, and transportation networks. They pinpoint major difficulties in operations like shortages of supplies, capacity, and coordination problems, and the ways firms respond and change.

This mixed-method approach combined helps to have a more integrated perspective of both systemic and operational effects of disruptions. This mix of empirical data and practitioner insights makes the study more helpful in its role to inform managerial decision-making and help to build stronger logistics systems. The results provide applicable implications to organizations and policymakers interested in enhancing logistics performance in an ever more volatile environment (Cheng et al., 2024; World Bank, 2023).

1.5 Research Question and Objectives

The key research question that will be used in this study is:

"*How does supply chain disruptions affect the logistics and warehouse performance?*"

The question is indicative of the increasing necessity to comprehend the impact of disruptions on the aspects of supply chains, specifically the functionality of warehouses and logistics systems that are vital in ensuring continuity and aiding recovery in case of a crisis (Hung et al., 2026; Rushton et al., 2022). With increasing frequency and severity of disruptions, precipitated by pandemics, geopolitical tensions, and climate-related events, and technological vulnerabilities, there is a growing necessity to analyse the impact of disruptions on the performance indicators of logistics and warehouse operations and stability of the entire supply chain (Kali et al., 2025; Mehmood et al., 2025).

To answer this research question, the research will aim at:

- **To identify key types of supply chain disruptions, which can be observed in the macro-level data**

This goal acknowledges the significance of comprehending the nature of disruptions that affect logistics and warehouse operations, relying on recent studies to classify the disruptions based on pandemics, geopolitical shocks, climatic events, and technological breakdowns (Agyemang & Irannezhad, 2025; López et al., 2025; Touloumidis et al., 2025). The recognition of these categories gives a basis on which the operational implications of the categories can be analysed.

- **To investigate the correlation between the level of disruption and the logistics and warehouse performance**

This goal is aimed at examining the impact of disruptions on such indicators of logistics performance as the quality of infrastructure, competence of the services, tracking services, and the reliability of shipments; warehouse operations such as capacity, inventory flow, and process stability (Hasan et al., 2025; Muradzikwa et al., 2025; Sharawi et al., 2025). These relations are crucial to understand the effect of disruptions on the functioning of the

operations and detect performance vulnerabilities (MOON & CHAE, 2024; Torralba-Carnerero et al., 2024).

- **To deliver managerial knowledge to enhance warehouse and logistics resilience**

This goal will highlight the practicality of the research, as it will provide insights to guide companies who want to enhance their logistical competencies by relying on the strategies of digitalization, collaboration, redundancy, and agility (Farrukh & Sajjad, 2025; Kencono et al., 2025; Seif & Jafari, 2026). The research can help decision-makers develop more resilient logistics and warehouse systems, which can withstand the disruptions in the future by synthesizing the current research (Lücker et al., 2025; K. Shahzad & Imran, 2021).

Collectively, those goals underpin the overall goal of the research: to further understand how disruptions in the supply chain impact warehouse and logistics performance and to help create more resilient and adaptive supply chains.

1.6 Study Scope and Limitation

The area covered in this research will include macro-level logistics performance and operational knowledge on the firm level. The study combines the global measures like the LPI with the qualitative data collected through the methods of semi-structured interviews to test the connection between the effects of supply chain disruption on the logistics and warehouse performance at various levels (Cheng et al., 2024; Rushton et al., 2022). This mixed method allows having a holistic view of the effects of disruption, integrating the trends of disruptions with real-life experiences.

The study is confined to the logistics performance trends at the global level, and the firm level information of the firms that belong to the industries and logistics intensive industries. The quantitative part addresses LPI data of 2018 and 2023 whereas the qualitative part can be seen as the reflection of the experiences of the firms functioning in Europe. The research is not intended to make a comparative study of industries or nations but rather find the common

disruption patterns and operational issues that are universally applicable in the logistics settings.

Even with its strengths, the study has several limitations. To begin with, the qualitative results rely on a small number of interviews, which might not fully capture the diversity of the disruption experience in both industries and regions (Torralba-Carnerero et al., 2024). Second, the quantitative study is based on the secondary data of LPI, which offers excellent national-level information but can easily miss firm-specifics of operation, where disruptions can be felt in the most straightforward manner (Sharawi et al., 2025). Third, the differences in definitions and measurements of disruptions and logistics performance used in the existing literature can affect the comparability of results in the literature (Agyemang & Irannezhad, 2025).

Irrespective of the limitations, the study has valuable contributions in that it fills the gaps between the macro level trends of performance and the realities of firm operations. The results can be used in conducting further studies and to implement the research in practice to enhance the resilience of logistics in a more volatile environment (Farrukh & Sajjad, 2025; Kencono et al., 2025).

1.7 Structure of Thesis

This study will be divided into six chapters that will cover a particular aspect of the research and will lead to a complete picture of the impact of supply chain disruptions on warehouse and logistics performances. **After this introductory chapter, Chapter Two** includes a comprehensive literature review, which defines and synthesizes the main concepts regarding the supply chain disruptions, logistics performance, warehouse operations, and resilience, as well as global performance indicators like the LPI. The chapter combines the latest studies and builds the theoretical basis of the work (Hasan et al., 2025; Hung et al., 2026).

Chapter Three provides the research methodology, presenting the mixed-methods design, sources of data and the analysis procedures that the research will employ. It describes how LPI data can be quantitatively analysed, as well as the qualitative insights gained through semi-

structured interviews, and offers a strong framework on how the effects of disruptions on the performance of logistics and warehouses can be studied (Cheng et al., 2024; Sharawi et al., 2025).

Chapter Four provides the results of the analysis, which reflects the main insights associated with the operational implications of disruptions to the performance of warehouses and logistics. Based on the findings of the quantitative study and the qualitative data, the chapter focuses on the role of disruptions in the determination of logistics reliability, stability in warehouses, and the performance of the supply chain in general (Agyemang & Irannezhad, 2025; Lücker et al., 2025).

Chapter Five will give the discussion and conclusion of the study. It analyzes the results and compares them to the existing literature, highlights the practical implications of the study to enhance logistics and warehouse resilience and outlines limitations and recommendations to future research (Farrukh & Sajjad, 2025; Kencono et al., 2025).

2 Literature Review

2.1 Introduction to the Literature Review

This literature review aims to summarize the recent studies on supply chain disruptions, warehouse performance, logistics performance, and resilience with a specific emphasis on the insight into the impact of disruptions on the operational results of global supply chains. With disruptions becoming more common and more drastic, fuelled by natural disasters like pandemics, geopolitical tensions, climate-related events, and technological fragilities, scholars have continued to highlight the necessity of investigating how these disruptive events affect logistics systems and warehouse operations (Hung et al., 2026; López et al., 2025). The chapter gives a systematic discussion of the main ideas, empirical evidence, and theoretical viewpoints underpinning the research, which gives a detailed basis to investigate the association between disruptions and logistics performance.

The literature review is also expected to define such key concepts as supply chain disruptions, logistics performance, warehouse performance, resilience, and global performance measures like the LPI. Such definitions play a pivotal role in creating conceptual clarity and making sure that the analytical framework provided in the study meets the academic discussion of the present day (Cheng et al., 2024; Hasan et al., 2025). The chapter situates the research in the wider context of the field of supply chain management (SCM) and demonstrates the importance of warehouse and logistics performance in the context of disruptions by synthesizing the findings of empirical studies, systematic reviews, and theoretical frameworks. Lastly, the literature review determines gaps in current literature and the position of the study methodologically. Although considerable efforts have been devoted to studying the issue of supply chain disruption, minimal focus has been placed on the operational implications of this issue on the warehouse and logistics performance, especially when assessed using macro-level indicators and current empirical data (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). The chapter thus forms the foundation of filling these gaps and working out a conceptual framework connecting disruptions to both logistics and warehouse performance.

2.2 Supply Chain Disruptions

2.2.1 Definition of Supply Chain Disruptions

Supply chain disruptions can be defined as unforeseen occurrences that dramatically disrupt the usual flow of materials, information, and financial resources through supply chain networks, introducing deviations in the planned operations and putting logistics and warehouse systems to a test. Recent studies have highlighted that disruptions are not equivalent to regular variability as they bring about significant operational, financial, and strategic impacts that tend to spread through various levels since global supply chains are interconnected (Farrukh & Sajjad, 2025; Hung et al., 2026). The disruptions in modern times are determined by their unpredictability, sudden growth, and systemic nature, impacting sourcing, production, transportation, and warehousing at the same time (López et al., 2025; Yang et al., 2024). Researchers point out that pandemics, geopolitical tensions, and climate-related events, cyberattacks, or technological breakdowns can lead to disruptions, presenting distinct challenges that impact the performance of logistics and warehouses (Rodríguez-García et al., 2026; Smith & Fatorachian, 2023). With increasingly complex and interdependent global supply chains, it has become imperative to examine the characteristics and consequences of disruptions to build resilient logistics systems that can help continue operations amid volatile circumstances (Kali et al., 2025; Queiroz et al., 2022)

2.3 Shocks in Global Supply Chains (Pandemics and Geopolitical)

2.3.1 Pandemic-Induced Disruptions

Disruptions due to pandemics constitute one of the greatest shocks on global supply chains in the recent past, and the COVID-19 has revealed vulnerabilities in structures in industries and regions. The pandemic initiated massive closures of borders, transportation bottlenecks, labor shortages, and the abrupt change in demand, causing unprecedented pressure on logistics systems and warehouse activities (Agyemang & Irannezhad, 2025; MOON & CHAE, 2024). Studies have indicated that these disruptions due to the pandemic not only decreased the efficiency of logistics but also enhanced the inventory imbalances, extended lead times, and compelled companies to implement emergency measures to preserve the continuity (Hung et

al., 2026; Rashid et al., 2024). Digitalization, visibility, and flexible warehousing systems also became highly valued during the pandemic as companies with advanced technological facilities could more easily adapt to the ever-changing circumstances (Kencono et al., 2025; Mehmood et al., 2025). In general, the disruptions caused by the pandemic revealed the weakness of global supply chains and the importance of resilient logistics and warehouse infrastructures that would be able to absorb the shock and facilitate the recovery.

2.3.2 Geopolitical Disruptions

Geopolitical shocks such as trade wars, sanctions, political instability and military conflicts have become some of the significant causes of supply chain instability with great impact on the performance of logistics and the operations of warehouses. Research indicates that geopolitical shocks disrupt supply chain and logistics, raise the cost of shipping, lower shipments dependability and compel companies to redesign supply networks (López et al., 2025; Yang et al., 2024). As an illustration, the transportation of freight across Eastern Europe has been redirected, causing more customs delays, and uncertainty to global logistics activities due to geopolitical tensions (Kali et al., 2025; Touloumidis et al., 2025). These disturbances tend to have ripple effects on supply chains, impacting the upstream suppliers, downstream distributors and all warehouse operations at the same time. Due to the increased frequency and unpredictability of geopolitical risks, deciphering their implications in logistics and warehouse performance has recently begun to gain importance in the creation of resilient supply chain strategies (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024).

2.4 Performance of Warehouse and Logistics under disruption

2.4.1 The definition of Warehouse Performance

Warehouse performance can be defined as efficiency, reliability and responsiveness of operations in the warehouse, which include inventory management, order fulfilment, optimization of warehouse storage and throughput capacity. According to the modern literature, the performance of the warehouse is a multidimensional concept that depends on the operational processes and technological opportunities, the skills of the workforce, and the

environmental factors (Mehmood et al., 2025; Rushton et al., 2022). Warehouse performance is even more crucial in disruption contexts, where warehouses act as buffers that accept variability, smooth material flows, and enable recovery actions in the event of an upstream or downstream disruption (Kencono et al., 2025; Pang et al., 2025). Researchers point out that disruptions can greatly influence the performance of the warehouse by causing an imbalance in inventories, capacity issues, and labour shortages, as well as raise the processing time, which makes the continuity of the service and operation levels of the warehouse difficult (MOON & CHAE, 2024; Rashid et al., 2024). With the shift of warehouses to more automated, digitally integrated systems, it is now necessary to comprehend how warehouses respond to disruption conditions to improve supply chain resilience (Rodríguez-García et al., 2026; Sharawi et al., 2025)

2.4.2 Definition of Logistics Performance

Logistics performance is the effectiveness and efficiency of logistics systems in supporting the flow of goods, information, and services along supply chains. It is a broad spectrum of abilities, such as the reliability of transportation, efficiency of customs, the quality of infrastructure, shipment monitoring, the competence of logistics services, and timeliness (Hasan et al., 2025; World Bank, 2023). Evidence demonstrates that logistics performance is one of the determinants of supply chain competitiveness, resilience, and sustainability, affecting the responsiveness of firms and nations to disruptions and continuity of operations (Cheng et al., 2024; Koyuncu et al., 2023; Lücker et al., 2025). Disruptions tend to impact negatively on the performance of logistics through increasing lead times, decreasing the reliability of shipments, overloading transportation, and causing bottlenecks that pose a challenge on the sustainability of supply chain activities (Agyemang & Irannezhad, 2025; Sharawi et al., 2025). With the increasing interconnectedness of global supply chains and their susceptibility to external shocks, the logistics performance has become a prime area of concern among researchers and practitioners who seek to improve the supply chain resilience and performance (Farrukh & Sajjad, 2025; Kencono et al., 2025).

2.5 Measuring Warehouse and Logistics Performance during disruption

2.5.1 Logistics Performance Index (LPI)

One of the most common international measures of the national logistics performance is the Logistics Performance Index, which provides a systematic way of analysing the cases when countries help transport goods across the borders and determine their effectiveness. The LPI, created by the World Bank, consists of six dimensions, such as the efficiency of customs, the quality of infrastructure, the competence of international shipments, the competence of logistics services, tracking and tracing, and the timeliness, all of which are indicative of the crucial elements of logistics performance (World Bank, 2023). New research highlights that these metrics are not just a gauge of logistics efficiency but also a proxy of resilience because those countries with better logistics would recover faster in the event of disruption and its continuity of operations would be higher (Cheng et al., 2024; Hasan et al., 2025). Studies also indicate that the central and the most significant indicators of the LPI network are logistics service competence, infrastructure quality, and tracking capabilities, which implies that these aspects are especially significant in determining the reaction of the supply chain to disruptions (Hasan et al., 2025; Sharawi et al., 2025). The LPI offers useful information on the ways in which the national logistics systems in the context of disruption absorb and adapt to the changing conditions as well as help the global supply chains to be resilient.

2.5.2 Warehouse Performance Measurement

Performance measurement of the warehouse refers to the effectiveness, dependability and responsiveness of the warehouse activities especially in the way they manage inventory, fulfilling orders, how they use warehouse space and their throughput capacity. Researchers point out that warehouse performance is a multidimensional concept whose development depends on the functioning processes, technological abilities, the skills of the workforce, and the environmental factors (Mehmood et al., 2025; Rushton et al., 2022). The performance of warehouses is even more vital in disruption contexts when warehouses are viewed as buffers that absorb variability and stabilize material flow, as well as facilitate recovery efforts when an upstream or downstream operation is disrupted (Kencono et al., 2025; Muradzikwa et al.,

2025; Pang et al., 2025). When assessing the performance of a warehouse in the case of disruptions, one needs to consider indicators, including inventory turnover, lead time, order accuracy, processing speed, and capacity utilization that can change considerably when under stress (MOON & CHAE, 2024; Rashid et al., 2024). The new studies of Warehousing 5.0 underline the necessity of incorporating human-robot collaboration, digital monitoring, and multi-criteria evaluation models to facilitate performance and resilience in warehouses, especially in the workplace where uncertainty and rapid change are inherent (Rodríguez-García et al., 2026; Sharawi et al., 2025). Such advances underscore the importance of broad-based performance measurement frameworks that can both record operational efficiency, as well as adaptive capacity.

