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Challenges faced by Logistics Service Providers in managing Environmental Uncertainty

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Summary

This study focuses on the difficulties logistics service providers (LSPs) encounter in responding to natural disasters and how such events raise the costs of both finances and relationships. The study discovered that even in the short term, natural disasters raise uncertainty and impose large financial costs. The effect on relational costs is yet unclear and there is still a need for more research. Concerning the usage of risk mapping tools and tracking technology, the findings showed that while mapping tool experiences vary, indicating the need for large-scale studies, tracking technology does not always live up to customer expectations in terms of reducing the financial impact of the delay. It was discovered that transparent communication with customers decreased financial costs but had no noticeable impact on relational costs. Even though they reduced delays, preventive measures often resulted in additional expenses that might have outweighed any financial advantages. Despite the additional costs associated with preventive measures, we found that proactive customer interaction and achieving customer expectations may reduce relationship costs. The data was gathered through semi-structured interviews with managers and staff of 12 LSP companies. Our study's small sample size limited its generalization.

Keywords: Environmental uncertainty, delay, financial cost, relationship cost, technology (tracking system), risk mapping, transparency, proactivity

Contents

Acknowledgements ... 2
Summary ... 3
Table of Figures ... 5
List of Tables ... 5
1. Introduction ... 6
1.1. Significancy of study ... 6
1.2. Purpose of the thesis ... 9
2. Background ... 9
2.1. Logistics service provider ... 9
2.2. Type of logistics service provider ... 9
2.2.1 Carrier ... 10
2.2.2. Forwarder ... 10
2.2.3. Third-party logistics ... 10
2.3. Disaster ... 10
2.3.1. Disaster classifications ... 11
2.3.2. Natural hazards ... 11
2.3.3. Technological hazards ... 12
2.4. Difficulties in measuring natural hazards ... 13
2.5. Uncertainty ... 14
2.5.1. Uncertainty in logistics ... 14
2.6. Delay ... 15
2.7. Cost ... 16
2.7.1 Direct cost ... 16
2.7.2. Indirect-Relationship cost ... 17
2.8. Mitigation factors ... 17
2.8.1. Risk management ... 17
2.8.2. Risk management tools ... 18
2.8.3. Proactive risk management ... 18
2.8.4. Technology management ... 19
3. Hypothesis developments and conceptional framework ... 20
3.1. Research hypothesis ... 21
4. Methodology ... 25
4.1. Research design ... 25
4.2. Data collection ... 26
4.3. Data analysis ... 27
4.4. Research ethics ... 27

5. Results 27
6. Discussion 33
7. Conclusion 35
8. Limitation of study 37
References 38

Table of Figures

Figure1. secretariat calculations, based on Clarkson's research, shipping intelligence

Network timeseries………………………………………………………………………...8

Figure 2. Natural hazards subgroups and types in the IRDR Peril classification and hazard Glossary…..……………………………………………………………………………….11

Figure 3. The conceptual framework…………………………………………………………21

List of Tables

Table 1. Top 10 economic losses 2022 ……………………………….……..………....7

Table 2. Summarized mitigation strategies ………………………………………………... 19

Tabel 3. Interviewees profile………………………………………………………….......27

Table 4. Correlation table between average delays day and uncertainty level……….........28

Table 5. The summary of participents' response…………………………………………28

Table 6. Correlation table between average delays deay and average financial cost………..29

1. Introduction

In today's interconnected global economy, logistic service providers (LSPs) play a crucial role in enabling the efficient transportation of goods across extensive networks in supply chains. Nonetheless, amid the complex nature of their operations, LSPs encounter significant challenges. Natural disasters are one of the threats that pose a particular disruption to them. Events such as floods, hurricanes, and earthquakes not only endanger physical infrastructure but also introduce considerable environmental uncertainty. Environmental uncertainty causes increased delays, which can result in large economic losses. Therefore, it is crucial to understand how LSPs can mitigate the impact of environmental uncertainty on their operations. Extensive research has focused on analyzing how natural disasters affect supply chains and identifying effective strategies to minimize their impact. but still, there is a gap in how LSP companies could mitigate these challenges. Considering the importance of the subject matter, this research has been undertaken to uncover more about the relationship between natural disasters, environmental uncertainty, delay, and the resulting financial implications for LSPs and the strategies that could be hired to address the challenging effects. In this study, we will focus more on how the utilization of tools such as risk mapping, technology (tracking system), transparent communication and proactive strategies could address these challenges of LSPs. In our research, we have identified natural disasters as antecedents, the cost (relationship/financial) as the dependent variable, and the degree of uncertainty as the independent variable. The number of days delay is a mediator variable. Technology (tracking system) and tools (risk mapping) are the first moderators that examine how their use can strengthen or weaken the level of uncertainty, and transparency and proactivity are the second moderators that try to find out how transparent and proactive communication with customer can create a relationship between days delay and weak or strong delay cost. The method we have utilized is semi-structured interviews with logistics service provider managers and employees.

1.1. Significancy of study

Many industries struggle with significant challenges as their supply chains are disrupted by disasters that are natural such as hurricanes, droughts, earthquakes, and floods, or human-caused such as war. For instance, the powerful earthquake in Türkiye in February 2023, caused considerable damage to the transport infrastructure of key ports, airports, and highways which caused numerous challenges for supply chain and logistics service providers in Türkiye as well as other countries (Asstra,2023). Movement restrictions imposed during the COVID-19 pandemic disabled logistics service providers from offering efficient transportation services. For example, air transportation capacity between China and Europe experienced a 40% decrease (Tardivo et al., 2021) which caused an increase in air freight (Bo et al., 2023). Heavy truck traffic was created due to the closing of entry and exit borders (Commission and Eurostat, 2022). There was a decrease in the demand for ocean freight services due to declining demand for goods (Tardivo et al., 2021). It is notable that in the early 2000s and before COVID-19, epidemics and pandemics such as SARS and Bird flu have already negatively impacted the world economy (Stecke & Kumar, 2009). Recent reports from the Emergency Events Database (EM-DAT, 2022) highlight the global significant economic losses resulting from natural disasters. As indicated in Table 1, the data highlights the diverse range of natural disasters and their economic impacts on different countries. The United States experienced the highest economic losses due to hurricanes, totaling $100.0 billion. Following hurricanes, droughts resulted in economic losses of $22.0 billion in the United States. Floods in Pakistan led to economic losses amounting to $15.0 billion. The earthquake in Japan resulted in economic losses of $8.8 billion. Droughts in China caused economic losses of $7.6 billion, while floods resulted in losses of $5.0 billion. Floods in Australia led to economic losses of $6.6 billion. Nigeria and India: Both countries experienced economic losses of $4.2 billion due to floods. Brazil: Droughts in Brazil resulted in economic losses of $4.0 billion (EM-DAT, 2022).

Table 1: Top 10 economic losses 2022

Country	Disaster type	Economic Loses in US$
USA	Hurricane	100.0 billion
USA	Drought	22.0 billion
Pakistan	Flood	15.0 billion
Japan	Earthquake	8.8 billion
China	Drought	7.6 billion
Australia	Flood	6.6 billion
China	Flood	5.0 billion
Nigeria	Flood	4.2 billion
India	Flood	4.2 billion
Brazil	Drought	4.0 billion

Source: CRED. (2022). Emergency Events Database (EM-DAT) report. Retrieved from https://www.cred.be/sites/default/files/2022_EMDAT_report

Besides natural disasters, human-caused disaster such as the recent war in Ukraine impacts the world's economy and supply chains (Johannessen,2023). War causes disruption such as the process of movement of goods, which causes an increase in the prices of products. For example, foodstuff and energy fees increased by 6.5% in February 2022 (Guenette et al., 2022).

