TRACEABILITY AS A TOOL FOR THE COMPETITIVE ADVANTAGE OF LOGISTICS FIRMS

(A SRI LANKAN LOGISTICS SERVICE PROVIDERS PERSPECTIVE)

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DECLARATION

I declare that this is my own work, and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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B. W. L. R. Samarakoon Date:

The above candidate has carried out research for the Master's thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. Amila Thibbotuwawa

…… 2023.09.16

Signature of the Supervisor: Date:

DEDICATION

To **Mevni, Thisath & Kanchana**, who have been affected in every possible means by this pursuit.

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ABSTRACT

Logistics services is an imperative sector of Sri Lankan economy Contributing 2.5% to annual GDP & it provides nearly 50,000 direct Employment opportunities to the citizens.

According to the Global Container Port Performance Index (CPPI) 2021, Colombo port was moved to the 22nd among 370 ports globally and Supply chain management services in Sri Lanka inevitably attract many Local & global Service providers.

The possibility of traceability integration in a Logistics service providers operation is linked with IT adoption; And conceptual resource-based view (RBV) framework is pertinent to same, which can be led to enhance LSP's capabilities & firm performance.

This paper focus on evaluating the traceability application on a Sri Lankan LSP and its resultant possibilities of enhancing the LSP's competitive advantage over the Fierce competition.

Through the analysis of existing qualitative data, this study has identified the global Traceability solutions in practice, positive negative effects & suitability of them in Sri Lankan context. Recognized websites, journal articles, Previous studies, Publications of application developers, etc. were used as the secondary data sources.

This study selected Questionnaire-based survey and the Delphi method as primary data collection methods. The target population and sample include Sri Lankan logistics service providers and commercial customers related to multiple industries. Purposive sampling is used to select appropriate samples which are aligning with the purpose of the research. Primary data assist to determine the market requirement & the opportunity for traceability solutions as a VAS service for LSP's. Delphi method is conducted to identify & conclude new solutions based on expert opinion.

Multiple methods were used for data analysis including central tendency measures, descriptive analysis, Likert scale analysis and error identification and reliability analysis etc. In addition, EXCEL and SPSS software were used to generate outputs from the analyzed data.

Several research aspects and many industry attributes were identified through the analyzed data. It is learnt that Sri Lankan logistics service providers can benefit greatly from implementing traceability systems to optimize their operations and deliver better customer experiences as data shows that the market demand does exist for track & trace solutions. By providing real-time information on the movement of goods and materials, 3PL companies can optimize their operations, enhance customer service, and comply with regulatory requirements.

Paper suggests that Blockchain technology-based solutions would be effective as it gives comprehensive solution to the engrained problems of the traceability usage, such as contract execution.

The findings can inform logistics firms, policymakers, and industry stakeholders in Sri Lanka and other similar contexts about the importance of traceability and its potential benefits. Further research avenues, such as the impact of traceability on supply chain performance and customer satisfaction, could be explored to enhance the understanding of this emerging area.

Key words: Resource-based view; Traceability; Supply chain performance, Logistic Service Providers; competitive advantage.

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LIST OF ACRONYMS

3PL Third-Party Logistics

4PL Fourth-Party Logistics

CLM Collaborative Logistics Management

CPFR Collaborative Forecasting Planning and Replenishment

E2E End-to-end

EDI Electronic Data Interchange

FTMS Field Task Management System

GPS Global Positioning System

GS1 Global system of standards

KPI Key Performance Indicators

LCT Logistics Control Tower

LSI Logistics Service Intermediary

LSP Logistics Service Provider

OFSCT Organic Food supply chain traceability

QTF Quality Task Force

RFID Radio Frequency Identification

SCOR Supply-Chain Operations Reference Model

TEU Twenty-foot Equivalent Unit

TMS Transport Management System

WMS Warehouse Management System

BCT Blockchain technology

IoT Internet of Things

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1 INTRODUCTION

1.1. Background of the research

In recent times, the logistics sector in Sri Lanka has witnessed notable growth and transformation due to factors such as heightened international trade, rapid economic progress, and technological advancements. Consequently, logistics service providers in Sri Lanka are encountering heightened competition from local and international counterparts, compelling them to establish unique differentiators to maintain a competitive edge.

Among the pivotal aspects in this competitive landscape, traceability has emerged as a significant factor. Traceability, denoting the capability to track the movement of goods throughout the entire supply chain, has gained increasing significance for logistics firms as a mean to enhance customer satisfaction, minimize costs, and optimize overall efficiency. By implementing robust traceability systems, logistics firms can offer their customers enhanced visibility and control over their supply chain operations, leading to improved inventory management and reduced risks of stockouts and other disruptions.

1.2 Research Gap, Research problem and Questions

Despite the potential advantages of traceability, several logistics service providers in Sri Lanka have been hesitant to adopt this tool due to reasons such as limited awareness, high implementation costs, and concerns about data security and privacy. Consequently, there is a need for further research to better comprehend the benefits and challenges of traceability in the context of Sri Lankan logistics firms, with the goal of establishing best practices and encouraging wider adoption.

This study seeks to bridge this gap by initiating and investigating how traceability can serve as a tool for enhancing the competitive advantage of logistics firms in Sri Lanka. Employing quantitative & qualitative research approaches, the study will delve into the experiences and viewpoints of logistics service providers, as well as commercial Logistic service users in Sri Lanka pertaining to the benefits and challenges of traceability, as well as the best practices for implementation and overcoming potential obstacles. The findings of this study will contribute to an adequate understanding of the role of traceability in the success of logistics firms in Sri Lanka and will inform

strategies aimed at improving competitiveness in this rapidly evolving and dynamic industry.

Logistics service is an imperative sector of the Sri Lankan economy Contributing 2.5% to the annual GDP & nearly 50,000 direct Employments. The competition between the LSPs in Sri Lanka is immense: comprised of 130 shipping agencies, 120 freight forwarders & 500 plus companies registered with the merchant shipping secretariat including clearing agents. Out of these companies, 70 % are local companies and the rest are international companies, including Maersk, MSC, Mac, GAC, Kuehne Nagel, Toll Global, CEVA, etc. Changes in digital transformation, new market entrants, customer expectations, and new evolving business models in the logistics and transportation industry are demanding technological developments.

Understanding Logistics traceability & its usability, and the possibilities of enhancing the LSP's competitive advantage using the concept of logistics traceability is focused.

The problem with market solutions for logistics traceability is that they often rely on individual companies voluntarily adopting and implementing traceability measures, which can lead to inconsistencies and gaps in the traceability process.

Firstly, there is a lack of standardization in traceability practices across the industry, making it difficult to compare and integrate information between different systems. This can result in information silos, where companies are only able to trace products within their own supply chain but are unable to track them across the entire industry.

Secondly, the cost of implementing and maintaining traceability systems can be high, especially for small and medium-sized service providers that may lack the resources or technical expertise to develop and implement their own systems. This can lead to a situation where only larger companies with more resources are able to implement effective traceability measures, creating an uneven playing field.

Finally, there is a lack of incentives for companies to invest in traceability measures beyond meeting regulatory requirements. Without consumer demand for transparent and traceable supply chains, companies may not see the value in investing in these measures, leading to a lack of adoption.

Therefore, market solutions alone may not be enough to ensure effective traceability throughout the supply chain. Government regulations and standards, as well as consumer demand for transparency, may be necessary to drive adoption and ensure consistent and reliable traceability practices across the industry.

The problem of logistics operations not leveraging logistics traceability is that it can lead to inefficiencies, increased costs, and decreased customer satisfaction.

Without traceability, it can be difficult to accurately track the movement of goods throughout the supply chain. This can result in delays, errors, and lost or damaged products, which can increase costs and reduce customer satisfaction. Additionally, without real-time visibility into inventory levels and delivery times, it can be difficult for companies to optimize their operations and respond quickly to changes in demand or supply chain disruptions.

Also, without effective traceability measures, it can be challenging to meet regulatory requirements, such as those related to food safety, environmental sustainability, and labor practices. Non-compliance with these regulations can result in legal and financial penalties, damage to brand reputation, and loss of customer trust.

In contrast, by leveraging logistics traceability, companies can achieve a number of benefits. For example, they can improve supply chain visibility, allowing them to track the movement of goods in real-time, optimize inventory levels, and reduce waste.

They can also enhance product quality and safety by implementing systems to track and monitor products throughout the supply chain. Finally, they can increase customer satisfaction by providing accurate and timely information about product delivery times, status and locations, improving communication and transparency.

Therefore, logistics operations that fail to leverage logistics traceability risk falling behind their competitors, incurring unnecessary costs, and potentially damaging their reputation and customer trust. By implementing effective traceability measures, companies can improve efficiency, reduce costs, and enhance customer satisfaction, ultimately driving growth and success.

In this respect, the key research question addressed in this study were:

- What are current market solutions in place for logistics traceability?
- What logistics operations can leverage through logistics traceability?

The main objective of the study is to identify the competitive advantage that can be leveraged through integrated traceability of Logistic Operations.

1.3 Importance of the study

In the logistics sector, traceability is a key notion that guarantees the security and safety of goods across the supply chain. It entails being able to follow and identify the passage of items from their point of origin to their destination. Traceability enables businesses to immediately take corrective action by assisting in locating the root cause of any potential problems or concerns.

Traceability is crucial in the food sector to guarantee product quality and safety. Consumers want to know the origins of their food 78% of the time, and 86% of the time, according to a poll by the Food Marketing Institute, a global trade organization. The relationships between organic food supply chain traceability, consumer wellbeing, and food safety are always positive. Food makers and retailers may give consumers this information thanks to traceability systems in place.

It is a crucial component of supply chain management, and in recent years, its significance has become more and more clear.

The fact that traceability promotes accountability and transparency across the supply chain is one of its main advantages. Traceability makes it feasible to recognize and address any potential problems, including those related to quality assurance, legal compliance, and safety. This is crucial in fields like the food and pharmaceutical sectors, where there is a high danger of contamination. Traceability is that it enables logistics firms to improve their operational efficiency. By tracking the movement of goods and materials, logistics firms can identify any bottlenecks or inefficiencies in their supply chain and take corrective action. This can help to reduce lead times, lower costs, and increase customer satisfaction. For example, a Sri Lankan logistics service provider can use traceability to monitor the movement of goods from the port to the warehouse and then to the final destination. This can help the logistics firm to optimize

their transportation routes and reduce the time taken to deliver the goods to the customer.

It can enhance customer service. By providing real-time information on the location and status of goods, logistics firms can keep their customers informed and respond quickly to any queries or issues that may arise. This can help to build customer loyalty and improve the overall customer experience.

Blockchain based, novel Logistic traceability systems are linked with Smart contract management now. It enhances the credibility & eliminate all potential disputes between stakeholders.

Furthermore, traceability can also help logistics firms to comply with regulatory requirements and industry standards. In the case of Sri Lanka, logistics firms need to comply with various regulations related to the movement of goods and materials, including customs regulations, port regulations, and environmental regulations. By implementing traceability systems, logistics firms can ensure compliance with these regulations and avoid penalties or fines. This can also help to improve the firm's reputation and credibility in the industry.

In conclusion, traceability is a critical tool for logistics firms to gain a competitive advantage in the industry. By providing valuable information on the movement of goods and materials, logistics firms can improve their operational efficiency, enhance customer service, and comply with regulatory requirements. Sri Lankan logistics service providers can benefit greatly from implementing traceability systems to optimize their operations and deliver better customer experiences.

Therefore, it is important for 3PL companies in Sri Lanka to invest in advanced technologies such as blockchain, barcoding, RFID, TMS, WMS etc. to ensure competitive, efficient and reliable logistics services.

1.4 Limitations

It is important to acknowledge that this study is limited in several ways. First, there were very few prior studies linked to the logistics traceability & solutions in Sri Lankan context; and it motivates to further studies on related topics.

sample size was relatively limited to Sri Lankan based companies, consisting of a limited number of local logistics service providers and commercial customers in Sri Lanka. As a result, the findings may not be generalizable to other regions or countries. The data collected may be subject to some inaccuracies, as it relied on self-reported information from these sources but the researcher had taken adequate measures to eliminate the inaccuracies. More published data on topic will revalidate the discussions of the topic.

Furthermore, the study focused on traceability as a tool for competitive advantage of Sri Lankan logistics service providers and consist of broader study areas which needs individual & exhaustive investigations. Also, there are many Software companies who develops & maintain industry specific traceability software systems which are not studied & compared extensively here. The thesis was looked from a business point of view & IT processes or implementations were not critically analyzed.

Despite these limitations, the findings will provide valuable insights & will initiate avenues into the perspectives of local logistics service providers and their commercial customers in Sri Lanka on the role of traceability in gaining a competitive advantage.

1.5 Research Layout

Chapter One – 'INTRODUCTION': It includes the study's background, issue statement, research questions, research objectives, the study's importance, as well as scope, limitations, and layout.

Chapter Two – 'LITERATURE REVIEW': This chapter contains a literature study that includes an appraisal of the existing literature on the logistics traceability, 3PL applications, Resource Based view & related firm competencies topics. Also, further research areas are identified.

Chapter Three – 'RESEARCH METHODOLOGY': This chapter discusses statistical techniques, the targeted population, and the research tools used to gather data.

Chapter Four – 'FINDINGS AND DISCUSSION': This chapter examines data adoption and decides whether the research questions were well addressed. In addition, it presents the outcomes of the research, particularly using analytical techniques and a discussion on the attainment of the research objectives through the findings of the study.

Chapter Five – ‘CONCLUSION’: This chapter summarizes the inferences made possible through the research. Key recommendations for future research efforts also are summarized.

2 LITERATURE REVIEW

2.1 Supply Chain Management

The supply chain management in the global context, plays a vital role in adopting to the globalization concept across various industries (Steven, 2015). According to the Council of Supply Chain Management Professionals (CSCMP), Supply chain management includes the planning and execution of all activities involved in the flow and transformation of goods and services, from raw materials to end customers. It incorporates the coordination and collaboration of various stakeholders, such as suppliers, manufacturers, distributors, and retailers, to ensure efficient and effective delivery of products and services.

Trade giants like Amazon has highlighted that Supply chain management involves the strategic coordination and optimization of sourcing, procurement, inventory management, warehousing, transportation, and customer fulfillment activities, while ensuring efficient and timely delivery of products to customers with minimized costs and maximized customer satisfaction. (Amazon, 2022) Mihai Felea and Irina Albăstroiu (2013) has illustrated few key concepts and derived concepts which support to explain the term Supply chain management.

Table 2-1 : The four major criteria of Supply Chain Management concept

Criteria	Concepts	Definition
1. Management activities	**Key Concepts:** planning, organizing, implementing, motivating, controlling **Derived Concepts**: goods, services, efficiency	SCM consist in planning organizing, implementing, motivating and controlling efficiently of all the activities involved in movement of goods and services from the first supplier to the ultimate customer.
2. Logistics activities	**Key Concepts**: transportation, processing, storage **Derived Concepts:** raw materials, work-in process inventory, finished goods	SCM includes transportation, processing and storage of raw materials, work-in process inventory and finished goods from initial extraction stage to the final customer.
3. Objectives	**Key Concepts:** value, customer requirements, trust, competitive advantage, relationships **Derived Concepts:** sustainable, long term	SCM include a number of value-added processes designed to satisfy customer requirements, to establish a long term relationships, to build the trust among the supply chain partners and to achieve a sustainable competitive advantage.
4. Components	**Key Concepts:** suppliers, manufacturers, warehouses, stores **Derived Concepts:** products, services	SCM encompasses suppliers, manufacturers, warehouses, stores, and other intermediaries that are involved in the movement of products and services from point-of-origin to point-of-consumption

Source: Adapted from Mihai Felea and Irina Albăstroiu (2013)

Pandemic situation & trade wars have caused significant disruptions to the worldwide economy, highlighting the crucial connection between effective supply chain operations and a business's overall success. Supply chain management plays a vibrant part in determining a company's financial well-being & customer satisfaction.

2.2 Supply Chain Performance

Performance of each supply chain affects more than just internal organizational borders; it also has an immense impact on the business growth as well as other stakeholders' performance. Angerhofer & Angelides (2006) provide a comprehensive analysis of the various factors that affect supply chain performance. The authors identify five key dimensions of supply chain performance, including efficiency, effectiveness, responsiveness, flexibility, and innovation. They discuss the different performance metrics that can be used to measure supply chain performance, such as customer service, inventory management, order fulfillment, and cost reduction.

Jabbour et al. (2018) indicates a broad overview of the relationship between supply chain performance and business performance. Supply chain cost, quality, delivery, flexibility, and innovation were indicated as various dimensions of supply chain

performance and discuss their impact on business performance. They also examine the role of supply chain management practices in improving supply chain performance and business performance. The review highlights the importance of supply chain performance for achieving business growth and competitiveness and provides insights for researchers on how to enhance supply chain performance.

Several studies have investigated the impact of stakeholder contribution on sustainable supply chain performance. A study done by Pagell et al. (2014) focuses on the relationship between supply chain management and stakeholder performance. The authors draw on stakeholder theory to argue that effective supply chain management requires consideration of the interests and needs of different stakeholders, such as customers, suppliers, service providers, employees, and communities. They discuss the impact of supply chain management on stakeholder performance, including environmental and social outcomes, and identify the challenges and opportunities associated with stakeholder engagement in supply chain management. The review provides insights for leaders and researchers on how to improve stakeholder performance through effective supply chain management.

Sérgio Luís Dias-Matos (2019) examines the role of stakeholders in supply chain management (SCM) and identifies the types of stakeholders involved in SCM. The authors identified six types of stakeholders: customers, suppliers, logistics service providers, regulators, shareholders, and employees. They also identified the key challenges faced by stakeholders in SCM, including lack of trust, coordination problems, and power imbalances.

Srivastava et al. (2013) found that stakeholder contribution, including government regulations, customer expectations, and NGO pressures, had a significant positive impact on sustainable supply chain performance. Likewise, Walker et al. (2014) study found that stakeholder engagement and collaboration were key factors in achieving sustainable supply chain outcomes.

Siems, Seuring, and Schilling's (2022) literature examines stakeholder roles in sustainable supply chain management. The review highlights the importance of stakeholder engagement, identifies different stakeholder groups and their interests, and discusses the impact of stakeholder pressure on supply chain practices.

Stakeholder contribution to sustainable supply chain performance has been a topic of growing interest in recent years. The concept of sustainable supply chain performance involves not only economic performance, but also social and environmental performance.

As such, supply chain stakeholders specially shipper, consignee, Logistic service providers, government, employees & other communities play a critical role in shaping sustainable supply chain practices and outcomes, which in return delivers the competitive edge firms are anticipating.

2.2 Supply Chain Efficiency

supply chain efficiency needs to be improved in order to gain advantage to the stakeholders of any supply chain. The Council of Supply Chain Management Professionals (CSCMP) defines supply chain efficiency as "the ability of a supply chain to provide maximum output with minimum input and waste." While the International Society of Logistics (SOLE) defines supply chain efficiency as "the ability to achieve maximum performance with minimum waste or effort in the supply chain."

Also study by PwC defines supply chain efficiency as "the ability to use resources effectively and efficiently to meet customer needs in the most cost-effective manner possible, while maintaining the desired level of quality and minimizing waste."

These definitions highlight the importance of information sharing, minimizing waste, maximizing output, meeting customer demands, and achieving performance goals while minimizing costs in order to achieve supply chain efficiency.

Inventory management, transportation, information systems, and collaboration among supply chain partners are identified as some of the different factors that impact supply chain efficiency (Ribeiro et al., 2020). The authors also discuss the different methods and tools that can be used to improve supply chain efficiency, such as lean management, six sigma, and total quality management.

The role of demand management has an effect in achieving supply chain efficiency. (Agarwal et al.,2015). The authors argue that effective demand management is essential for improving supply chain efficiency, as it enables better coordination between supply and demand and reduces waste and variability in the supply chain. They examine the

different approaches and tools that can be used for demand management, such as forecasting, segmentation, and collaborative planning, forecasting, and replenishment (CPFR) etc.

Singhal and Waddell (2016) examine the relationship between sustainability and supply chain efficiency. The authors argue that achieving sustainability objectives, such as reducing carbon emissions, waste, and water usage, can lead to improvements in supply chain efficiency by reducing costs and improving customer satisfaction. Different approaches and tools that can be used to integrate sustainability into supply chain management, such as life cycle assessment, eco-design, and closed-loop supply chain management were indicated in their study.