2.6 Resilience in Supply Chains and Responses to Operations.

2.6.1 Definition of Resilience

Supply chain resilience is the capacity of a supply chain to predict, absorb, adapt, and recuperate disruptions and keep operational performance or swiftly recover it. Recent studies underline the fact that resilience is not a reactive capacity but a dynamic, tactical feature, which allows supply chains to operate successfully in the conditions of volatility, uncertainty, complexity, and ambiguity (Hosseini Shekarabi et al., 2025; Hsieh et al., 2023; Ivanov, 2022). Researchers emphasize that resilience is a multi-dimensional concept that encompasses robustness, agility, flexibility, redundancy, and collaboration all to assess the ability of the supply chain to endure shocks and be continued (Farrukh & Sajjad, 2025; Kencono et al., 2025). Resilience in disruption contexts is directly connected to logistics and warehouse operations since they serve vital roles in stabilizing the material flows, inventory variations and recovery efforts (Habibi et al., 2025; Mohammed et al., 2025; Rushton et al., 2022). With the increased interconnectedness of global supply chains and their susceptibility to external shocks, the notion of resilience has become a key topic in supply chain studies as a manifestation of the necessity to have systems capable of adapting to swiftly evolving conditions and maintaining performance despite stress (Gesese & Singh, 2025; López et al., 2025; Yang et al., 2024).

2.6.2 Resilience Strategies

The idea of resilience strategies is broad and includes various practices that can improve the capacity of the supply chain to act in response to disruptions, such as redundancy, agility, collaboration, digitalization, diversification, and scenario planning. Redundancy entails keeping extra capacity, inventory, or suppliers to temporarily absorb changes whereas agility is the capacity to respond swiftly to alterations in need or provision of supplies (Farrukh & Sajjad, 2025; Hosseini Shekarabi et al., 2025). Teamwork (internal and external) is a highly important aspect of improving visibility, information dissemination, and response coordination to help the supply chains better deal with disruptions (Hung et al., 2026; Queiroz et al., 2022; Stentoft & Mikkelsen, 2024). Another important resilience measure is the introduction of digitalization, where technologies like real-time monitoring, predictive analytics, and automation enhance visibility, decision-making, and flexibility in operations (Duong & Chong, 2020; Mohammed et al., 2025; Rashid et al., 2024). Scholars underline that the strategies of resilience have to be specific to the particular features of disruptions because various kinds of shocks demand various responses: pandemics, geopolitical tensions, and climate-related events (Agyemang & Irannezhad, 2025; López et al., 2025). In general, resilience strategies can be decisive in increasing logistics and warehouse performance in case of disruptions and help in maintaining the stability of supply chains in the long term.

2.6.3 Leadership and Resilience

The role of leadership in the development of the supply chain resilience is great, especially in the decision-making, communication, and strategy during disruptions. According to the recent studies, transformational, participative, and crisis-oriented leadership are among the leadership styles that alleviate the adverse effects of disruptions on the logistics innovation and performance (Ali et al., 2024; Farrukh & Sajjad, 2025). Good leaders create an atmosphere of flexibility, promote teamwork, and facilitate the use of digital technologies, which will help them be more resilient (Kencono et al., 2025; K. Shahzad & Imran, 2021). Resilience strategies are another area impacted by leadership since leaders can be instrumental in resource allocation, prioritization of initiatives, and coordination of responses across the supply chain functions (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). Strong leadership is also

needed to sustain the continuity of operations, workforce stability, and recovery efforts in the context of disruption, which underscores its role as a key facilitator of supply chain resilience (López et al., 2025; Yang et al., 2024).

2.7 Research Gap and Positioning of Methodologies

Even though the available literature offers valuable information on supply chain disruption, resilience measures and logistics performance, it has a few critical gaps that present the rationale of conducting this study.

To begin with, although disruptions have been extensively studied at the strategic, macroeconomic and network levels, there is a lack of studies that specifically consider the operational impacts of disruptions on the performance of warehouses and logistics. Most of the existing literature focuses on high-level frameworks, conceptualization, and strategic responses, but the impact on operations at a daily level, including inventory instability, throughput cuts, capacity pressure, and logistics performance decline, have not been well explored (Hasan et al., 2025; Sharawi et al., 2025). This disconnect is especially noteworthy since at the operational level, where warehouses and logistics systems take the first hit, the consequences of shocks, in turn, are usually apparent, and the survival of supply chain flows depends on them (MOON & CHAE, 2024; Rashid et al., 2024). The absence of operational analysis makes it impossible to develop targeted interventions that can enhance logistics resilience by the firms and policymakers.

The second gap is related to the fact that macro-level performance indicators, including the LPI, are rarely used in disruption-centered studies. Despite the popularity of LPI as a tool used to measure how well the countries logistics capabilities, there is a shortage of literature that investigates the impact of disruptions on the elements of LPI over time, and how shifts in logistics performance are indicative of larger trends in supply chain instability (Cheng et al., 2024; Hasan et al., 2025). Current studies tend to view the LPI as a fixed indicator instead of a dynamic one that can reflect the changing effects of a global shock (pandemic, geopolitical conflicts, climate-related occurrences, etc.) (Agyemang & Irannezhad, 2025; López et al., 2025). This poses a methodological gap because the LPI is an effective tool to explain the

impacts disruptions have on logistics systems on a national scale. Literature will not be able to capture systemic vulnerabilities that determine the performance of operations without including macro-level indicators.

The third gap is due to the disjunction in literature between the qualitative and quantitative viewpoints. Although qualitative research offers valuable information on firm-level experiences in the context of a disruption, including labour shortages, delayed shipments, and stockpile imbalances, it is often not related to macro-levels of logistics performance or national-level resilience measures (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). On the other hand, quantitative research usually concentrates on general performance patterns without reflecting the finer details of operations of warehouses and logistic managers. This discussion constrains the building of integrated frameworks that portray the complete range of disruption effects along the layers of the supply chain. With increased disruptions, both in type and intensity, comes the necessity of the research-integration of micro-level operational issues with macro-level performance trends to have a holistic view of supply chain vulnerability and resilience (Hosseini Shekarabi et al., 2025; Kencono et al., 2025). Lastly, literature has shown that there is a gap in methodology in terms of the time aspect of disruptions. Numerous studies analyse after the disruptions or single events, whereas the interaction of disruptions of various types is not analysed over time or how cumulative shocks of different types affect the logistics performance (Hung et al., 2026; Kali et al., 2025). This restricts the capacity to learn about the resilience trends in the long run and the dynamic character of operational vulnerabilities. Since the number of disruptions is rising (both geopolitical disturbances and climate-related ones), the research synthesizing the existing results in various types of disruptions and studying their interconnected impact on warehouses and logistics is required.

This study addresses these gaps by adopting a mixed-methodological approach of research that combines macro-level and performance indicators, qualitative insights at the firm level, as well as the current empirical literature. The quantitative aspect evaluates the alterations in the indicators of the LPI to capture systemic effects of disruptions at the national scale, and the qualitative aspect is based on semi-structured interviews to investigate operational

challenges in warehouses and logistics systems. Integrating knowledge at different levels of analysis and specifically addressing the operational implications, the study offers a holistic understanding of the impact of disruptions on the performance in warehouses and logistics in a period of increased volatility.

2.8 Literature and conceptual framework synthesis

The literature analyzed in this chapter proves that the disruption of supply chains has become a multidimensional phenomenon with great pressure on logistics systems and the work of warehouses. In the literature, disruptions are depicted to be caused by different sources, such as pandemics, geopolitical unrest, climate-related incidents, and technology failures, among others, all of which pose their own peculiarities affecting material flows, decreasing the reliability of transportation, and putting pressure on the capacity of warehouses (Hung et al., 2026; López et al., 2025). Researchers continuously emphasize that disruptions are spreading quickly through the interconnected network of supply chains, triggering a series of events, which intensify the operational instability and the inability of firms to continue operations (Kali et al., 2025; Queiroz et al., 2022). This synthesis shows that disruptions are no longer isolated but systemic shocks that need to be responded to using an integrated approach to logistics and warehousing functions.

The critical role of logistics performance in deciding the extent to which supply chains can respond to disruptions is also highlighted in the literature. Research highlights that the logistics performance metrics, including the quality of infrastructure, the efficiency of customs, the visibility, and competence of logistics services are the most important elements of resilience, as they determine how fast, visible, and reliable supply chain operations will be during crises (Hasan et al., 2025; Sharawi et al., 2025). On the same note, the performance of warehouses as a crucial operational factor has been identified, and studies have revealed that warehouse serves as buffers that take in variability, stabilize inventory flows, and aid recovery efforts in the event that upstream or downstream operations are impaired (Mehmood et al., 2025; Pang et al., 2025). The logistics and warehouse performance integration is thus crucial to understanding the implications of disruptions on operational performance and ways to become more resilient.

In addition, the literature emphasizes the significance of resilience strategies including redundancy, agility, collaboration, and digitalization to reduce the effects of disruptions and sustainability of operations. Researchers believe that the notion of resilience is a dynamic capability, which allows supply chains to anticipate, absorb, adapt to, and recover disruptions, and logistics and warehouse functions are at the epicenter of the process (Farrukh & Sajjad, 2025; Hosseini Shekarabi et al., 2025). Digital technologies are demonstrated to improve the visibility of firms, their decision-making, and flexibility of operations, allowing the companies to react to the rapidly evolving situation more efficiently (Mehmood et al., 2025; Rashid et al., 2024). The collection and synthesis of these understandings proves that resilience is not one-dimensional strategy but a multi-dimensional one that necessitates coordinated actions on the functions of a supply chain.

The conceptual framework formulated based on literature combines the use of three fundamental elements:

i. types of disruption of the supply chain
ii. influences the performance of logistics and warehouses, and
iii. resilience measures which buffer these effects.

The framework shows how the disruptions affect the logistic performance indicators and logistics of a warehouse, and the resilience strategies increase the capability of the supply chain to stay on track and recover post-shocks. This framework gives a systematic basis of the analytical nature of the consequences of disruptions in operations and the objective of the study to comprehend the impacts of disruptions on the performance of warehouses and logistics.

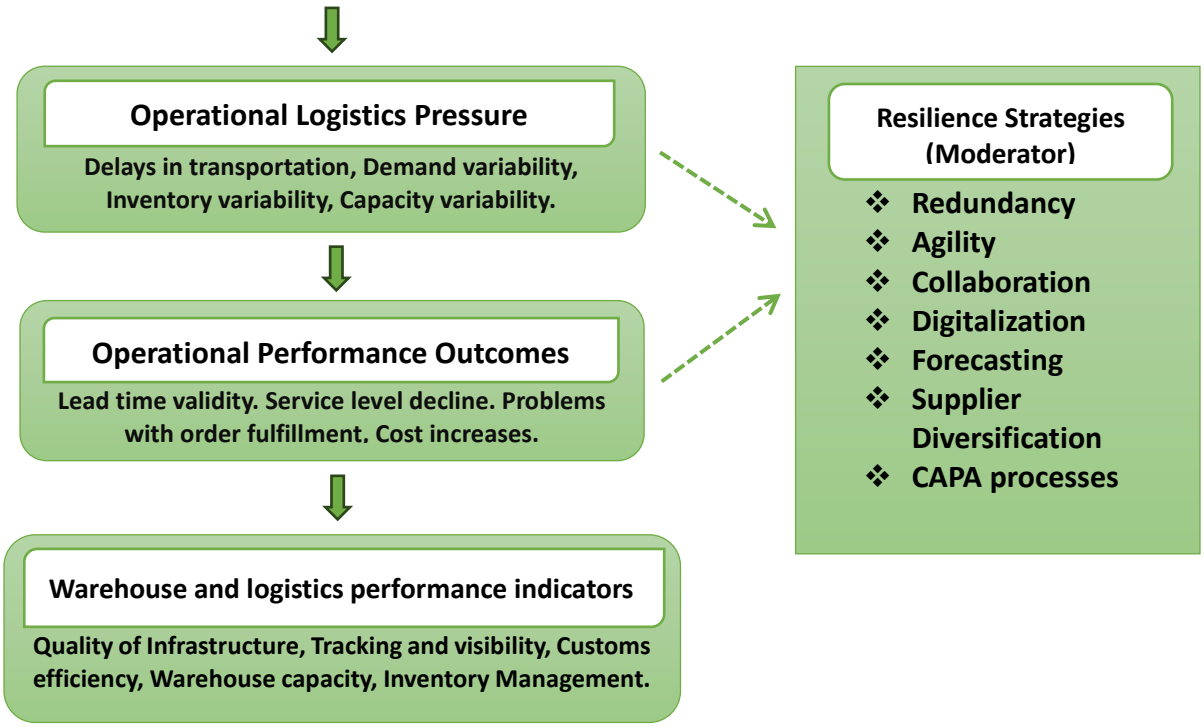

Figure 1. Theoretical Framework of Supply Chain Disruptions

2.9 Research Assumptions

In this research, a few assumptions will be used as the basis of analysis and interpretation of the results. First, based on the assumption, the supply chain disruptions can be characterized by the fact that they affect the logistics and warehouse performance, which are measurable and observable and can be analysed with the help of modern literature and global performance indicators, including the Logistics Performance Index (Cheng et al., 2024; Hasan et al., 2025). This supposition is confirmed by many studies that prove that disruptions affect the reliability of logistics, efficiency of transportation, stability of inventory, and throughput in warehouses (MOON & CHAE, 2024; Rashid et al., 2024). By taking the assumption that disruptions generate recognizable patterns of operation, the study can generalize findings among various contexts and come up with a holistic view of the effects of disruption.

Second, the research presupposes that resilience measures are crucial to the moderation of the impact of the disruptions on the logistics and warehouse performance. It is also always

demonstrated that the resilience strategies, including redundancy, agility, collaboration, and digitalization, can increase the shock-absorbing capacity of the supply chain, continuity, and recovery of disruptions (Farrukh & Sajjad, 2025; Hosseini Shekarabi et al., 2025). This supposition is consistent with the larger body of supply chain resilience literature, which highlights that resilience is a dynamic capability that can be used to make supply chains flexible to swiftly evolving circumstances and stay functional during stressful situations (Ivanov, 2022; Yang et al., 2024). The study can investigate the interaction of the resilience strategies with logistics and warehouse performance in the event of disruption by assuming that resilience strategies affect the performance of the operations.

Third, the research presupposes that macro-level variables like the LPI give valuable information about the national logistics potential and reaction to disruptions. Although the LPI possibly does not reflect operational nuances of a firm, it provides important data on the wider logistics context that firms can operate in, such as the quality of infrastructure, efficiency in customs, and the competence of logistics services (Sharawi et al., 2025; World Bank, 2023). This supposition enables the work to combine macro-level performance patterns and micro-level operational data to have a more comprehensive view of the effects of disruption. Lastly, the analysis presupposes that up-to-date literature of 2020-2026 will be the most applicable and relevant in terms of disruptions, logistics performance, and resilience due to the radical changes in global supply chains over the past five years. Besides that, the analysis draws on the data of LPI in 2018 and 2023 to record the pre and post disruption situation, which will make it possible to compare the performance of logistics in the past and present over time.

2.10 Overview of the Chapter

The chapter has reviewed thoroughly the available literature on supply chain disruptions, logistics performance, warehouse performance, and resilience providing a detailed discussion of the main concepts, empirical and theoretical viewpoints that underpin the study. The chapter started by identifying the meaning of supply chain disruptions and discussing their nature, emphasizing how the contemporary disruptions, which include pandemics,

geopolitical conflicts, climate-related disruptions, and technology failures, pose huge challenges to the logistic systems and warehouse operations (Hung et al., 2026; López et al., 2025). It subsequently discussed the effects of disruptions on logistics and warehouse performance, the significance of logistics performance indicators and warehouse capabilities in keeping operational continuity during crises (Hasan et al., 2025; Mehmood et al., 2025).

The chapter also discussed the strategies of resilience, showing how redundancy, agility, collaboration, and digitalization can improve the capacity of the supply chain to react to disruptions and aid recovery (Farrukh & Sajjad, 2025; Kencono et al., 2025). This synthesis of the insights of the modern literature has revealed the main gaps in the current literature, especially the lack of integration between the macro-level performance indicators and the operational studies of the warehouse and logistical performance (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). The chapter has ended with a conceptual framework that combines the disruptions, logistics performance, warehouse performance and resilience strategies, which serves as an analysis framework in the later chapters.

Overall, the literature review provides the theoretical and empirical premises of the study, showing that more in-depth knowledge of how disruption impacts warehouse and logistic performance, as well as the role of resilience to increase the stability of the supply chain, is required. The presented insights inform the research methodology and will be used to develop a detailed analysis of the impact of disruptions in the following chapters.