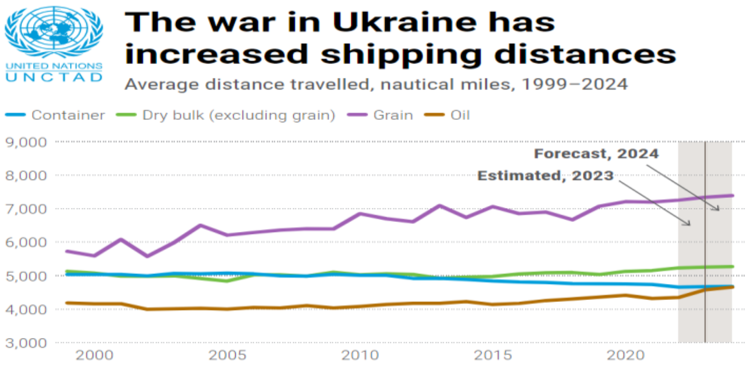

Figure 1: UNCTAD secretariat calculations, based on Clarkson's Research, Shipping Intelligence Network timeseries (as of 8 June 2023).

In the words of the United Nations Conference on Trade and Development, the war between Russia and Ukraine has resulted in significant disruptions to shipping routes. This is because the fighting has made the regular routes, ports, and waterways hazardous or inaccessible. Ships must now travel longer distances to reach their destinations. This has resulted in increased freight costs and longer delivery times (UNCTAD, 2023). Our research will focus on natural disasters. Given the importance of the issue, it is critical that LSPs, as key parts of the supply chain, develop appropriate approaches to mitigate the effect of unexpected environmental concerns on their operations and implement proactive actions. The results of this research have important consequences for academics and industry. This study aims to understand more about the difficulties in managing natural disasters in the field of logistics. In addition, the practical consequences of our findings will offer LSPs feasible options to strengthen their resilience against disruptive events, hence improving operational efficiency and lowering financial or relational risks. In essence, this study strives to clarify the path toward a more resilient and adaptive logistic service sector, capable of navigating the challenging circumstances of environmental uncertainty with foresight and efficacy.

1.2. Purpose of the thesis

The main goal of this study is to investigate and lay out the methods employed by logistics service providers in response to natural disaster disruption. Particularly, the study aims to study: This study aims to explore and describe the strategies used by logistics service providers to deal with disruptions caused by natural disasters. The study specifically attempts to investigate:

1- What effects do natural disaster-related uncertainties have on logistics service providers in terms of delivery delays, and what are the resulting consequences in terms of finances and relationships?

2- How could proactivity, transparent communication strategies, risk mapping, and tracking technologies assist logistics service providers in mitigating the uncertainties and delays that LSPs face during natural disasters?

We hope that our findings could help companies improve their future risk mitigation strategies, especially while dealing with natural disasters.

2. Background

In this section, we first outline the key variables and definitions central to the above-mentioned investigation and provide context.

2.1. Logistics service provider

Logistics service providers (LSPs) play a pivotal role in shaping the overall logistics performance within supply chains (Forslund, 2012). LSPs serve their clients to boost their performance in a variety of ways, through logistics or supply chain optimization, cost savings, value creation, growth, and strategy development (Fabbe-Costes et al., 2008).

2.2. Type of logistics service provider

Logistics service providers can be categorized in a variety of ways. Several names have been employed to identify logistics service providers. Cui and Hertz (2011) categorize logistical services providers as Carriers, Freight Forwarders, and Third-party logistics providers.

2.2.1 Carrier

Carriers provide physical transportation of goods or materials from one location to another. Carriers invest much in transport vehicles and facilities providing smooth operations. Shipping lines, airlines, and trucking companies are a few examples of carriers.

2.2.2. Forwarder

Freight forwarders oversee combining goods and linking carriers with clients. The forwarder does not physically move the goods but specializes in managing the logistics process (Cui & Hertz, 2011). Freight forwarder companies negotiate with carriers to secure the best routes at competitive prices for the transportation of goods. They utilize various modes of transportation, including ships, airplanes, trucks, and railroads, often combining multiple modes for a single shipment. For example, they may arrange for goods to be transported from a manufacturing plant to a seaport via truck, then shipped to the destination city by sea, and finally delivered to the customer's location via another truck (Raja & Venkatachalam, 2020).

2.2.3. Third-party logistics

Third-party logistics service providers cooperate with carriers, logistics intermediaries, and other service providers. These service providers act as an intermediary between the seller and the buyer, providing transportation and warehousing services, as well as other services like consolidation and deconsolidation, cross-docking, picking and packing, custom clearance, track and trace information, insurance services, payment services, tendering and contracting carriers, and forwarding services (Stefansson 2006).

2.3. Disaster

The term disaster has been defined in many ways by numerous researchers based on the method employed to describe both their causes and effects. In the words of the United Nations Office for Disaster Risk Reduction, disasters occur through a combination of hazards, vulnerabilities, and inadequate measures. Disasters are unexpected and unplanned events that cause devastation, loss, and damage due to natural, technical, or societal causes. Disasters normally happen on a single huge scale with a high impact. Some scholars indicate disasters as situations that exceed the local capacity to withstand, deal with, and recover, necessitating external assistance and involving a variety of stakeholders (Al-Dahash et al.,2016).

2.3.1. Disaster classifications

There are numerous classifications for disasters. Shaluf (2007) categorized disasters into natural, human-caused, and hybrid disasters. Natural disasters are incidents that originate from various sources including internal (under the Earth's surface), external (topographical), weather-related (meteorological/hydrological), and biological events. These events, commonly known as "Acts of God," are typically uncontrollable and can have devastating consequences. In contrast, human-caused disasters result from human actions and decisions, categorized into socio-technical and warfare disasters. Socio-technical disasters include major accidents during industrial activities leading to fire, explosion, and toxic releases from major hazard installations. Warfare disasters include inter-state conflicts resulting in casualties, international conflicts like border disputes, and non-conventional warfare using harmful agents and toxins. Hybrid catastrophes are the result of a combination of human and natural causes. For instance, the extensive deforestation causing soil erosion, exacerbated by heavy rainfall, leads to disasters (Shaluf, 2007). The Emergency Events Database (EM-DAT, September 2023) classified disasters into two primary groups: 'Natural' and 'Technological'. Within these categories, disasters underwent further subdivision into groups, subgroups, types, and subtypes, as delineated in the EM-DAT Public Table columns.

2.3.2. Natural hazards

The natural group is classified into up to six additional levels: Geophysical Hazards, Hydrological Hazards, Meteorological Hazards, Climatological Hazards, Biological Hazards, and Extra-terrestrial Hazards. The technological group is less detailed and comprises three main types: transport, industrial, and miscellaneous accidents.

Figure 2: Natural Hazards Subgroups and Types in the IRDR Peril Classification and Hazard Glossary (2014)

The United Nations Office for Disaster Risk Reduction (UNDRR) provides critical insights into these hazards, helping to enhance global understanding and preparedness.

Meteorological and hydrological hazards are those resulting from the state and behaviour of the Earth's atmosphere, its interaction with the land and oceans, the weather and climate it produces, and the resulting distribution of water resources. These hazards are observed, monitored, and forecasted by the national meteorological and hydrological services of each country (UNDRR, 2020).

Extraterrestrial hazards involve events that occur outside of the Earth, including asteroid and meteorite accidents or solar storms. Solar storms can cause major disruptions and damage to satellite communications and electric power infrastructure, resulting in significant economic losses. Asteroid impacts may cause serious local damage and catastrophic destruction, even universal extinction (UNDRR,2020).