Gunasekaran et al. (2017) describes six key elements of agility: flexibility, responsiveness, reliability, adaptability, quickness, and efficiency. They find that these elements are important for achieving competitive advantage and improving supply chain performance.

Also, Shekhar et al. (2019) focuses on the critical element of data in effective supply chain management. The authors highlight the growing importance of data analytics for supply chain management and identify the key areas where data analytics can be applied, such as demand forecasting, inventory management, and logistics systems optimization. They also discuss the challenges and opportunities associated with data analytics in supply chain management.

Studies has identified that there are different types of supply chain integration, including internal integration, external integration, and inter-organizational integration. They also discuss the benefits and challenges associated with supply chain integration and same will associate with the firm's ability to afford such novel mechanisms in order to gain a competitive advantage.

2.3 New Trends and Technologies in Supply chain Management

Companies now recognize that their supply chain is a crucial business process rather than just a cost center, which was the perception in the past. Distribution networks are transitioning from being centralized to being distributed and, eventually, adopting a hybrid model. Instead of relying on a single mode of transportation, companies are increasingly using multimode logistics and transportation to optimize their operations.

companies ship products directly to customers, in addition to using traditional channel shipping methods. However, these trends also bring about increased risks and disruptions in the supply chain due to adverse events. These trends present various challenges that include enhancing communication with suppliers, adopting Mult sourcing strategies for goods and services, conducting thorough safety stock audits, implementing improved risk planning techniques, and diversifying product offerings and customer base. Additionally, more companies are prioritizing social and environmental responsibility, which can lead to positive brand image, compliance with stricter regulations, efficient utilization of energy resources, and reduced material consumption. Technology plays a crucial role in helping companies address these challenges in supply chain management and logistics. (Pagano & Matthew, 2020)

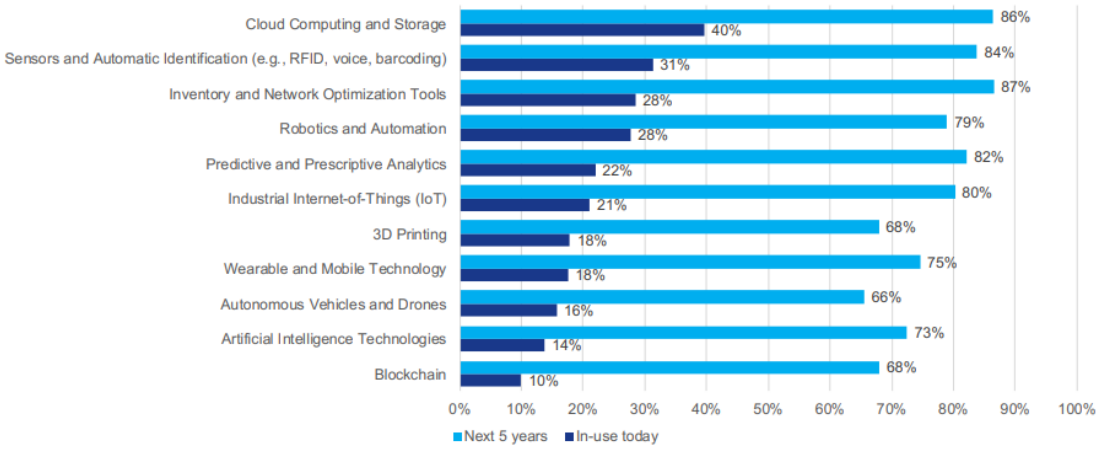
Since supply chain expenses can account for up to 80% of sales depending on the industry, they are frequently one of the first functional areas of a company where technological change is implemented (Sehgal, 2010). (BCI, 2017; Manuj & Mentzer, 2011) Global supply chains are intricate and exposed to a range of risks. (Brosch, 2015; Morales, 2015) Risk can be found in sourcing, delivery speed, pricing, and quality. Rapid technological advancements have opened up several options for businesses in every sector to expand internationally and obtain competitive advantages while lowering risks and eventually increasing profits (Degun, 2014; Myerson, 2016; Robinson, 2018).

Technology and big data can be used to close the skills and resource gap that prevents effective tracking (BCI, 2017); in addition, they can boost the integrity of these supply chains by increasing the tractability and traceability of the goods on them (Groenfeldt, 2017; Popper & Lohr, 2017; Yiannas, 2017). In order to support the health of their particular firms, supply chains must therefore continuously adapt to technological improvements within their operations and systems (Mariani, Quasney, & Raynor, 2015; Myersen, 2018; Robinson, 2018; Slone, Dittmann, & Mentzer, 2010). Companies that use new technology are better able to compete (Alleven 2017; Marr 2017). The technical developments in logistics and supply chain management in the United States have been examined by Liotine, Pagano, and Varma (2016).

As a decentralized platform, blockchain may complement ERP technology in all supply chain operations, delivering transparency, visibility, efficiency, and cost savings,

according to Banerjee (2018), who demonstrated a high degree of expertise in this regard. In order to share data in a standardized, safe, transparent, and reliable manner, distributed ledger technology (the blockchain) and the GS1 standard were used to construct a permissioned, completely distributed network of peers (Collak, 2018; Margo, 2017). Wolfson (2018) explained how several blockchains connect participants by creating a transparent, shared record of information about the origin, processing, shipping, and other aspects of food. Costs may be decreased, traceability can be increased, and security can be improved by integrating and using blockchain technology.

Figure 2-1 : ***Adoption Rate of Supply chain Technologies***



Source: MHI 2022

MHI (2022) identifies below categories of Supply chain management technologies and the current adoption in their study.

1. Maturing technologies

- Optimization software
- Sensors/Telematics
- Cloud computing
- Data warehouse and integration
- Automated storage (AS) and retrieval

2. Growth technologies

- Mobility
- Wearability
- Data analytics
- Social media

3. Emerging technologies

- 3D printing
- Drones
- Autonomous vehicles

4. Exponential technologies

- Blockchain
- Internet of Things
- Virtual reality (VR)
- Machine learning

2.4 Concept of Traceability in supply chain management

As a consequence of the complex supply chains with what the industries deal with, traceability has become one of the main contributing factors to have an optimal and agile supply chain solution. As per the reports of International Organization for Standards (ISO), traceability has been defined as the ability in tracing the application, history, usage and location of a certain item or the characteristics of that item as recorded under identification data (Standardization (ISO), n.d.).

Millions of transport units are controlled and monitored daily throughout the world with little to no control and awareness of their status in the present. It is difficult to achieve traceability along a whole supply chain without access to trustworthy data tracking and tracing. (Martinez-Sala et al., 2009).

The different stakeholders of a company including the governments, end customers, distributors, suppliers, and marketers tend to seek for the information that are readily available in ensuring the quality of products offered, avoiding disruptions, and mitigating risks within global supply chain (Silvestro & Lustrato, 2014). Because of the

extensive pressure put by different stakeholders at various levels, the companies have executed integrated tools of traceability for both interior and exterior parties to obtain readily available information all over the supply chain (Shafiq, Klassen, Johnson, & Awaysheh, 2014).

Due to evolving manufacturing processes with robust competition, supply chains have progressed into a more intricate stage and many stake holders are involved holding a plethora of data and information. In order to provide a quality product to the consumer and gain a competitive edge, producers must understand the source of the issue and the location of the affected product. With the ability to track an item's history, use, or location, traceability has emerged as a method that assists in addressing issues that call for product visibility throughout the whole supply chain. This needs to be discussed with two major processes linked; track and trace (Mishra, Henry, Sekhari, & Ouzrout, 2018).

Track is the capability to locate items or article physically in a facility or to recognize items utilized for fulfilling outbound sales orders which is the process to find out an in downstream of supply chain. Trace is the capability to search for historic records to identify component or ingredient sources and manufacturing processes, etc. Which is the process to find out items in upstream of supply chain (Mishra, Henry, Sekhari, & Ouzrout, 2018).

Track & Tracing is one of the key indicators of logistics performance of a specific economy, which determines the overall logistics operation standards of the said economy.

Table 2-2 : ***Components of the Logistics Performance Index***

Economy	LPI Score	Customs Score	Infrastructure Score	International Shipments	Logistics Competence	Timeliness Score	Tracking and Tracing Score
Singapore	4.3	4.2	4.6	4.0	4.4	4.3	4.4
Hong Kong	4.0	3.8	4.0	4.0	4.0	4.1	4.2
China	3.7	3.3	4.0	3.6	3.8	3.7	3.8
India	3.4	3.0	3.2	3.5	3.5	3.6	3.4
Sri Lanka	2.8	2.5	2.4	2.8	2.7	3.3	3.0
Bangladesh	2.6	2.3	2.3	2.6	2.7	3.0	2.4
Bhutan	2.5	2.7	2.2	2.3	2.6	2.6	2.3
Afghanistan	1.9	2.1	1.7	1.8	2.0	2.3	1.6

Source: Adapted from https://lpi.worldbank.org/

Traceability can be defined in two ways: internally and externally. Internally, traceability means that a partner receives traceable goods that are processed internally to produce another traceable item or items. The internal processes may involve raw material processing, packaging, warehouse storage, or destruction. The external traceability of the product explains how it moved through the supply chain.

External traceability allows for the tracking of product locations throughout the physical flow of the supply chain. (Mishra, Henry, Sekhari, and Ouzrout 2018).

In order to improve traceability throughout the supply chain, Cerullo, Guizzi, Massei, and Sgaglione were able to build a system that combines and implements information flow utilizing an ICT platform (Cerullo, Guizzi, Massei, and Sgaglione, 2017). Two traceability facets; internal traceability and supply chain traceability have been described by underlying research. While supply chain traceability helps on understanding the complete supply chain, internal traceability aims on identifying the vendors who deliver the finished product directly.

Traceability, according to Bechini et al. (2007), is the capacity to track the history, application, or location of an entity using documented identifications. Managing the successive connections between batches and logistical units across the whole supply chain network is the idea behind tracking and tracing. With the advancement of many technologies, traceability in supply chain management has become viable and progressing with many positive outcomes, at present.

Edirisinghe (2013) has identified the elements that contribute to poor logistics performance and the necessary adjustments to be made in Sri Lankan policies, strategies, and infrastructure. Trackability and traceability have been identified through the research as crucial elements that require technological development.

Due to their low cost and ease of use with minimal technological expertise, barcodes and QR codes are the most prevalent and widely utilized identifying tools in the industry. Software for traceability is used to coordinate and record information throughout the supply chain to improve the quality and security of the products. Due to its ability to track products without the involvement of people, RFID technology has grown in popularity as a result of technological improvements and the complexity of the industry (Kandel et al., 2011).

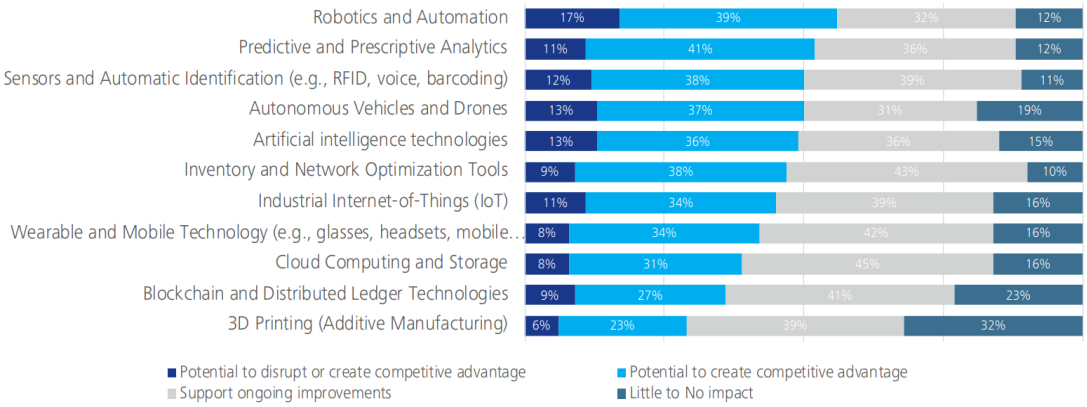
Kros et al., (2018) have recognized the factors that impact the effectiveness of executing tools of track and traceability in a firm. The underlying research has recognized 05 dimensions which support the traceability of an organization. These 05 dimensions include internal system management, external system management, Lot traceability, non-conforming procedures, and top management involvement.

Marconi et al., (2017) has examined the information needed for evaluating the impact of supply chain in terms of the utilization of traceability methodologies. The bottom-line research puts the base to understand the bottlenecks exist in supply chain effectively through executing the robust traceability tools. Dai et al., (2015) have developed a framework to address the issues effectively which raise from the major recalls of products where the manufacturer's responsibility gets reduced and shared with suppliers via the improved mechanisms of traceability. Büyüközkan & Sgaglione, (2018) have explained the digitalization of supply chain and the value of it to the business in a broad sense. The various technologies adopted for traceability in logistics sector play a crucial role in the Digital Supply Chain (DSC) concept. Further, above study has identified that information sharing as the key of having a robust integration in supply chain.

Although most businesses believe that implementing integrated traceability will be very expensive for them, many academics, including Decker et al. (2008), have argued that traceability doesn't always cost money; rather, it gives businesses a competitive edge by increasing customer satisfaction, reducing the number of product recalls, and guaranteeing delivery quality. According to Kraisintu and Zhang (2011), using reliable traceability solutions across the supply chain will help a firm accomplish its long-term financial objectives. In order to streamline the supply chain, Bel (2006) outlined the importance of communicating timely information to all parties involved, including customers, suppliers, and governmental organizations.

Also, as per the conducted Survey of MHI (2022) indicates that Auto ID technologies & Sensors in Supply chain can create a competitive advantage for the stake holders. The potential to create competitive advantage by the usage of sensors & Auto IDs are 50%, while 36% anticipate same through blockchain application in Supply chain operations.

Figure 2-2 *: Impact of technologies on supply chain*



Source: MHI 2022

2.5 The importance of traceability in supply chain Management

The need for tracking and tracing in the supply chain is expanding, as are the pressures to create standardized solutions to address such logistics and stronger legislative obligations. This information should be implemented from the raw material stage to the sale of the goods. Advancements in logistics and global supply chains now allow for the monitoring of shipments through sensor networks, wired or wireless connections, and GPS-based tracking devices. Effective logistics tracking and tracing can be achieved through various technologies such as barcodes, QR codes, wireless sensor networks (WSN), RFID, and GPS. The importance of traceability in SCM has been highlighted across key categories.

2.5.1 Enhanced Visibility:

Logistics traceability provides real-time visibility into the movement of goods, enabling supply chain partners to monitor and manage inventory levels, identify bottlenecks, and make informed decisions to optimize operations. By controlling inventory that is in motion, proactively updating status, preventing disruptions, and reducing risk, it helps businesses increase their customer service and minimize costs (Gnimpieba, Nait-Sidi-Moh, Durand & Fortin, 2015). This enables businesses to adapt their supply chains to suit changing demands by making them more transparent and agile (Yao, Wu, Wang & Soc, 2009).

Implementing auto-ID enabled tracking and tracing systems can help deal with the increased uncertainties and complexity in business-to-business and business-to-customer connections. According to Urciuoli (2010) and Xu et al. (2011), it guarantees

supply chain visibility, agility, adaptation, and security. A supply chain network manages a large number of commodities at once that require a delivery strategy to lower the associated logistical and labor costs to handle consumer claims. The costs associated with filing claims as a result of incorrect goods routing are reduced by the use of an independent tracking system for delivery of products. (Ko et al., 2011).

Auto-ID tracking infrastructure allows for real-time monitoring of moving objects throughout the logistics and supply chain, enabling accurate inventory management and detailed tracking. This technology eliminates manual errors and supports automatic collection and processing of real-time field data through wireless sensors (Li et al., 2011). Auto-ID technologies also enable tracing within the logistics and supply chain network by building a unique supply chain history for identified objects, including their location, ownership, and telemetry. Among available auto-ID technologies, barcodes, QR codes, RFID are commonly used in logistics and supply chain networks (Lin, 2009).

Block chain, IOT, virtual/augmented/extended reality (VR/AR/XR), machine learning etc. have been identified as having a substantial influence on global supply chain operations (Anthony M. Pagano, 2020). Each transaction record can be rendered irrefutable by the blockchain, giving all parties with access to the ledger the capacity to track ingredients or components back to their true place of origin. (Lohr & Popper, 2017)

The global approach to traceability in the logistics sector has steered towards Blockchain and Internet of Things (IoT) technology. These cutting-edge technologies have the potential to reshape traceability throughout the supply chain and ultimately lead to profitable, higher-quality businesses with a large number of delighted customers (Olson, 2019).

2.5.2 Supply Chain Efficiency:

By tracking the flow of goods, logistics traceability helps identify inefficiencies, delays, and disruptions in the supply chain. This allows for proactive measures to be taken, such as rerouting shipments or reallocating resources, to improve overall efficiency. Efficiency issues with product monitoring and tracing inside supply networks for logistics are becoming more and more common for businesses. Customers may become dissatisfied as a result, and there may be issues with supply chain coordination. By enhancing supply chain transparency with the help of suitable tools, the customer may

track the delivery process by being able to identify the position of the shipment (Yao, Wu, Wang & Soc, 2009).

Collected crucial tracking data such as temperature, humidity, and location automatically, significantly contribute to monitoring and managing logistics and supply chain networks s (Wong et al., 2009). Such systems often include electronic data interchange (EDI) for direct data exchange, article-numbering systems, barcoding for identification, and databases for efficient storage, management, and analysis of collected information (Wang and Potter, 2007). These Logistics information offers dual benefits: serving as a link between information systems and material flow and providing administrative advantages by reducing paper-based systems and improving information accuracy (Johansson and Pålsson, 2009).

2.5.3 Quality Control:

Traceability plays a crucial role in ensuring product quality and safety. By tracking the origin and handling of goods, companies can quickly identify and recall products that may be defective, contaminated, or non-compliant with regulations, thereby protecting consumers and mitigating risks.

Additionally, according to reports (Mai, Bogason, Arason, & Arnason, 2010), effective traceability systems guarantee customers' trust and confidence through safety and quality standards. According to Chryssochoidis, Kehagia, and Chrysochou (2006), effective traceability systems can increase the value of the products and hence raise the overall profit margin. Pettitt, (2001) also argues that the traceability ensures constant safety, particularly in food supply chains.

Goods are identified in a logistics tracking system through either human data entry or auto-ID technology. Auto-ID technologies, such as barcodes and RFID, offer higher-quality information than other types of data obtained from manual entry (Smith and Offodile, 2002).

2.5.4 Compliance and Regulations:

Traceability is often required to comply with industry-specific regulations and standards. It helps demonstrate compliance with legal and quality requirements, such as food safety regulations, environmental regulations, and product labeling standards.

Traceability also decreases labor productivity losses. Traceability ensures constant safety, particularly in food supply chains (Pettitt, 2001). Also, traceability is identified as an effective risk management tool that provides options for addressing potential risks that may arise in a supply chain by isolating problems through recalls or withdrawals, which then stop unsafe or contaminated products from reaching customers (Hobbs 2006).

Additionally, effective traceability systems might lessen the likelihood that a responsible supplier will need to provide well-documented traceable information to ensure compliance with rules (Fritz & Schiefer, 2009).

2.5.5 Customer Satisfaction:

Traceability enables companies to provide accurate and reliable information to customers regarding the status and location of their orders. This improves customer satisfaction, builds trust, and enhances the overall customer experience. Hobbs (2006) indicates that a major benefit of traceability is that it provides consumers with accurate and targeted data and information about specific products. This enables consumers to obtain the pertinent information, and in food supply chains, it allows businesses to gain customer confidence through traceability. The positive & productive information provided by traceability systems enable the company to maintain its good image throughout its market (Mai, Bogason, Arason, & Arnason, 2010).

2.5.6 Sustainability and Ethical Practices:

Traceability allows companies to track the environmental and social impact of their supply chains. It helps identify areas for improvement in terms of reducing waste, carbon emissions, and promoting ethical sourcing practices.

By recording certifications and associated data on the blockchain, supply chain participants can ensure that products are sourced and produced in accordance with sustainable standards. This promotes responsible sourcing, supports ethical practices, and allows consumers to make informed choices. (Duong, 2020).

2.6 Technical Fundamentals of Logistics Track & Trace Systems

Terrestrial systems or satellite-based systems can be used to implement Track-and-trace systems in logistics. Terrestrial systems operate on Earth, while satellite-based systems require hardware in space. (Pavkovic, Berbakov, Ulianov & Hyde, 2016).