3 Methodology

3.1 Introduction

This chapter introduces the methodological framework that informs the study, describes the philosophical assumptions, research methodology, research design, data sources, data collection process, analytical methods and ethical issues that form the basis of the study. Awareness of research philosophy is crucial as methodological decisions should be made according to the prior assumptions regarding the nature of knowledge and reality (Saunders et al., 2023). Since the study seeks to determine the impact of supply chain disruptions on the performance of warehouses and logistics, there is the need to adopt a strong and multi-layered methodology that is capable of capturing both macro-level trends that are manifested in the global logistics indicators and the micro-level operational reality that industry participants face (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024).

The chapter thus takes the form of a mixed-method design combining both the quantitative analysis of secondary data and the qualitative data that are collected in form of primary data. The quantitative component utilizes the data on the LPI and GDP per capita of 2018 and 2023 provided by the World Bank and allows conducting a comparative evaluation of the logistics performance in the past and present due to the significant global disruptions like the COVID-19 pandemic and geopolitical tensions. These data offer a solid base upon which statistical relationships, performance trends and structural changes can be identified in 134 countries (Hasan et al., 2025; Sharawi et al., 2025; World Bank, 2023). The qualitative aspect that is complementary to the quantitative analysis is a series of five interviews with professionals working in five different companies from Finland which work at the end of global supply chains. The insights obtained during these interviews allow practitioner-level understanding of the impact of disruptions on warehouse operations, logistics performance, and resilience strategies, which would not be possible solely through numerical data. With the combination of both the methodological elements (quantitative and qualitative), the study gains more explanatory power and makes sure that the findings are based on both empirical data and the real-life experience. The chapter thus defines the methodological rigor required to answer the

research objectives and gives a clear description of data collection, analysis as well as interpretation of the data.

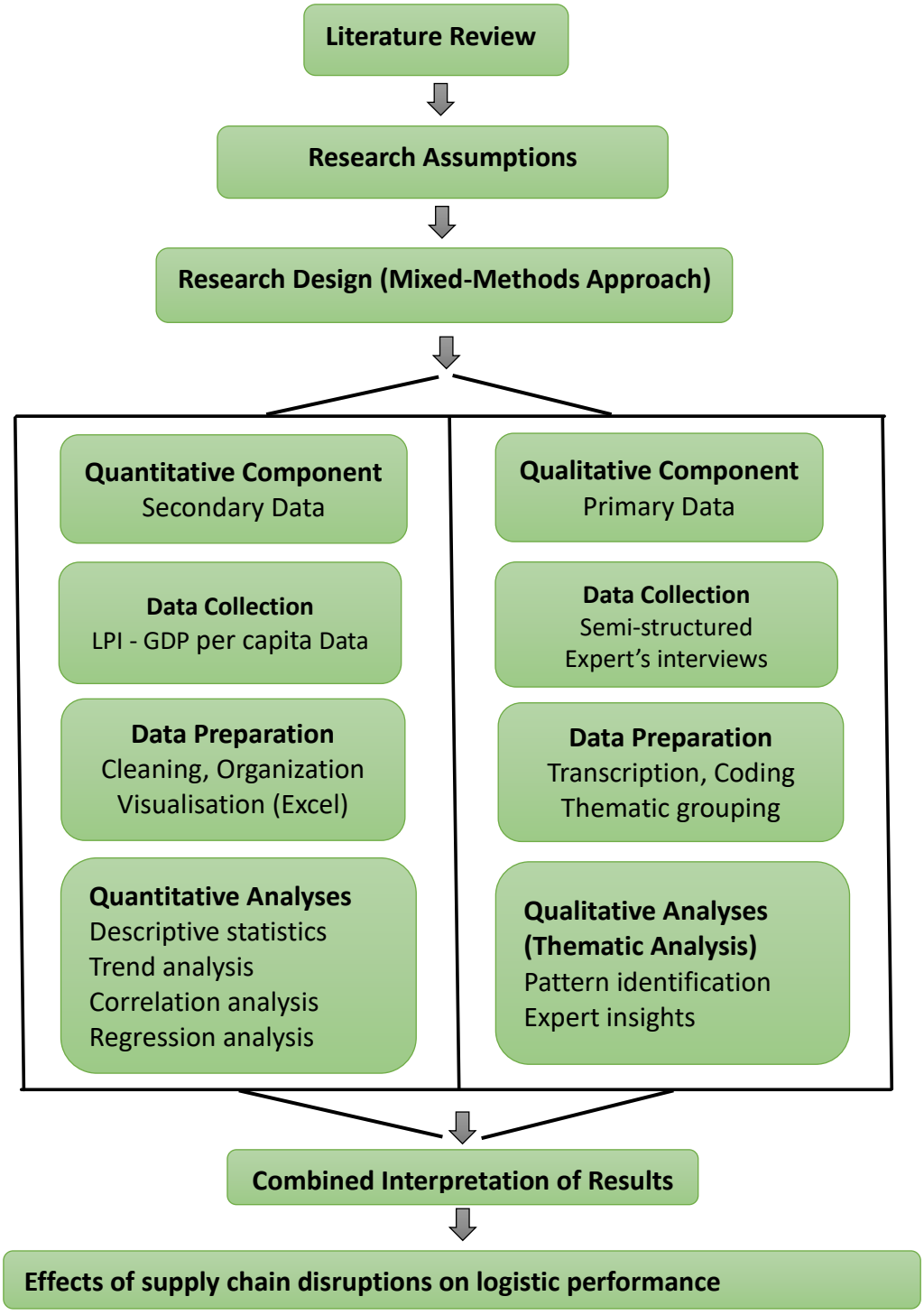

Figure 2. The methodological framework of the study

This paradigm outlines the overall research process including theoretical formulation to the analysis and interpretation of results.

3.2 Research Philosophy

This study has a post-positivist philosophical orientation because it takes the reality that there is an objective reality, but it can only be perceived in an imperfect manner because social, economic, and operating systems are too complex. Post-positivism is especially suited to the studies that have a combination of statistical analysis and interpretative insights, as it acknowledges the importance of empirical measurement but also accepts the fact that knowledge is context-dependent, uncertain, and subject to interpretation (Creswell, 2014; Guba & Lincoln, 1994; Saunders et al., 2023). Such a philosophical position corresponds to the quantitative aspect of the research that utilizes statistical methods including descriptive analysis, correlations, regressions, paired samples t-tests to analyze the relations between the indicators of logistics performance and the variables of the economy. These methods are indicative of the post-positivist focus on probable reasoning, empiric testing, and seeking approximate truths as opposed to certainty.

Simultaneously, the research has some interpretivist touches to facilitate the qualitative aspect, which aims to comprehend the experiences of practitioners and organizational reactions to disruptions via semi-structured interviews. Interpretivism focuses on the significance of context, meaning, and subjective understanding, which is why it is highly appropriate to understand how logistics professionals conceptualize disruptions, challenges at a warehouse, and resilience strategies (Crotty, 2020; Gannon et al., 2022). The interpretivist approach enables the research to include detailed information of five semi structured interviews with professionals in Organisation 1, Organisation 2, Organization 3, Organisation 4 and Organization 5 to supplement the statistical trends detected in the quantitative analysis. Such a dual philosophical basis is indicative of the multi-faceted nature of supply chain disruptions that include quantifiable performance variations and human-influenced reactions. The post-positivist and interpretivist principles are merged in this way to enrich the findings, as the study takes a philosophical pluralism that promotes flexibility in methods and makes the findings more comprehensive. This pluralistic position especially suits mixed-method research because it will enable the research to combine the numerical trends with experiential

knowledge and thus give a more in-depth insight into the impact of disruption on logistics and warehouse performance (Creswell, 2014; Saunders et al., 2023). The philosophical framework thus enhances the methodological soundness of the study, and its method of analysis is consistent with its research purposes.

3.3 Research Approach

The research is based on a mixed-method type of research which is the combination of quantitative analysis of secondary data and qualitative analysis of primary data to give a multi-dimensional view of the effects of supply chain disruptions on the performance of the warehouse and logistics. This method is explained by the fact that disruptions are complex phenomena that need both empirical measurements and interpretations in the context to be fully comprehended. The quantitative part predominates, as it portrays the wide statistical analysis done on the data of **LPI and GDP per capita of 134 countries** in two periods of time (2018 and 2023). This aspect allows the study to determine macro-level trends, quantifying differences in logistics performance, and analysing how economic conditions and logistics capabilities are related to each other (Cheng et al., 2024; Hasan et al., 2025). Using 2018 and 2023 data, the analysis of the research can capture both pre- and post-disruption trends and provide an understanding of how global shocks transform logistics systems.

The qualitative component is a built-in support component and is at the practitioner level, offering complementary insights to the quantitative results. The five semi structured interviews present practical insight into the impacts of disruption on the operations of the warehouse, the performance of logistics and the resilience strategies. These insights can be used to fill a gap in the literature that has shown a lack of integration between quantitative and qualitative views, which suggests a gap between macro-level indicators of performance and micro-level realities of operations (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). The qualitative data also contribute to the explanation of the statistical findings as it gives the explanation to the observed trends, i.e., the change in logistics competence, timeliness, or the infrastructure performance.

The mixed-method design increases the explanatory ability of the study, through triangulation, where results of one technique confirm or add to results of the other. This combination enhances the plausibility, richness and solidity of the research so that the findings are based on empirical data as well as experience on the part of the practice. The research methodology is suitable to the aims of the study and offers a comprehensive view of the impact of disruptions on the logistics and the performance of warehouses by delivering the quantitative rigor and qualitative depth of the research.

3.4 Research Design

The research design is mixed-method research, which combines both the quantitative secondary data analysis and the qualitative data collection of primary research to give a holistic view of the effects of supply chain disruptions on logistics performances. The mixed-method type of research design is especially appropriate when researchers need to address a complex question since the design of such study enables researchers to embrace the benefits of quantitative measurement and the richness of qualitative interpretation (Creswell, 2014; Tashakkori et al., 2021). The design fits well with the philosophical approach adopted in the study, in which the various types of evidence are seen as adding to the overall comprehension of social and operational phenomena (Gannon et al., 2022; Saunders et al., 2023).

The quantitative part is a comparative longitudinal study, analysing the evolution of the logistics performance of 2018 and 2023 based on the World Bank data on the Logistics Performance Index (LPI) and Gross Domestic Product (GDP) per capita. Longitudinal designs can be used when the objective is to measure the evolution of conditions over time and the desire to evaluate the change of a condition at various time points (Creswell, 2014; Saunders et al., 2023). Such a structure is especially applicable, in the light of the significant global disruptions that have taken place over the past years, which have impacted the logistics systems of the whole world in a major way (Agyemang & Irannezhad, 2025; Hung et al., 2026). The design will allow identifying the structural changes in logistics performance and economic conditions by comparing two different time points.

Besides its longitudinal aspects, the research design has a cross-sectional dimension since the LPI and GDP per capita data sets have 134 countries per year. Cross-sectional designs enable researchers to analyse the differences across the units at one moment, which is why they are appropriate to determine the differences between countries with different logistics infrastructures, economic systems, and resilience levels (Saunders et al., 2023). This heterogeneity is necessary to comprehend the differences between the impact of disruptions on countries and recognise patterns that could remain hidden in a longitudinal study only design or in cross-sectional design only (Cheng et al., 2024; Sharawi et al., 2025). The longitudinal and cross-sectional combination boosts the analytical rigor of the study and improves the possibility of conclusion to various contexts.

The qualitative part of this research is designed as an integrated section of the mixed-method design, encompassing five semi-structured interviews with the professionals working in organizations representing various and strategically significant sections of global supply chains. Embedded qualitative designs enable researchers to incorporate contextual knowledge into a largely quantitative model, which will better interpret statistical results and add a layer of meaning that cannot be achieved through numerical data (Creswell, 2014; Tashakkori et al., 2021). The chosen organizations provide practitioner insights to help understand the impact of disruptions on the work of the warehouse, logistics performance, coordination of production, and resilience approaches on the firm level.

The integration of qualitative understandings into the larger research design facilitates the methodological triangulation as well since evidence of various sources can be utilized in validating and enriching the results (Creswell, 2014; Saunders et al., 2023). This combination enhances the validity and depth of the study in that it makes sure that the macro-level quantitative patterns are discerned with the micro-level operational experiences. The research design offers a strong background to the study of the impact of disruptions on logistics and performance of warehouses by integrating both quantitative and qualitative evidence in a consistent mixed-method framework.

3.5 Data Sources

3.5.1 Quantitative Data Sources

The quantitative part of the research is based on the secondary source of data that is the LPI of the World Bank and GDP (per capita) data of 2018 and 2023 (World Bank, 2023). LPI is a well-known international scorecard that evaluates the national logistics potential in six dimensions, namely, the customs efficiency, the quality of infrastructure, the international shipments, the logistics competence, tracking and tracing, and timeliness (Hasan et al., 2025; World Bank, 2023). These indicators offer a full picture of the logistics performance and are especially applicable in the analysis of the impact of disruptions on the supply chain operations at the national scale. The choice of 2018 and 2023 will enable the research to compare the logistics performance prior to and following major world disruptions, such as the COVID-19 pandemic, geopolitical tensions, and climate-related incidents that had a significant effect on global supply chains during the timeframe (Kali et al., 2025; López et al., 2025).

The years 2018 and 2023 were chosen because the LPI is not released every year; the 2023 release is the first release since 2018, so these are the latest similar datasets to be used. The World Bank also provided GDP per capita data on the same years, which could offer a measure of the national economic performance, which is closely related to logistics capabilities. The concept of GDP per capita is prominent in supply chain studies because it is an indicator of economic power, potential to invest in infrastructure, and market activity. Through the correlation of GDP (per capita) with LPI, the study will determine the impact of economic conditions on the logistics performance and how such disruption can change the correlation in the long run. The quantitative data are reliable, comparable, and transparent because of the standardized, publicly available datasets, which helps to guarantee the methodological rigor of the study. The quantitative data in this study were all sourced through the World Bank Open Data platform that offers publicly available and standardized indicators in the world.

3.5.2 Qualitative Data Sources

The qualitative part of the research relies on five semi-structured interviews with the professionals from Finland. The sample of these organizations was chosen by purposive sampling since they constitute various and strategically significant areas of world supply chains such as industrial automation, global logistics services, marine and energy technology, electrical equipment manufacturing and international transport coordination. They are operationally exposed to supply chain disruptions, which puts them in a good position to offer practitioner-level insights into the impact of disruptions on the operations of a warehouse, logistics performance, production coordination, and resilience strategies.

Every organization brings their own insight:

- Organization 1 provides the information on manufacturing processes, automation, and warehouse-related issues.
- Organization 2 offers a transport-delays perspective on transportation delays, routing delays, and delivery delays.
- Organization 3 brings with it insights into large-scale industrial production, global sourcing, and continuity of business operations.
- Organization 4 offers knowledge on international transportation, customs, and international routing interruptions.
- Organization 5 provides the perspective of inter-unit coordination, the problem of material flows, and the logistics of operations in the marine-energy sector.

The themes covered in the interviews included disruption experiences, warehouse challenges and the effects of logistics performance, resilience strategies and organization responses. Semi-structured interviews were selected due to their flexibility to seek more and more on the issues of interest and consistency among participants. This method is mostly suggested in qualitative studies, because semi-structured interviews allow the researcher to get the meaning, experience, and interpretation of the participants in a flexible but systematic way (Creswell, 2014; Saunders et al., 2023). The qualitative data give contextual information that supplements the quantitative results and serves to fill the gap between the macro-level performance indicators and the micro-level operational realities.

3.6 Data Collection Procedures

3.6.1 Data Collection Procedures: Quantitative

The process of quantitative data collection had several systematic procedures that would guarantee accuracy, consistency, and readiness to analyse it. To begin with, the LPI and GDP per capita data were downloaded directly from official database of the (World Bank, 2023) which guarantees using authoritative and reliable sources. GDP (per capita) is a continuous numerical variable that is expressed in constant US dollars and not based on Likert scales or sub-factors. It is a sum of goods and services created in a country, and it is given as one aggregated economic variable. After downloading the values in the World Bank database, the GDP per capita values were manually entered into the Excel file. The dataset was then loaded into Microsoft Excel and SPSS to clean and prepare them. Data cleaning was done by ensuring that there were no missing values, inconsistencies, and differences in countries in the two years. To ensure comparability of results across the analyses, the countries with incomplete data were dropped to end up with a final sample size of 134 countries in both years.