Geohazards are geological hazards, divided into three clusters: seismogenic and volcanogenic, resulting from Earth's internal processes, and shallow geohazards due to surface or near-surface processes. Seismogenic hazards cause ground shaking, subsidence, tsunamis, and rockfalls, while volcanogenic hazards cause lava flow, rockfall, and ground gases. Some geohazards may be exacerbated by human activity (UNDRR, 2020).

Biological hazards, including pathogenic microorganisms, toxins, and bioactive substances, can cause significant loss of life, impacting people, animals, plants, crops, livestock, and endangered species. They can also lead to severe economic and environmental losses. Exposure to zoonotic pathogens often leads to emerging infectious diseases in humans. Many biological hazards are not considered due to their unique characteristics, such as agent diversity and transmission routes. These hazards pose a high risk for epidemics and pandemics, particularly from highly virulent microorganisms. Natural hazards can exacerbate conditions for biological hazards, such as water infrastructure damage and the introduction of novel pathogens. Examples of recent large outbreaks, epidemics, or pandemics include COVID-19 (from 2019), Ebola in the Democratic Republic of Congo (2018–2020) and West Africa (2013–2016), and the Zika virus in the Americas and Pacific regions (2015–2016) (UNDRR, 2020).

2.3.3. Technological hazards

Technological hazards represent many risks to transportation systems, infrastructure, and public services. Radioactive and nuclear materials are among the hazards, are conventional explosives like landmines and improvised explosive devices, along with creating dangers from information and communication technology. The dependency on ICT in critical infrastructure operations increases cybersecurity concerns, including viruses, malware, identity theft, and data breaches. These risks provide substantial issues, including trauma, burns, infections, and long-term health consequences for survivors. In addition, cyber hazards are changing, with issues such as losing data, viruses, network challenges, and misconfiguration, further complicating risk management efforts (UNDRR,2020).

All disasters, regardless of their causes, have one thing in common: they have a significant impact on people, property, and the environment (Shaluf, 2007). After obtaining an in-depth knowledge of natural hazard typologies, it is necessary to navigate the complexity associated with their measurement, shedding light on the problems that drive accurate evaluation and mitigation.

2.4. Difficulties in measuring natural hazards

Despite advances in technology and disaster preparedness, such as early warning systems, remote sensing and monitoring, communication and information sharing, geographical information systems (GIS), drone technology, predictive analytics and machine learning, resilient building and infrastructure, early flood detection systems, satellite navigation, and cloud computing, natural disasters keep having a global impact. So, investment in preparedness and response activities to reduce the negative consequences of natural disasters on people, property, and the environment is crucial. However, the use of modern technology in NDM still faces numerous barriers. For instance, the costs of implementing and maintaining these technologies could prove too expensive for some populations, especially in nations that are developing. Without consistent data collection and processing procedures, comparing data from different times and places becomes challenging preventing the development of efficient plans for response. In addition, utilizing these technologies needs a high level of technical knowledge, which may be inaccessible in some regions. Plus, the rapid pace of technological progress causes a constant flood of modern technology and applications. This is a challenge for those responding to emergencies, that have to constantly improve their abilities and adapt to the most modern developments. Finally, the efficient application of these technologies in NDM demands greater collaboration and coordination within various groups and governments. This includes harmonizing procedures and processes to facilitate the seamless sharing of data and information (Krichen et al., 2023).

2.5. Uncertainty

Uncertainty is about not being able to accurately anticipate what will happen in the future. It is the idea that certain events or outcomes are unpredictable, meaning we cannot confidently know or forecast what will occur (Krickx, 2000). Uncertainty has many aspects. For instance, in a business context, uncertainty might influence how well a company performs or how stable it is as an organization. This implies that when there is uncertainty, it can create challenges or fluctuations in different areas of a business, potentially affecting its overall success and stability (Anderson & Schmidtian, 1984). A variety of factors can contribute to uncertainty, which can be characterized according to its source (Gultekin et al., 2022). Depending on whether uncertainty arises inside or outside of the supply chain, Trkman and McCormack (2009) divide uncertainty into endogenous or exogenous groups. Three distinct categories of uncertainty have been identified by Krickx (2000): (1) internal/organizational, (2) external/environmental, and (3) strategic. For instance, unforeseen natural disasters or changes in customer preferences might cause environmental or external uncertainty. Uncertainty inside an organization arises from decision-makers inability to effectively communicate with their partners and analyze all the necessary information, resulting in a lack of coordination. In a business environment, strategic uncertainty is the condition of not knowing with certainty what other companies may act or intend to do. In light of this, it makes it hard for companies to remain informed of their suppliers, customers, and competitors. As stated by Kreye (2018), external factors that are out of the control of a company and could have significant effects on operations include market conditions, customer preferences, innovations in technology, regulatory changes, economic fluctuations, competitive actions, political instability, and natural disasters. In our study, we will focus on natural disasters as one of the environmental uncertainties that impact the logistics service providers' operation.

2.5.1. Uncertainty in logistics

The organized movement of goods, services, and even people is referred to as logistics. Formerly employed in military operations, logistics is now used for business activities like international trade. When we discuss international logistics, it refers to an extensive network that includes traders, bankers, carriers, forwarders, and others involved in international trade and the flow of goods and services (Wood et al., 1995). Uncertainty in logistics relates to unpredictability or variability in supply chain processes and operations.

This uncertainty can arise from various sources and can impact different aspects of logistics management. Gultekin (2022) categorized uncertainties faced by Logistic Service Providers into four main types: supply, demand, internal, and external uncertainties. The category offers a detailed framework for understanding the multifaceted challenges inherent in logistics operations. Supply uncertainty included several critical factors such as forecast horizon, shipper reliability, production issues, and supply chain processes. The forecast horizon refers to the difficulty in accurately predicting demand over various times, impacting decisions on inventory management, production scheduling, and procurement strategies. Shipper reliability concerns the performance and dependability of transportation partners in terms of transit times, adherence to schedules, and their ability to handle disruptions effectively. Production issues, another component of supply uncertainty, arise from challenges within manufacturing processes, such as equipment breakdowns, labor shortages, or delays in sourcing raw materials, which can disrupt supply chains. Additionally, supply chain processes encompass inefficiencies or disruptions across various stages, including procurement, manufacturing, warehousing, transportation, and distribution, which contribute to supply uncertainty.

2.6. Delay

Delivery delays in logistics occur when products arrive later than anticipated, and this may have a significant impact on the costs and operations of the entire supply chain. All parties involved are impacted by these delays, which are frequently the result of supply chain interruptions and present substantial problems to shippers, customers, and logistics service providers (Sanchez-Rodrigues et al., 2010). For instance, delivery delays can lead to operational disruptions for shippers and may even result in overflowing warehouses or distribution facilities, which could have an impact on inventory control. In addition, delays may result in a shortage of materials, which could affect just-in-time (JIT) strategies that are essential to sustaining effective inventory levels (Gong, 2012). Perishables and chemicals are examples of items that can lose value or incur quality change during long travel (Leviakangas, 2010). LSPs can encounter serious consequences, such as possible customer attrition and revenue loss if they are unable to meet consumer expectations concerning delivery periods (Ballou and Srivastava, 2007). LSPs need to reduce the expenses incurred by supply chain disruptions, both directly and indirectly.

2.7. Cost

When discussing the effects of disasters, scholars tend to distinguish between direct and indirect costs (Hallegatte, 2015). The term "direct costs" refers to the immediate and tangible financial consequences that arise from coming into direct physical touch with the hazard. This includes any actual property that is damaged or destroyed, such as buildings, stores of goods, inventories, infrastructure (such as utilities, roads, and bridges), or any other tangible property. Direct costs are the immediate costs incurred to rebuild, replace, or repair the damaged assets as a result of the danger. They are usually measurable in financial terms. These expenses are obvious and related to the danger's physical effects on the assets (Meyer et al., 2013). Any losses that result from a disaster's consequences rather than the occurrence itself are considered indirect losses. Such losses, that go beyond direct physical damage are often referred to as "higher-order losses" (Hallegatte & Przyluski, 2010).