Tracking of shipments is usually carried out via terrestrial systems (Klein et al. 2009). Machine-readable labels are attached to packages. These labels confine order data, allowing automatic sorting stations to read them and guide the shipments to their destinations. The information from the labels is received by central database, which prepares the data based on requirements, and makes it accessible to relevant parties through portals, ERP systems, or email (Kothris, Beach, Allen & Karlsson, 2001). For tracking larger units like trucks over longer distances, satellite-based systems such as GPS are commonly used. These systems establish a connection with the company headquarters via mobile networks to display the exact position of the unit (Kothris et al., 2001).

Terrestrial systems work discretely, tracking objects as they pass through individual process steps, while satellite-based systems provide continuous real-time tracking of objects (Kandel, Klumpp & Keusgen, 2011).

2.6.1 Positioning technologies in logistics – Outdoor

2.6.1.1 GPS

GPS tracking is commonly used for outdoor tracking, but its applicability indoors is limited due to factors like walls and metal surfaces that reflect signals, making accurate tracking challenging (Chirakkal, Myungchul & Dong Seog, 2014). Localization software utilizing GPS has shown improved accuracy, allowing for the determination of 3D coordinates even in challenging conditions. The median accuracy achieved ranges from 4.5 to 8 meters (Piras and Cina, 2010).

This setup allows for easy integration into various data management systems, benefiting all stakeholders in the supply chain (Klumpp & Kandel, 2011).

2.6.1.2 GSM/5G

GSM tracking relies on mobile telecommunication technology and requires coverage by a GSM network for tracking purposes. The covered area is divided into cells, each served by a base station. Multiple base stations are managed by a mobile service center, which acts as an interface between the mobile network and the Public Switched Telephone Network (PSTN) (Hussain & Kwak, 2009). GSM is the most widely deployed cellular telephony standard globally, operating in over 220 countries with nearly 800 mobile operators. As of now, GSM/3G/4G remains the current standard for

mobile tracking. As per Drane et al. (1998) an accuracy of around 100m would be achievable.

Using 5G for tracking is developing fast. In UK, Bristol port to 5G, the 5G Logistics project will provide complete product traceability through geo-fencing and ongoing surveillance of the movement of goods and commodities. In addition to increasing visibility, tracking at the container, pallet, and individual item levels increases productivity since real-time automated monitoring and recognition replaces current manual scanned barcode identification. This provides assurance that products are where they should be and may travel through ports promptly and without incident for logistics companies and their clients (uk5g.org, 2022)

2.6.2 Positioning technologies in logistics - Indoor

2.6.2.1 Barcodes

Vartiainen, Kallonen 17 and Ikonen (2008) describe the 1D barcodes as a mix of vertical lines and spaces, where combinations of these two are called elements and represent different characters. The standardized 1D barcode consists of 13 numbers and is used worldwide for the Many different purposes. In general, whenever a barcode is read, the status of the shipment can be changed to the next required action. Once this is done, the ID of the person who made the change and a time stamp are stored into a database, so that transparency is increased and each handling step is documented (Vartiainen et al., 2008).

According to Kandel et al. (2011) barcode tracking is part of an event-monitoring since no notifications are sent automatically to a receiver. Nevertheless, barcode tracking can easily be included into active tracking methods, since with scanning the barcode, the shipment can be connected to the transportation vehicle it is loaded into. Shuyi et al. (2013) talk about the new generation of 2D barcodes (QR codes), which consist of a black and white matrix in which information are gathered. The information can be stored in vertical as well as horizontal directions. There are several sizes of barcodes available ranging from Micro QR codes to 177 x 177 modules with their maximum capacity of saving up to 7,089 numerals. The size also depends on the available space of the product, so that Micro QR codes are often seen on small electronic components.

2.6.2.2 RFID

Radio Frequency Identification (RFID) technology has gained significant popularity in recent years as a track-and-trace solution in logistics and manufacturing. Unlike barcode systems, RFID enables object identification from a distance without requiring a direct line of sight. RFID tags offer more applications than barcodes, allowing for additional data measurement such as product type and environmental factors like temperature and acceleration (Want, 2006). RFID tags within the same defined space can communicate with each other without manual assistance, making it a promising technology for high-precision tracking (Lu, Wang, Zhao & Zhai, 2018). RFID operates through wireless communication, using radio waves for contactless identification of stationary or moving objects. The identification process is based on resonance or reflection principles through electromagnetic or magnetic coupling. Depending on the RFID frequency (near field or far field), the coupling element utilizes a dipole antenna or antenna coil (Anandhi, Anitha & Sureshkumar, 2019). RFID tags are classified into three categories: active, passive, and semi-passive (Choy & Ng, 2006).

2.6.2.3 W-LAN

GPS tracking faces challenges when applied to complex indoor environments, necessitating the exploration of alternative active tracking methods that enable real-time localization. WLAN (Wireless Local Area Network) localization techniques rely on metrics derived from received radio signals (Heidari & Pahlavan, 2008). These metrics include angle of arrival, received signal strength, time of arrival, and time difference of arrival. Time of arrival measures the absolute time it takes for a synchronous signal to be received, while time difference of arrival calculates the time difference between sending and receiving the signal. Trilateration is another significant tracking technology in WLAN, which involves measuring the distance from multiple WLAN access points to the trackable device (Torteeka, Xiu & Yang, 2014).

2.6.2.4 Ultra-Wide Band

Indoor positioning requires high precision and accuracy, but it can be influenced by various objects and signals. Ultra-Wide Band (UWB) technology has gained increasing interest for indoor positioning due to its capability for highly accurate positioning (Alarifi, Al-Salman, Alsaleh, Alnafessah & Al-Hadhrami, 2016). UWB is a radio frequency technology that spreads information across a wide spectrum of radio frequencies, allowing it to transmit a diverse range of data while consuming minimal

energy. UWB can utilize the time difference of arrival to determine the distance between a reference point and the target, as mentioned by Promwong and Southisombat (2016).

By sending out incredibly brief radio signal pulses, UWB radio communicates with high data rates in the relevant area so that the ability to send massive amounts of data via UWB's large bandwidth and low frequency helps this technology get beyond indoor positioning issues caused by signal interference from objects and walls (Alarifi et al., 2016).

2.6.2.5 Bluetooth low energy

Bluetooth-based indoor localization has been a long-standing approach, with Bluetooth classic initially used for position determination. However, its inefficiency and lengthy connection process limited its widespread adoption (Yang, Poellabauer, Mitra and Neubecker, 2020). The introduction of Bluetooth 4.0, specifically Bluetooth Low Energy (BLE), changed the situation significantly (Kriz, Maly and Kozel (2016). BLE stands out for its low energy consumption and enhanced configuration options, enabling more efficient positioning compared to WLAN-based positioning. Bluetooth Low Energy is a wireless technology designed for short-range communication, specifically for low-power control and monitoring applications. Bluetooth is already widely established in devices such as mobile phones, laptops, and automobiles, making it advantageous for implementing BLE technology (Dalkilic, Cabuk, Arikan & Gurkan, 2017).

2.7 Logistics Track & Trace systems for supply chain stakeholders

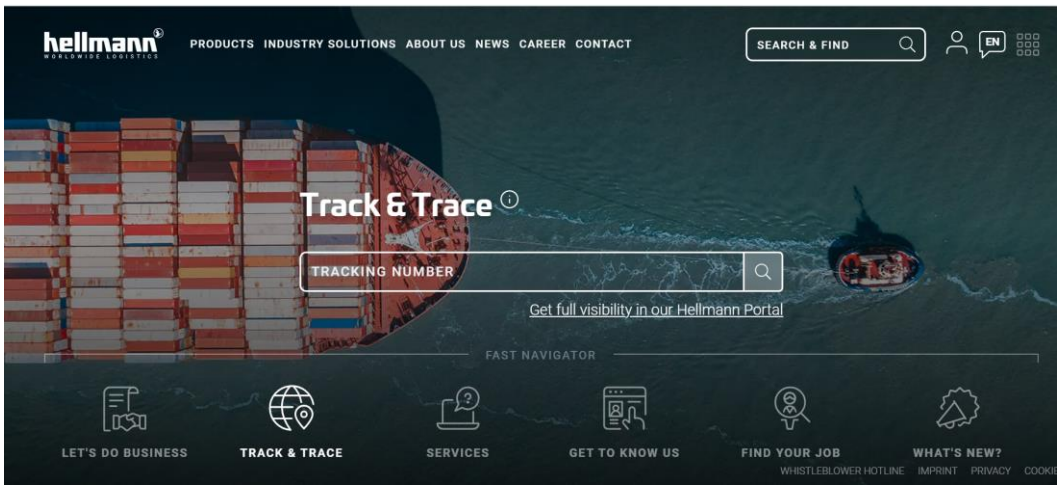
There are several supply chain track and trace systems available currently, each offering different features and functionalities (Zunder & Thomas, 2011). Novel technology based, these systems can be used to close the skills and resource gap that prevents effective tracking. In addition, they can boost the integrity of these supply chains by increasing the tractability and traceability of the goods on these international supply chains. (Groenfeldt, 2017; Popper & Lohr, 2017; Yiannas, 2017). Pagano, and Varma (2016) identified many different methods which are in place for the logistics track & tracing purpose. These techniques cover a range of technology options and strategies used to track, monitor, and collect up-to-date data on shipments and products within the supply chain.

2.7.1 3PL Online Tracking Portals:

This tool offers consignees a simple and quick option to follow their shipments in real time. The live shipment tracking service offers comprehensive visibility into the location, condition, and security of shipments worldwide. The tracking solution provides real-time data on various parameters such as humidity, temperature, light exposure, vibration, and door opening, enabling detailed control and monitoring. The installation process is simple, allowing for quick integration into the supply chain without requiring extensive IT or personnel resources. The system combines AIS data, Port data & carrier data for a seamless visibility.

The tracking device used is versatile and suitable for all types of transport units, including containers, trucks, pallets, and parcels. It allows for seamless tracking of goods throughout their journey, even across international waters. Additionally, it includes an automated digital returns management feature, making it convenient for post-use handling. The device, which is about the size of a postcard, can be easily returned by dropping it into a mailbox. Alternatively, a disposable version called Smart Visibility is available for cases where returns are not feasible. The pay-as-you-go model makes Smart Visibility an attractive option (Hellmann Worldwide Logistics, 2023)

Figure 2-3 ***: Sri Lankan 3PL's Online Track & Trace Portal***



Source: https://www.hellmann.com/en/#track, (2023).

2.7.2 Mobile Applications:

Logistics providers often offer mobile apps that allow consignees to track their shipments using their smartphones or tablets. According to C H Robinson, (2023) the global logistics and supply chain giant, these apps may provide push notifications for

important updates; also, can be linked with other ERP, Web interfaces for a complete solution. With real-time visibility to global shipments, streamlined operations though integrations and automation, a digital ecosystem for managing complexity, and valuable insights and analytics, mobile applications empower you to work smarter and achieve cost savings and improved service.

Figure 2-4 ***: Navisphere® Mobile Application for Track & Trace***

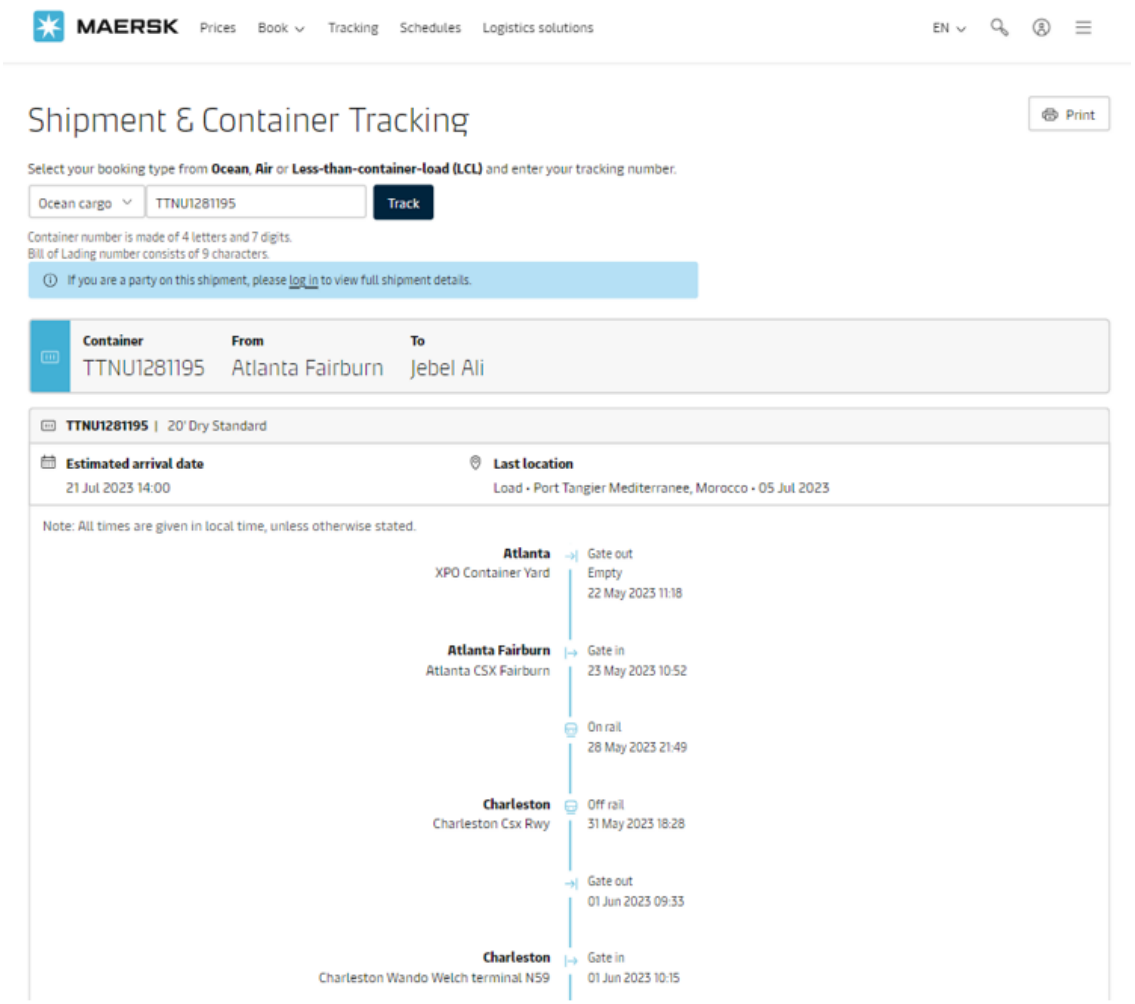
Source: https://www.chrobinson.com/technology/, (2023).

2.7.3 Carrier Tracking Systems:

Shippers can rely on tracking systems provided by the shipping carriers they choose. These systems typically allow shippers to track their shipments using unique tracking numbers or reference codes like BL no, Container No, etc. Besides providing information on the current location of the freight container, a successful tracking enquiry will allow you to see, Type and size of the container, estimated date and time

of the container's arrival at each milestone & All the stops including loading and discharge in your container's journey (Maersk, 2023).

Figure 2-5*: Maersk Tracking system*



Source: https://www.maersk.com/tracking/, (2023).

2.7.4 Electronic Data Interchange (EDI) systems:

EDI enables shippers to exchange shipment information electronically with logistics providers, allowing for real-time tracking updates and status notifications.

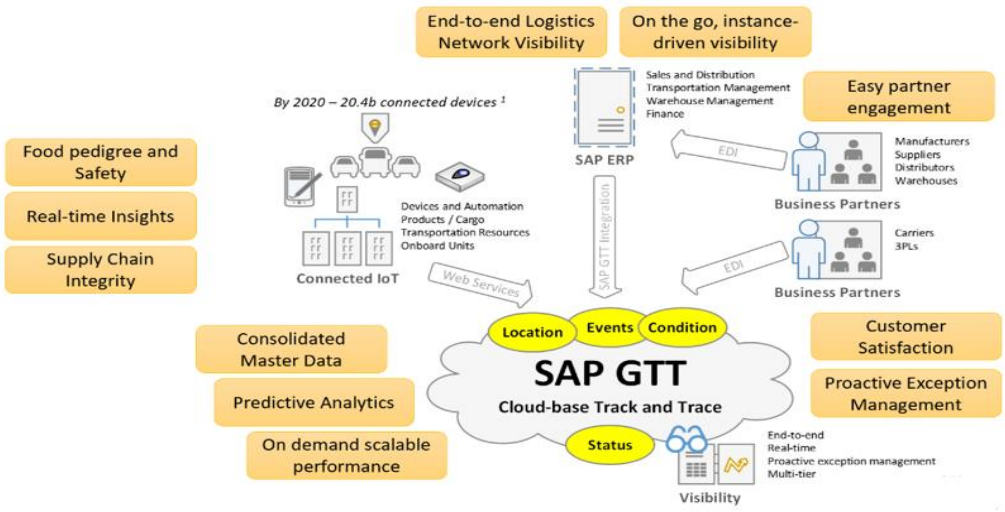
EDI software is typically used to gather all the necessary data. These data are exchanged here via text files. One of the most widely utilized technologies for data transport and communication today is EDI. Computer systems can easily process information because they employ standardized electronic forms. Real time information, integrated communication ability, automated data entry, Faster and error free, Increased trading

partners are the best advantages of this method. While disadvantages like Time consuming, Expensive setups, one way communication are also highlighted (https://www.container-xchange.com/blog, 2023).

2.7.5 Integrated logistics Optimization Systems

Using integrated logistics platforms with end-to-end monitoring capabilities, some stakeholders can keep tabs on their shipments at different points along the supply chain. The noteworthy development is the integration of logistics software into a comprehensive supply chain execution technology platform, encompassing various applications like WMS, TMS, labor management systems, supply chain visibility, analytics, and more. Although currently, only a few companies have fully implemented these integrated platforms, it is anticipated that more firms will seek single-vendor suites in the future. SAP Track & Trace, IBM Food Trust, Oracle Blockchain, GE Predix are few examples of Integrated logistics solutions which are unified with track & trace capabilities. These solutions are based on AutoID, IoT & blockchain technologies, not limiting to TMS or WMS systems and provide seamless access across the supply chain with complete visibility (MHI, 2018). As companies transition from loosely integrated solutions to well-integrated software platforms, they aim to improve efficiency, visibility, reduce complexities, and optimize their overall logistics operations (Lee, O'Marah, & John, 2012).

Figure 2-6*: SAP Global Track and Trace Overview*



Source: https://www.sap.com/products/business-network/global-track-and-trace, 2023).

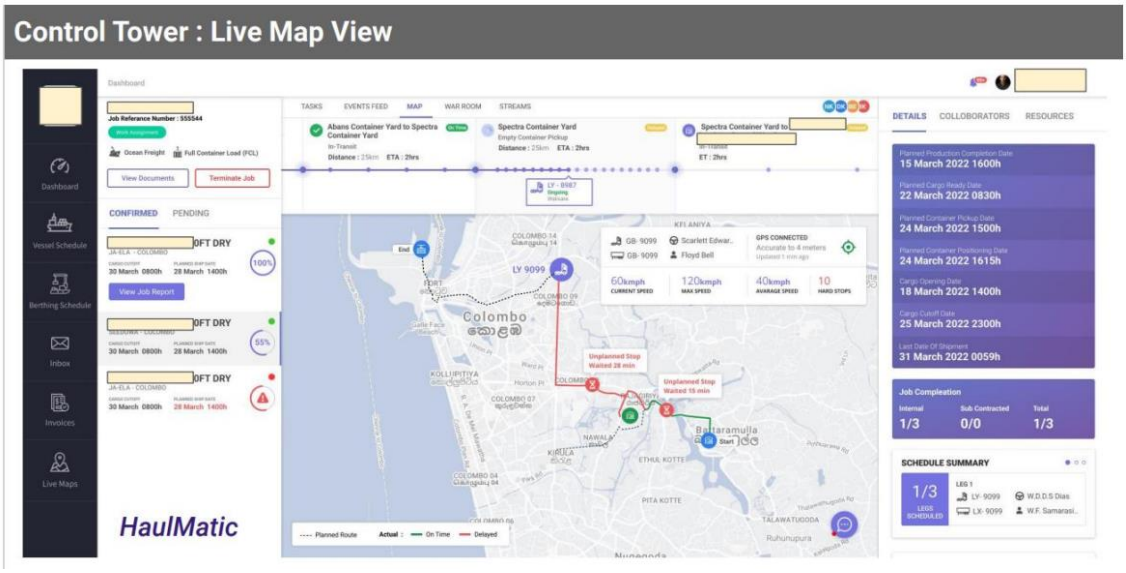
2.7.6 Blockchain & IoT based Track & Trace Solutions

Information asymmetry and inconsistency among supply chain participants create challenges in tracking specific transactions and goods. To address this, a distributed ledger, such as a blockchain, can be used in conjunction with serialization to enable the recording and tracing of goods between parties. By recording transactions on the blockchain, including information like location, date, price, and quantity, the integrity of the product's transaction history becomes irrefutable. This allows all parties accessing the ledger to trace the origin of ingredients or components. (Lohr & Popper, 2017).