Second, variables were standardized and labelled distinctly to make them easy to analyse. The LPI elements were divided into single variables: customs, infrastructure, international shipments, logistics competence, tracking and tracing and timeliness, which permitted in-depth analysis of the change in certain logistics dimensions. The values of GDP (per capita) were also standardized to have uniformity of units and formatting. After cleaning the datasets and aligning them, they were combined into one file to make comparisons of the data pairs, analysis of correlations and regression analysis. The preparation of structured data provided this structured data preparation with the guarantee of quantitative analysis based on the accurate, consistent, and analytically sound data.

3.6.2 Data Collection Procedures: Qualitative

The process of the qualitative data collection was based on five semi-structured interviews with the (Organization 1-5) professionals. Participants requested that the names of companies be anonymized, which is why they are anonymous. The participants were approached through

email and given a brief of what the study was all about and its purpose and the themes to be discussed. Upon giving informed consent, interviews were set at a time that was at the convenience of each participant. Each session (lasting about 30-40 minutes) was conducted online in Zoom or Microsoft Teams, depending on the preference of the participants.

An interview guide was created to maintain a uniformity among all interviews and to give the participants the freedom to expound on their experiences. The guide contained open-ended questions about the disruption of the supply chain, problems in the warehouse, the effect of logistics on the performance and resilience strategies, and the organizational response. During and right after every interview, notes were taken to capture important findings, and all the data were kept in confidence to protect the privacy of the participants.

This methodical and ethically based approach guaranteed the validity and applicability of the qualitative information. The five interviews represented varied practitioner views that add to the analysis of quantitative results and enhance the capacity of the study to relate the macro-level logistics performance patterns with the operational realities in the firms.

3.6.3 Comparison of Qualitative and Quantitative Methods in this study

Aspect	Qualitative Research	Quantitative Research
Focus	Knowledge of supply chain disruptions, logistic issues, and operational experience	Comparing logistics performance indicators (LPI) both before and after significant events in the world and analyzing their correlation with the economic state of the world.
Type of data	Non-numerical (interview answers, professional opinions)	Numerical (LPI scores, GDP per capita data, statistical outputs)
Sample	5 industry professionals	134 countries (2018 and 2023)
Data collection method	Semi-structured interviews with industry experts	Secondary data from World Bank LPI and GDP per capita data
Data analysis technique	Thematic analysis and interpretation of responses	Statistical analysis (descriptive statistics, correlation, regression, paired t-test)
Research questions	Exploratory: How disruptions affect logistics and operations	Confirmatory: What were changes in logistics performance indicators when there were big disruptions in the world in 2018 and 2023?

Purpose of this study	To describe real-world consequences of disruptions and determine operational issues	To identify and quantify changes in logistics performance during the disruption period
Strengths	Gives depth, context, and practical insights from industry professionals	Gives objective, generalizable, and statistically validated results
Limitations	Limited sample size, potential subjectivity	May overlook contextual and operational complexities
Application	Explaining the effects of disruption, resilience strategies, and operational issues	Identifying logistics performance trends and examining disruption-related changes across countries

Table 1. A comparative overview

To explain more the combination of qualitative and quantitative approaches that have been employed in this research.

3.7 Variables and Measures

The analysis is based on a systematic list of variables to determine the effect of supply chain disruptions on logistics and warehouse operations in different countries. The dependent variable of the quantitative part is a composite measure created by the World Bank called the LPI, which assesses the national logistics capacity on six dimensions: customs efficiency, infrastructure quality, international shipments, logistics competence, tracking and tracing and timeliness. The LPI is a good proxy to measure the logistics performance during disruption conditions, with all these dimensions describing the efficiency, reliability, and responsiveness of the logistics systems (Cheng et al., 2024; Hasan et al., 2025). The LPI components are examined individually to give a more in-depth picture of the change in the general LPI score. This disaggregation is fundamental since the disruptions might affect some logistics dimensions more than the rest- such as timeliness might decrease because of border closures, and infrastructure scores might not change or even get better because of long-term investments.

The explanatory (independent) variable is GDP per capita to investigate its relationship with logistics performance. Since disruption intensity is not directly observable through a single

global dataset, this study captures its effects indirectly by comparing logistics performance before and after major global disruptions using LPI data. GDP (per capita) is also a contextual variable of the general economic capacity that can affect investment in logistics infrastructure and capabilities (Agyemang & Irannezhad, 2025; Sharawi et al., 2025). The study explores by comparing GDP (per capita) with LPI scores with the view to addressing possible relationships between economic circumstances and logistics performance but does not suggest a causal relationship. Inclusion of the GDP per capita also enables the study to examine whether disruption was more specific to countries with less economic potential hence leading to inequalities in logistics performance in the world. The study concentrates on thematic variables in the qualitative component of the study based on semi structured interviews. These variables comprise experiences of disruption, challenges of the warehouse, logistics performance effects, resilience strategies, and organizational responses. These topics were chosen according to the gaps that were revealed in literature, and they suggest the necessity of further insight into the impacts of disruptions on the operational realities at the firm level (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024). The qualitative results also provide insights into the impact that economic and infrastructural differences have on organizational reactions to disruption and logistics performance. The quantitative and qualitative variables combine to form a holistic analytical system that can capture macro-level performance patterns, as well as micro-level operational knowledge.

Variable	Type	Description	Source
Customs Efficiency	Dependent	Efficiency of customs clearance operations, such as swiftness and easiness of border operations	World Bank LPI
Infrastructure Quality	Dependent	Quality of trade and transport infrastructure including ports, roads, and ICT systems	World Bank LPI
International Shipments	Dependent	Ease and affordability of international shipments organization	World Bank LPI
Logistics Competence	Dependent	Quality and competence of logistics services (e.g., transport operators, freight forwarders)	World Bank LPI
Tracking & Tracing	Dependent	Capability to track and trace the consignments along the supply chain	World Bank LPI
Timeliness	Dependent	Frequency of making shipments to destination within scheduled/anticipated delivery time	World Bank LPI
Gross Domestic Product (GDP)	Independent	Gross domestic product (GDP) per capita is an explanatory variable used to represent economic conditions. It does not explicitly capture logistics investment but serves as a	World Bank Open Data

		proxy for the overall level of economic development of a country, which is potentially linked to other development indicators, such as logistics performance (Koyuncu et al., 2023).	
Disruption Experiences	Qualitative	Disruption types and causes (e.g., geopolitical tensions, strikes, material shortages, routing problems)	Interviews
Warehouse Problems	Qualitative	Operational problems like capacity, inventory and material availability problems	Interviews
Logistics Performance Effects	Qualitative	Effects of disruptions on logistic operations, such as delays, urgent shipments, and variable inventory levels	Interviews
Resilience Strategies	Qualitative	Measures to reduce disruptions, including buffer stock, multi-sourcing, forecasting and proactive coordination	Interviews
Organizational Responses	Qualitative	Firm-level operational responses, communication patterns, and coordination systems of disruptions in the organization	Interviews

Table 2. The key variables of empirical analysis

3.8 Data Analysis Techniques

Supply chain disruption is studied using both quantitative and qualitative approaches of analysis to determine the effect on logistics and warehouse performance. The quantitative analysis will be initiated by descriptive statistics, which will summarize the central tendencies and variability of the values of LPI and GDP per capita of 2018 and 2023. These statistics give a general picture of the changes in performance by different countries and give possible trends that should be investigated further. Subsequently, paired samples t -tests are made to determine whether the differences in LPI scores and their components between 2018 and 2023 are significantly different. The method is suitable since it involves comparing two related data sets, i.e. pre-disruption and post-disruption values of the same countries, which will enable the study to draw a conclusion on whether disruptions had quantifiable effects on the logistics performance (MOON & CHAE, 2024; Rashid et al., 2024).

The study also calculates effect sizes to supplement the t -tests are used to measure the magnitude of performance change. Effect sizes can be crucial to understanding the practical implications of statistical differences, especially in large datasets where small differences can be statistically significant but operationally insignificant (Saunders et al., 2023). Pearson

correlation analysis is also carried out in the study to analyse the strength and direction of the relation between GDP (per capita) and LPI in both years. Through this analysis, it is possible to understand whether economic performance is always related to logistics capabilities and whether disruptions had a change in this relationship. Lastly, simple linear regression models are employed to evaluate the predictive ability of GDP per capita on LPI, which give an idea on how economic conditions affect logistics performance on a national level. These quantitative methods are consistent with recommended statistical procedures (Saunders et al., 2023).

The qualitative analysis will use a thematic analysis technique, which consists of coding of interview transcripts to determine common themes, patterns and understandings. This approach would be appropriate in semi-structured interviews since it would enable a systematic interpretation of the experience of participants, but it would not reduce the richness of the qualitative data (Creswell, 2014). The analysis starts with open coding, which aims at extracting the initial concepts and then with the axial coding, which is used to group similar concepts into general themes like disruption impacts, warehouse challenges, and resilience strategies. This structure follows established qualitative analysis processes that construct higher-order themes from first-order concepts (Gioia et al., 2013). These themes are subsequently compared to quantitative findings to triangulate the interpretation of the results and identify areas of agreement and disagreement. Combining both quantitative and qualitative methods leads to a deeper level of analysis of the study, and the conclusions of the study are based not only on empirical research but also on the experience of a practitioner. This combination of qualitative and quantitative data follows mixed-methods guidelines for triangulation (Tashakkori et al., 2021).

3.9 Reliability, Validity and Trustworthiness

Methodological rigor is dependent on ensuring the reliability and validity of the findings of the study. Within the quantitative part, reliability is ensured through the utilization of standardized and well-known datasets of the world bank that utilize consistent measurement procedures over years and countries. The LPI is designed based on a well-developed survey procedure of logistics professionals on a global scale, and the elements of the LPI have shown

a high internal consistency and construct validity in an earlier study (Cheng et al., 2024; Hasan et al., 2025). The economic indicator of GDP (per capita) also adds to the reliability since GDP per capita is a globally accepted indicator of the economic performance of the nations. The application of proper analytical methods, such as t-tests, correlations and regressions, which are long-established tools of analysing relationships and differences in quantitative data, helps enhance statistical validity.

In the qualitative aspect, reliability is achieved by following the set standards, such as credibility, transferability, dependability, and confirmability. Semi-structured interviews are used to achieve credibility since they enable participants to give elaborate and genuine descriptions of their experiences. Transferability is facilitated using detailed description of the interview situation and participants roles so that the readers can determine the applicability of the results to other environments. Reliability is achieved by methodically recording the data collection and data analysis processes, and confirmability is enhanced by reflexive practices that reduce researcher bias and guarantee that the research results are based on participant data, not on researcher assumptions.

The study used ethical principles in the quantitative and qualitative analysis to ensure ethical integrity. The quantitative analysis involved secondary data from the World Bank, which poses little ethical concern. However, ethical principles were observed by properly acknowledging data sources; refraining from altering data sets; and securely storing and using files for academic purposes. For the qualitative part of the study, ethical considerations were taken to ensure participants' rights and privacy. Participants were provided with information about the purpose, voluntary nature and confidentiality of the study. Consent was sought for each interview, and participants were reminded they could withdraw. To maintain confidentiality, organisation names were replaced with anonymous names (Organisation 1-5) and person details were removed from the interview transcript. Data from interviews were securely stored and only accessible to the researcher. These steps ensured the qualitative data collection process was conducted according to ethical standards, and the confidentiality of participants was maintained.

3.10 Methodological Limitations

The research has several limitations, which despite its methodological strengths, the research study recognizes that the study can affect its findings interpretation.

To begin with, the quantitative analysis is performed using two time points, i.e., 2018 and 2023, which does not allow to identify long-term trends or changes in logistics performance. These years were chosen since the LPI is not released on an annual basis; the latest release (2023) is the first to be published since 2018 and thus the only comparable dataset that can be used during this time.

Second, the analysis will be based on the secondary data of the LPI and GDP per capita data set. Even though these sources are extensively employed and most effective, they might not be able to reflect every aspect of logistics performance and the operational complexity that disruptions cause at the firm level.

Third, the qualitative element relies on five semi-structured interviews of the Organizations which operate mainly in Europe. Although these interviews may be useful sources of practitioner insights, the sample size is small and might not reflect the entire range of disruption experiences across industries, regions, and organizational set-ups. Qualitative data are thus contextual and not meant to be generalizable.

Lastly, combining quantitative and qualitative evidence adds a complexity to the methodology because the two sets of data have different scales, scope and levels of abstraction. Although there are these constraints, the mixed-method design helps to improve the level of depth and credibility of the research by merging macro-level trends in performance with firm-level operational data.

3.11 Chapter Summary

This chapter has presented the methodology that will be used to conduct the study, which includes the philosophical assumptions, research methodology, research design, data sources,

the methods of data collection, data analysis methods and ethical implications. The research takes a mixed-method design approach, combining both quantitative analysis of secondary data and qualitative analysis of primary data, where relevant information is thoroughly examined to determine the impact of supply chain disruptions on logistics and performance of the warehouse. The quantitative part will utilize data on LPI and GDP per capita in 2018 and 2023 and will use statistical methods (descriptive analysis, t-tests, effect sizes, correlations, and regressions) to determine performance changes and relationships. Qualitative element would be semi-structured interviews offering practitioner perceptions that would supplement and put the quantitative results in perspective.

The chapter was also concerned with reliability, validity, trustworthiness and ethical integrity; so, the study is conducted in accordance with the high methodological standards. The methodological design of the study offers a solid basis on the analysis of disruption effects and the formulation of valuable conclusions despite its limitations. The following chapter provides the outcomes of the quantitative and qualitative analyses where the results are presented in detail, and the disruptions are identified as being the reason the logistics performance differs among countries and organizations.

4 Empirical Results

4.1 Introduction

The chapter includes the empirical results of the study by combining quantitative research on global logistics performance indicators, with qualitative information on the industry practitioners. This chapter aims to investigate how disruption in supply chains has affected the performance in logistics in various countries and organizations using both the macro-level and the micro-level operational experience. The quantitative aspect examines the secondary data of the World Bank LPI and GDP per capita of 2018 and 2023 to allow a comparative evaluation of the logistics performance in 2018 and 2023, prior to the occurrence of major world shocks like the COVID-19 pandemic, geopolitical tensions, and transportation bottleneck Statistical analysis- such as descriptive analysis, paired samples t -tests, effect sizes, correlation analysis and regression modelling are employed to discover performance changes, relationships, and structural patterns in 134 countries.

In addition to the quantitative analysis, the qualitative part of the study reports the results of five semi-structured interviews with the representatives of Organization 1, Organization 2, Organization 3, Organization 4 and Organization 5. The organizations are various links of world supply chains, such as industrial production, logistics, marine and energy technology, electrical equipment production, and transport coordination between units. The interviews give practitioner-level information about the operational implications, logistics performance implications, and resilience measures related to the disruption of supply chains. The views of manufacturing and production settings are provided by Organization 1 and Organization 3, and the problems are the lack of materials, limitations in suppliers, and pressure on the warehouse space. Organisation 2 provides knowledge on the logistics and distribution end, such as transportation delays, routing delays and labour issues. Organization 4 and Organization 5 offer more insights into coordination of global transport, internal flows of materials and the impacts of geopolitical and operation disruption on the everyday logistics operations.

This chapter presents a detailed perspective of the impact of disruptions on the logistics systems both at the national and organizational levels by combining quantitative and qualitative results. The chapter ends with a synthesis which links macro-level trends in performance with micro-level realities of operations which underlies the discussion and implications in Chapter Five.