2.7.1 Direct cost

Natural disasters can cost logistics service providers financially in several ways. For instance, in the road services sector, vehicles that have queues or delays at delivery sites use more fuel, need greater amounts of services, and require their drivers to work longer periods. These factors substantially increase the cost of operations for road service companies (Gong et al., 2012). In sea service, natural catastrophes can cause port congestion, which affects many parties involved in import, export, transportation, and port operations. a study by Bai et al. (2022), port congestion is the result of a ship's overcrowding at a port, resulting in delays in cargo loading, unloading, and docking. This leads to extra costs and scheduling difficulties. To speed up the movement of goods between vessels or inland transportation modes, several seaports (hubs) serve as transshipment ports. The seamless operation of the main ports is essential for transshipment, which is the transfer of cargo from one vessel to another or from one vessel to another route of transportation within the port. While smooth port-hinterland connections are crucial, delays at major hubs could cause problems with transshipment plans, creating friction in the supply chain and resulting in extra costs (Merk & Notteboom, 2015). Companies can encounter financial losses as a result of missed sales opportunities and demurrage charges, which are payments for delays in unloading goods (Gui et al., 2022). The considerable financial and operational challenges that LSPs encounter following natural disasters are highlighted by these compounding impacts.

2.7.2. Indirect-Relationship cost

Effective customer service is a top priority for all businesses including the logistics service providers. In LSP companies, several components play a key role in providing excellent customer service. These include achieving high order fulfillment rates, making sure deliveries happen frequently and quickly, keeping an eye on inventories, reliably delivering goods on schedule, making sure things arrive in optimal arrangement, and supplying proper documentation. Any delay could affect customers and may cause losing them. Studies show that it costs six times as much on average to acquire new customers as it does to retain current ones, therefore maintaining customer satisfaction is crucial for keeping them (Sarder, 2021). To efficiently and quickly meet customer needs, these processes must be coordinated, which can only be achieved through offering excellent customer service.

2.8. Mitigation factors

Natural disasters cause enormous destruction and financial losses, making it hard to figure out the full scope of the damage. Proactive measures, however, may mitigate this negative impact. LSPs in this type of situation need to come up with plans that ensure continuous service or product availability. Simangunsong and Stevenson (2012) distinguished between two main methods for dealing with uncertainty:

1- Strategies for reducing uncertainty: These methods involve dealing with uncertainty at its origin. For instance, using suitable price strategies or providing incentives could help balance customer demand.

2- Coping Strategies with Uncertainty: This strategy attempts to successfully adapt to uncertainty instead of reducing it. predict customer demand, providing them with the ability to accurately and efficiently plan to minimize changes in demand while keeping uncertainty.

Based on Simangunsong and Stevenson’s (2012) approach efficient risk management is crucial when dealing with natural disasters.

2.8.1. Risk management

Risk management is an important aspect of the supply chain's design that includes the identification, evaluation, and control of possible hazards that may affect the whole operation of the supply chain. Logistics service providers should properly recognize and control risks to prevent negative results from cascading through the supply chain, considering the interdependence of logistics hazards and their impact on the whole supply

(Govindan and Chaudhuri, 2016). Plenty of research (Shahbaz et al., 2019; Prakash et al., 2017; Wang et al., 2014; Wang, 2018) indicates how uncertainty and risk are connected in practical situations. Therefore, managing risk in logistics—especially where it is vulnerable to natural disasters—presents several issues requiring proactive and comprehensive risk management strategies. Logistics service providers can improve adaptability to natural disasters and reduce disruptions to the supply chain by including these methods in their logistics system design.

2.8.2. Risk management tools

Identification and analysis of risks are crucial components of risk management. When risks are identified, decision-makers are made aware of possible occurrences that could be uncertain. The main purpose of risk identification is to recognize future uncertainties so that proactive preparations can be performed to deal with them. There are many methods for risk analysis and identification. Risk mapping is a useful tool for understanding possible results and mapping out risk sources in a methodical way (Brindley, 2017). The purpose of risk mapping purpose is to determine the probability of particular dangers arising, as well as their severity and the impacted regions, over a specified period.

2.8.3. Proactive risk management

In the context of uncertainty caused by natural disasters, the importance of proactive risk management and transparency becomes even more pronounced. Uncertainty reduction is a key objective in business communication interactions. Effective communication helps organizations minimize uncertainties by ensuring that accurate and relevant information is shared among stakeholders. This process is essential for making informed decisions and maintaining operational efficiency. Beulens et al. emphasize the importance of transparency in achieving uncertainty reduction. They define transparency as the availability of necessary information at the right time and in the right manner. Therefore, for communication to be effective, information must not only be accurate and relevant but also timely and accessible to those who need it. By fostering transparency, businesses can enhance trust, improve coordination, and ultimately reduce the uncertainties that can hinder their operations (Parris & Arnold, 2016).

2.8.4. Technology management

Tracking and tracing systems have become essential in logistics, significantly enhancing customer service and operational efficiency. These technologies provide real-time updates on shipment status and location, boosting transparency and reliability across the supply chain. Various tracking technologies, such as GPS for location tracking, vibration and shock sensors for monitoring shipment conditions, and automated systems like Electronic Data Interchange (EDI) for efficient data sharing among logistics partners, are utilized. These systems bridge the gap between information networks and the physical movement of goods, enabling logistics service providers to quickly address issues and maintain precise delivery schedules. By adopting and continuously improving these advanced tracking systems, logistics providers can differentiate themselves in a competitive market, attract and retain customers, and ensure smooth logistics operations. This not only enhances customer satisfaction with accurate delivery information but also streamlines the entire production and delivery process, strengthening market position and reducing costs associated with customer dissatisfaction (Shamsuzzoha & Helo, 2011). The summary of risk mitigation strategies of our study is available in Table 2.

Table 2: Summarized mitigation strategies

Risk mitigation strategies	Implementation Impact(s)
Risk Mapping	• Useful tool for understanding possible results and mapping out risk sources in a methodical way
Technology (tracking system)	• Provide real-time updates on shipment status • Increase transparency and reliability across the supply chain by efficient data sharing among logistics partners • Eenhances customer satisfaction
Transparent communication with customers	• Can enhance trust • Improve coordination • Reduce the uncertainties
Proactivity	• Enhances resilience by predicting and quickly fixing disruptions. • Increase customer loyalty