Although some experts remain rather doubtful about expectations being met, blockchain technology (BCT) and the Internet of Things (IoT) have emerged as crucial underlying traceability technologies for the future to overcome the shortcomings of the Auto-ID based technologies (Tsang et al. 2018; Pournader et al. 2020; Wang, Han, and Beynon-Davies 2019). With this technological breakthrough, the SC becomes more transparent and aware, and traceability is better able to quickly explore bigger volumes of data (Ivanov and Dolgui 2020; Shou et al. 2021). BCT continues to have enormous potential with some successful business cases, despite some failed attempts to adopt it in industry (Pournader et al. 2020). The Internet of Things (IoT) also offers an enlarged system built on already-existing technology like RFID, WSN, barcodes, etc. (Coronado Mondragon, 2021). AI and blockchain technologies are making significant advancements in the field of supply chain management. AI, combined with advanced analytics, enhances visibility by analyzing large volumes of data from various operations within the supply chain. It aids in optimizing inventories and decision-making processes, leading to increased precision, reliability, and efficiency across payment, insurance, shipping, logistics & many other sectors of supply chains (Behnke and Janssen, 2020).

Blockchain technology enhances trust by enabling multi-party visibility of digital events throughout the supply chain. It improves data quality, integrity, and visibility, reducing errors in communication or data transfer. By managing, processing, and storing large amounts of data, blockchain ensures data authentication, access history maintenance, and user access restrictions (Smith, 2018).

Figure 2-7 ***: Blockchain Based TMS System in Sri Lanka***



Source: https://haulmatic.com, (2023)

2.8 Outsourcing of 3PL services & Key criteria for the Selection of a 3PL Service provider

Increasingly, 3PL providers are integrated into supply chains (Jayaram & Tan, 2010; Tezuka, 2011; Chu & Wang, 2012) because 3PL helps to manage the entire supply chain. Tezuka (2011) also highlights that supply chain participants may enjoy advantages derived from four contributory sources of 3PL specialization: scale, know-how, searching ability, and IT skills. Under the context of the supply chain, 3PL providers interact with suppliers, manufacturers, and retailers to provide various logistics services to them.

The outsourcing of logistics to third party providers has become an increasingly powerful trend in modern companies. Logistics alliances are becoming a way of life for many firms and to achieve competitive advantage in the marketplace (Ratten, 2004). It has been estimated that about 40 per cent of the global logistics is outsourced (Wong et al., 2000). As a result, an emerging demand of 3PL services.

The logistical issues are now being incorporated in the strategic agenda instead of being considered as an operational issue. The logistics function can provide a tool to maneuver the competitive marketplace to outperform rivals in meeting the high expectation of their stakeholders and customers. By way of outsourcing logistics,

shippers can concentrate on their core area of production to meet the conformance standard.

The potential 3PL services providers can satisfy its customers' demand by proper and timely delivery. Thus, the 3PL services providers can help the shippers in retaining and enhancing the required competitive advantage by way of fulfilling the customers' expectation. Past research has emphasized the important role played by the logistics services in the success of the shipper. The logistics services play an important role in fulfilling the strategic objectives of shipper (Manzinin et al., 2007). The influence of including logistics in strategic management, on customer satisfaction and firm performance has been found positive (Tracey, 2006). Logistics has also been playing a tremendous role in providing a competitive advantage for companies in a networked economy and market (Gunasekaran and Ngai, 2004). Looking to the role played by logistics services in shippers' performance, the logistics outsourcing has become crucial. Thus, the 3PL services providers play a vital role in the success of the shipper. The selection of a potential 3PL services provider, who can help a shipper to achieve its strategic objectives, is becoming imperative.

Selection process demands detailed research on whether a 3PL services provider can satisfy the need and expectation of shipper or not. A single criterion may not be enough to critically scrutinize and identify potential 3PL services providers, as the set of criteria important for one situation may not hold well for the other. Below are the main criterions for the Selection of a 3PL Service provider according to Qureshi, (2007).

2.8.1 Quality of service & Standards

By bringing value, it contributes significantly to product distinctiveness. Service quality & standards are equated with the quality of the logistics systems (Staff, 1991). 3PL service Provider should raise the perceived quality of clients in order to satisfy them and improve the shipper's market share. The qualities of the ideal logistics partner include a clearly defined quality program. Total quality management and Kaizen are examples of world-class approaches that foster excellent attitudes toward measurement and performance. Through empirical research, Spencer et al. (1994) and Van Hoek (2001) demonstrated that the growth of 3PL coalitions has been considerably aided by the creation of measuring systems.

2.8.2 Amount and standard of fixed assets

Before choosing 3PL service providers, the availability of the necessary physical equipment, size, and quality will be considered. The size and caliber of fixed assets contribute to the efficient performance of the providers' obligations (Hum, 2000).

By delivering deliverables in real time, it not only improves delivery performance but also increases client satisfaction. As a result, prompt and flawless delivery services improve the level of customer service. Hum (2000) emphasized the need for strategic logistics capabilities in order for 3PL service providers to be strategically positioned. He also stressed the importance of fostering internal resources and expertise (intellectual assets).

2.8.3 Delivery performance

The advantage of a 3PL services provider is said to be an improvement in client satisfaction through prompt delivery and upkeep of a high service standard. Thus, reliability and speed are used to measure delivery performance. Stock et al. (1998) assert that efficiency and dependability are crucial in logistics. High delivery performance improves shippers' reputation and keeps customers pleased. The reputation and market share of shippers are impacted by the 3PL service providers' delivery performance since good delivery performance increases market share and vice versa. Therefore, delivery performance is a crucial factor to consider when choosing 3PL service providers.

2.8.4 Operational performance

It ensures the effectiveness and efficiency of the 3PL service provider. High performance strengthens business ties. Having a specific goal with quantifiably measurable results and meaningful achievement promotes long-term partnerships (Bowersox and Daugherty, 1990). Higher operational performance facilitates operation and configuration. Additionally, it enhances system security, responsiveness, and the confidentiality of sensitive data, as well as the capacity to monitor performance, detect faults, be able to remedy potential problems, and offer full accounting data (Spencer et al., 1994). Additionally, it enables the 3PL service provider to provide the shipper with ongoing operational status updates. The ability of a supplier to produce performance that can be quantified is one of the most important criteria to take into account when choosing a supplier (Spencer et al., 1994; Van Hoek, 2001).

2.8.5 Compatibility & industry specialization

It is a crucial requirement since Compatibility makes it possible for the user and the supplier to collaborate. One of the elements of a good partnership that can lead to a long-term relationship is cultural and value compatibility (Bowersox and Daugherty, 1990). Additionally, it results in productive outsourcing partnerships when the Service provider owns a specialization in providing 3PL services to relevant industries.

A good example is a 3PL service offerings for construction & projects industry, which demands specific know how of the 3PL Service provider. According to an empirical study by Boyson et al. (1999), the second most significant attribute was consistency with the company's culture and philosophy. The compatibility and productivity of the shipper and the provider of 3PL services are increased by a long-term relationship. Since compatibility makes it possible for the shipper and the 3PL services provider to collaborate, it must be considered while evaluating potential 3PL services providers. Workflow efficiency and relationship flexibility are facilitated by compatibility.

2.8.6 Financial stability

Boyson's (1999) empirical research highlights that one of the most crucial factors in choosing 3PL service providers is financial stability. This ensures a low-risk partnership and leads to cost reduction and lower logistical risks for the collaborating company. Many scholars, such as Sink and Langley (1997), Bradley (1993), and Harrington (1994), emphasize the importance of financial stability for logistics partners. Menon et al. (1998) also found financial stability to be among the top-ranking criteria in their survey. Businesses appreciate vendors who offer excellent customer service, fair pricing, and strong financial stability (Boyson et al., 1999). Financially, sound 3PL services provider boosts customer satisfaction and reduces cost through a dedicated resource base, it also reduces logistical risks for partnering firm (Bowersox and Daugherty, 1990).

2.8.7 Geographical spread and range of services

Shippers seek out 3PL service providers with a large geographic presence and a variety of services. Bottani and Rizzi (2006) claim that shippers choose 3PL service providers with a broad range of services over conventional outsourcing for a specific task in-depth. Shippers' desire for a one-stop shop is also met if 3PL service providers attempt to broaden their geographic reach and depth of services. A 3PL service provider might therefore become an integrated logistics provider or a supplier for single sourcing as a

result. The geographic reach and service breadth of 3PL service providers have increased as a result of their ability to react quickly to shippers' new requirements.

2.8.8 The opportunity for long-term relationship

Continuous development, building trust, and sharing risk and reward are the building blocks of a long-term partnership. Both the shipper or consignee and the 3PL services provider benefit from the long-term partnership.

Access to the information systems of 3PL service providers aids in monitoring and assessing 3PL service providers in order to develop a long-lasting partnership. According to Langley et al. (2002), the relationship with the 3PL services provider is essential since it advances the company's primary goal. According to Schultz (2002), maintaining healthy relationships should follow seven rules, including benefit sharing, realistic RFPs, checking the hype vs. reality, monitoring everything, maintaining accurate records, and understanding that "it's not an all-or-nothing game and nobody is perfect."

2.8.9 Reputation

Brand name is an endorsement of the product's quality, dependability, degree of customer service, and customer pleasure. A well-known brand tempts the shipper to enter and start a committed partnership. Additionally, reputation contributes to the development of customer relationships, which supports long-term business. The reputation of 3PL service providers also ensures good financial standing, which is a key factor in enticing shippers to choose them. Reputation was one of the additional characteristics that many 3PL users took into account in the research of major American manufacturers (Lieb and Randall, 1996).

2.8.10 Optimum cost

According to Lieb and Randall (1996) and Leahy et al. (1995), the cost of service is a key factor in choosing 3PL service providers. In this fiercely competitive climate, shippers are demanding value-added services in order to get more for less.

Cost of service has been a major problem for both due to factors like tracing and tracking, short lead times, bundled services, etc. (Milligan, 2000). However, although some research (Sink et al., 1996; Menon et al., 1998) placed more emphasis on operational performance and service than cost of service, others (Spencer et al., 1994; Bradley, 1993; Maltz, 1995) emphasized cost of service as an important factor.

2.8.11 Flexibility in operation and delivery

Due to its capacity to draw customers, this has emerged as a clear choice among service providers (Stank et al., 1998). It enhances the possibility of providing better customer service. It enhances customer service by allowing the 3PL service provider to efficiently fulfill a wide range of delivery requests concerning time, location, and method. Monitoring operational and delivery flexibility is crucial.

It is essential to assess how well 3PL service providers customize their services to meet the shipper's ever-changing requirements in a dynamic market environment.

Providers of 3PL services could support the shippers' or consignee's ambitious objective of reaching customers fast changing need in real time (Qureshi, 2007).

2.8.12 The quality of management

To ensure a high level of service, it infuses the system with innovation and reactivity. The goal of a 3PL service provider is to boost client happiness by providing prompt deliveries and upholding a high standard of service. To have a lasting impact, strategic decision-making is also aided by managerial quality. The level of management affects other factors, including service quality, the quantity and quality of fixed assets, and IT capabilities. Information sharing and trust are strengthened by high-quality management (Qureshi, 2007)

2.8.13 Information sharing and trust

Jenkins (2000) argues that a 3PL service provider should be reliable and easy to work with since compatibility is boosted by information sharing and reliability. According to Sheen and Tai's (2006) empirical investigation, businesses with a high level of outsourcing emphasis on quality, cost, and compatibility in the management of information and transportation.

To control their inventory, shippers might have to divulge information to 3PL service providers. High levels of data sharing are made possible through information exchange and trust, which boosts confidence between shippers and 3PL service providers. Shippers have faith that the 3PL service providers will protect their private information at all times. The information exchange at each level closes the gap and enables shippers and 3PL service providers to take advantage of each other's services and to take initiatives and corrective action for the required coordination and integration (Rahman and Qureshi, 2007).

2.8.14 Information technology capability

This is a crucial factor to consider while choosing 3PL service providers. The ability to provide is enhanced by the IT capabilities of 3PL service providers, who also significantly improve operational efficiency.

Adopting advanced software, such as enterprise resource planning environments, track & trace solutions, networking for electronic data interchange, simulation programs, truck routing tools, carrier loading optimization tools, consolidation packages, etc., can boost IT capability. To streamline processes and increase productivity, hardware such as servers, networking, internet, and intranet connections, radio frequency devices, bar code printers and scanners, radiofrequency identification, global positioning systems, satellite tracking devices, etc. The usage of tracking and tracing tools by 3PL service providers increases their responsiveness, which helps them provide consumers with better services (Rahman, 2004). The ability to provide is enhanced by the IT capabilities of 3PL service providers, who also significantly improve operational efficiency and financial stability. Long-term service cost reduction may result from improved IT capability (Vaidyanathan, 2005).

2.9 Freight forwarder Competitiveness & Resource based view

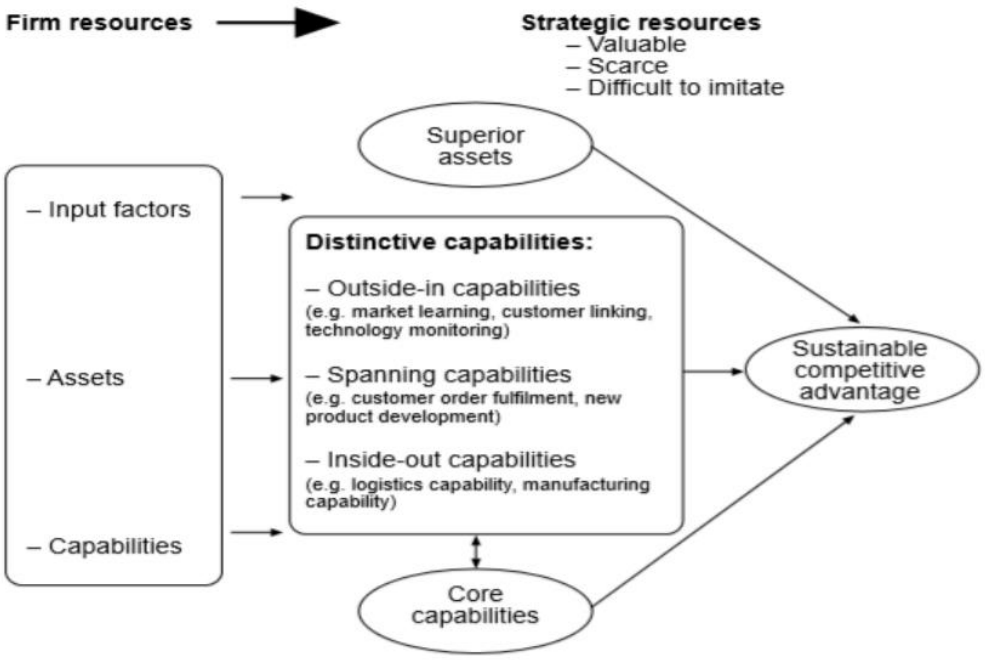
3PL service providers in general face strong competition and selecting as a logistics service provider for a clientele will be based on above key criterions and screening.

Incorporating Logistics track & trace systems in to LSP's service offerings relates to Freight forwarders Information technology capabilities, Management qualities, Finance stability attributes which are mentioned above.

It is evident that a Logistics service provider needs established capabilities in order to implement & maintain a robust Supply chain which attributes above average advantages.

Porter, (1980) in his book "Techniques for Analyzing Industries and Competitors" s discusses that companies can achieve competitive advantage through cost leadership or differentiation. Cost leadership involves achieving the lowest cost of production in the industry, which can allow a company to offer products or services at a lower price than its competitors. Differentiation, on the other hand, involves offering a unique product or service that customers perceive as valuable and are willing to pay a premium for.

Figure 2-8*: Resource based view & the Firm Competitiveness*



Source: Adapted from Day (1994)

Another study by Zhou and Li (2010) looked at the impact of competitive advantage on firm performance. The study found that firms that were able to achieve cost leadership or differentiation had higher levels of profitability than their competitors. However, firms that were able to differentiate themselves through innovation or branding had a greater impact on firm performance than those that achieved cost leadership through efficiency. The effectiveness of each strategy depended on the industry and market conditions. In some industries, cost leadership was more effective, while in other industries such as supply chain & Logistics services, differentiation too was more effective.

A 3PL (Third-Party Logistics) company can gain a competitive advantage through various sources, including Technology, Geographic reach, Customized solutions, Operational excellence, Strategic partnerships & Sustainability.

In a review of literature by Li and Zhang (2016), it was found that technology was a key source of competitive advantage for 3PL companies. The review highlighted the importance of technology in enabling 3PL companies to improve operational efficiency, reduce costs, and provide real-time visibility to customers.

A study by Kwon and Hwang (2014) examined the role of strategic partnerships in the competitive advantage of 3PL companies.

The study found that strategic partnerships with carriers, suppliers, and other logistics providers could enable 3PL companies to offer a comprehensive range of logistics services to their customers, which could improve service quality and reduce costs.

Also, a 3PL company can gain a competitive advantage through its ability to offer sustainable logistics solutions. The study found that customers are increasingly demanding sustainable logistics practices, and that 3PL companies that can provide these solutions can differentiate themselves from their competitors according to a study by Beamon et al. (2008).

Another significant source of competitive advantage is the company's operational excellence, as per Boer et al. (2011). The study highlighted the importance of lean management practices, process optimization, and continuous improvement initiatives in achieving operational excellence.

This study is focused to determine 3PL companies' ability to gain competitiveness only through effective integration of traceability solutions into their service offerings as a mean of differentiation. This will be linked basically to the firm's readiness & capabilities on IT adoption.

According to Wang, Lai, & Zhao (2008) the investment and successful implementation of IT is a means to enhance logistics firm's competitiveness. Establishing of different Logistics systems with novel technologies such as warehouse management systems, transportation management systems, and automation tools will be a 3PL providers' attempt to integrate the flow of information between 3PL providers and other supply chain participants. These IT investments & integration will be a unique resource which are valuable, rare, inimitable, and non-substitutable to a greater extent. Barney, (1991); Wernerfelt, (1984) shows that the differences in firm's market performance are fundamentally due to the distinctive resources and capabilities that are valuable, rare, inimitable, and non-substitutable.

Bharadwaj, (2000) argues that the information advantage achieved through the adoption of sophisticated technologies and the synergistic benefits achieved through an integrated system provide the sources of sustained competitive advantage for a firm.

According to Zheng, Fu, and Yang (2012) and the Third-Party Logistics Study (2014), 3PL providers invest in a variety of information technologies, including Blockchain, GPS, RFID, bar coding, Electronic Data Interchange, and supply chain planning.

These literature reviews suggest that a 3PL company can gain a competitive advantage through various sources. Though the specific sources of competitive advantage may vary depending on the company's strategy, market, and customer needs, enabling logistics traceability systems for a third-party logistics (3PL) service provider can enhance value additions in related supply chains and create a definite competitive advantage for the service provider.

Businesses may improve their operations and build a solid logistics system by setting and monitoring particular KPIs across the supply chain. However, maintaining a healthy business across all departments also enables you to meet revenue and growth targets.

2.10 Chapter Summary

The chapter begins by discussing the foundational concepts of Supply Chain Management, emphasizing the significance of efficient supply chain performance and the role of traceability in enhancing it. The discussion then delves into the importance of traceability in Supply Chain Management, focusing on its potential as a tool for gaining a competitive advantage in the logistics industry. The chapter explores how traceability facilitates better supply chain efficiency, allowing logistics firms to meet a broad spectrum of delivery requests concerning time, location, and form. Additionally, the chapter studies new trends and technologies in Supply Chain Management, highlighting the role of technical fundamentals in logistics track and trace systems. It explores how these systems enhance visibility, improve resource management, and foster operational flexibility.