4.2 Quantitative Data Analysis

4.2.1 Descriptive Statistics: LPI 2018 vs 2023

Descriptive Statistics

Year		N	Minimum	Maximum	Mean	Std. Deviation
2018	Overall LPI score	134	1,95	4,20	2,9385	,58310
	Customs	134	1,57	4,09	2,7418	,59407
	Infrastructure	134	1,56	4,37	2,8097	,69277
	International shipments	134	1,80	3,99	2,8934	,52580
	Logistics quality and competence	134	1,88	4,31	2,8890	,63038
	Tracking and tracing	134	1,64	4,32	2,9740	,62809
	Timeliness	134	2,04	4,41	3,3104	,58241
	Valid N (listwise)	134				
2023	Overall LPI score	134	1,90	4,30	3,0082	,60413
	Customs	134	1,50	4,20	2,8104	,63011
	Infrastructure	134	1,70	4,60	2,9336	,72733
	International shipments	134	1,70	4,10	2,9276	,53232
	Logistics quality and competence	134	1,80	4,40	3,0358	,65240
	Tracking and tracing	134	1,60	4,40	3,0634	,68326
	Timeliness	134	2,10	4,30	3,2463	,57251
	Valid N (listwise)	134				

Table 3. Descriptive Statistics of Variables of Logistics Performance

The descriptive statistics give a general idea of how the global logistics used to work before the major disruptions and after these disruptions. The findings reveal a minor but positive change in the average LPI mean score where the average score increased to 3.0082 in 2023 compared to the situation in 2018, which was 2.9385. This slight increase can hint at the fact

that, even in the times of considerable disturbances, such as the COVID-19 pandemic, geopolitical tensions, and transport bottlenecks, many nations keep enhancing logistics by investing in infrastructure, digitalization, and supply chain modernization. The increase of the global average is an indication of some sort of logistics resilience that was able to sustain or even improve performance despite the difficult circumstances. However, not all LPI components have improvements. The most significant growth in 2018 to 2023 is in infrastructure, logistics competence, tracking and tracing. These profit increases are in line with the internationalisation trends of automation and digitalisation of tracking systems and professionalisation of logistic services. These structural enhancements are evidence of the fact that nations have placed the long-term capability construction on their agenda even in the times of disruptions.

Timeliness, which has been historically the strongest dimension LPI, on the other hand, decreased by 0.0104 to 3.2463. This reduction is an indication of the general delays due to border controls, congestion, shortages, and rerouting issues. The decrease aligns with qualitative data, where interviewees mentioned that during times of disruption, there were delays, backlog and more reliance on urgent shipments. These results underscore the susceptibility of logistic processes that are time sensitive to external shocks. Descriptive results also show that there is significant cross-country variation. The ranges of LPI scores in the two years are below 2.0 to above 4.0 and the standard deviations are relatively large indicating that there are still global inequalities in logistics performance. The more successful countries tended to be able to hold on to their lead whereas the less successful countries were much more volatile. These results reflect the sensitivity of time-sensitive logistics processes to shocks. Generally, the descriptive statistics from the baseline trends to be used in the subsequent inferential analyses. They give a vivid insight into the changes in global logistics performance between 2018 and 2023 and lay the groundwork to look at whether these variations are statistically significant and the connection between them and economic performance.

4.2.2 Average Global LPI Chart.

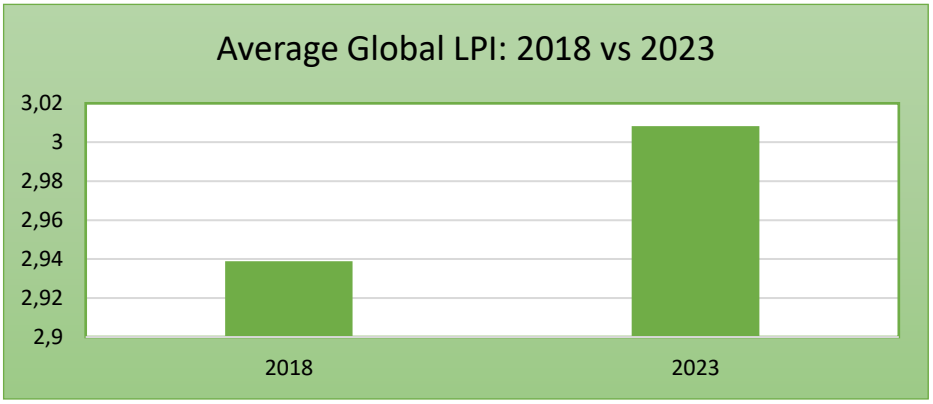

Figure 3. Average Global LPI: 2018 vs 2023

The bar chart shows how the average global LPI will change in the period between 2018 and 2023. The findings indicate a slight change in the mean of the world whereby it has improved to slightly above 3.00 in 2023 as compared to 2.94 in 2018. This positive trend shows that the logistics of various countries were becoming stronger over this time despite the significant disruptions, such as the COVID-19 pandemic, geopolitical tensions, instability of transport routes, and labor shortages. The improvement can be traced to the continuous changes in infrastructure, logistical abilities, and coordination of operations that led to more resilient supply chain systems. This pattern is widely in line with qualitative data, where practitioners identified better coordination, planning, and responses to disruption as their major strategies in the disruption period. In general, the bar chart supports the descriptive statistics as it indicates that the global logistics systems were resilient and improved progressively between 2018 and 2023 despite the severe external forces.

4.2.3 Comparison of LPI Components Chart.

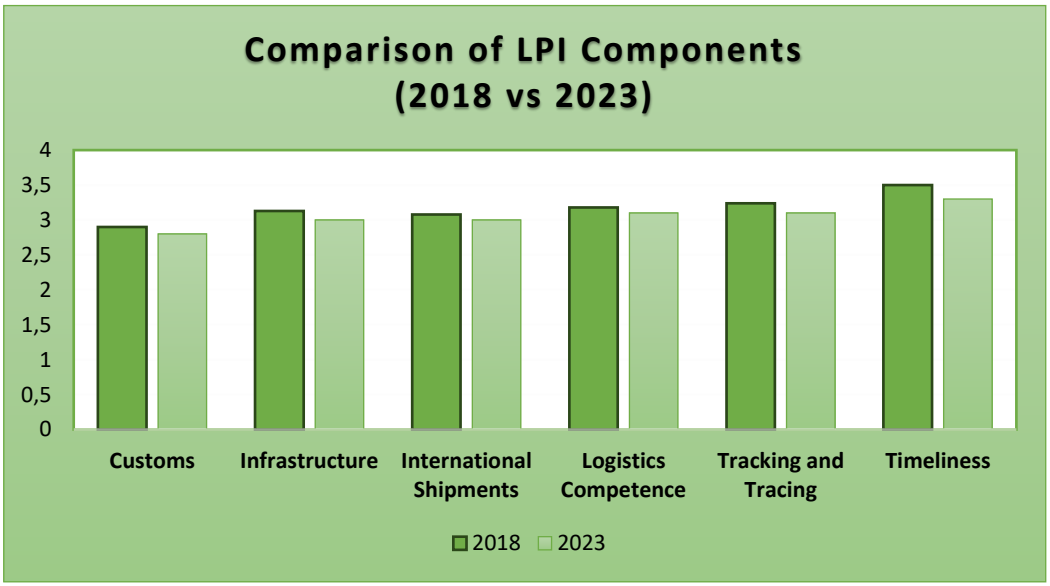

Figure 4. LPI Components (2018 vs 2023) Comparison

The bar chart is a comparison of the six indicators of the Logistics Performance Index in 2018 and 2023 and shows how the various dimensions of the global logistics systems have changed during the disruption period. The findings indicate that several structural components, including Infrastructure, Logistics Competence, and Tracking and Tracing, had improved by 2023 compared to 2018, which indicates the ongoing investments in the areas of digitalization, professionalization, and modernization of logistics. These advancements indicate that a significant number of countries diversified their long-term logistics capabilities amid the disruptions in the world. Timeliness, on the other hand, decreased across the two years, which is in line with the general delays due to transportation bottlenecks, labor shortage, port congestion, and supply chain imbalances. International Shipments reveals that there is slight variation which means that the international trade flow remains stable. Overall, the chart shows one very clear trend: the structural capabilities were enhanced, whereas the overall reliability of operations was undermined, which supports the general observation the global logistics systems were improved, but were strained as well during the disruption period.

4.2.4 Pre vs Post COVID Comparison of LPI

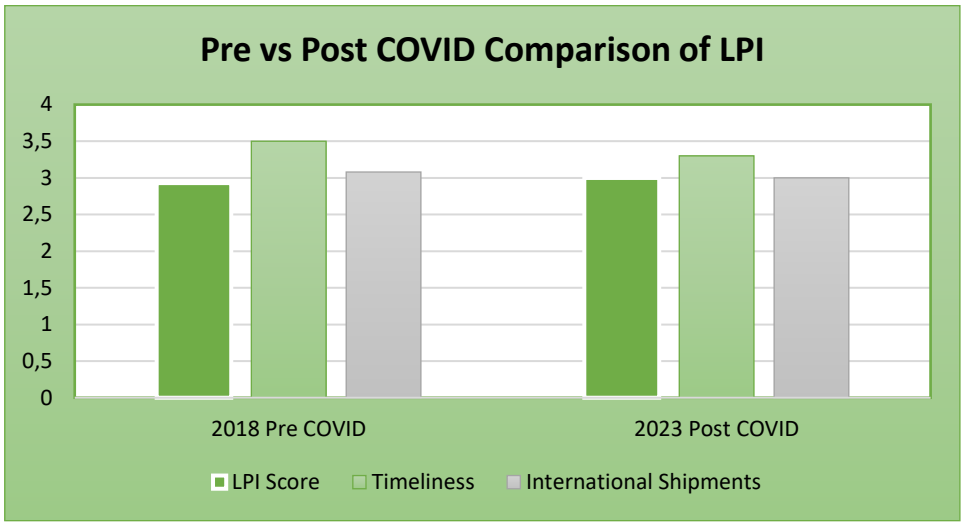

Figure 5. Pre vs Post COVID Comparison of LPI

The bar chart is a comparison of the key logistics performance indicators prior to and during the COVID-19 pandemic, comparing 2018 as the pre-COVID indicator and 2023 as the post-COVID indicator. The findings indicate that the overall LPI score has slightly improved, and the figure has increased by 0.0661 between 2018 and 2023, meaning that the global logistics systems were resilient despite significant disruptions. International Shipments also were not that volatile as they rose slightly by 0.1724, indicating that international trade flows were not significantly impacted, and only small-scale fluctuations were experienced during the disruption period. Timeliness, conversely, decreased in 2023 to 3.2463, down by 0.0764 in 2023 compared to 3.3104 in 2018, attributable to the effects of transportation bottlenecks, labor shortage, port congestion, and supply chain imbalance during and after the pandemic. This is consistent with the qualitative findings, where practitioners cited delays, backlogs, and more uncertainty in delivery performance. Overall, the figure reveals a definite trend: the structural logistics capabilities have been enhanced or kept at the same level, whereas operational reliability, especially in the aspect of timeliness, has slightly deteriorated. This implies that, despite the increased operational capabilities and adaptability of the logistics systems, the systems suffered an increase in operational pressure during the COVID-19 period, leading to performance trade-offs in the various dimensions.

4.2.5 Paired Samples Tests

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	OverallLPIscore.2018: Overall LPI score - OverallLPIscore.2023: Overall LPI score	-,06971	,21537	,01860	-,10651	-,03291	-3,747	133	<,001	<,001
Pair 2	Customs.2018 - Customs.2023	-,06860	,29047	,02509	-,11823	-,01897	-2,734	133	,004	,007
Pair 3	Infrastructure.2018 - Infrastructure.2023	-,12391	,29193	,02522	-,17380	-,07403	-4,913	133	<,001	<,001
Pair 4	Internationalshipments.2018: International shipments - Internationalshipments.2023: International shipments	-,03417	,33233	,02871	-,09095	,02262	-1,190	133	,118	,236
Pair 5	Logisticsqualityandcompetence.2018: Logistics quality and competence - Logisticsqualityandcompetence.2023: Logistics quality and competence	-,14687	,28668	,02477	-,19586	-,09789	-5,930	133	<,001	<,001
Pair 6	Trackingandtracing.2018: Tracking and tracing - Trackingandtracing.2023: Tracking and tracing	-,08948	,33252	,02873	-,14630	-,03266	-3,115	133	,001	,002
Pair 7	Timeliness.2018 - Timeliness.2023	,06416	,34858	,03011	,00460	,12372	2,131	133	,017	,035

Table 4. Paired Samples Tests

Paired samples t-tests were performed to ascertain whether the differences in LPI scores in 2018 and 2023 were statistically significant. Since the 134 countries were measured in both years, paired samples approach is suitable to measure significant changes in global logistics performance over time. The findings demonstrate that most structural elements of the LPI had statistically significant positive changes, which means that the global logistics systems were becoming stronger even in the conditions of significant disruptions. The total LPI score also changed significantly (mean difference = -0.0697, p <.001), and the negative value of the mean difference means that the score will be higher in 2023. It implies that structural investments, including digitalization, upgrades of infrastructure, and modernization of logistics, were beneficial over the long term to mitigate some adverse effects of global disruptions. Customs performance also enhanced significantly (p =.007), and this is an indicator of improvement in the efficiency of the border and the use of digital customs processes. There was a statistically significant and significant improvement in infrastructure (p <.001) that continued to invest in transport networks and logistics facilities. The logistics competence increased dramatically (p <.001) which means that the logistics providers did respond to the challenges associated with disruptions and increased their capabilities. The increased tracking and tracing also became (p =.002) according to the global increase of the

digital visibility tools and real-time monitoring systems. Conversely, the change in international shipments was not statistically significant (p =.236), but the mean difference shows that there was a small increase. This implies an apparent stability and not an apparent improvement of the global shipment performance in the disruption period. However, timeliness decreased considerably (mean difference = +0.0642, p = .035), which showed slower and less predictable deliveries. This fall is indicative of transportation bottlenecks, labor shortages, port congestion and supply chain imbalances witnessed during and after the pandemic. Generally, the results of the paired t -test demonstrate one apparent tendency: the structural logistics capabilities increased greatly, but the operational reliability (especially the timeliness) worsened. This trend is aligned with qualitative experience, where practitioners have indicated enhancements in systems and processes with delays, backlogs, and coordination issues. Collectively, these results suggest that the global logistics systems were more capable and strained in operations at the same time during the disruption period.

4.2.6 Effect Sizes

Paired Samples Effect Sizes

			Standardizer[a]	Point Estimate	95% Confidence Interval Lower	Upper
Pair 1	OverallLPIscore.2018: Overall LPI score - OverallLPIscore.2023: Overall LPI score	Cohen's d	,21537	-,324	-,497	-,149
		Hedges' correction	,21659	-,322	-,494	-,149
Pair 2	Customs.2018 - Customs.2023	Cohen's d	,29047	-,236	-,407	-,064
		Hedges' correction	,29212	-,235	-,405	-,064
Pair 3	Infrastructure.2018 - Infrastructure.2023	Cohen's d	,29193	-,424	-,601	-,247
		Hedges' correction	,29359	-,422	-,597	-,246
Pair 4	Internationalshipments.2018: International shipments - Internationalshipments.2023: International shipments	Cohen's d	,33233	-,103	-,272	,067
		Hedges' correction	,33422	-,102	-,271	,067
Pair 5	Logisticsqualityandcompetence.2018: Logistics quality and competence - Logisticsqualityandcompetence.2023: Logistics quality and competence	Cohen's d	,28668	-,512	-,692	-,331
		Hedges' correction	,28831	-,509	-,688	-,329
Pair 6	Trackingandtracing.2018: Tracking and tracing - Trackingandtracing.2023: Tracking and tracing	Cohen's d	,33252	-,269	-,441	-,096
		Hedges' correction	,33441	-,268	-,438	-,096
Pair 7	Timeliness.2018 - Timeliness.2023	Cohen's d	,34858	,184	,013	,354
		Hedges' correction	,35056	,183	,013	,352

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Table 5. Effect Sizes

Effect sizes were computed to determine the extent of change between 2018 and 2023, which was insightful besides statistical significance. Whereas p-values can be used to demonstrate

whether differences are unlikely to be accidental, effect sizes can demonstrate the practical importance of observed differences and can be used to assess whether the observed changes are important in practical logistics situations. The biggest effect sizes were found in logistics competence (d = -0.512), infrastructure (d = -0.424), and tracking and tracing (d = -0.269). Based on traditional standards, they are small to moderate impacts, which suggests significant enhancement of the structural and technological competencies of the global logistics systems. The negative values indicate greater scores in 2023, which implies the fact that the countries enhanced the logistics capacity by investing in digital technologies, developing infrastructure, and professionalizing logistics services. The effect size of logistics competence is rather bigger, which shows that logistics providers adapted to the issues of disruption, enhancing their skills, processes, and the adoption of technologies. Timeliness demonstrates a weak yet significant negative impact (d = +0.184), which states the fact that the performance on delivery slowed down and became less predictable. This is in line with the international trends of transport choke points, labor shortages, port congestion, and imbalances in supply chains during and following the pandemic. This decline is in line with qualitative data, where practitioners mentioned delays, backlogs, and more working hard. The effect size (d = -0.103) of international shipments is very small, meaning that there is a little change between 2018 and 2023. This implies that there was relative stability in this dimension, although at the micro level, firms had their operations disrupted. In general, the effect size analysis gives a subtle insight into the change in logistics performance. The dimensions related to the infrastructure, logistics competence, and tracking systems, which were structural and capability-related, improved significantly, whereas operational reliability, especially timeliness, deteriorated. Such a contrast illuminates the necessity to trade off longer-term capacity building with the strategies that contribute to the short-term resilience of operations. The paired t -test results are complemented by the effect size results and enhance the overall mixed-method interpretation.