3. Hypothesis developments and conceptional framework

This chapter will examine the research on uncertainty effects on logistics service provider's performance. Samantha (2018) investigated the impact of natural disasters on small and medium-sized businesses, revealing that such events can significantly harm these businesses compared to other challenges due to their negative consequences on the local communities. Yong-Hyun Choi et al. (2018) examined the effects of demand uncertainty, a form of environmental uncertainty, on logistics performance. Their analysis supported the hypotheses concerning the relationships among demand uncertainty, logistics system integration, and logistics performance, driven by various factors including customers' needs, sales fluctuations, market dynamics, competitors' strategies, and technological changes. Sugiono & Wibowo (2022) analyzed the effects of environmental uncertainty and Incoterms on strategic alliances within logistics service provider companies. The findings showed that environmental uncertainty and Incoterms positively and significantly influence strategic alliances, particularly emphasizing risk-sharing aspects, risk management related to Incoterms, and market turbulence linked to environmental uncertainty. Lho & Lim's (2014) study on the impact of climate and weather variations as external environmental factors on logistics highlighted significant adverse effects of weather conditions on cargo transportation. Sanchez & Potter (2010) assessed the causes of supply chain uncertainty in transport operations using the logistic triad uncertainty model, where the core members (shipper, customer, provider) identified delays as a prominent source of uncertainty. Wang (2018) identified delays arising from customer errors, road congestion or closures, heightened customer expectations, variable fuel prices, and delays in pickup/delivery as significant uncertainties in the supply chain. These findings align with those of Simangunsong et al. (2012), pointing out the impact of supply chain uncertainty on logistics performance. The findings suggest that supply chain uncertainty and risk negatively affect logistics performance. Furthermore, the most significant impact of supply chain uncertainty and risk originates from external factors outside the company. Natural disasters are unpredictable, thereby comprehensive prevention is neither feasible nor attainable. Events like typhoons, floods, and earthquakes result in significant harm to people, property, and the economy. Companies struggle to return after such disasters, especially because they disrupt various forms of transportation, including roads, railways, air travel, and maritime routes (Wisetjindawat et al.,2017). Despite extensive research on supply chain disruptions due to natural disasters, there is a notable gap in understanding their specific impact on the operations of logistics service providers. This study aims to bridge this gap by investigating the degree of uncertainty LSPs face from natural disasters and its relationship with delivery delays. Additionally, we will examine whether these delays result in financial or relational costs for LSPs. We argue that tools like risk mapping and technologies such as tracking systems can either mitigate or exacerbate uncertainty levels. Furthermore, we hypothesize that proactive communication with customers and transparent communication can reduce delays and associated costs. Our study will also explore the strategies that LSPs adopt to address the challenges posed by natural disasters. The conceptual framework for understanding the elements and relationship is shown in Figure 3.

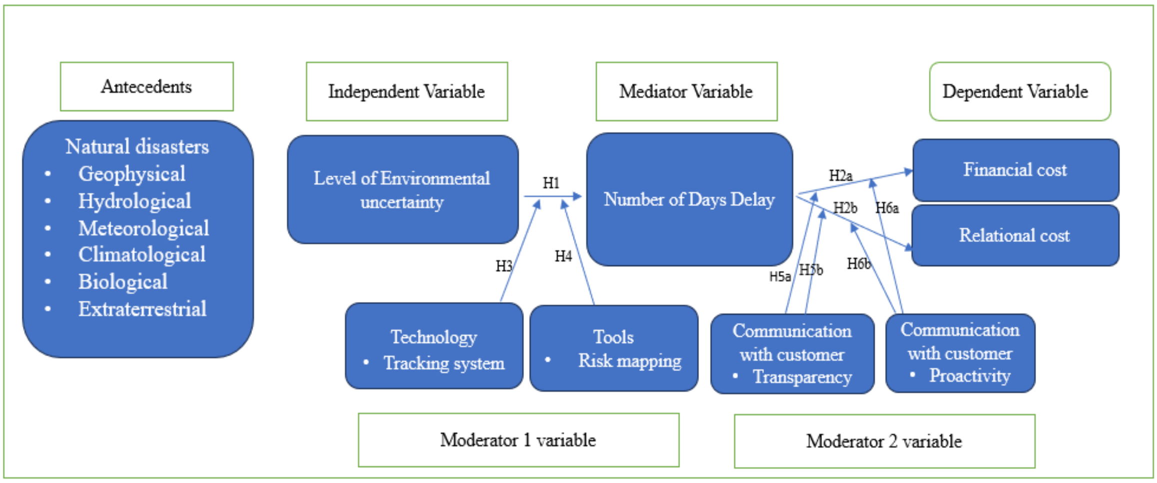

Figure 3:The conceptual framework

3.1. Research hypothesis

In this section, we will discuss the study's hypothesis.

H1: Environmental uncertainty has a positive impact on the number of days delay

In supply chain management, uncertainty is a critical factor that influences logistics performance, particularly in terms of delays. Various studies confirm this perspective. For instance, Wang (2018), McKinnon and Ge (2004), and Simangunsong et al. (2012) highlight that supply chain uncertainty is a significant contributor to delays in logistics operations. We argue that environmental uncertainty, by its nature, introduces variability and unpredictability, which extends the duration of delays.

H2a: The higher number of days delay leads to a higher number of financial costs

There is no argument that supply chain disruptions are costly. Transport delays are an issue that can quickly disable the entire supply chain because, in addition to preventing flow movement, stoppages in materials and/or goods transfer spread quickly to supply chain segments, leading to shortages, inventory stock, manufacturing interruptions, unsatisfied customer orders, and/or stoppages in commodities transit. For example, severe snowfall in southwestern Sweden began in December 2009 and continued until March 2010. Many tones of temperature-sensitive commodities have frozen in wagons due to delays in transshipment to trucks. During this time, the volume of rail goods in Sweden was reduced by an entire 20%. The Halsberg marshaling yard, which is important to Sweden's rail freight operations, was closed for 14 days. This stoppage alone has cost 200 to 250 million SEK (Ludvigsen & Klæboe, 2014). we argue that the higher number of days delay leads to a higher number of financial costs.

H2b: The higher number of days delay leads to a higher number of relationships cost

For logistics service providers, a single late delivery may affect their level of customer service. Late deliveries can have a chain of effect on the various operations of receivers, disrupting schedules, inventory management, and production timelines. This unreliability can lead to substantial relational costs for logistics service providers When deliveries are late, receivers face operational disruptions that can lead to increased operational costs, such as overtime labor, express shipping fees for delayed components, or production halts. These issues not only affect the immediate operational efficiency of the receivers but also damage their trust and satisfaction with the LSPs. Customers rely on timely deliveries to maintain their supply chain integrity and meet their commitments. Delivery delay can affect the relationship between the sender and the receiver (Ballou and Srivastava, 2007). We hypothesize that as the number of days delay increases, the relational costs incurred by LSP also rise.

H3: The positive effect of environmental uncertainty on number of days delay is weakened when we have mitigation technology

In the logistics industry, technology plays an essential role. The ability to track shipments can reduce uncertainty in logistics operations, resulting in fewer and shorter delays (Sarder, 2021). We aim to understand whether enhanced real-time monitoring through a tracking system in uncertain conditions consistently weakens the effect of uncertainty on number of days delay.

H4: The positive effect of environmental uncertainty on number of days delay is weakened when you have a mitigation risk mapping

Risk management is critical for reducing the potential of supply chain disruptions. Companies may significantly decrease the likelihood and impact of interruptions by preparing for predicted hazards ahead of time (Skora & Xia,2011). Drawing on this insight, we intend to determine whether risk mapping consistently helps companies and weakens the positive effect of environmental uncertainty on the number of days delay

H5a: The positive effect of the number of days delay on financial cost is weakened by transparent communication

Shared information among supply chain members is crucial for improved visibility and responsiveness. This transparency reduces uncertainty and enables the supply chain to adapt more readily. When all parties can access the same information, they can work together more efficiently to address disruptions. This collaborative effort reduces the need for costly last-minute interventions and helps maintain smoother operations. Information-enriched supply chains perform better than those without access to information beyond their corporate boundaries and postponement strategy can be cost-effective and time-efficient, facilitated by shared information, allowing the supply chain to align with actual demand (Christopher & Lee, 2004). We seek to understand whether transparency can consistently assist LSP companies in weakening the financial impact of the number of days delay.

H5b: The positive effect of the number of days delay on relational cost is weakened by transparent communication

Beulens et al. emphasize the importance of transparency in mitigating uncertainty. They define transparency as the availability of critical data at the right time and in the right manner. For communication to be effective, information must be accurate, relevant, timely, and accessible to those who need it. By promoting transparency, companies can enhance trust and cooperation, reducing uncertainties that may disrupt their operations (Parris & Arnold, 2016). Building on these insights, we propose the hypothesis that transparent communications weaken the positive effect of the number of days delay on relational cost.