Furthermore, the literature review covers the outsourcing of logistics service providers (LSPs) and key criteria for selecting a third-party logistics (3PL) service provider. The chapter probes into the concept of freight forwarder competitiveness and the resource-based view of logistics firms. Literature review lays the foundation for understanding how traceability can be a pivotal factor for gaining a competitive edge in the Sri Lankan logistics industry from the perspective of logistics service providers.

3 METHODOLOGY

3.1 Research Problem

The Chapter addresses the formulation of the research problem and the definition of research objectives based on the gap identification. In order to assist the study, the main research problem is divided into sub sections. The analysis and the solution generation are selected based on the desired outputs. Questionnaire development, population and sample generation, data collection and analysis are discussed in Later Chapters. (Chapter 3, Chapter 4).

3.2 Research Problem and sub problems

The main objective of the study is to identify the possible competitive advantage through integrated traceability system application of Logistic Operations. The study aims to focus on the perspective of Sri Lankan logistics service providers. Therefore, the main research problem can be categorized into two sub sections as follow.

3.2.1 Sub Problem 01

What are the market solutions in place for logistics traceability?

The question is focused on addressing the global approaches and current approaches used by Sri Lankan organizations. In addition, suggested applications that would leverage the Sri Lankan Logistics industry can be identified.

3.2.2 Sub Problem 02

What logistics operations can leverage through logistics traceability?

The question is focused on identifying logistics activities that can be monitored through tracking and tracing that leverage the logistics performances and enhance the competitive advantages.

3.3 Research Objectives

- Investigate and evaluate global best practices in logistics tracking and traceability, focusing on innovative approaches and technologies.
- Examine the existing landscape of logistics tracking and tracing mechanisms in the Sri Lankan context, considering industry-specific challenges and requirements.
- Develop actionable recommendations for the implementation of effective tracking and tracing practices tailored to the Sri Lankan logistics environment.
- Identify specific logistics operations and processes that can benefit from the application of advanced tracking and traceability solutions, aiming to enhance efficiency and performance.

This chapter elaborates and justifies the procedures and analysis methods used to proceed with the study toward the result generation. In addition, the justifications stressed within the chapter are based on the theoretical fundamentals.

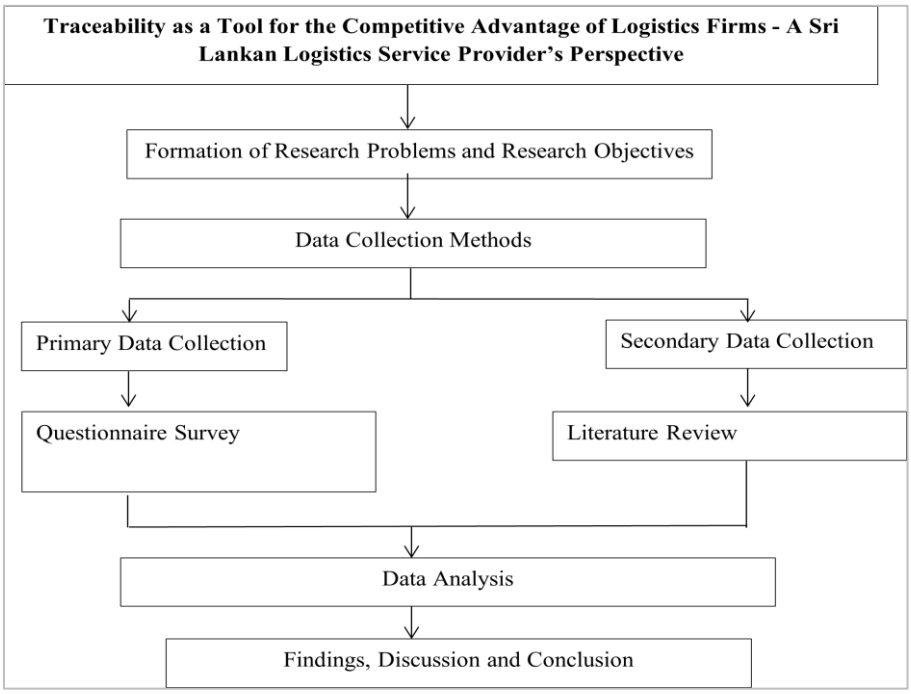
3.4 Research Framework Design

The research framework is developed as the guidance to proceed with throughout the study. Besides, Framework assists to obtain desired objectives and making the right decisions in respective situations. Data collection can be highlighted as the critical step that leads the study to enhance its objectives. Data collection was conducted in two ways, through primary data collection and secondary data collection, methods.

Extensive literature review, which was the secondary data collection method used to gather global knowledge & developments related to the subject areas, namely logistics traceability, novel technologies & systems in supply chain management & Supply chain conceptual perceptions which are applicable. In order to identify & receive valid responses to determine the solutions for the given research problems, Questionnaire survey & the Delphi sessions were used as the primary data collection methods.

The collected can be classified as quantitative data and qualitative data. Suitably the most appropriate data collection method was used. The types of data that needs, and method and tools of data analysis was decided to obtain effective solutions for desired research questions and objectives.

Figure 3-1 : ***Research Framework – Methodology***



3.5 Data Collection

Based on the desired research objectives, the data needed to analyze the study was decided. Sri Lankan based Shippers; Consignees & Supply chain experts were the respondents of the Primary Data surveys which were arranged in line with the data types that needed to be collected.

3.5.1 Primary Data

Primary data collection can be defined as collecting information directly for the study. In other words, the information collected is not represented in any other form and the data are entirely used for the study. Among multiple methods that can be used to conduct primary data collection, the study selected Questionnaire-based surveys and The Delphi method as primary data collection methods.

3.5.2 Secondary Data

Secondary data collection can be defined as, collecting information from previously established sources. The information available from secondary sources were not entirely valid for the study as the research topics & Sri Lankan context data were not widely available. But the data absorbed through the Literature review in context of global supply chain management was quite rich & gives valuable insights & guidance into the study. Multiple sources were used to collect secondary information, such as

International Journal of Logistics Research and Applications journals, Science direct reports, Supply Chain Management Review, MIT Sloan Management Review and other authorized documentations, including published books.

3.5.3 Quantitative or Qualitative Data Collection

3.5.3.1 Quantitative Data Collection

In order to identify the potential of Sri Lankan LSP's & to meet other research objectives and to derive on conclusions, respondent's quantitative data namely, statistics and demographic data are needed. In addition, the collected information should be in a position that can be transferable into visualizing formats such as numbers, figures and tables. The literature shows that the most effective and reliable quantitative analysis tools are excel and SPSS software. Therefore, the study aimed to use SPSS and EXCEL software applications to analyses quantitative data. In addition, quantitative data are to be collected through primary data collection. The method used is questionnaire surveys.

3.5.3.2 Qualitative Data Collection

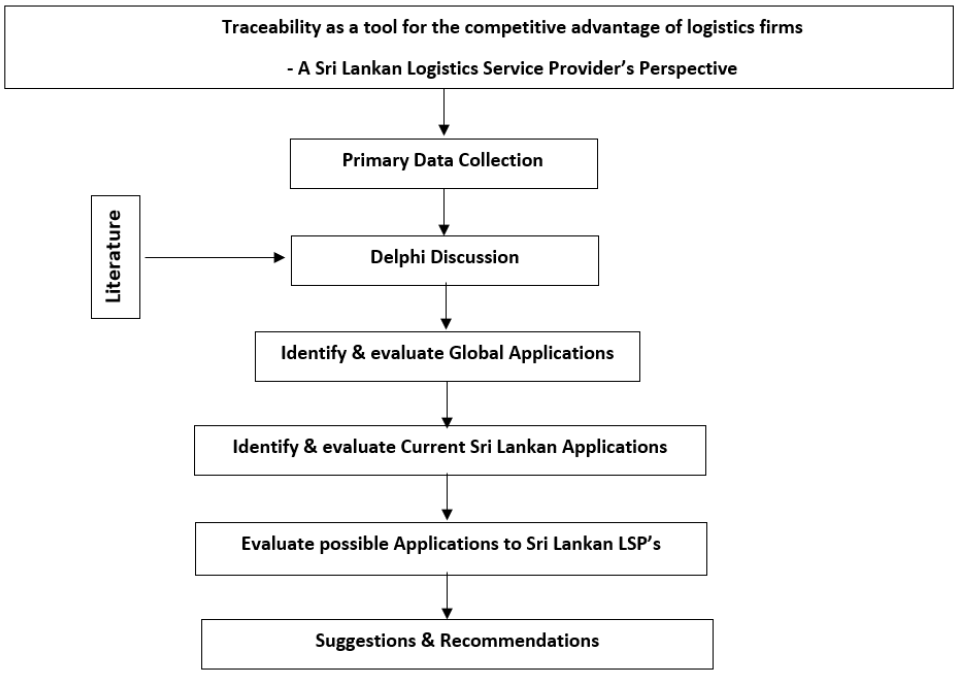
Qualitative data collection is used to identify non-numerical information. The collected information cannot be transformed into numerical results. The study mainly collects qualitative data to acquire the knowledge and familiarization of the tracking and tracing applications that are in the national and international context. In addition, the aim of qualitative data collection is to identify possible applications that can be used in the Sri Lankan context. Importantly, the study conducts qualitative data collection as a fundamental for the Delphi sessions. In conclusion, the study used qualitative data collection for secondary data collection and Quantitative data for primary data collection.

3.6 The Delphi Method

Delphi Method is chosen for its ability to leverage expert knowledge, encourage qualitative depth, capture diverse perspectives, foster consensus, maintain confidentiality, support iterative refinement, and adapt to the research objectives. These attributes make it the most suitable methodology for this study, ensuring the reliability and richness of the data collected. The method serves as a primary data collection method to acquire qualitative data. As illustrated in figure 3.2., the Delphi Method has multiple stages to collect information. These sessions had greatly contributed by adding

valuable & diverse views & inputs of the supply chain management, traceability concept & practical difficulties & possibilities of all stakeholders in the industry. The Delphi method is conducted to identify market situation and to propose traceability solutions based on expert opinion. The specialty of the method is the availability of group discussions. Therefore, during discussion rounds, panel members who are industry experts have the option to develop their own responses based on the discussions. The group responses allow the researcher to identify the most appropriate and effective solution to desired research questions.

Figure 3-2 ***: Procedure of the Delphi Method***



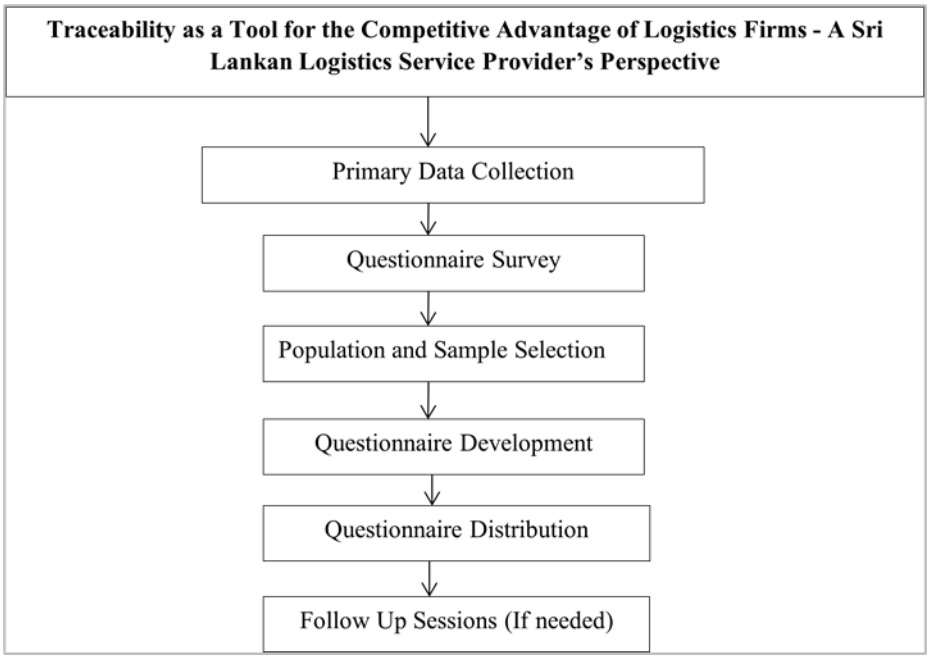
The Delphi Method consists of three stages. Generally, multiple rounds or multiple discussions are to be conducted within these stages. The first stage is allocated to background analysis. Problem identification and information gathering to understand the selected research area are valid practices in the first stage. Literature, documents related to previous studies, and authorized other documentation can be used prior to the first Delphi session. The second stage comprises panel selection. The selection of expert professionals in the field is the most common practice. This study used 10 expert panelists initially and included online discussions as well for a desired outcome. In addition to few academic professionals, Supply chain & Logistics experts of Sri Lankan based companies, Blockchain Solution developer was included.

After identifying the Delphi panel, the third stage is consisting of organizing the collected information and knowledge to identify the recommendations that are needed to generate solutions. Desired solution areas can be identified as, identifying global approaches that can be used in the Sri Lankan context while evaluating current approaches. In addition, operations that can be optimized through implementing tracking and tracing are another area to be identified.

3.7 Questionnaire Survey

The questionnaire survey is selected as a primary data collection method to acquire both quantitative and qualitative data. As illustrated in figure 3.3., the data collection has multiple stages, population and sample selection, questionnaire development, questionnaire distribution and follow-up sessions.

Figure 3-3*: Questionnaire Survey Procedure*



3.7.1 Population and Sample Selection

3.7.1.1 Target Population and Sample

The target population and sample include Sri Lankan logistics service providers and commercial customers. The population of "Logistics service providers" and "Commercial Customers" consist of multiple industries including, food and beverages, healthcare and pharmaceuticals, retail and consumer brands, Hi-Tech and consumer electronics, Mining & extractions. As per the purposive sampling general requirements, a minimum of 30% survey responses were expected & the online survey was distributed

among a 150-target population. The response rate was 40% & due to the pandemic situation in the country, the turnaround time was extended for few times, inevitably.

The population does not consider the business operations of the organizations. Therefore, organizations that are engaged in exports, imports and transshipments are also taken into consideration from the perspective of commercial customers. The size of the organization is not considered within the population.

3.7.1.2 Sampling Methods

For conducting the customer opinion survey, sampling techniques of snowball sampling and purposive sampling was used in this study. These sampling techniques will ensure the collection of resourceful data from Sri Lankan logistics firms. Purposive sampling will be useful to select appropriate samples which are aligning with the purpose of the research and gather the information to the objectives of the research. Snowball sampling will be used in this study to identify possible employees to be targeted at different levels in the organization to collect their opinions. With these sampling, mechanisms researcher has tried to examine more sensitive & reliable data including existing track and traceability practices, Future on solutions, the current impact of the non-availability of traceability systems, the market readiness for novel innovations including hardware and software basis, etc. in the Sri Lankan context.

Furthermore, the study will use these samples to identify to what extent logistics firms in Sri Lanka can expand the track and traceability technologies compared to the global context.

3.7.2 Questionnaire Development

In detail, the questionnaire has developed considering the audience, mode of distribution, and factors to be addressed. As the questionnaire is valid for a specific time period, the method of attracting and impressing the recipient is a must to be focused and the time allocation per recipient was one of the critical factors.

As per the appendix 01, the questionnaires are consisting of two sections. The first section is allocated for general information. The objective of the first section is to obtain information to measure the potential of Sri Lankan logistics operations and to retrieve demographic related data. In addition, the respondent’s analysis was to be analyzed from both customer and logistics service provider's perspectives. The second section is to identify the needs of logistics operations, technologies used and other technological

attributes. In addition, the service ratings were focused. Mainly, the applications identified through The Delphi Method and suggestions too will be used to generate results.

3.7.2.1 Questionnaire Development – Phase 01

Phase 01 of questionnaire development is focused on the desired objectives of the study. As the study consists of multiple objectives, the applications and suggestions evaluated through The Delphi Method are used to derive the questions for the questionnaire. Therefore, besides the general information, the following factors are considered when deriving the questions.

- Analyze the current implementations of logistics tracking and tracing mechanisms
- Identify the operations that can be optimized through tracking and tracing mechanisms
- The criteria customers pay attention to when choosing tracking and tracing mechanisms (Technical and financial)
- Identify organizational implications & potential benefits of logistic track & trace systems at individual level.

3.7.2.2 Questionnaire Development – Phase 02

The target audience is limited to the management and executive levels. As the questionnaire survey is based on technological attributes, the operational level employees were not selected for the sample. According to the target audience, the question types and question formats and styles were selected. A rational questionnaire distributed, and the questions formatted in understandable language. For instance, theoretical terminologies might not always be used in industry. Hence researcher provided the necessary phrases within the questionnaire. The researcher here has allowed the recipient to fill out the questionnaire, giving him necessary freedom. The questionnaire developed in a way that does not harm the privacy of the respondent. Moreover, ethical, and religious phrases were not referred.

The reliability of the questionnaire had maintained because the audience is not willing to allocate a longer time period for a questionnaire. Time consciousness was highly considered but the required data on the other hand was aimed. Less open-ended questions, ratings and multiple-choice questions were used to develop the questionnaire.

3.7.3 Questionaries Implementation

Virtual platforms were used to distribute the survey. The selection was essentially persuaded based on the convenience level, pandemic situation and data cleansing requirements. Follow-up sessions including random zoom & telephone conversations were conducted with the respondent for a far better outcome to achieve maximum contribution from the recipient.

3.7.4 Important Research Challenges

The occurrence of error factors can be highlighted as a main challenge for the data collection through questionnaire surveys. Also, the developed pandemic situation affected critically to the overall research process while data collection was delayed unexpectedly. The biasness and consistency measures should have to be implemented to minimize the effects of the error. In addition, data cleansing is decided to conduct to reduce misleading responses.

3.8 Data Analysis

Data analysis comprises multiple methods. The methods namely, central tendency measures, descriptive analysis, Likert scale analysis and error identification and reliability analysis were used. In addition, EXCEL and SPSS software were used to generate outputs from the analyzed data. Relevant error measures and reliability analysis for the rating scale are also explained.

3.8.1 Identifying the potential of commercial customers and the logistics service providers

Descriptive analysis is assigned to identify potential and industry characteristics. The analysis is proposed to conduct with both Supply chain industry commercial customer's perspective and the logistics service provider's perspective. The main objective is to identify the probable requirements, supply & demand attributes within the Sri Lankan context. In addition, individual business operations and recipient validation are also to be addressed. Factors that analyze can be expressed as follow.

- Industry experience in operations
- The scale of the business
- Type of business operations
- Geographical service distributing areas
- Respondent’s Suitability
- Service providing Capacity

- Enabled industries operating in
- Key performance indicators

3.8.2 Analyzing Rating Scales

In order to analyze the filled ratings in the questionnaires, a standard method is needed, because the ratings are directly linked with human perceptions. Mainly, the filled values are needed to be on one level. Likert Scale and Semantic Differential Scales are the most common practices used in academia.

The Likert Scale was used to analyze the personal opinions that vary between like and dislike or agree and disagree. The literature describes that the opinions can be rated by numerical values as, the lowest value to the most disliked or disagree factor and the highest value to the most liked or agreed factor. According to theories, the scale can be varied into 3 scores, five scores or seven scores. The analysis is consisting of five scaled Likert scales and three scaled Likert scales. Based on the number of respondents, the scale ranges have to validate to ensure the accuracy of results.

In order to identify the requirements of commercial customers and to identify the service providing areas that are enabled within the logistics service providers, the five scaled scale was developed. Furthermore, a similar scale is assigned to analyze concerned performance measures that customers are expecting and to analyze customer experience with the current logistics service providers. The scale is used to analyze,

- Logistic requirements
- Logistics service outsourcing
- Key Performance dimension factors
- Experience with the current logistics service provider
- Information sharing with customers

3.8.3 Reliability and validity analysis

Necessary procedures were implemented prior to the analysis, to mitigate error occurrences and validate data analysis results. In order to reduce, respondents' mistakes and data finalizing mistakes by the researcher, incomplete forms had been neglected, and the data cleansing stage conducted prior to the analysis. In other words, the raw data set will be monitored, and cleansed dataset will be used to degenerate results through analysis.