4.2.7 Correlations Analysis

Correlations

		LPI 2018	GDP 2018
LPI 2018	Pearson Correlation	1	,440**
	Sig. (2-tailed)		<,001
	N	134	134
GDP 2018	Pearson Correlation	,440**	1
	Sig. (2-tailed)	<,001	
	N	134	134

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

		LPI 2023	GDP 2023
LPI 2023	Pearson Correlation	1	,414**
	Sig. (2-tailed)		<,001
	N	134	134
GDP 2023	Pearson Correlation	,414**	1
	Sig. (2-tailed)	<,001	
	N	134	134

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6. Correlations of 2018 and 2023

Correlation analysis was used to analyze the correlation between GDP per capita and LPI in 2018 and 2023. The findings indicate that there is a moderate positive correlation in both years, which means that those countries with high GDP per capita tend to have greater logistics performance. In 2018, the correlation was r = .440 (p <.001), while in 2023 it was slightly lower at r = .414 (p <.001). The two relationships are significant, and this confirms that the economic strength correlates with the logistics capability among countries. The marginal decline in correlation from 2018 to 2023 implies that the logistics services performance during the period of disruption may not be strongly driven by economic capacity. This shows that although GDP per capita is a critical predictor of logistics performance, it fails to completely explain cross-country variation, particularly in the circumstances of global disruption. This interpretation is consistent with qualitative data. The interviewees explained the operational problems like delays, shortages of materials, congestion, and coordination problems which the firms experienced irrespective of the economic power of the environments in which they operated in. These experiences point out that even those countries that have a robust economy may experience severe logistics limitations in case they are subjected to wide-scale disruptions.

Overall, the correlation analysis shows that the relationship between GDP per capita and LPI is not that strong with the course of time, but it is stable. This finding indicates that while

economic performance remains an important factor in explaining logistics performance, it cannot explain the variance in performance during the crisis.

4.2.8 Regression Analysis

A simple linear regression model was applied to investigate the relationship between GDP per capita and Logistics Performance Index (LPI) of 134 countries in 2018 and 2023. GDP per capita was considered a continuous numerical variable (USD), and LPI scores ranged from 1-5. These two variables were entered into SPSS through the University Citrix Workspace and analyzed through the Enter method. To ensure transparency and replicability, the entire GDP data has been made available in Appendix 10. GDP per capita values are given in large numerical units, and the regression coefficient was given in scientific notation (1.405E–5). This is a normal result from predictors operating on different scales and linear regression can still be used provided that the coefficients are interpreted in terms of their units (Field, 2024). There were no transformations made because the analysis aimed to look at the direct link between logistics performance and economic strength.

The results of ANOVA showed that the regression models were statistically significant in both years (2018: $F = 31.777$, $p < .001$; 2023: $F = 27.262$, $p < .001$), which means that GDP per capita significantly predicts LPI for both years. Significance levels are reported using the following thresholds: *p < 0.10, **p < 0.05, ***p < 0.01.

Year	R	R2	Adjusted R2	F Statistics	GDPpc Coeffiient	Std. Error	Beta	t-value	Sig (F)	Sig (t)
2018	0.440	0.194	0.188	31.777	1.405E-5	0.000	0.440	5.637	<0.001 ***	<0.001 ***
2023	0.414	0.171	0.165	27.262	1.185E-5	0.000	0.414	5.221	<0.001 ***	<0.001 ***

Table 7. Regression Analysis

The GDP per capita is found to explain 19.4% of the variability in LPI in 2018 and 17.1% of the variability in LPI in 2023. The decrease in R^2 and standardized beta values shows that the

explanatory power of GDP per capita decreased slightly during the disruption period, however, it is still a statistically significant predictor. This indicates that the impact of economic strength on logistics capability has remained a key driver, but external factors like COVID-19, geopolitical tensions and transport bottlenecks have tempered the ability of GDP to explain performance variations. These qualitative results support this conclusion. Even in prosperous times, interviewed companies indicated that delays, shortages, congestion and coordination problems existed. These experiences demonstrate that disruptions can negatively affect logistics performance even if a country's income is low. In summary, the regression analysis demonstrates that this variable, GDP per capita, has been a constant force and also has its constraints in times of world instability.

4.2.9 Scatterplot of GDP per capita vs LPI (2018)

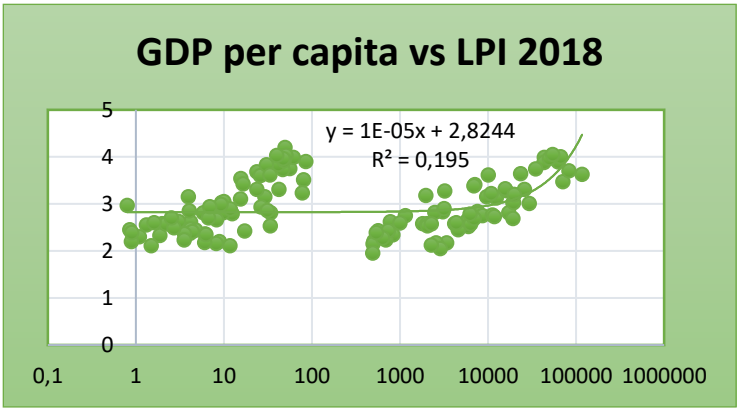

Figure 6. Scatterplot of GDP per capita vs LPI (2018)

In 2018, the scatterplot shows that there is a positive relationship between GDP per capita and the LPI. The positive slope of the trendline shows that the better the countries are in terms of GDP per capita, the better their logistics performance is. The coefficient of determination (R2 = 0.195) indicates that GDP per capita explains about 19.5 percent of the change in LPI indicating an average relationship. Even though GDP per capita is not the only factor that determines the logistics capability, the visual trend supports the results of the regression by proving that economic power was an important factor that preconditioned the formation of logistics performance before any significant global challenges.

4.2.10 Scatterplot of GDP per capita vs LPI (2023)

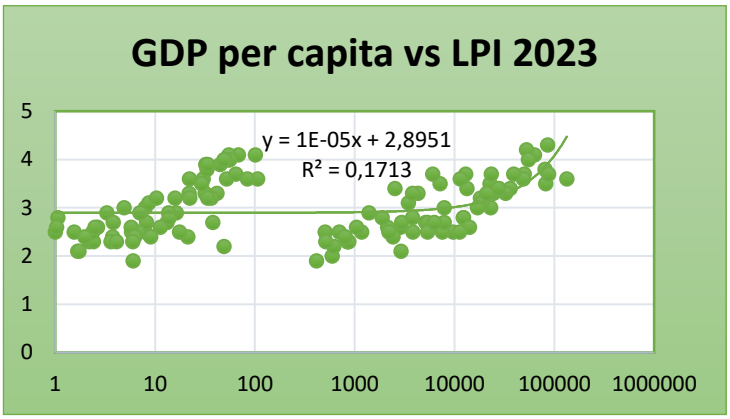

Figure 7. Scatterplot of GDP per capita vs LPI (2023)

In the 2023 scatterplot, there is also a positive correlation between GDP per capita and LPI, but the coefficient of determination (R2 = 0.171) is slightly lower. This implies that GDP per capita captures approximately 17.1 percent of the changes in logistics performance- a bit lower than in 2018. The deterioration of the relationship indicates that all disruptions around the world, such as the COVID-19 pandemic, geopolitical conflicts, and supply chain cones, have impacted the logistics systems in the countries, irrespective of the income level. Even the economies with high incomes were delayed, had labor shortage, and were congested, diminishing the predictive ability of GDP per capita alone. This graph corroborates the results of the regression and reflects the increased role of resilience, flexibility, and institutional capacity in the development of logistics performance throughout the disruption period. This interpretation concurs with qualitative insights, practitioners mentioned operational problems of delays, material shortages, and congestion, and coordination problems. These experiences indicate that economic resilience was not enough to protect the logistics systems against disruption-related forces. Altogether, the scatterplots support the results of the regression analysis in the sense of a steady yet a little weaker correlation between GDP per capita and logistics performance with time. The findings indicate that although economic capacity is a key determinant of logistic capacity, resilience, flexibility, and institutional preparedness have become more critical to influence logistics performance during and post significant disruptions.

4.2.11 Comparative Analysis: Top 10 vs Bottom 10 GDP per capita Change

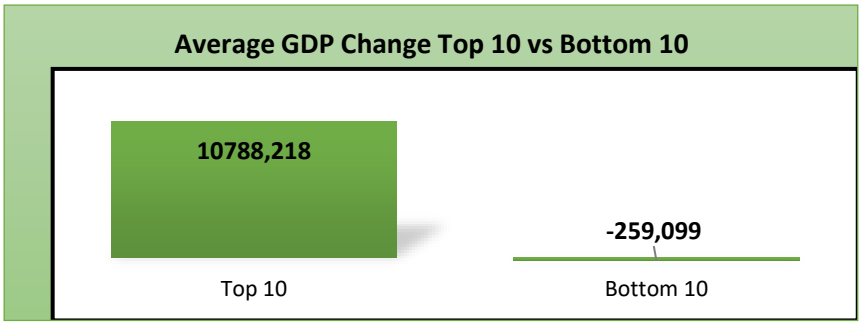

Figure 8. Comparative Analysis (Top 10 vs Bottom 10)

To compare the differences in the change in GDP per capita in the top 10 countries and the bottom 10 countries, a comparative analysis of the top 10 and the bottom 10 countries was made using Microsoft Excel. The findings show that there was a significant gap with the top 10 countries registering an average growth of 10,788.218 in their GDP per capita and the bottom 10 countries registering an average decrease of -259.099. This comparison shows how the global disturbances have been uneconomically affected in various countries as those that perform poorly struggle more to stick to the economic track. The fact that the negative change in GDP per capita of the bottom 10 countries indicate that not only was economic growth slowed down, but also in certain instances, economic performance was lowered. This difference has significant consequences on logistics performance. The higher the economic growth of countries, the more the country is likely to invest in logistics infrastructure, digital technologies and workforce capabilities and this helps to increase the LPI components of infrastructure, logistics competence and tracking systems. However, the opposite can be said about nations with a decreasing or worse economic performance as countries with weaker economies might encounter limitations in maintaining such investments, and their logistics systems can be more susceptible to external shocks. This trend is in line with the regression and correlation results, which indicate that GDP per capita is an important - though slightly weakened - factor that is correlated with logistics performance.

These results are also in line with qualitative observations made by the interviewed firms where practitioners talked about disruptions such as straining operational capacity,

coordination and availability of resources. Although these challenges were evident in various settings, their effects are bound to be more detrimental in settings with weak economic and institutional abilities. All in all, the comparative analysis reveals the unequal economic impact of global disruptions and points to the significance of enhancing the economic resilience, as well as the logistics capabilities. The findings indicate that greater adaptability, coordination, and investment in infrastructure is especially relevant to the countries with weak economies, so that the logistics performance can be improved and the countries may be less prone to the impact of future disruptions.

4.2.12 Overview of Quantitative Results

The following table is a summary of all the important quantitative results of descriptive statistics, paired samples tests, effect sizes, correlation analysis, regression modelling and GDP per capita distribution comparisons. Collectively, these findings give a holistic picture of how global logistics performance and economic conditions changed in 2018-2023 and are the foundation of the qualitative analysis and synthesized discussion that follows.

Analysis	Key Result	Significance	Interpretetion
Average Global LPI (2018 vs 2023)	2.94 → 3.01		The overall logistics performance increased marginally.
Component Comparison	Infrastructure ↑ Competence ↑ Tracking ↑ Timeliness ↓		Structural capabilities increased; operational reliability decreased.
Pre vs Post COVID LPI	LPI ↑ Timeliness ↓		COVID caused delays but did not stop structural improvements.
LPI t-test (Overall)	Mean diff = –0.0697	p < .001 ***	LPI significantly increased.
Customs	–0.0686	p = .007 **	Improved efficiency at the border.
Infrastructure	–0.1239	p < .001 ***	Strong improvement in infrastructure
International Shipments	–0.0342	p = .236	No significant change.
Logistics Competence	–0.1469	p < .001 ***	Improved competence.
Tracking & Tracing	–0.0895	p = .002 **	Visibility improved.
Timeliness	+0.0642	p = .035 *	Timeliness significantly declined.
Logistics Competence	d = –0.512	CI does not cross 0	Large improvement.
Infrastructure	d = –0.424	CI does not cross 0	Medium improvement.

Tracking & Tracing	d = –0.269	CI does not cross 0	Small medium improvement.
Timeliness	d = +0.184	CI does not cross 0	Small decline.
International Shipments	d = –0.103	CI crosses 0	Negligible change
GDPpc LPI (2018)	r = 0.440	p < .001 ***	Moderate positive relationship.
GDPpc LPI (2023)	r = 0.414	p < .001 ***	Relationships slightly weakened.
GDPpc Change – LPI Change	r = 0.016	p = .854	No significant relationship; economic change failed to predict logistics change.
GDPpc → LPI (2018)	R^2 = 0.194	p < .001 ***	GDPpc explains 19% of LPI.
GDPpc → LPI (2023)	R^2 = 0.171	p < .001 ***	Predictive power weakened slightly.
GDPpc Coefficient (2018)	1.405E–5	p < .001 ***	Higher GDPpc → higher LPI.
GDPpc Coefficient (2023)	1.185E–5	p < .001***	Slightly weaker effect after disruption.
Top 10 vs Bottom 10 GDPpc Change	+10,788 vs –259		Huge inequality in economic resilience.
GDPpc Change Distribution	Imbalanced distribution		Disruptions affected countries unevenly.

Table 8. Overview of Quantitative results

4.3 Qualitative Findings

The qualitative results are based on interviews with five companies involved in various stages of the supply chain. While their areas of operation vary (manufacturer, logistic and energy-technology equipment), the companies all described how recent events impacted their businesses. For clarity, the results are broken down into themes and supported by quotes from each company.

4.3.1 Theme 1: Nature of Disruptions

Interviews indicated that the nature of disruptions were different in each company based on their position in the supply chain. At Organization 1, the nature of disruptions was largely supplier-driven. The Production Manager said that *“the biggest disruptions are related to supplier production capacity issues, which cause material shortage and in turn delays in production.*” These were problematic because "*material shortages can stop production entirely when critical components are unavailable*". According to the Material Coordinator at

Organization 3, *showed a different trend. Rather than global shocks, demand in the energy sector was high, increased demand has significantly impacted supply chain operations, and quality issues with suppliers caused delays. Geopolitical tensions* were a factor in Organization 4's difficulties. The logistics expert noted that "*the Middle East crisis has impacted global logistics flows significantly" but also that the U.S. customs tariffs had " made export and import procedures more complex and challenging*". *This led to uncertainty in planning day-to-day operations*. Organization 5 was subject to global and local impacts. They cited *"geopolitical issues affecting shipping routes"*, political strikes in Finland, and material shortages, "*the most challenging for daily operations*". As a logistics company, Organization 2 struggled with labor and transport issues. The interviewee stressed that *"strikes or work stoppages were the most challenging*" particularly when there were only a few employees on duty. These testimonies illustrate that while manufacturers faced material and supplier performance challenges, logistics companies were more impacted by labor issues and global transportation challenges.