H6a: The positive effect of the number of days delay on financial cost is weakened by proactivity

To avoid supply chain disruptions, companies have to determine not only immediate hazards to their operations but also potential causes and vulnerabilities at each critical point throughout the supply chain. This method facilitates in assessing the financial impact of hazards prioritizing them, and determining which components require action. A proactive approach empowers companies to prepare for and reduce the impact of disruptions. While it may not be feasible to completely avoid all transportation interruptions, such as highway and flight delays caused by natural disasters, there are several methods of decreasing such interruptions, allowing companies to handle their supply chains and minimize costs. Immediate financial effects can be reduced by forecasting and dealing with feasible problems, responsibly handling resources, strengthening communication, and making quick alternatives. A proactive strategy is critical for decreasing and recovering from disruptions since it helps companies figure out hazards and prepare for solutions instead of focusing just on reactions that are adopted after disruptions occur and then quickly recovering from them (Skora & Xia, 2011). We strive to uncover whether proactivity consistently weakens the positive effect of the number of days delay on financial costs.

H6b: The positive effect of the number of days delay on relational cost is weakened by proactivity

It is essential to consider the role of proactive enhancements in logistics and customer relations. According to Marcus and Lukassen (2011), proactive enhancements are customer-oriented improvements implemented by a logistics service provider. These enhancements increase logistical efficiency and can create additional benefits for the customer, such as increased customer loyalty and a greater share of the market. By focusing on proactive measures, LSPs can address potential issues before they escalate, improve overall performance, and enhance customer satisfaction. Proactivity, which prioritizes customer needs and logistical efficiency, helps prevent delays and reduce their impact when they do occur. We aim to uncover whether proactivity weakens the positive effect of the number of days delay on relational cost.

4. Methodology

This chapter provides an overview of the research design, data collection techniques, target population, sampling strategy, sample size, and data analysis methodologies. The chapter discusses the research design, which involves using online interviews with logistics service providers managers, and employees.

4.1. Research design

When developing a survey, several data-gathering methods could be employed including qualitative, and quantitative. Quantitative is commonly used to refer to any data-gathering technique (e.g. as a questionnaire) or data analysis tool (such as graphs or statistics) that produces or uses numerical data (Saunders et al., 2003). Qualitative data includes data gathered or evaluated through methods like focus groups, interviews, surveys, observation, and case studies (Adams & Berzonsky,2008). Qualitative data might include visuals and audio recordings alongside text. Qualitative research will provide a valuable means to collect and capture the richness and fullness of the research topic (Saunders et al., 2003). Interviews as one of the qualitative data-gathering methods can be conducted in person or over the phone, with face-to-face interviews being used for special surveys or populations. Interviewers can use nonverbal cues to motivate respondents and monitor their expressions. Face-to-face interviews are the most flexible data collection method, aiming to obtain accurate information about characteristics from a large number of people, minimizing errors, and ensuring valid research answers (De Leeuw et al., 2012). There are 3 kinds of interviews. Unstructured, Semi-structured, and Structured. With unstructured interviews, the researcher has a clear plan, but minimum control over how the respondent answers. The conversation can go in many directions and will vary much by the respondent. In semi-structured interviewing, a guide is used, with questions and topics that must be covered. The interviewer has some discretion about the order in which questions are asked, but the questions are standardized, and probes may be provided to ensure that the researcher covers the correct material. This kind of interview collects detailed information in a somewhat conversational style. Semi-structured interviews are often used when the researcher wants to delve deeply into a topic and to understand thoroughly the answers provided. In structured interviews, the questions are fixed and they are asked in a specific order. Multiple respondents will be asked identical questions, in the same order. Structured interviews most closely approximate a survey being read aloud, without deviation from the script (Harrell & Bradley, 2009). This study takes semi-structured Interviews.

4.2. Data collection

A comprehensive examination of academic publications, industry reports, and relevant literature was conducted to build a theoretical framework and identify key topics and trends in logistics. Semi-structured interviews were conducted. In semi-structured interviews, open-ended questions are prepared for the interview. We considered using semi-structured interviews to be appropriate as they enable the interviewees to share their viewpoints as they feel appropriate. In addition, the person being interviewed is permitted to ask questions if they arise and it allows the researcher to collect more information. Semi-structured interviews, however, may take a bit of time, and participants may not be interested. Before conducting the interviews for this study, we prepared 13 questions. The questions were developed based on a previous study by Skora & Xia (2011) on risk management in transportation disruption. We carefully reviewed the questions and created our questions by the study's aim. The purpose of this study was to obtain a better understanding of how natural disasters impact logistics service providers. then we presented the questions to the supervisor to ensure any necessary corrections were made. When the corrections were done, and the supervisor confirmed the questions were appropriate, we registered our interview questions and consent letter for recording in Sikt.no (Norwegian Agency for Shared Services in Education and Research) and after their approval, we conducted the online interview through Stavanger University Zoom panel. All the interviews were recorded in the Sikt.no database and transcribed by them. The interviews for the study comprised 12 online interviews on Zoom with logistics service providers in our selected companies and countries. To ensure the validity, we decided to interview the right companies and persons (those that have expert knowledge in the field). The average length of the interviews was 30 minutes. The interviewee's profile is available in Table 3.

Table 3:Interviewees profile

ID No.	Position/Role	Activity	Country
P1	CEO	Shipping company	Iran
P2	Documentation employee	Shipping company	Bangladesh
P3	Sales department	Freight forwarder	Norway
P4	Managing director	Freight forwarder	U.A.E
P5	Director Business development	Freight forwarder	Denmark
P6	Project leader	Shipping company	India
P7	Sales supervisor	Shipping company	U.A.E.
P8	Sales supervisor	Shipping company	U.A.E.
P9	Operation supervisor	Shipping company	U.A.E.
P10	Head of security	Freight forwarder	Norway
P11	Managing Director	Shipping company	Iran
P12	Sales supervisor	Shipping company	Iran

4.3. Data analysis

A visual evaluation of the actual surveys might be sufficient if there are not enough samples and there are fewer available usually 20 or fewer. Without requiring a lot of data entry or statistical analysis, researchers can effectively verify the quality and integrity of the data they have gathered. This allows them to quickly resolve any problems that may arise and proceed with additional analysis or interpretation as needed (De Leeuw et al., 2012).

4.4. Research ethics

This study met the standards of ethics applicable to human volunteers. Participants were provided with information about the research's goal, and permission was obtained before data collection. The privacy and anonymity of participants were maintained during the study's procedure. The consent letter can be found in Appendix 1.

5. Results

This section presents the findings from the qualitative and quantitative analysis of 12 semi-structured interviews conducted with logistics professionals (P1 to P12).

H1: Environmental uncertainty has a positive impact on the number of days delay

The average days delay and uncertainty level have a correlation coefficient of 0.2743 (Table 4), which indicates a positive correlation between environmental uncertainty and the number of days delay, despite the small sample size. The hypothesis is supported by qualitative data gathered by the participants as well (Table 5).

Table 4:Correlation table between average delays day and uncertainty level

	Average days delay	Uncertainty Level
Average days delay	1 000000	0.274394
Uncertainty Level	0.274394	1 000000

Table 5:The summary of participant's' response

ID No	Average days delay	Uncertainty Level
P1	60	10
P2	25	3
P3	60	7
P4	45	5
P5	45	5
P6	19	8
P7	18	6
P8	15	7
P9	30	4
P10	2	6
P11	65	8
P12	45	4

H2a: The higher number of days delay leads to a higher number of financial costs

The average days delay and average financial cost have a correlation coefficient of -0.038 (Table 6), which implies a negative relationship between these variables. The qualitative data indicates that all participants experienced financial costs as a result of days delay, even if the correlation is nearly zero, suggesting that there is no linear connection between the average number of delay days and the average financial cost. Higher costs are invariably associated with longer delays, and even short delays have been reported to result in higher costs.