Reliability analysis was established to measure the Likert scale results. Cornbrash's alpha strategy was suggested to test the internal consistency of the developed Likert scale and generated results. Cronbach's Alpha illustrates internal consistency as a value between 0 – 1, while o represents weak consistency and 1 represents perfect consistency. Based on the values between 0 -1, the consistency level can be expressed by six levels, the unacceptable level, which is as same as, weak consistency that scores below 0.5. Factors that score between 0.5 and 0.59 are expressed as, poor consistent factors and factors that range between 0 6 to 0.69 are considered, questionable factors.

Acceptable consistency values start from 0.7. Therefore, the minimum value that a particular factor should require to be at the acceptable level is 0.7. The acceptable level varies within three ranges, between 0.7-0.79 gives an acceptable consistency value and the factors between 0.8-0.89 own a good consistency value and the factors that show a crouch back alpha value more than 0.9 can be determined as an excellent consistency value.

3.8.4 Analyzing the use of tracking and tracing tools

The section is aimed to identify the technologies that are currently practiced within the organizations and the problems that are currently encountered with mentioned techniques. In addition, knowledge and familiarization with ERP systems are also to be analyzed. The willingness to use new approaches in line with expected outcomes is also addressed in this section. The willingness to acquire new technologies to enhance logistics performance is measured in multiple aspects.

3.9 Chapter Summary

Chapter 03 emphasized the methodology that proceeds within the study. The methodology comprises multiple attributes namely, designing the research frameworks, selecting data sources and data collection methods. Quantitative & qualitative approaches were selected with purposive sampling & snowball sampling. The chapter describes the questionnaire development and the Delphi methods that drive the data collection procedures. The data analysis methods SPSS, EXCEL, Likert scale, Cornbrash's alpha usage was discussed based on the types of data that has to be analyzed to generate desired outputs.

4 RESEARCH FINDINGS

4.1 Introduction

Chapter 04 comprises analyzed data collected through primary data collection. Commercial customers and logistics service providers in the Sri Lankan context were used to collect relevant information. The results generated through data analyzing tools were addressed based on the industry perspective. Subsection 4.2 is enclosed with the results that has being identified with the Delphi method. As mentioned in previous chapters, data collected through the Delphi sessions were used to develop the questionnaire as well. Section 4.3. described the multiple attributes of general information that has been gathered from the questionnaire survey. Section 4.4. is allocated to interpret results generated through Likert scale analysis with relevant reliability and validity analysis. Technological aspects and opinions of survey respondents were addressed in the last sub sections respectively (4.5., 4.6.)

4.2 The Delphi Method

In order to conduct the Delphi method, background analysis was conducted. The information assembled from the extensive literature review was used to reinforce productive rounds of Delphi sessions. The knowledge of current traceability applications in Global supply chain arena, identified through secondary data collection methods were useful in moderating the multiple rounds of Delphi sessions.

The Delphi method was used to identify multiple research aspects including,

- The current implementations of logistics tracking and tracing mechanisms in Sri Lanka
- 3PL operations that can be optimized through tracking and tracing mechanisms in Sri Lanka
- The criteria customers pay attention to when choosing tracking and tracing mechanisms (Technical and financial)
- The expert recommendations that are needed to generate logistics tracking and tracing solutions.

4.3 Key Findings of the Delphi method

4.3.1 The current implementations of logistics tracking and tracing mechanisms in Sri Lanka

- Paper-based documentation remains prevalent in Sri Lanka's logistics industry, with many companies relying on manual systems for tracking and tracing shipments.
- However, there is increasing interest in digitizing logistics operations, and several companies are adopting electronic data interchange (EDI) systems to streamline processes and improve traceability.
- Other tracking and tracing mechanisms currently used in Sri Lanka include GPS-enabled tracking devices, radio frequency identification (RFID) tags, and barcoding systems, but very limitedly.
- There is a growing trend towards integrating these different tracking and tracing mechanisms to create a more comprehensive and efficient system.
- Challenges to the adoption of advanced traceability systems in Sri Lanka include high costs, lack of infrastructure, and limited technical expertise. But it is visible that few Sri Lankan Tech companies together with industry experts have initiated global standard solutions already.
- Finally, there is recognition among industry players that traceability can provide a competitive advantage, particularly in terms of improving customer satisfaction and reducing supply chain risks.

4.3.2 The 3PL operations that can be optimized through tracking and tracing mechanisms in Sri Lanka

- Import and export sea freight can benefit from tracking and tracing mechanisms, which can be used to track shipments, monitor delivery times, and provide real-time updates to customers.
- Land transport is a key area where tracking and tracing mechanisms can be used to optimize operations, including route optimization, real-time tracking, and predictive maintenance for vehicles.
- Reefer plugins and transport can also benefit from tracking and tracing mechanisms, which can be used to monitor temperature and humidity levels, track container locations, and ensure compliance with regulatory requirements.

- Container and reefer rent services can be optimized using tracking and tracing mechanisms to monitor container locations and condition, schedule maintenance, and improve inventory management.
- Warehousing operations can benefit from tracking and tracing mechanisms, which can be used to monitor inventory levels, track item locations, and improve order fulfillment.
- Container yard services can be optimized using tracking and tracing mechanisms to monitor container movements and inventory levels, and to improve yard management and scheduling.
- Customs brokerage operations can be optimized using tracking and tracing mechanisms to provide real-time updates on the status of shipments and to ensure compliance with regulatory requirements.
- Cross-docking operations can be optimized using tracking and tracing mechanisms to improve inventory management and reduce handling times.
- Inventory management can be improved using tracking and tracing mechanisms, which can provide real-time updates on inventory levels, track items as they move through the supply chain, and improve demand forecasting.
- Product labelling and packaging can be optimized using tracking and tracing mechanisms to improve traceability, ensure compliance with regulatory requirements, and prevent counterfeiting.

4.3.3 The criteria's customers pay attention to, when choosing tracking and tracing mechanisms (Technical and financial) in Sri Lanka

4.3.3.1 Technical Criteria:

- Real-time tracking and updates: Customers highly prioritize tracking systems that provide real-time information on shipment location and status. Timely updates allow for better decision-making and improved supply chain visibility.
- Integration capabilities: Customers value tracking and tracing mechanisms that seamlessly integrate with their existing systems, such as inventory management and order processing software. Compatibility with multiple platforms is essential for smooth operations.
- User-friendly interface: Ease of use and intuitive interfaces are critical factors for customers, as they seek tracking systems that are simple to navigate and require minimal training for their staff.

- Multi-modal tracking: Since Sri Lanka's logistics involve various transportation modes, customers prefer tracking mechanisms that can monitor shipments across land, sea, and air routes for comprehensive end-to-end visibility.
- Security and data privacy: Customers prioritize systems with robust security measures to protect sensitive shipment data and ensure data privacy compliance.

4.3.3.2 Financial Criteria:

- Cost-effectiveness: Affordability plays a significant role in the decision-making process. Customers prefer tracking and tracing mechanisms that offer a good balance between features and cost.
- Return on investment (ROI): Customers assess the potential ROI of implementing tracking systems. They are willing to invest more if the mechanism can demonstrate substantial improvements in operational efficiency and customer satisfaction.
- Transparent pricing: Customer's value clear and transparent pricing structures. Hidden costs and unexpected charges are viewed negatively and can influence their choice of provider.
- Scalability: As businesses grow, customers seek tracking and tracing solutions that can scale along with their operations without significant cost increases.

4.3.4 The expert recommendations that are needed to generate logistics tracking and tracing solutions in Sri Lanka

The panel of experts discussed possible tracking and tracing practices that could be implemented in Sri Lanka to improve logistics operations and gain a competitive advantage. The discussion covered a range of technologies, including blockchain, RFID, and other tracking and tracing systems.

Each track and trace technology or tool has been evaluated by considering multiple attributes namely,

- Implementation Cost & ROI
- User friendliness, Ease of understanding & Ease of use
- Features and specifications
- Information needs for implementation
- Security and data privacy
- Overall 3PL operation Integration capability

- Cost-effectiveness
- Multi-modal tracking ability
- Applicable pricing mechanisms
- Scalability:

4.3.4.1 Key Findings:

- Blockchain technology has the potential to revolutionize the logistics industry by providing a secure, tamper-proof system for tracking and tracing shipments. However, its implementation in Sri Lanka may face challenges such as regulatory issues and a lack of technical expertise. Meantime, it was revealed that at least 01 company is in implementation stage of a blockchain based solution. Blockchain platform is desperately useful to Sri Lankan shippers who need adherence to strict food regulations & compliances in order to gain an advantage in their respective international markets, by proving the organic ingredients or components of their supply chains, back to their true place of origin.
- RFID tags are already being used in Sri Lanka for tracking and tracing, and their adoption is expected to grow as costs decrease and technical capabilities improve. Some panelists suggested that the use of RFID in conjunction with other tracking technologies could provide a more comprehensive solution.
- Barcoding systems are widely used in Sri Lanka and are relatively low-cost but may not provide the level of detail and accuracy required for more complex logistics operations.
- GPS-enabled tracking devices are also used in Sri Lanka, but their effectiveness may be limited in areas with poor network coverage or challenging terrain.
- The use of electronic data interchange (EDI) systems, which allow for the electronic exchange of logistics data, is becoming more common in Sri Lanka and is expected to continue to grow.

Based on these findings, freight forwarding companies in Sri Lanka may want to consider adopting a combination of tracking and tracing technologies, such as RFID and blockchain, to create a more comprehensive and secure system. However, they will need to carefully consider the costs, technical requirements, and regulatory issues associated with these technologies. The use of more traditional tracking technologies such as barcoding, and GPS may also be appropriate in certain contexts.

Ultimately, the choice of tracking and tracing practices will depend on the specific needs and capabilities of each individual company.
Identified applications and tools can be highlighted as,

- Blockchain technology
- Real Time GPS connected ERP system
- Temperature and Humidity Monitoring (Reefer Tracking)
- RFID & IOT based Tracking systems
- Multi-Modal Integrated Tracking Solutions
- Mobile Apps and Customer Portals
- Electronic Data Interchange Solutions

4.3.5 Possible Challenges of tracking and tracing implementations

The main causes that have led to arising problems can be expressed as,

- High Implementation Costs: The upfront costs associated with implementing tracking and tracing technologies, such as hardware (sensors, RFID tags, GPS devices) and software systems, can be a significant barrier for smaller freight forwarders with limited financial resources.
- Lack of Technical Expertise: Adopting and integrating tracking and tracing technologies require technical expertise for system setup, maintenance, and troubleshooting. A shortage of skilled personnel in this area can pose challenges for implementation.
- Fragmented IT Systems: Many freight forwarders may have legacy IT systems that are not easily integrated with new tracking and tracing solutions. Overcoming compatibility issues between different systems can be challenging.
- Limited Technology Infrastructure: Some areas in Sri Lanka might have limited access to advanced technology infrastructure, including stable internet connectivity and reliable cellular networks. This can hinder the real-time transmission of tracking data and updates resulting unreliability on the system.
- Resistance to Change: Resistance to new technologies and processes from employees, especially if they are accustomed to manual or traditional methods, can slow down the adoption and implementation of tracking solutions. This may be caused by Less awareness of the benefits of the system too.

- Data Security Concerns: Concerns about data breaches, cyberattacks, and unauthorized access to sensitive shipment data can be significant. Freight forwarders need to ensure that the tracking solutions they implement have robust security measures in place.
- Integration with Stakeholders: Collaboration and data exchange with partners, such as shipping lines, customs authorities, and clients, require seamless integration. Differences in technology platforms can complicate integration efforts. Also, Willingness to share information too is a considerable challenge.
- Regulatory and Compliance Issues: Adhering to local and international regulations related to data privacy, security, and customs procedures is essential. Ensuring that tracking solutions comply with these regulations can be complex and time-consuming
- Coverage and Accuracy: Tracking solutions relying on GPS signals or cellular networks might face challenges in areas with poor coverage or signal interference, affecting the accuracy of real-time tracking data.
- Customization Needs: Tracking and tracing solutions need to be tailored to the specific requirements of freight forwarders and their clients. Off-the-shelf solutions might not always meet these unique needs

4.4 General Information Analysis- Descriptive Analysis

The descriptive analysis methods were used to analyze the general information including the demographic data that has been gathered from data collection. The main objective of the collection of general information is to identify the respondent's fittingness to be a contributor as a survey recipient. Because false information or random opinions that do not match the actual scenario will lead to misinterpretations. In addition, the respondent should be a responsible person from the selected organization and he or she should be empowered with qualifications and experience in the industry to answer the industry-based questions displayed in the questionnaire.

The second objective is to identify the potential of commercial customers, who are seeking logistic services to enhance their logistics performances. This information will require to identify the appropriateness of the responding company as a survey contributor & helps to validate the overall research objectives.

In addition, the questionnaire results gathered from the survey for the logistics service providers can be used to determine the Sri Lankan logistics service providers' strengths and potential strengths to address said customer's supply chain service needs.

4.4.1 Profile Analysis of Respondents - Descriptive Analysis

The rrespondent's fittingness to be a contributor is analyzed by considering both the commercial customers' perspective and the logistics service provider's perspective. Population and sample selection interprets that the respondent should be at the executive level or the management level. Based on the hierarchical level of the organization, the management level is addressed through the manager and senior managers' positions. Hence, the respondent's position can be determined by Figure 4.1.1 and Figure 4.1.2.

Figure 4-1*: Respondent's Position*

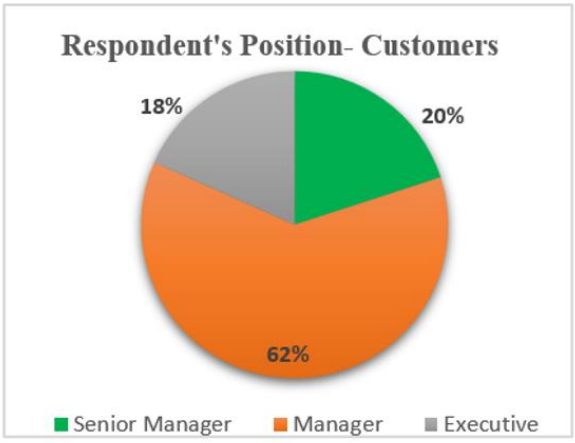


Figure 4.1.1. Respondent's Position - Commercial Customers

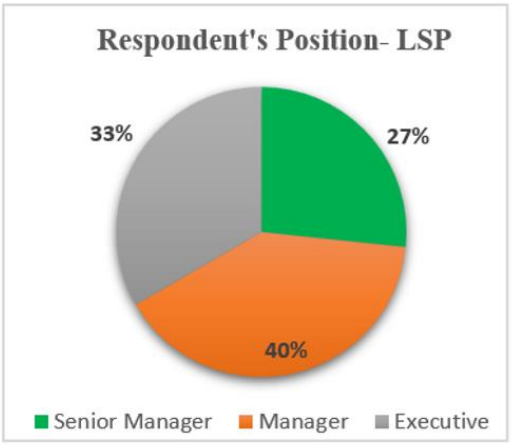


Figure 4.1.2. Respondent's Position - Logistics Service Providers

The results show that respondents' positions within the organization vary within expected positions namely, executive, manager, and senior manager. In addition, the results do not depict positions other than that mentioned in the methodology. Meanwhile, the questionnaire was not biased toward the selected job positions. An acceptable combination of respondents can be observed in both commercial customers and logistics service providers. This can be used to verify that; selected individuals are qualified to be the survey respondents and the analyzed results can be evidently used to make outputs.

4.4.2 Potential of commercial Customers - Descriptive Analysis

The potential strengths of Sri Lankan commercial customers who are pursuing logistics services can be analyzed through gathered information. It can be analyzed by means of, industry experience, the scale of the organization, business operations and the business industry that operations are conducted.

The business experience of commercial customers and the scale of the business can be identified using Figure 4.2.1 and Figure 4.2.2.

Figure 4-2*: Organization Size & Industry Experience*

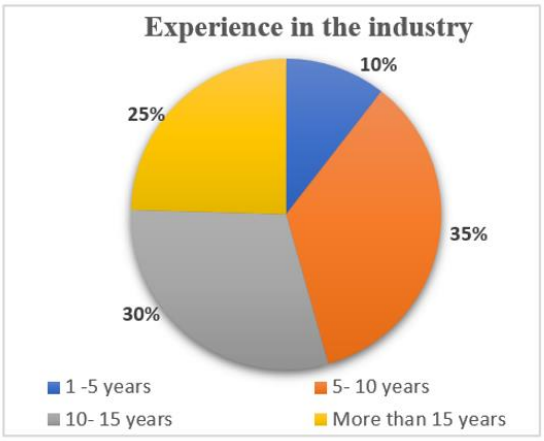


Figure 4.2.1. Industry Experience - Commercial Customers

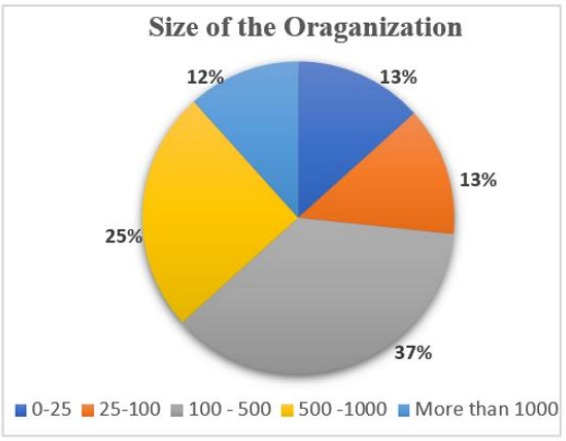


Figure 4.2.2. Size of the Organization - Commercial Customers

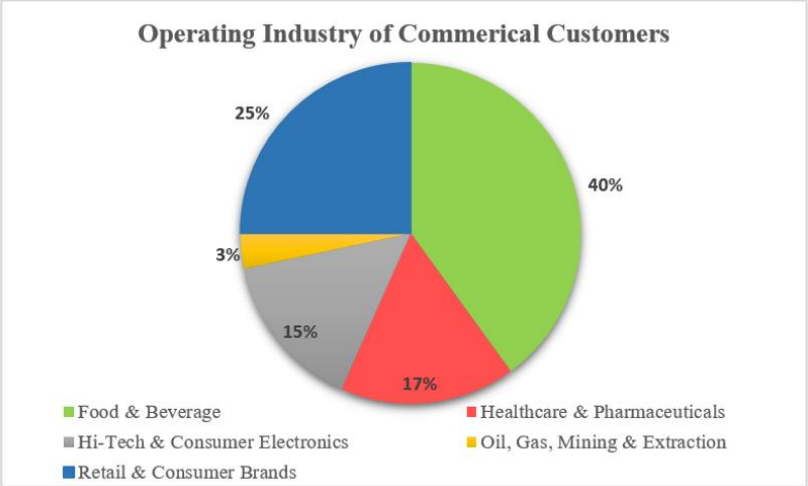
The business experience shows the customer's operations experience within the industry. The Knowledgeable, experienced stakeholder can specifically use their strength to identify the market conditions & the requirements to enhance their logistics excellence. In addition, Figure 4.2.1 indicates a better combination of industry experiences. It can be highlighted as a result of the random and snowball sampling method.

The size of the organizations of commercial customers can be elaborated in Figure 4.2.2. The size of the organization is measured by means of the number of employees within the organization. Literature shows the linkage between the number of current employees and the business scale of the organizations through four (4) categories, small, medium, large and enterprise. Small organizations own employees up to 250, and medium scale organization owns up to 500 employees.

While large scale organizations have a maximum of 1000 employees and enterprises own more than 1000 employees.

Based on the organization's business scale, the logistics requirements, and outsourcing facilities requirements are changed. Therefore, the size of the organization is critical to be identified while introducing tracking and tracing tools to enhance their logistics operations. Based on the industry in that commercial customers conduct their business operations, classification can be expressed in, Figure 4.3.

Figure 4-3*:Business Operating Industry*

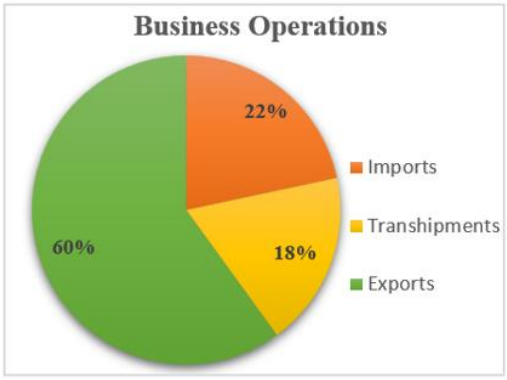


The operating industry of commercial customers was analyzed based on their operating industry. Industries were categorized into five (5) sectors based on the main business operations. Figure 4.3 denotes a well-mixed combination of respondents. This can be used to identify logistics operations and the requirement of tracking and tracing solutions in a wider scope. The reason to have unbiased percentages for each industry can be highlighted as the use of random sampling and snow sampling methods for data collection.