4.3.2 Theme 2: Warehouse Performance challenges

Disruptions had a significant impact on warehouse and internal logistics, although the nature of the problems varied. Organization 1 talked of how shortages led to unstable material flows. The Production Manager said that disruptions created "*periods of overload in internal logistics (rush situations)*" and the company had to choose between internal and external storage. Organization 3's capacity issues were ongoing. According to the interviewee, *“demand has increased and so have inventories, but warehouse capacity has not expanded, creating bottlenecks and congestion in the warehouse.”* In contrast, at Organization 4 warehouse problems were related to transport, not capacity. The interviewee noted *"port congestion, overall delays, and significantly increased freight rates"* which led to warehouse planning and stock movement complexities. Organization 5 reported shortages and transport delays led to “*risk of production delays or stoppages*”; materials needed to be moved between locations. The respondent also mentioned increasing *“reliance on buffer stock”* to cope with uncertainty. Organization 2 warehouse operations were affected by backlogs. The interviewee said strikes caused “*a backlog of work as well as delayed picking and end-customer deliveries*” for some

time after the strikes. For all companies, warehouse operations were more reactive and under stress in times of disruption, albeit for different reasons.

4.3.3 Theme 3: Logistics Performance Impacts

Every company has experienced impacts on logistics performance, with different causes. Shortages impacted on-time delivery at Organization 1. The respondent said that disruptions *"stop production and cause delays to shipments*" - the impact of upstream problems had flow-on effects. Organization 3 had occasional delays in the peak season. The interviewee noted that "*there have been some delays in deliveries to production and customers,"* especially due to supplier quality or capacity issues. Organization 4 experienced lengthy delays from rerouting. The logistics expert said that *"some shipments had to be diverted around the Cape of Good Hope"*, which caused delays. Organization 5 reported a combination of delays, expedited shipments and stock level problems. The respondent noted that there were "*delays in delivery times*" and "*urgent shipments between suppliers and factories*" due to disruptions. Organization 2 noted many delays during the strikes. The interviewee said that service performance was impacted "*not only during the strike but also after them due to backlog."* These insights reveal that logistics performance declined in all firms, but for different reasons, from supply to geopolitical and labor instability.

4.3.4 Theme 4: Resilience Strategies

Companies implemented strategies to deal with disruptions, in line with their roles and limitations. Organization 1 established additional suppliers The Production Manager said that the firm has responded by *"sourcing additional suppliers,"* and they have *"increased capacity with existing suppliers"*. Longer-term plans include *"diversifying suppliers and increasing production capacity."* Organization 3 is creating resilience in the process, some of which is still ongoing. The respondent noted "*plans to increase warehouse capacity, automate and streamline quality check of suppliers.*" Organization 4 had procedures and kept a close eye. The interviewee said that *"we have guidelines for how to proceed,"* and the logistics department "keeps material flowing despite the interruption". Organization 5 was proactive and responsive. The respondent explained that the company is "*proactively sourcing missing*

components" to other sites, *"moves material between sites*" and rapidly responds to changes in the logistics plan when issues arise. Organization 2 prioritized communication and processes. The interviewee stressed *"proactive identification of exceptional situations advance communication and continuous updates*," and the CAPA system to avoid re-occurrences. Across companies, disaster resilience focused on visibility, communication, diversification of suppliers and logistics.

4.3.5 Theme 5: Lessons Learned

Participants shared several lessons learned about how to deal with disruption, but some were more reflective than others. Organization 1 noted the importance of planning and forecasting. The Production Manager said "*predictive planning and better forecasting*" help to reduce uncertainty. Organization 3 is still during issues and so has not yet documented lessons learned. But the respondent emphasized the importance of "*good communication and good forecasting of demand".* For Organization 4, information is key. The interviewee explained that "*ensuring everyone is well informed and supported where and when necessary*" is crucial in disruptions. Organization 5 provided several key takeaways, including the importance to "*be proactive and anticipate risks",* diversified suppliers, and ensure effective communication across the team. Similarly, Organization 2 highlighted the importance of communication: *"when potential disruptions are properly anticipated, controlled, and communicated, their effects can be significantly minimized."* Across the board, the message was that resilience requires anticipating and planning for disruptions, having effective communication channels, and being adaptable.

4.4 Correlation of Quantitative and Qualitative Results

The integration of quantitative and qualitative data shows a high degree of correspondence between the global trends mapped out in the LPI data and the experiences of the five case-study organizations. One prominent example of this is the drop in timeliness from 2018 to 2023. The quantitative analysis revealed a marked decrease in this indicator, and all interviewees reported delays as a key issue. Organization 1 said disruptions *"stop production processes and lead to delays in shipments"* Organization 2 told reporters that there was *"a*

backlog of work as well as delayed picking and end-customer deliveries". Similarly, Organization 4 reported goods were "*rerouted around the Cape of Good Hope*", increasing lead times. These examples help explain why timeliness fell even as other LPI measures improved the impact of disruptions on the flow of goods had a greater impact than the index measures of structural capabilities. The gains in logistics competence, infrastructure and tracking and tracing also are consistent with the qualitative findings. A few firms mentioned initiatives to improve their internal processes. Organization 1 noted the *"sourcing additional suppliers to increase capacity*" while Organization 2 "*proactively identify exceptional situations and continuous updates*" using CAPA processes. Organization 5 also pointed to the company's move to proactive planning, including "*maintaining multiple suppliers to reduce dependency*". Such actions reflect the types of longer-term capability enhancements associated with the positive effect sizes found with the quantitative findings.

The quantitative results explain the slight decline in the correlation between GDP per capita and LPI from 2018 to 2023. While GDP per capita was still a good predictor of LPI, the lower correlation implies that the impacts were more equal across countries, regardless of economic activity. This is supported by the interview findings: even well-resourced companies reported extreme constraints. Organization 3 explained that "*even a single missing component can halt production"* and Organization 5 explained how material shortages were "*the most challenging for daily operations*". These examples demonstrate how external shocks constrained performance during strong economic times, contributing to GDP per capita being a slightly worse predictor in the disruption period.

The quantitative result that international shipments were not affected by the crisis is also supported by the interviews. No company mentioned a crisis in world trade, but rather fluctuations and instability. Organization 5 noted *"emergency shipments between suppliers and factories"* and Organization 1 reported "*periods of overload in internal logistics".* And Organization 4, *"port congestion and overall delays."* Such volatility doesn't necessarily alter the index, but introduces pressure, as per the stable but stressed indicator of international shipments.

Overall, the combined evidence reveals the impact of the disruptions on logistics operations is mixed. Quantitative evidence shows overall trends in timeliness and capability building, while qualitative evidence explains how these trends occurred. The evidence highlights the value of resilience measures - such as better forecasting and communication, supplier diversification and operational processes - in assisting businesses to cope with uncertainty and perform in a volatile global context.

4.5 Chapter summary

The chapter was able to combine the results of the quantitative and qualitative analysis to construct a more accurate image of the impact of the recent disruptions on the logistics and warehouse performance on the global and organizational levels. The quantitative model revealed that several of the structural components of the Logistics Performance Index, including infrastructure, logistics competence, and tracking and tracing, kept on improving between 2018 and 2023.

Meanwhile, the timeliness decreased, suggesting that despite the advancement of long-term development of capabilities, day-to-day operational reliability continued to be seriously impacted by the disruption-related pressures. The findings also validated that GDP per capita was a significant predictor of logistics performance, but its impact became a bit smaller in 2023, indicating that disruptions moved across the boundaries of the economies and impacted countries more equally than in the past. The analysis of the top and bottom GDP per capita performers further revealed increasing disparities in the economic resilience, demonstrating the effects of disruptions as magnified by existing inequalities. The patterns were enriched by the qualitative findings that revealed the way disruptions occurred within the actual organizations. Challenges that were described by the companies all reflected the statistical trends, including material shortages, delays of suppliers, labor challenges, congestion, and backlogs. These experiences assist in understanding why there was a decrease in timeliness as well as international shipments in comparison to operational strain.

Another aspect of the interviews that helped understand the progress in logistics competence and tracking is the reaction of companies to disruptions: companies addressed them by

making forecasting more effective, enhancing communication, diversifying suppliers, and relying more on the organized process and digital tools. The chapter demonstrated a high correspondence between the macro-level information and the micro-level experiences of the companies used. The mixed-method approach allowed observing not only what has varied in the global logistics performance, but also why these changes have taken place.

5 Discussions and Conclusions

5.1 Conclusion

This paper aims to address one of the main and more pressing problems in modern supply chain research: **"*How does supply chain disruptions affect the warehouse and logistics performance?*"** The results indicate that the disruption does not have a consistent impact on the logistics systems. Rather, they redefine performance at a variety of levels, creating a pattern where structural capabilities on a long-term basis are maintained and sustained at the same time as operational reliability on the day-to-day basis becomes less reliable. Quantitative analysis showed that several structural elements of the Logistics Performance Index (LPI) such as infrastructure, logistics competence and tracking and tracing have improved significantly during 2018 to 2023. These gains are a result of long-term investment in digitalization, professionalization and logistics framework. With geopolitical tensions and transport bottlenecks, many countries kept on building the building blocks in their logistics systems.

However, despite these structural advantages, there was a sharp decrease in timeliness, which means that the level of operational reliability was reduced. It is one of the most significant results of the study. It indicates that the behavior of structural resilience and operational resilience in the face of disruption differs. Structural capabilities are also very slow moving and long-term investment is very beneficial as opposed to operation performance, which is highly sensitive to sudden shocks, such as supplier delays, labor shortages, port congestion, and unpredictable flows of materials. That is, a logistics system might become paper-based and still have a hard time with the integrity of its delivery performance in the event of disruptions.

The qualitative results give a more in-depth explanation as to why this occurs. The companies interviewed reported a great variety of challenges related to disruption. The upstream firms were experiencing lack of essential components, constraint on the capacity of suppliers and fluctuating lead times. Downstream logistics providers were faced with congestion in the warehouses, labor strikes, rerouted shipments, and fluctuating volumes. These experiences

demonstrate how disturbances spread unevenly up and down the supply chain, creating bottlenecks which directly impact the warehouse throughput, inventory balance and process stability. This interpretation is further supported by the fact that the GDP per capita - LPI relationship got weaker in 2023. Even such countries with high incomes and good logistic systems as were found in the USA, operational instability was observed. This implies that economic robustness will not necessarily lead to resilience. Rather, resilience relies on adaptive ability, institutional preparedness, and coordinated response systems. Collectively, the results indicate that supply chain disruptions result in a two-speed pattern of performance. The logistics capabilities in structure are improving, but the operations' performance is more in jeopardy. The warehouses take much of the direct impact and resilience is increasingly based on adaptability, visibility and coordination among functions in the supply chain.

The research was able to achieve all three research objectives. The first goal, to define large groups of supply chain disruptions, was met with the assistance of the literature review and the qualitative results. The analysis found disruptions associated with pandemics, the existence of geopolitical tensions, climate events, supplier failures, labor shortages, and transport bottlenecks. All the companies interviewed reflected these categories and it proved that they are relevant in the modern supply chain. The second goal, to analyze the correlation between the intensity of disruption and the performance of logistics and warehouses was met by the combination of LPI data and qualitative evidence. The results reveal that the disruptions undermine operational performance despite the structural capabilities enhancing. This shows that there is a non-linear association between the disruption level and performance results. The third goal, to give managerial insights on how to become more resilient, was fulfilled by identifying practical strategies utilized by companies, such as predictive planning, supplier diversification, communication protocols, digital visibility tools, and structured problem-solving frameworks, including the CAPA process of Organization 2. Altogether, the paper addresses the research gap as it relates the indicators of logistics macro-level to operational experiences at the firm-level domain. It reveals that disruptions manifest not just in measurable logistics performance but also in the realities of everyday life of warehouse and logistics business.

5.2 Discussion

This section will elaborate the findings in relation to what has been done in previous studies and how the study has contributed to the overall academic discourse on supply chain disruptions, logistics performance and warehouse operations.

5.2.1 Structural vs Operational Resilience

The fact that structural LPI components improved, whereas the timeliness declined is consistent with there being previous research by (Mohammed et al., 2025; Rushton et al., 2022), who argue that long-term logistics capabilities are independent of the short-term operational shocks. This study, however, builds on their work with the demonstration that structural enhancements can be accompanied by operational weakness. The two-speed pattern herein observable, which links the continuity of the structure and the volatility of operations is hardly documented in the previous studies and provides a more detailed picture of the impact of disruptions in logistics systems.

- **Diffusion of Supply Chain Disruptions across the Supply Chain Tiers**

The qualitative results can be related to the work of (Ryciuk & Zabrocka, 2024; Torralba-Carnerero et al., 2024), who highlight that disruptions in the supply chain are unevenly distributed across the functions of the supply chain. This paper offers a twist whereby the upstream manufacturing companies can experience instability created by the suppliers, whereas the downstream logistics companies can be affected by labor and transportation bottlenecks. Such a stratified insight brings to the fore the importance of resilience measures to be implemented at the individual vulnerabilities of each of the supply chain tiers.

- **The weaknesses of GDP per capita as a Predictor of Logistics Performance.**

The dwindling GDP per capita-LPI connection challenges the belief, which is widespread in (Hasan et al., 2025; Sharawi et al., 2025)that economic strength is a valid indicator of logistics performance. The results indicate that institutional readiness, digitalization, and adaptive capacity are ever more influential in shaping resilience. When supply chains are very much

interconnected, wealthier nations can be more vulnerable to global shocks due to their stronger logistics systems.

- **Warehouse-Level Impacts**

The specifics of operations of warehouses close the gap that (Mohammed et al., 2025; Rushton et al., 2022) have identified, as they observe that the effects of operations on warehouses have not been explored thoroughly. This research is important as it records how disruptions lead to inventory disbalances, throughput unstable, and capacity strains. These insights could help provide a more in-depth perspective on the impact of warehouse-level implications and the significance of internal logistics processes in influencing overall supply chain performance.

5.2.2 Theoretical Contributions

This study contributes to the supply chain literature on supply chain resilience, supply chain logistics performance and warehouse operations in several ways.

The study makes a significant contribution to the theory of supply chain resilience, by empirically differentiating between structural resilience and operational resilience. The quantitative results revealed that structural LPI components (infrastructure, logistics competence and tracking and tracing) remained to improve from 2018 to 2023, while timeliness significantly decreased. The qualitative results supported this trend: the structures were reported as being good, with delays, backlogs, rerouting and unstable material flows. All these findings show that there is no direct link between structuring capability development and operational stability in disruptions. This contradicts the general notion, widely found in resilience research, that the better a logistics system, the more resilient it is in crisis scenarios.

Second, the study contributes to the literature on logistics performance that is unique by redefining the role of GDP per capita. The quantitative analysis showed an increasing deviation of the GDP–LPI relationship in 2023, indicating that the power of the economy is not enough to guarantee a logistics resilience in the face of global shocks. This is echoed by the qualitative results – despite good resources, firms still reported serious issues with shortage of materials,

delays and capacity. It is an indicator of the increasing relevance of adaptive capacity, coordination, and institutional readiness aspects, which are not accounted for in GDP.

Thirdly, the study brings a methodological contribution by combining macro-level indicators with micro-level operational experiences in logistics research that is mixed method. The study is a combination of LPI data and interviews with firms, thus bridging the gap between quantitative logistics performance research and qualitative operational research. This integration highlights the various impacts of the disruptions worldwide on different tiers of the supply chain, and the operational realities from day to day that are reflected in national level performance patterns.

Lastly, the research builds on the growing body of literature on operational resilience. The qualitative results indicated that warehouses take up a lot of the immediate operational pressures that result from the disruptions. The findings point to the importance of the warehouse function in the continuity of supply chains, which is not yet well represented in the existing literature on disruptions.

5.2.3 Practical Implications

The results provide several practical implications to managers who are interested in enhancing the resiliency of logistics and warehouses. Organizations should be able to become more flexible in their operations by getting ready to deal with a sudden shock through cross-training, contingency staffing and buffer transport capacity. It is also important to have predictive planning. Forecasting, sensing the demand, and planning scenarios can assist organizations predict the paths of disruption and improve their response. Supplier diversification was a strategy that was critical. Upstream vulnerability can be reduced by reducing dependence on individual suppliers and avoiding downstream production interruptions. Communication and coordination are also key factors. Coherent procedures and embedded information systems can facilitate a less siloed decision-making process and enhance responsiveness.