P10: `Financial cost on average was Five. Delay: 2 days. Plan B which has extra cost`

P4: Number of delays: 45 days. We are facing a lot of storage charges from the port. We are losing the money.

P7: The number of delays was 18 days. we faced lot of losses in case of like rate increase of the like a GR is in our shipping GR is one general rate increase due to rate increase we faced lot of amounts.

Table 6:Correlation table between average delays day average financial cost

	Average days delay	Average financial cost in ($)
Average days delay	1 000000	-0.38298
Average financial cost in ($)	-0.38298	1 000000

The hypothesis is supported by the collected qualitative responses.

H2b: The higher number of days delay leads to a higher number of relationships cost

The correlation coefficient of -0.024 between the number of days delay and relational costs indicate a weak negative relationship between these factors. This means there is no noticeable pattern showing that as the number of days delay increases, relational costs either go up or down. Based on qualitative data, some participants (P4, P5, P9, P12) reported significant relational costs such as upset clients, daily struggles, trust issues, and damaged relationships with delays ranging from 30 to 45 days. Participants (P1, P2, P3, P6, P10, P11) reported no significant relational costs despite experiencing delays of 2 to 65 days.

P9: Reported problems with trust and unhappy customers.

"30 days delay, the problem is that is the trust. the clients are disturbed with us of course for the next booking they are cross thinking should we go ahead with them or no and the second thing is that because of that the vessel getting delayed and that's the reason".

P11: Reported not losing any clients even though having a 65-day delay.

"65 days delay, not really lost or losing our clients".

P10: 2 days delay, no issue with clients, because the customers understood that the situation was as it is.

We are unable to definitively accept or reject the hypothesis in light of the qualitative findings.

H3: The positive effect of environmental uncertainty on number of days delay is weakened when we have mitigation technology

Participants (P1, P4, P6, P8, P9, P11) either do not use technology or consider it ineffective in mitigating delays due to environmental uncertainties, participants (P3, P5, P7, P10, P12) report using tracking technologies that offer some mitigation advantages and help track and control delays to some extent. considering that the majority of participants either do not employ mitigation technology or consider it to be useless, the existing data does not strongly support the hypothesis.

H4: The positive effect of environmental uncertainty on number of days delay is weakened when you have a mitigation risk mapping

Participant P1 notes that there were no tools available, but experiences encouraged the development of future standards. It is clearly stated by participants (P2, P3, P4, P7, P8, P9, and P12) that they do not make use of any risk mapping methods. Participants P5 and P6 point to the usage of risk management for larger shipments, implying a degree of readiness. Participant P10 provides an overview of a thorough risk-mapping-based business continuity planning strategy that benefited them during the pandemic. Participant P11 states that risk mapping tools do exist, however they are not always completely effective.

P10: "We have risk mapping, it's a part of our business continuity management system. So, there we have all the different scenarios that we can be involved in. So, take an example in 2019, We had one of the areas where the pandemic, and everybody said, that is not an issue. And when the pandemic hit us, we were prepared because we had this risk and we had done our job and we were prepared for it."

P11: "Yeah, you know, we have it. And also, some shipping line have this map or a strategy for, you know, solving, unexpected events. But it's not helpful as 100% or also 50% also for solving the matter. Because it's an unexpected cause, unexpected matter. Which is, you know, when it happened, you can think about that to how to solve it, how to do or plan to solve it."

Based on the gathered information from the interviews, we face limitations in supporting or rejecting the hypothesis.

H5a: The positive effect of the number of days delay on financial cost is weakened by transparent communication

The majority of participants (P2, P3, P4, P6, P8, P9, P10, P11, P12) indicate that while communication was effective, it did not significantly reduce the days delay and financial costs caused by environmental uncertainties. A small number of participants (P1, P5, P7) report that effective communication helped mitigate delays and financial costs. Therefore, the hypothesis is not supported.

H5b: The positive effect of the number of days delay on relational cost is weakened by transparent communication

Participants (P1, P2, P4, P10, P11) declare that transparency helped maintain customer relationships and reduce relationship costs, while participants (P3, P5, P6, P7, P8, P9, P12) argue that transparency alone was insufficient to mitigate the relationship costs associated with delays. The hypothesis is not supported by qualitative evidence.

H6a: The positive effect of the number of days delay on financial cost is weakened by proactivity

Many of the participants (P2, P4, P5, P6, P9, P10, P11, and P12) highlighted the proactive measures taken to reduce the impact of days delay. Although stated that many of the proactive measures come with extra costs (P4, P5, P11). For instance, P4 addresses paying more to transfer containers quickly, while P11 argues about how expensive it is to rent a vessel or purchase new containers. P10 indicates that taking proactive actions often involves choosing between more expensive options and quicker ones (e.g., air vs. marine transportation). Even though they usually shorten days of delay (P2, P4, P6, P10, P12), they may not always decrease the financial impact because the actions taken may result in costs that remain high or even rise (P4, P5, P11).

P4: "You are going to pay the cost a bit extra to the DP world to ship your container from T1 to T3 so that you can catch another vessel."

P5: "We booked our own ships to sail containers... because there were no ship sailings."

P10: "If the trains are blocked, we have to add trailers... it's about communicating the seriousness of the situation and how we predict the transportation... Or do you want to send it by air? It's a different cost."

P11: "Buying or ordering new vessels or chartering vessels to compensate the lack of space... it costs more and most of the lines cannot pay that amount."

The hypothesis is not supported by the available data.

H6b: The positive effect of the number of days delay on relational cost is weakened by proactivity

Most of the participants (P1, P2, P3, P4, P6, P7, P8, P9, P10, P11, P12) stressed how crucial it is to tell customers about the actions and activities that are undertaken. Customers are often more aware and cooperative when they are informed, as reported by some (P2, P4, P7, P8, P10).

P1: "Submitting information will help our team to have a complete understanding of the issue. Then they can forward this information to the client and make them calm and happy."

P2: "We inform the client immediately... we did not lose any of our customers."

P4: "We will pick the goods once the vessel is available. So, they are also competent that our goods will go once the vessel will come."

P7: "We inform them on time to avoid the damage of a relation with our customers."

P11: "We have to call the clients and talk to them and convince them in a nice way to calm down their anger."

The collected data supports the hypothesis.

6. Discussion

This chapter reviews the study's findings.

H1: Environmental uncertainty has a positive impact on the number of days delay

Based on the information obtained for this study, there are more days of delay when there is greater environmental uncertainty. This relationship is in line with the conceptual framework that has been conducted by Wang (2018), McKinnon and Ge (2004), and Simangunsong et al. (2012), which stressed that supply chain delays and inefficiencies are mostly caused by uncertainty.

H2a: The higher number of days delay leads to a higher number of financial costs

Qualitative data collected from participants confirms that delays, even those that last fewer days, always have a financial cost. These costs include notable rises in shipping freight charges due to inadequate loading capacity, storage fees for vessels that are laying at port longer than necessary to allow for the possibility of loading or offloading cargo, increased expenses for warehousing and demurrage, and losses in commodities, repackaging of those cargoes that were not adequately packed.

H2b: The higher number of days delay leads to a higher number of relationships cost

Our qualitative data presents a more mixed picture, while other studies have provided evidence supporting the reasonable theory that greater delay times are associated with higher relationship costs for LSPs, we find that neither the participant who had experienced a 65-day delay nor the participant who had experienced only two days delay lost their customers and the customers remained loyal.