The type of business operation and dealing international markets can be identified in Figure 4.4.1 and Figure 4.4.2. Commercial customers' business operations and service distribution within countries can be expressed in the above figures. The type of business operations varies among three (3) categories as, "exports", "imports" and "transshipments ". Figure 4.4.1 only validates commercial customers who are engaged in international business operations. While the commercial customers who engaged in business operations in the domestic level were not included.

In addition, the results from figure 4.4.1 do not depict a mixture of service operations in a specific industry, but it represents the type of business operations that vary within commercial customers' business operations industries taken as a whole.

Figure 4-4*: Type of business operation & Service Distribution*



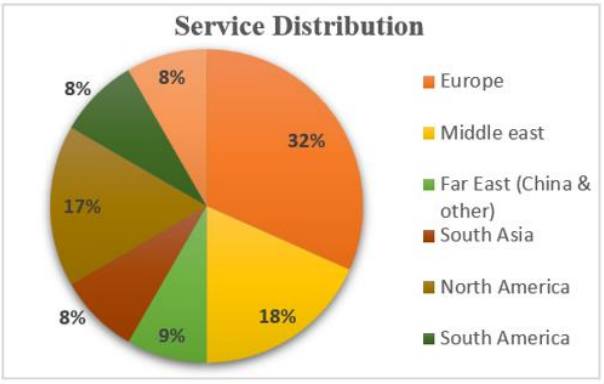


Figure 4.4.1. Type of Business Operation - Commercial Customers

Figure 4.4.2. Service Distribution - Commercial Customers

4.4.3 Potential of the logistics service providers - Descriptive Analysis

The potential strengths of Sri Lankan logistics service providers who are pursuing serving multiple services to customers can be analyzed through gathered information. It can be analyzed by means of, industry experience, the scale of the organization, business operations areas and clients per month.

The business experience of the logistics service providers and the scale of the business can be identified using Figure 4.5.1 and Figure 4.5.2.

The analysis is conducted to identify the industry experience of the logistics service providers. As mentioned in previous sections, industry experience, logistics requirements and scale of organizations of commercial customers were clearly identified. In contrast, the industry experience and scale of the organization of the logistics service providers have been analyzed. The experience of the logistics service providers is a critical component to determine the quality and effectiveness of their performances. In addition, being an industry expert is beneficial to maintain a variety of services that enhanced with quality and standards. Figure 4.5.1 depicts a wide range of industry experiences.

Figure 4-5 : ***Industry Experience & the organization Size***

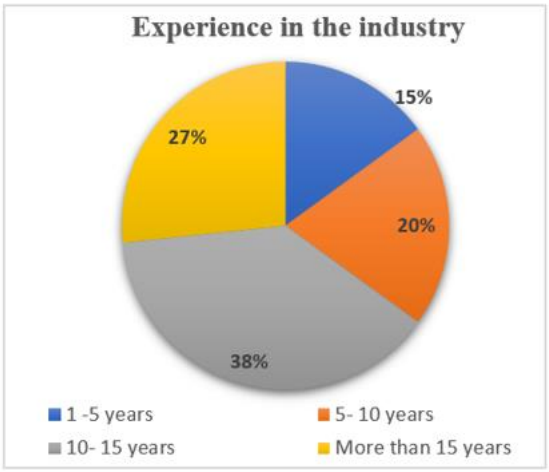


Figure 4.5.1. Industry Experience - Logistics Service provider

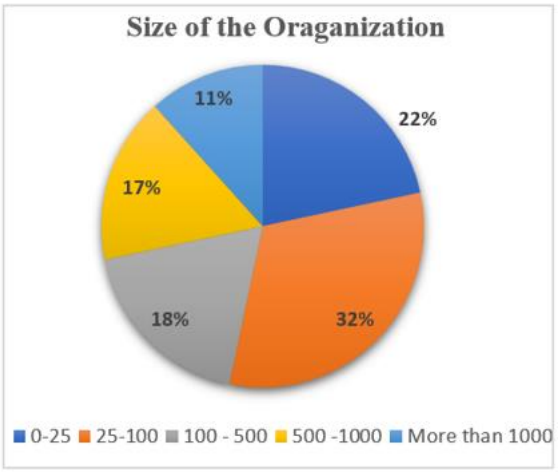


Figure 4.5.2. Size of the Organization - Logistics Service provider

Identifying the scale of business operations of the logistics service providers is essential to determine the service differentiation capabilities and availability of advanced technological practices. Figure 4.5.2 illustrates the different operating scales within logistics service providing organizations. The size of the organization is measured by means of the number of employees within the organization. The literature illustrates the linkage between the number of current employees and the business scale of the organizations through four (4) categories, small, medium, large and enterprise. The small organizations own employees up to 250 and, the medium scale organization owns up to 500 employees. While large scale organizations have a maximum of 1000 employees and enterprises own more than 1000 employees. The figure shows a decent blend of organizations in different scales. The client classification by means of industry and service providing capacity can be analyzed in Figure 4.6.1. and Figure 4.6.2.

Figure 4-6 : *Client Classification & Service providing Capacity*

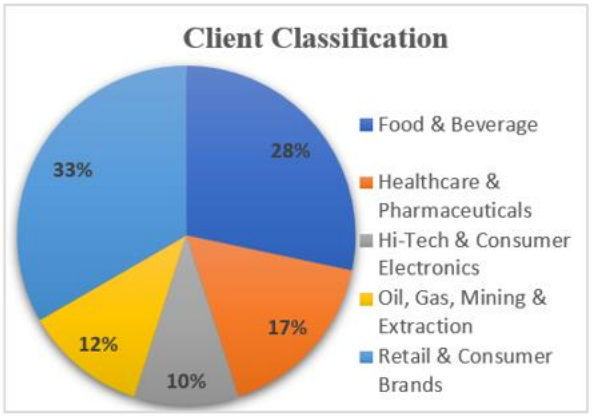


Figure 4.6.1. Client Classification - Logistics Service provider

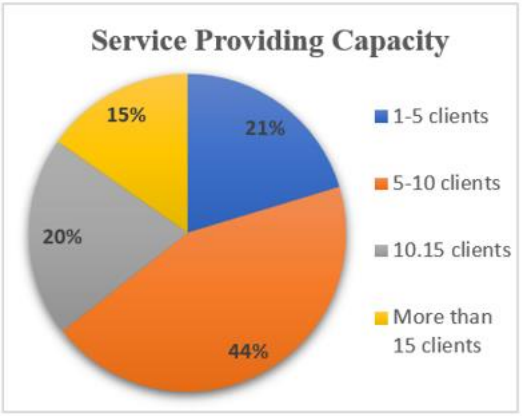


Figure 4.6.2. Service providing Capacity - Logistics Service provider

This analysis graphically illustrates the current supply chain service capabilities of Sri Lankan logistics service providers in general. According to the information collected, Sri Lankan logistics service providers have strengths in facilitating multiple logistics services mainly to the retail and consumer brands industry, food and beverages industry, and health and pharmaceutical industries; in other words, the commercial customer's demand for Logistics services are for these industries in Sri Lankan perspective.

Service providing capacity illustrates the number of clients or customers that acquire services from the logistics service providers. Figure 4.6.2 shows the average number of customers per month. But this analysis is not addressed to a specific industry or to any service type and it considered the service as a whole.

4.5 Commercial customer's logistics requirement analysis

The commercial customers Logistics requirements are many & different. The outsourcing preferences includes the demand side of the logistics services. Therefore, this section includes the intended analysis findings about the demand for logistics services.

4.5.1 Customer requirement identification

In order to identify the demand for logistics services, customer requirements have to be clearly analyzed. The Table 4.1. shows the requirement analysis by means of customer demand percentage and the percentage of outsourced facilities.

Table 4-1 : ***Logistics Requirements***

Logistic requirement	Customer Demand	Outsourced Percentage
Domestic transportation, management & planning	**67%**	**50%-75%**
Import Freight / Export freight	**65%**	**50%-75%**
Information technology (IT) services	**42%**	**50%-75%**
Customs Brokerage	**42%**	**25%-50%**
Warehouse	**17%**	**50%-75%**
Container / Reefer rent services	**13%**	**50%-75%**
Container Yard space	10%	25%-50%
Inventory management	7%	25%-50%
Reefer Plugins	3%	25%-50%
Product labeling, packaging, assembly, kitting	3%	25%-50%
Service parts logistics	3%	25%-50%
Supply chain consultancy services provided	3%	25%-50%
Reverse logistics (defective, repair, return)	2%	25%-50%
Customer service	2%	25%-50%
Freight bill auditing and payment	2%	25%-50%
Order management and fulfillment	2%	25%-50%
Cross-docking	2%	1% -25%

The Delphi results and previous literature are used to list down the logistics facilities required by a typical commercial customer. The Likert scale results show the logistics requirements vary within three (3) distinct ranges. Additionally, it can be clearly identified that the majority of mandatory logistics operations require logistics service providers involvement with a higher percentage of such services are outsourced.

Also, the outsourcing percentages of logistics services vairy within High, Average & low ranges similar to that of logistics demand. Domestic transportation management, Import & Export freight arrangement, Information technology (IT) services, Customs Brokerage,

Warehousing & Container / Reefer rent services are the prominent areas that customers are requesting services for. The fact that there is a significant demand for logistics services within commercial customers in Sri Lanka is highlighted. A positive and noteworthy demand for logistics facilities does exist within the Sri Lankan freight forwarder market and the results depict that generally, services outsourcing must be made to fulfil the business operations & enhance commercial customers supply chain efficiency.

Table 4-2 : ***Customer Expectations & current Experience***

Performance Metric	**Code**	**Expectation**	**Experience with current LSPs**
Price	M1	Average	Average
Cost Minimization	M2	High	Average
Volume Flexibility	M3		
Coordination	M4		
Shipping Accuracy	M5		
Product Quality	M6	High	High
Delivery Speed	M7		
Product Range	M8		
Product Customization	M9		
Forecasting Accuracy	M10		
Order Compliance	M11		
Shipment Visibility Info	**M12**	**Very High**	**Average**
It Capabilities	**M13**		
Market Responsiveness	**M14**		
Customer Service	**M15**	**Very High**	**High**

4.5.1.1 Commercial Customer Expectations Vs Current Experience with LSP's

As a mean to further validate the customer demand, table 4.2 demonstrates the service expectation of the customers and the current experience from their relevant freight forwarder's services. The results-based on the commercial customers' perspective who are searching for logistics service providers. The table consists of two aspects, namely the logistics service expectation Levels of customer and the current experience with the contracted or agreed logistics service providers.

The expectations of logistics Customers for services, shows the performance metrics that the customer considered when selecting the logistics service provider to receive services. It can be clearly identified that the expectation of customers is mainly based on added resources & trust including IT capabilities, market responsiveness and shipment visibility information, which are competitive advantages from LSP's perspective.

The responses received indicates that logistics service providers are concerned in technologies and tools aimed at optimizing logistics tracking and traceability. This interest will be driven by the intention to leverage such solutions to achieve a competitive edge in the industry.

Furthermore, when considering the commercial customers experience with their existing logistics service providers, a significant divergence is observed in terms of few performance metrics, namely Shipment Visibility Info, IT Capabilities, Customer Service & Market Responsiveness. This service expectations mismatch identified in multiple performance metrics can be used to illustrate the availability of the supply - demand gap by means of service expectations of the Commercial customer and the current experience they get from LSP's.

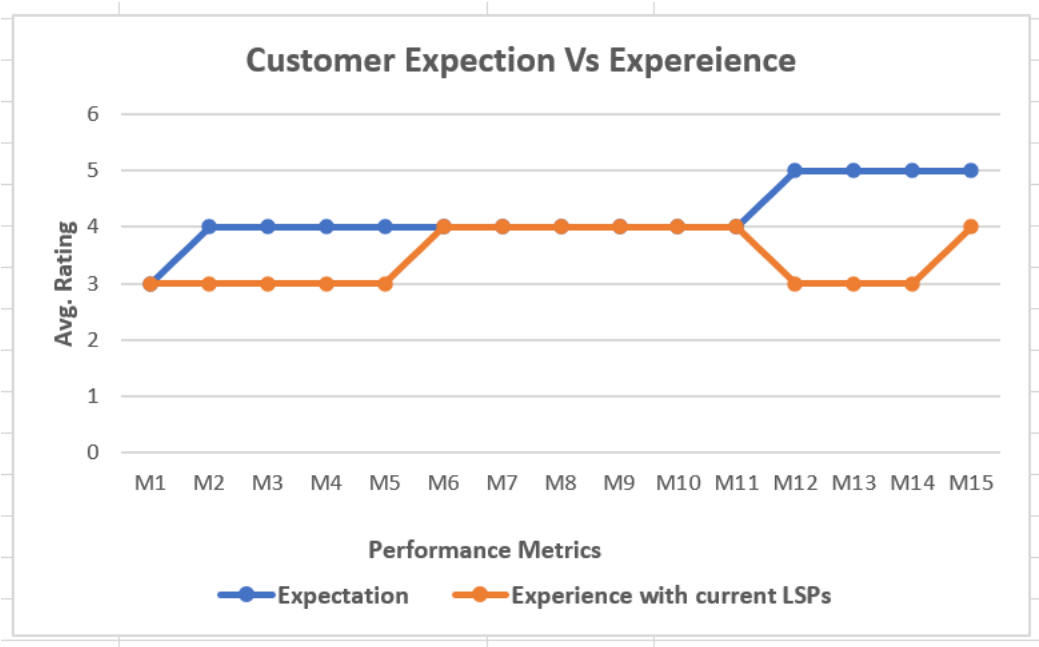
In contrast, the analysis indicates that the majority of services fall into the category of average experiences, as reported by customers. This means the service expectations in few metrics are met with LSP's provided services.

For better understanding, the coding system was used to illustrate the logistics performance metrics denote from M1 to M15. The service and demand mismatch can be clearly identified through the graphical illustration in Figure 4.7.

According to the chart, multiple performance metrics have considerably lower experience than the expectations for relevant metric.

Shipment Visibility Info, IT Capabilities, Customer Service & Market Responsiveness are indeed interrelated, and deficiencies in one area can impact the others. For instance, Insufficient IT capabilities can hinder the adoption and utilization of traceability systems, which in turn can impact shipment visibility and overall customer satisfaction. Also Lack of information distribution or poor shipment visibility can affect customer service & market responsiveness of any stakeholder within the supply chain as partners may not have accurate updates on these shipments.

Figure 4-7 : *Customer Expectation Vs Current Experience*



4.6 Analysis on Current practices and problems of Logistics Traceability

Current practices and problems are analyzed based on the information from both the logistics service providers and commercial customers. The information analyzed is based on following surveyed factors.

- Accessibility to Shipment information
- Current use of QR, RFID, Barcode & EDI systems
- Shipment Visibility information
- Time to receive shipment information
- Modes of sharing the shipment information

Figure 4-8 : ***Accessibility to Shipment information***

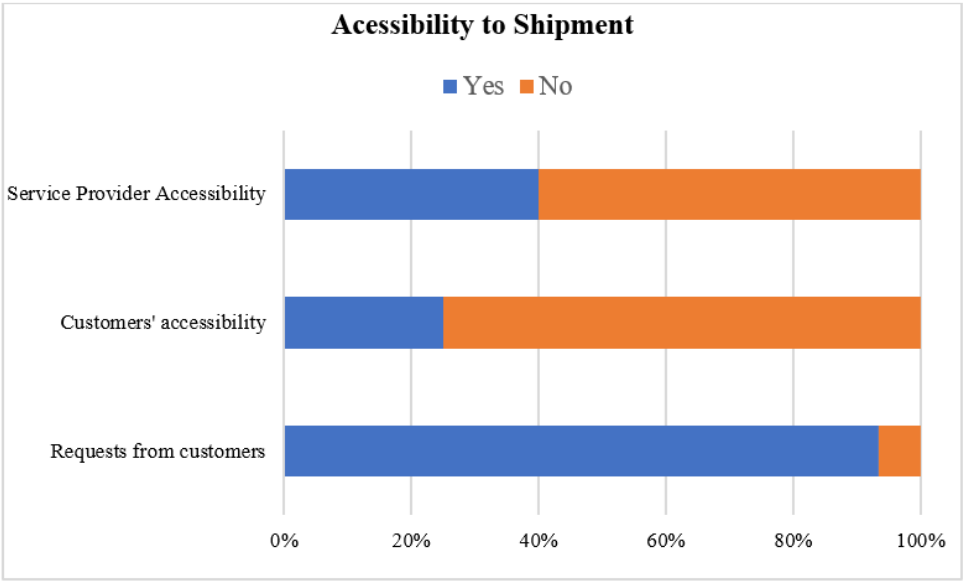


Figure 4.8 depicts the respondent's accessibility to information on shipments. The accessibility is checked with the logistics service providers and customers. Meanwhile, logistics service providers' accessibility is analyzed based on their own accessibility for shipment information and considered the customer requests received to the logistics service provider for such information.

The graphical illustration shows that the logistics service providers have a considerably higher percentage of access, which is 40%, compared to customers (25%) for shipment information. Moreover, 93% of the customers has requested shipment information, indicating that the traceability information is absolute beneficial for them.

Many logistics service providers are already educated or initiated implementing on different platforms that allow commercial customers to access their shipment information online. These web portals or mobile apps are capable & used to view shipment status, real-time tracking updates, and documentation.

Some commercial customers face challenges with consistent access to shipment information due to technical glitches, limited platform compatibility, or connectivity issues in certain regions.

4.6.1 Current Use of QR, RFID, Barcode or EDI Systems:

Figure 4-9 : ***Current Use of QR, RFID, Barcode or EDI Systems***

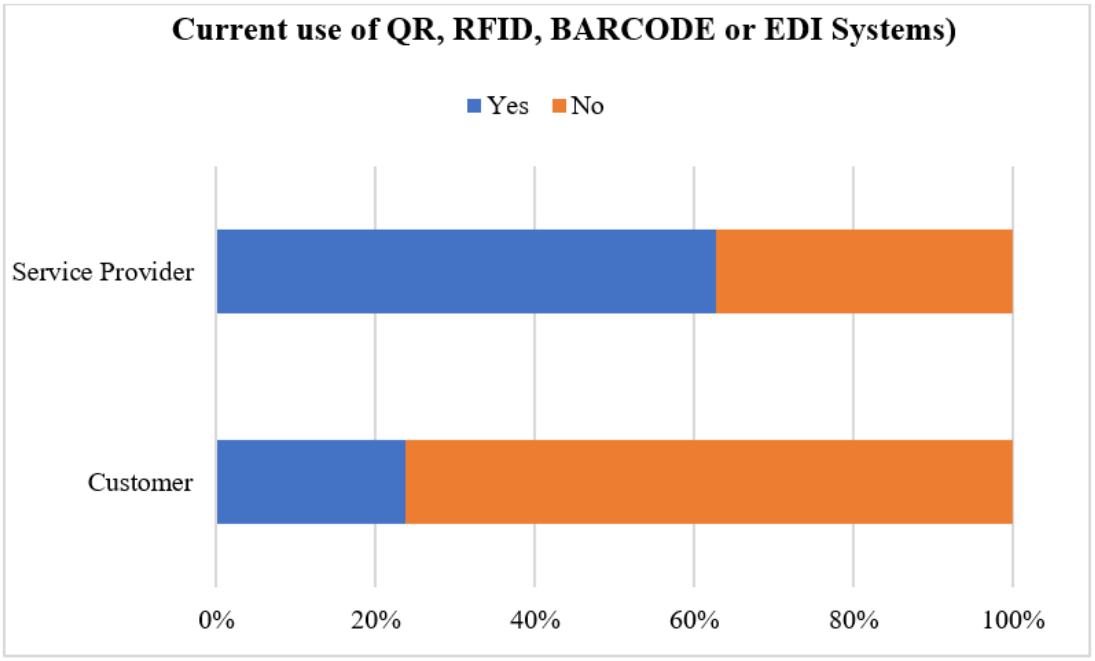


Figure 4.9 illustrates the current technological tools used by both commercial customers and logistics service providers. The question is raised to identify the respondents' opinions on current usage of solutions that can be used to enhance the tracking and tracing functionalities.