Learning and failure prevention can be institutionalized in organizations with the help of structured and designed resilience frameworks, like CAPA process of Organization 2. Lastly,

digital visibility tools such as real-time tracking, control towers, and integrated platforms, allow quicker detection and response to disruptions. Combined, these implications are a viable roadmap of the organizations that should strive to establish more robust logistics and warehouse systems.

5.2.4 Limitations

Even though this research provides valuable information regarding the impact of supply chain disruptions on the performance of logistics and warehouses, there are several limitations that need to be considered. These limitations do not discredit the usefulness of the findings but serve to help demarcate the limits within which the findings should be viewed. One of the initial restrictions relates to the quantitative aspect. The analysis is based on two points, 2018 and 2023, as the Logistics Performance Index (LPI) is not released yearly. These years are the latest similar data sets that are available, but they fail to represent the short-term variation that took place during the disruption period. Consequently, the quantitative results indicate more structural changes than the finer-grained time dynamics that might have occurred during these years. The second limitation is associated with the qualitative sample. The research is based on interviews with five organizations, all of which present valuable practitioner insights. Nonetheless, the sample is rather small and context specific. The experiences of these companies might not be fully reflective of the diversity of the effect of disruption on various industries, geographical locations, or the size of the organization. A more diverse or larger sample could show new trends or a different experience. A third constraint is due to the use of secondary data in the quantitative analysis. Although the LPI and GDP per capita are the most recognized and reliable measures of operational realities where the disruption is most directly experienced. Problems related to warehouses, which include congestion, labor shortage, or delays in processes, may not be reflected in national-level indicators, i.e., some operational subtleties will not be reflected in the quantitative results. Lastly, integration of the mixed method adds an aspect of interpretive judgment. The combination of macro-level indicators of performance and micro-level organizational experiences enhances the analysis, but a close interpretation is necessary to ensure that the two sets of data complement each other, not overload each other. Here is a certain degree of

subjectivity that is unavoidable in mixed-method studies. Collectively, these restrictions give valuable context to the interpretation of the findings and lead to opportunities of future research, such as longitudinal study designs, broader and more general qualitative sample, and more specific operational data.

5.2.5 Further Research

Future research may widen this study by using multi-year longitudinal data to be able to capture the trends in logistics performance at a much higher degree of precision. Since this study used two time points, a longer time series would assist in the identification of how fast logistics systems degenerate or recuperate in the long term when exposed to a long period of disruption. The next promising line would be to explore the specific type of disruption, such as a cyberattack, energy crisis, or a climate-related event and understand its own operational and strategic implications. The various types of disruption might have distinctive impacts on logistics systems, and investigating each of these in isolation may contribute to conceptual knowledge. It would also be effective to expand the qualitative aspect to reinforce future research. Such an inclusion as small and medium-sized enterprises, port authorities, logistics service providers, and public agencies would give a more comprehensive picture of how disruptions are experienced across various supply chain roles. Moreover, some of the new technologies that should be considered closer include artificial intelligence, blockchain, automation, and digital twins. Such tools are becoming more advocated as resilience enablers, but there is a paucity of empirical evidence on the practical effectiveness of such tools. Lastly, in future studies, the connection between national logistics capability and firm-level resilience might be further investigated. The multi-layered concept of supply chain resilience could be illuminated by understanding how country-level infrastructure, institutional preparedness, and policy environments contribute to organizational response.

5.3 AI declaration

Artificial intelligence tools were used in this thesis to improve language quality, clarity, and coherence. The paraphrasing of support was done with QuillBot and the grammar correction and linguistic improvements were made with Grammarly. The ideas, analysis, interpretations, arguments and overall academic content of a thesis, however, are the sole work of the researcher.

The researcher thoroughly reviewed, edited and corrected all AI-generated suggestions to ensure that they are currently in line with the purpose of the study and meet the academic standards. The final content, accuracy and integrity of the thesis is the responsibility of the researcher. AI tools were only used to support the writing and editing process and not replace the researcher's own thinking.

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Appendices

Appendix 1. Interview Questions

- **Could you describe your job position and its relation to supply chain, production, or internal logistics in your company concisely?**
- **Being one of the long-term workers in your company, what types of supply chain disruptive events do you consider to be the most impactful to your business?**
- **What were the most difficult issues to run the business daily?**
- **What effect did these problems have on the logistics or operations of the warehouse?**
- **Do you experience any changes in the level of logistics performance such as the speed of delivery, level of stock, or access to the necessary materials?**
- **What was the response of your company to these disruptions at the operational level?**
- **What was the contribution of warehouse or internal logistics towards the handling of these situations?**
- **What did you learn about your company in the process about the supply chain management or the logistics operations.**
- **Are there any long-term changes to strengthen the resiliency of logistics or warehouse operations?**
- **What do you consider to be the most important aspect of effective logistics operations during supply chain disruptions in your view?**
- **How do the supply chain disruptions affect the production planning and scheduling in your business operations?**
- **In case materials or components are late, what is the effect on production efficiency or capacity utilization?**
- **What is the interaction of the production, warehouse as well as the logistics functions during the disruption period?**
- **Has disruption changed inventory policies (e.g. safety stock levels or buffer inventory)?**
- **Which of the four areas - sourcing, manufacturing, warehousing, and distribution is the most exposed in the event of disruptions in your opinion?**

Appendix 2. Variables used in the Quantitative analysis

Variable	Description
LPI Score	Overall logistics performance index
Customs Score	Efficiency of clearance processes of customs.
Infrastructure Score	Quality of logistics infrastructure.
International Shipments Score	Facilities in making international shipments.
Logistics Competence	Quality of logistics services
Tracking and Tracing	Capability of tracking and tracing shipments.
Timeliness	How often the shipments are made to the destinations in time.

Data source: World bank logistics performance index (LPI)

Appendix 3. Regression Analysis Results (GDP and LPI, 2018)

Correlations

		LPI 2018	GDP 2018
LPI 2018	Pearson Correlation	1	,440**
	Sig. (2-tailed)		<,001
	N	134	134
GDP 2018	Pearson Correlation	,440**	1
	Sig. (2-tailed)	<,001	
	N	134	134

**. Correlation is significant at the 0.01 level (2-tailed).

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GDP 2018[b]	.	Enter

a. Dependent Variable: LPI 2018

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,440[a]	,194	,188	,52546494325

a. Predictors: (Constant), GDP 2018

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8,774	1	8,774	31,777	<,001[b]
	Residual	36,447	132	,276		
	Total	45,221	133			

a. Dependent Variable: LPI 2018

b. Predictors: (Constant), GDP 2018

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2,824	,050		56,772	<,001
	GDP 2018	1,405E+−5	,000	,440	5,637	<,001

a. Dependent Variable: LPI 2018

Appendix 4. Regression Analysis Results (GDP and LPI, 2023)

Correlations

		LPI 2023	GDP 2023
LPI 2023	Pearson Correlation	1	,414**
	Sig. (2-tailed)		<,001
	N	134	134
GDP 2023	Pearson Correlation	,414**	1
	Sig. (2-tailed)	<,001	
	N	134	134

**. Correlation is significant at the 0.01 level (2-tailed).

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GDP 2023[b]	.	Enter

a. Dependent Variable: LPI 2023

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,414[a]	,171	,165	,5521

a. Predictors: (Constant), GDP 2023

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8,309	1	8,309	27,262	<,001[b]
	Residual	40,232	132	,305		
	Total	48,541	133			

a. Dependent Variable: LPI 2023

b. Predictors: (Constant), GDP 2023

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2,894	,052		55,203	<,001
	GDP 2023	1,185E+−5	,000	,414	5,221	<,001

a. Dependent Variable: LPI 2023

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	Customs Score	Infrastructure Score	International Shipments Score	Logistics Competence and Quality Score	Timeliness Score	Tracking and Tracing Score
1	1	6,941	1,000	,00	,00	,00	,00	,00	,00	,00
	2	,038	13,502	,40	,01	,01	,00	,00	,00	,00
	3	,007	31,164	,27	,13	,09	,27	,00	,05	,09
	4	,005	35,693	,00	,01	,03	,68	,02	,23	,07
	5	,003	47,591	,29	,23	,04	,04	,08	,55	,36
	6	,003	52,377	,02	,44	,15	,01	,36	,08	,46
	7	,002	53,815	,02	,19	,68	,00	,54	,10	,02

a. Dependent Variable: LPI Score

Appendix 5. Dataset

Economy	LPI 2018	LPI 2023	GDP 2018	GDP 2023
Luxembourg	3,63	3,6	116926,76	133230,619
Norway	3,70	3,7	82792,8427	87497,218
Singapore	4	4,3	66881,6067	85412,2303
Qatar	3,47	3,5	71039,9308	81816,9798
United States	3,89	3,8	62499,8744	81032,2621
Netherlands	4,02	4,1	53955,077	63515,6031
Sweden	4,05	4,0	54018,4554	54950,2835
Finland	3,97	4,2	49654,2497	52834,2917
United Kingdom	3,99	3,7	43702,9976	49944,4702
New Zealand	3,88	3,6	43257,0769	49075,9563
Italy	3,74	3,7	34904,1082	39277,0839
Saudi Arabia	3,01	3,4	29360,0659	36156,8483
Slovenia	3,31	3,3	25888,0481	32660,4754
Lithuania	3,02	3,4	19247,2315	27786,0058
Portugal	3,64	3,4	23541,1401	27634,6183
Slovak Republic	3,03	3,3	19573,3717	24614,8735
Greece	3,20	3,7	19873,4015	23343,7104
Uruguay	2,69	3,0	19249,9405	23019,4222
Latvia	2,81	3,5	17252,171	22710,2638
Oman	3,20	3,3	19901,7616	21027,7385
Panama	3,28	3,1	16151,3273	18797,1934
Romania	3,12	3,2	12416,1343	18244,4187
Chile	3,32	3,0	15659,4809	17067,0365
Russian Federation	2,76	2,6	11211,8877	14159,3877
Turkey	3,15	3,4	9684,1182	13375,0947
China	3,61	3,7	10085,6638	12951,1782
Serbia	2,84	2,8	7559,86166	12281,7079
Montenegro	2,75	2,8	8673,59128	12259,8775
Malaysia	3,22	3,6	10901,802	11386,0396
Mauritius	2,73	2,5	11818,7481	11269,9684
Albania	2,66	2,5	5897,65453	9730,86922
Belarus	2,57	2,7	6360,0375	7896,75388
Peru	2,69	3,0	6978,49122	7887,54186
Jamaica	2,52	2,5	5976,90363	7542,40084
Thailand	3,41	3,5	7099,7765	7195,10131
Paraguay	2,78	2,7	6258,44992	6299,99027
South Africa	3,38	3,7	6914,17803	6034,27209
Algeria	2,45	2,5	4577,21029	5370,47724
El Salvador	2,58	2,7	4183,54621	5365,44491
Ukraine	2,83	2,7	3059,05176	5139,59814
Vietnam	3,27	3,3	3222,31003	4323,35032
Bhutan	2,17	2,5	3400,20417	3831,32535
Philippines	2,90	3,3	3168,51037	3804,08274
Sri Lanka	2,60	2,8	4358,56096	3798,89017
Egypt, Arab Rep.	2,82	3,1	2484,70316	3456,78968

Papua New Guinea	2,17	2,7	2566,36834	2966,0683
Angola	2,05	2,1	2860,09365	2916,13663
Uzbekistan	2,58	2,6	1813,08531	2878,96879
India	3,18	3,4	1966,25455	2530,12031
Cambodia	2,58	2,4	2036,67378	2429,74853
Zimbabwe	2,12	2,5	2270,89532	2195,22492
Nigeria	2,53	2,6	2057,87945	2138,76384
Solomon Islands	2,57	2,8	2278,19909	1882,64394
Benin	2,75	2,9	1151,74097	1394,17785
Tajikistan	2,34	2,5	834,288405	1178,4799
Mali	2,59	2,6	996,379292	1043,95339
Burkina Faso	2,62	2,3	779	874
Gambia, The	2,40	2,3	729	849
Syrian Arab Republic	2,30	2,3	1,10	847,0
Liberia	2,23	2,4	692,203127	799,19447
Sudan	2,43	2,4	731,027466	797,283447
Congo, Dem. Rep.	2,43	2,5	564	699
Yemen, Rep.	2,27	2,2	634	616
Somalia	2,21	2,0	509,497274	596,885985
Madagascar	2,39	2,3	536	512
Central African Republic	2,15	2,5	493	505
Afghanistan	1,95	1,9	491,337221	413,757895
Ireland	3,51	3,6	80,475	106,502
Switzerland	3,90	4,1	85,56	101,51
Iceland	3,23	3,6	77,963	84,425
Denmark	3,99	4,1	61,457	68,208
Australia	3,75	3,7	56,357	64,64
Austria	4,03	4,0	50,963	56,216
Belgium	4,04	4,0	47,627	54,914
Germany	4,20	4,1	49,385	54,793
Canada	3,73	4,0	46,618	54,376
Israel	3,31	3,6	42,285	52,146
Hong Kong SAR, China	3,92	4,0	48,31	50,617
Cuba	2,20	2,2	8,911	49,021
United Arab Emirates	3,96	4,00	46,974	48,941
France	3,84	3,9	41,54	44,854
Malta	2,81	3,3	34,035	41,725
Bahamas, The	2,53	2,7	33,618	37,828
Cyprus	3,15	3,2	29,326	36,605
Japan	4,03	3,9	39,85	33,776
Kuwait	2,86	3,2	31,369	33,663
Spain	3,83	3,9	30,527	33,313
Korea, Rep.	3,61	3,8	33,429	33,128
Taiwan, China	3,60	3,9	25,889	32,337
Czech Republic	3,68	3,3	23,66	31,8
Estonia	3,31	3,6	23,629	30,273

Bahrain	2,93	3,5	26,324	29,29
Hungary	3,42	3,2	16,593	22,302
Poland	3,54	3,6	15,658	22,119
Croatia	3,10	3,3	15,466	21,873
Guyana	2,36	2,4	6,121	21,307
Trinidad and Tobago	2,42	2,5	17,184	17,616
Costa Rica	2,79	2,9	12,429	16,39
Bulgaria	3,03	3,2	9,474	15,892
Argentina	2,89	2,8	11,786	13,908
Mexico	3,05	2,9	9,971	13,713
Kazakhstan	2,81	2,7	9,813	13,158
Dominican Republic	2,66	2,6	8,286	11,28
Brazil	2,99	3,2	9,282	10,35
Gabon	2,16	2,4	8,199	9,079
North Macedonia	2,70	3,1	6,72	8,629
Georgia	2,44	2,7	4,801	8,237
Armenia	2,61	2,5	4,205	7,973
Bosnia and Herzegovina	2,81	3,0	5,865	7,969
Colombia	2,94	2,9	6,924	7,0
Moldova	2,46	2,5	4,156	6,801
Iraq	2,18	2,4	6,038	6,251
Libya	2,11	1,9	11,774	6,027
Fiji	2,35	2,3	6,27	5,971
Mongolia	2,37	2,5	4,078	5,796
Guatemala	2,41	2,6	4,353	5,758
Indonesia	3,15	3,0	3,946	4,92
Iran, Islamic Rep.	2,85	2,3	4,055	4,115
Djibouti	2,63	2,7	3,038	3,804
Bolivia	2,36	2,4	3,588	3,748
Venezuela, RB	2,23	2,3	3,53	3,617
Honduras	2,60	2,9	2,507	3,28
Bangladesh	2,58	2,6	1,992	2,652
Congo, Rep.	2,49	2,6	2,716	2,496
Mauritania	2,33	2,3	1,882	2,421
Ghana	2,57	2,5	2,195	2,384
Kyrgyz Republic	2,55	2,3	1,322	2,191
Lao PDR	2,70	2,4	2,55	2,0
Cameroon	2,60	2,1	1,612	1,737
Haiti	2,11	2,1	1,501	1,684
Guinea	2,20	2,5	892	1,555
Rwanda	2,97	2,8	797	1,062
Guinea-Bissau	2,39	2,6	895	1,035
Togo	2,45	2,5	852	1,001