H3: The positive effect of environmental uncertainty on number of days delay is weakened when we have mitigation technology

Previous research supports the idea that technology could lessen uncertainty in logistics. Sarder (2021) demonstrates how a real-time tracking system could improve control, and visibility, and speed up processes. Our findings indicate that access to the tracking system technology might not always meet expectations. For example, having real-time information through the vessel's tracking system is not helpful when the vessel is en route to its planned destination and we are aware that there is port congestion due to a natural disaster that occurred at the destination port. Sometimes, it may not be possible to change the route immediately, even if it is applicable, this could lead to higher shipping distances and further delays.

H4: The positive effect of environmental uncertainty on number of days delay is weakened when you have a mitigation risk mapping

Skora and Xia (2011) stress that by predicting potential hazards, companies may significantly lower the probability and impact of interruptions. Since the majority of the participants have not utilized risk mapping. future research needs to be undertaken because only three participants (P5, P6, P10) had experience with risk mapping during disasters. Based on Participant P10's experience the companies should consider including risk mapping into their system as it can provide a continuity planning strategy that helps them manage potential issues due to uncertain conditions.

H5a: The positive effect of the number of days delay on financial cost is weakened by transparent communication

Previous research studies point out the importance of transparency for enhancing supply chain efficiency. As stated by Christopher and Lee (2004), sharing information among supply chain participants reduces uncertainty, enhances visibility and responsiveness, and enables more effective disruption management. This concerted effort may improve efficiency while reducing the need for costly unexpected events interventions. Our results show that although the participant had transparent communication with their customers during the disaster it did not significantly reduce the number of days delay and financial costs caused by environmental uncertainties. As an example, one participant claimed that transparent communication is ineffective when the vehicle cannot move due to port or road traffic and the cargo is still inside it.

H5b: The positive effect of the number of days delay on relational cost is weakened by transparent communication

Our hypothesis that transparent communications minimize the positive impact of the number of days delay on relationship costs is not confirmed by our qualitative data. However, it has been proven that transparency helps maintain relationships with customers and reduces relationship costs in some situations. Based on these results; while enhancing transparency is important, it should be coupled with further strategies such as discounts on freight charges to support the customers to be more effective.

H6a: The positive effect of the number of days delay on financial cost is weakened by proactivity

Our findings show a complex connection between proactive measures and the costs caused by days delay. Despite preventive approaches that are capable of significantly decreasing days delay, they tend to come with additional costs that could exceed any potential financial gains. This indicates that although being proactive is essential for maintaining operations and shortening the length of disruptions, proactive measures do not necessarily result in lower costs.

H6b: The positive effect of the number of days delay on relational cost is weakened by proactivity

Our hypothesis that proactivity reduces the positive effect of days delay on relationship costs is supported by our qualitative data. Even in circumstances of unforeseen delays, maintaining and improving customer relationships require proactive communication and visibility. Companies that proactively pay attention to customers and care about their expectations may mitigate the relational costs caused by logistical issues.

7. Conclusion

The findings show the relationship between environmental uncertainty, the number of days of delay, the financial and relational costs imposed on the logistics service providers as a result of the number of days of delay, and the utilization of risk mapping and tracking systems to weaken the number of days of delay, employing transparent and proactive communication with customers during environmental uncertain conditions to weaken the impact of the number of days of delay on LSP companies. Some hypotheses have been confirmed, but further study is still required to discover these connections utilizing bigger and more complete data sets to create comprehensive strategies that would improve LSP response to environmental uncertainty. The data gathered for this study indicates that logistics managers should prioritize the following:

Enhancing the positive effects of employing risk mapping in logistics service provider companies

As discussed, participants' P10, P5, and P6 experiences reveal that companies with deep risk mapping and preparedness strategies were more capable of dealing with unforeseen events such as the pandemic. This level of preparation can help reduce the number of days of delay and consequent costs. Thus, logistics service providers that currently have no risk mapping tools are suggested to concentrate on the setting up of comprehensive modern AI-generated risk mapping tools as part of their company's continuity management systems.

Implementing proactive strategies

Implementing proactive strategies could help to reduce the number of days of delay. These may include stronger preparation, planning, and a quicker response to unforeseen events. For example, pre-booking loading schedules with carriers (vehicles or vessel owners), finding alternative routes, providing flexible transportation options, enhancing communication with all parties involved, and developing long-term contact with service providers. Logistics service providers, based on their experience, could provide the customers with the information required for the types of packaging of goods that are sent to areas that are at risk of natural disasters. This may minimize damage to the goods and reduce the need for repackaging and associated costs. While proactive measures can be costly, managers should evaluate the cost and benefit ratio of such actions.

The academic research could help logistics companies understand what makes risk mapping effective in lowering the number of days delays and raised costs due to environmental uncertainty caused by natural disasters. Researchers should explore a variety of proactive tactics, such as improved preparation, precise planning, and methods for responding quickly to unforeseen events. For example, research could focus on the effectiveness of pre-booking and long-term contract impacts to prepare the logistic service provider companies for potential challenges.

8. Limitation of study

Our findings have limitations to be generalized due to our small number of samples. Some reasons that we can point out are first, managers' and key participants' availability was limited, and many potential participants had hectic schedules and were unable to set aside time for the study. Furthermore, the limited time frame for data collection made it difficult to find a bigger sample size. These factors limited our capacity to obtain a larger sample size, despite our best attempts to enhance participation. As a result, further research with additional data from multiple sources should be performed to uncover better assistance approaches.

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Appendix 1: Consent letter

Hello,

You are being asked to take part in a research study that involves your work experience as a manager or employee of a logistics service provider.

The aim of this research study is to understand the challenges faced as by a logistics service provider in managing natural disasters e.g., floods, earthquakes, hurricanes/typhoons, wildfires, tornadoes. We understand that these disasters create changes in your business environment. Further, we are keen to learn your strategies in managing natural disasters.

Your responses will contribute to academic research aimed at improving preparedness and resilience of logistics companies in addressing these challenges.

Procedure: In this research study, you will not have any more risks than you would in a normal day of life.

Your responses will be kept confidential and used for academic purposes only.

You will not be personally identified in the analysis. While storing the data from the interview, a participant ID number will be used instead of your name.

We will conduct the interview using Zoom or similar software based on your consent. Analysis will be done using NVivo or similar. Data will be stored in a secure academic database on university-licensed cloud storage to ensure confidentiality. Only the primary researchers will have access to your interview responses for the purpose of analysis.

Compensation: NOK 0

As it is a Master's Thesis, the primary researcher is resource constrained. At any time during the interview, you may choose to terminate the interview.

Interview time: Approximately 30- 45 minutes. The actual time may vary, depending on your circumstances.

Location: Online.

Frequency: One-time

Consent:

We will seek your consent electronically at the start of the interview process: We will proceed with the interview only after you consent at the start of the survey. If you are willing to volunteer for this research, please indicate your consent:

Would you like to participate in this interview? Yes No

Appendix 2: Correlation table

	Number of diaaster	Average financial cost (in $)	Average relationaship cost	Average delays day	Uncertainty Level
Number of diaaster	1.000000	-0.268566	-0.414070	-0.090094	0.268140
Average financial cost (in $)	-0.268566	1.000000	0.067025	-0.038298	0.111856
Average relationaship cost	-0.414070	0.067025	1.000000	-0.024595	-0.041057
Average delays day	-0.090094	-0.038298	-0.024595	1.000000	0.274394
Uncertainty Level	0.268140	0.111856	-0.041057	0.274394	1.000000