The results show a poor use of electronic data interchange tools by commercial customers, including EDI systems. Only 23% of commercial customers are using these systems. Meanwhile, the logistics service providers have a substantial percentage of respondents who are experiencing electronic data interchange tools for tracking and tracing functionalities. 62% of Logistics Service providers use either QR, RFID, Barcode or Electronic Data Interchange (EDI) systems to exchange shipment-related information electronically. It streamlines data & document sharing, enhance communication, and reduce manual data entry.

While these systems offer efficiency gains, some participants encounter challenges with system compatibility between different parties & greater technological inconsistencies. Integrating EDI, QR & other systems with various software platforms can require technical adjustments and coordination.

4.6.2 Shipment Visibility information

Figure 4-10 : *Current Experience of Shipment Information*

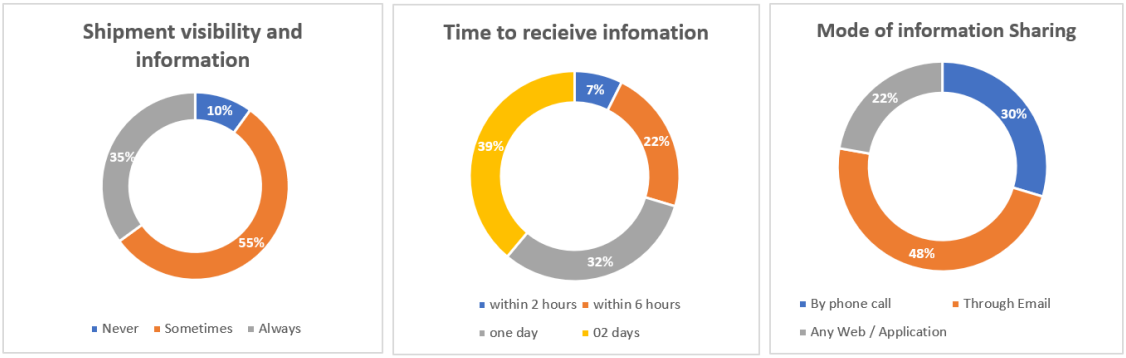


Figure 4.10 illustrates the analysis results for customers' experiences related to shipment information. It can be expressed by three (3) attributes, “how often a customer can have shipment information “? “How much time generally it takes to share this information “? and “which mode is used to share the information?”

In terms of the receiving frequency of the shipment information; it shows that only 35% of customers have that information always, & 10% of commercial customers never get this vital information at all.

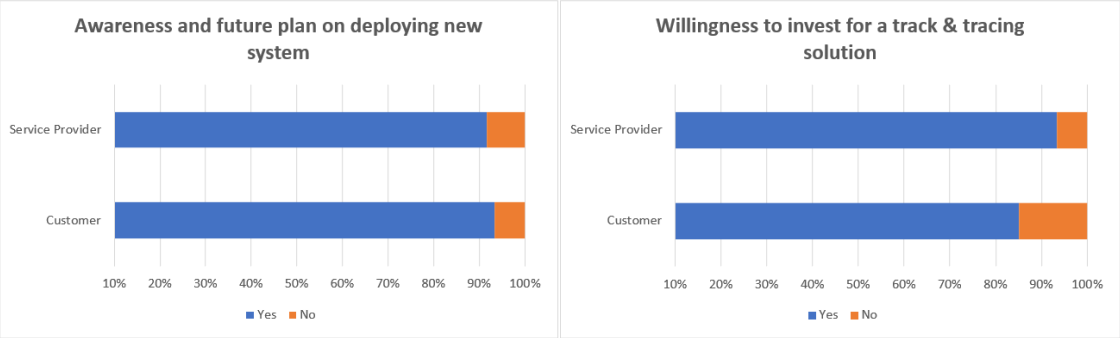
Time to receive this information also a valid factor. Only 7% of customers receive information within 2 hours, a surprising 39% customers receive information only after 2 days.

The mode of receiving this information also illustrates no positive results on current practices. 48% Customers receive information through email while only 22% uses any web based or other Tracking applications.

In general, the graphical illustration shows the gaps within the information sharing between stakeholders. Hence it can be concluded that many difficulties in shipment tracking and tracing are faced by commercial customers. In other words, this confirms the need of further systematized approach & mechanisms for Track & tracing solutions for Sri Lankan Logistics industry.

4.6.3 Opinion and willingness on new technological systems to enhance tracking and traceability

Figure 4-11 : ***Awareness and future plans on deploying new system & willingness to invest for a Track Tracing solution.***



The study focused on the evaluation of awareness and willingness to invest in new tracking and tracing technologies, from the perspectives of both commercial customers and logistics service providers. This assessment aimed to gauge sensitivity to global trends and the demand for innovative solutions.

The findings revealed a notable level of awareness and preparedness for adopting new traceability systems. An impressive 93% readiness was observed among commercial customers, while logistics service providers exhibited a slightly lower yet substantial 92% readiness in the same context. These statistics underscore a clear market demand for potential track and tracing systems, presenting a significant opportunity for logistics service providers who can initiate and successfully implement such solutions.

Graphical representations (Figure 4.11.1 and Figure 4.11.2) illustrate the awareness and future goals of both commercial customers and logistics service providers. Interestingly, both parties displayed a strong inclination to invest in improved track and trace solutions. This outcome suggests that nearly all respondents possess a keen interest in technological advancements and future strategies, paired with a robust willingness to invest in tracking and tracing solutions.

4.7 Analysis of Recommendations and Suggestions:

To gain insights into logistics practices and technological transformation perspectives, open-ended questions were presented to the participants.

The primary aim was to uncover their suggestions and ideas, considering the wealth of knowledge possessed by the experienced and qualified professionals surveyed. The collected suggestions serve as valuable inputs for shaping the final outcomes of the study.

The questions posed were as follows:

- "What challenges do you encounter in implementing track and tracing practices?"
- "Considering the options available, what are your current methods for tracking?"
- "What track and tracing solution do you believe is best suited for your organization?"

The solutions derived from the Delphi method were utilized as a comparative framework to identify the most significant challenges and suitable digital transformation practices that could enhance the efficiency of logistics traceability and tracking. Furthermore, the analysis brought to light various domains that stand to benefit from the implementation of traceability and tracking tools.

4.7.1 Challenges related to tracking and tracing practices – Customer Perspective

This Section delves into the challenges associated with tracking and tracing practices from the customer's perspective. These challenges were derived from a thorough examination of the responses provided in the open-ended questions. It becomes evident that the majority of challenges stem from discrepancies between customer expectations and their actual experiences. Essentially, customers aspire to see their anticipated desires align seamlessly with real-time practices.

Table 4-3 : ***Challenges to tracking and tracing practices***

Internal Challenges		**External Challenges**
Organizational Challenges	**Technical Challenges**	
High Implementation Cost	Less technical expertism in the industry	Integration problems due to trust issues
Integration problems due to trust issues	Data Security and privacy issues	Coverage of networks
Less adaptability to changes	Incompatible Technical infrastructure	possible Regulatory concerns
Willingness to share information		
Less awareness of the benefits of the system		

4.7.2 Suggestions and Current Solutions – Customer Perspective

Based on the respondents' opinions, which had been collected through a questionnaire survey from commercial customers, suggested solutions to enhance tracking and tracing were finalized as below.

- Enterprise resource planning (ERP) system to identify the location of the goods through GPS Real time connectivity
- RFID or QR code enabled services that function through the logistics service providers
- Web or smart device application to visualize real time tracking information
- Enabling Blockchain technology throughout the supply chain
- Machine learning techniques to identify and share real time information

4.8 Reliability Analysis for Likert Scale

Table 4-4 : ***Reliability Analysis***

Reliability Statistics			
Factor	**Cronbach's Alpha**	**Cronbach's Alpha Based on Standard Items**	**No. of Items**
Customer Requirement	0.801	0.801	60
Outsourcing %	0.742	0.748	60
Performance expectation	0.903	0.901	60
Current Experience	0.811	0.811	60
Shipment visibility information	0.769	0.757	55
Time taken to share information	0.780	0.782	55
Modes of Sharing	0.876	0.875	55

Reliability analysis was conducted in order to measure the consistency of the scales used and the generated results. According to descriptions in previous chapters, differentiated scales were used to analyze the responses. For instance, the rating questions consist of three scaled Likert scales and five scaled Likert scales. Therefore, multiple reliability analysis must be conducted with SPSS and Table 4.4 demonstrate the reliability summary of all factors analyzed through the Likert scale.

The findings validate that the outcomes derived from the Likert scale remain well within the acceptable range of internal consistency. In essence, the conclusions drawn from the analysis can be confidently regarded as dependable outputs.

4.9 Chapter Summary

The 'Research Findings' chapter investigates into the comprehensive outcomes derived from a multi-faceted array of research analysis techniques. These methodologies comprise of central tendency measures, descriptive analysis, Likert scale analysis, and reliability analysis. To ensure the suitability of respondents, profile analysis was executed, complemented by an industry overview from the dual perspectives of customers and logistics service providers.

Central tendency measures spotlighted pivotal logistics services & requirements, outsourced services, and key performance matrices, offering valuable insights into industry preferences. The utilization of descriptive analysis further unveiled the intricate relationships existing between identified factors, enriching the understanding of interconnections.

Employing the Likert scale analysis, we delved into the opinions of both customers and logistics service providers, gathering perspectives on logistics requirements, service providing factors, and technological aspects as well. Qualitative analysis with the Delphi results served as a guiding light for understanding the open-ended question responses. In parallel, manual keyword identification unveiled prevalent technological tendencies, given that numerous respondents emphasized technology over tools and functionalities.

In order to minimize error occurrences, data cleaning steps were adopted, ensuring the accuracy of subsequent analyses. Furthermore, to gauge the stability of the measurement scales employed across the analyses, reliability analysis was executed, affirming the consistency of our analytical framework.

5 DISCUSSION

5.1 Introduction

Chapter describes the interpretations of research findings that has being determined through data analysis. The interpretations can be categorized into several subsections, from The Delphi methods, general information analysis, customer requirements with expectations and experience, service provider strengths and capabilities, and willingness to have technological shift within the track and trace solutions. In addition to that, reliability analysis and recommendations will be discussed based on the findings.

5.2 General Information Analysis - Descriptive Analysis

The analysis of general information encompassing demographic data served two primary purposes. Firstly, it ensured that the selected respondents were suitable for participation in the survey, guarding against misinterpretations arising from false or incongruent data. Secondly, it allowed for the validation of research objectives and the determination of potential strengths within Sri Lankan commercial customers and logistics service providers.

5.2.1 Profile Analysis of Respondents - Descriptive Analysis

A comprehensive examination of respondents' profiles reaffirmed their suitability as contributors to the study. By considering both commercial customers' and logistics service providers' perspectives, the analysis confirmed the alignment of respondents' hierarchical positions with those expected in executive, managerial, and senior managerial roles. This diversity supported the credibility of the study's outcomes, and it can be concluded that the selected individuals were well-qualified to participate.

5.2.2 Potential of Commercial Customers - Descriptive Analysis

The analysis of potential strengths among Sri Lankan commercial customers seeking logistics services offered valuable insights. It considered factors such as industry experience, organization scale, business operations, and the industries in which they operated. Results showed that the majority of commercial customers possessed over five years of industry experience and represented medium, large, and enterprise-scale organizations. This indicates their strength and experience in logistics activities.

Moreover, a wide spectrum of industries was observed, with retail and consumer brands and food and beverage industries standing out prominently. This diversity in operating industries underscores the broad demand for logistics operations and the need for tracking and tracing solutions.

International business operations spanned imports, exports, and transshipments, with a significant focus on Europe, Far-east, Middle East, and North America. The size of the organization was found to be a critical factor in determining logistics requirements and outsourcing facility needs.

The industry analysis highlighted a well-mixed combination of respondents, affirming the broader scope of logistics operations and tracking and tracing solution requirements. The unbiased percentages within each industry segment were attributed to the use of random and snow sampling methods for data collection.

Additionally, the type of business operations ranged across exports, imports, and transshipments, primarily catering to international markets. This analysis focused exclusively on commercial customers engaged in international business operations, emphasizing the importance of tracking and tracing tools in such contexts. The results underscored the diversity of business operations within the industries studied.

5.2.3 Potential of the Logistics Service Providers - Descriptive Analysis

The analysis of logistics service providers' potential strength focused on their industry experience, organizational scale, business operations areas, and client handling capacity per month. This examination revealed that Sri Lankan logistics service providers boast well-established industries with experienced organizations and practitioners, which contribute to the quality and effectiveness of their services. Furthermore, the analysis identified advanced technological practices within their operations.

The client classification, based on industry and service capacity, indicated that logistics service providers have a competitive number of customers from various industries. Additionally, their service provision capacity demonstrated a multi-functional approach, serving primarily the retail and consumer brands industry, food and beverages industry, and health and pharmaceutical industry, with client numbers ranging from 1 to 15 per month.

5.3 Commercial Customer's Logistics Requirement Analysis

The analysis of commercial customer requirements considered their needs, potential strengths, outsourcings, service expectations, and current experiences. The findings unveiled a wide spectrum of facility requirements, with the highest demand and outsourcing percentages observed in supply chain consultancy services, container/reefer rental services, and warehouse and information technology (IT) services. It can be concluded that commercial customers, while open to outsourcing, exhibit the greatest desire for these facilities.

Logistics service expectations and current experiences with contracted or agreed logistics service providers were examined to identify customer expectation mismatches with the provided service. The research highlighted that customer expectations primarily revolve around IT capabilities, market responsiveness, and shipment visibility information. This underscores the logistics service providers' focus on optimizing logistics tracking and traceability technologies and tools.

Commercial customers' logistics requirements are diverse, encompassing a range of services. The analysis found that demand for logistics services varies across different categories, with a significant percentage of services being outsourced. This highlights the substantial demand for logistics facilities within the Sri Lankan market and underscores the importance of outsourcing to enhance commercial customers' supply chain efficiency.

To further validate customer demand, the analysis considered customer expectations and current experiences with logistics service providers. Expectations were largely centered on factors such as IT capabilities, market responsiveness, and shipment visibility information, which are viewed as competitive advantages from the logistics service providers' perspective. It is evident that logistics service providers are actively planning in technologies and tools to optimize tracking and traceability, aligning with customer expectations.

However, a noticeable discrepancy was observed in several performance metrics when comparing customer expectations to their current experiences. Notably, areas such as Shipment Visibility Info, IT Capabilities, Customer Service, and Market Responsiveness exhibited significant disparities, indicating a service expectation mismatch between commercial customers and their current logistics service providers.

In contrast, the analysis revealed that the majority of services fell into the category of average experiences, suggesting that while some metrics met customer expectations, others did not. The use of a coding system, ranging from M1 to M15, illustrated these logistics performance metrics. The graphical representation depicted a substantial gap between customer expectations and actual experiences in multiple performance areas, underscoring the need for alignment between customer demands and the services provided by logistics service providers.

This service expectation mismatch highlights the importance of addressing deficiencies in areas such as IT capabilities, shipment visibility, customer service, and market responsiveness, as these factors are interrelated and can significantly impact overall customer satisfaction and the efficiency of supply chain operations.

5.4 Analysis on Current Practices and Problems of Logistics Traceability

The examination of current practices and issues in logistics traceability involved a comprehensive analysis of input from both logistics service providers and commercial customers. This analysis encompassed several surveyed factors, including accessibility to shipment information, the current use of QR, RFID, Barcode, and EDI systems, shipment visibility information, the time it takes to receive shipment information, and modes of sharing shipment information.

5.4.1 Accessibility to Shipment Information

The accessibility to shipment information was assessed, with logistics service providers and customers both providing insights. The results illustrated that logistics service providers have a significantly higher level of access (40%) compared to customers (25%) for shipment information. Remarkably, 93% of customers have requested shipment information, emphasizing its importance to them. Some logistics service providers have initiated platforms, such as web portals and mobile apps, enabling commercial customers to access shipment information online. However, certain commercial customers face challenges related to consistent access, including technical glitches, platform compatibility issues, and connectivity problems in specific regions.

5.4.2 Current Use of QR, RFID, Barcode, or EDI Systems

The assessment of technological tools revealed that commercial customers exhibit limited use of electronic data interchange (EDI) systems, with only 23% utilizing these tools.

In contrast, logistics service providers demonstrated a more substantial adoption rate of QR, RFID, Barcode, or EDI systems, with 62% using these tools for electronic information exchange. While these systems offer efficiency gains, participants encountered challenges related to system compatibility and technological inconsistencies, necessitating technical adjustments and coordination.

5.4.3 Shipment Visibility Information

An analysis of customers' experiences concerning shipment information revealed several attributes, including the frequency of receiving shipment information, the time taken to share this information, and the modes of information sharing. Notably, only 35% of customers consistently receive shipment information, while 10% never receive it. Furthermore, 39% of customers receive this information after two days, and 48% receive it via email, with only 22% using web-based or other tracking applications. These findings highlighted existing gaps in information sharing among stakeholders, indicating significant challenges faced by commercial customers. This underscores the need for systematic approaches and mechanisms to improve tracking and tracing solutions in the Sri Lankan logistics industry.

5.5 Opinion and Willingness on New Technological Systems to Enhance Tracking and Traceability

The study assessed awareness and willingness to invest in new tracking and traceability technologies from the perspectives of commercial customers and logistics service providers. Results indicated a high level of awareness and a strong willingness to invest in these technologies. A remarkable 93% of commercial customers and 92% of logistics service providers demonstrated readiness to adopt new traceability systems. This high level of interest and preparedness reflects a substantial market demand for innovative track and trace solutions, presenting significant opportunities for logistics service providers.

5.6 Analysis of Recommendations and Suggestions

To gain insights into logistics practices and technological transformation perspectives, open-ended questions were posed to participants, soliciting their suggestions and ideas. The responses were analyzed to identify significant challenges and suitable digital transformation practices that could enhance logistics traceability and tracking.

Key findings in this context include:

5.6.1 Current Challenges Related to Tracking and Tracing Practices – Customer Perspective

Challenges related to tracking and tracing practices from the customer's perspective were examined. These challenges primarily revolved around discrepancies between customer expectations and their actual experiences. Key challenges included high implementation costs, technical expertise gaps in the industry, integration issues arising from trust concerns, data security and privacy issues, network coverage limitations, regulatory concerns, limited adaptability to changes, and a lack of awareness regarding the benefits of these systems.

5.6.2 Suggestions and Current Solutions – Customer Perspective

Based on feedback from commercial customers, several suggestions and solutions were identified to enhance tracking and tracing practices, including the use of enterprise resource planning (ERP) systems with GPS for real-time location identification, RFID or QR code-enabled services offered by logistics service providers, web or mobile applications for real-time tracking, blockchain technology integration, and machine learning techniques for real-time information identification and sharing. These insights underscore the potential avenues for improving logistics traceability and tracking in the Sri Lankan context.

5.7 Delphi Session Outcome

Delphi session of the research further solidifies these findings. It provides a structured framework for addressing challenges and capitalizing on opportunities within the logistics sector. Experts' inputs align with the research, reaffirming the importance of bridging service expectation gaps and enhancing information sharing mechanisms.

5.7.1 Current Logistics Tracking and Tracing practices in Sri Lanka

In Sri Lanka, logistics tracking and tracing practices are currently finding its ways for transformation. While paper-based documentation remains prevalent, there is a gradual shift toward digitization, notably with the increasing use of electronic data interchange (EDI) systems.

Although emerging technologies like GPS-enabled tracking, RFID tags, and barcoding are being employed only to a limited extent, they have not yet reached full-scale adoption. Challenges persist, including the high costs involved, limited infrastructure, and gaps in technical expertise.

Despite these hurdles, stakeholders in the logistics industry acknowledge that effective traceability can confer a competitive advantage, improving customer satisfaction and mitigating supply chain risks.

5.7.2 Areas for Optimization Through Tracking and Tracing in 3PL Operations in Sri Lanka

In 3PL operations in Sri Lanka, several areas can be optimized through tracking and tracing.

- Import and export sea freight operations can enhance shipment tracking and customer communication.
- Land transport operations can optimize routes and enable predictive maintenance.
- Reefer plugins and transport can monitor conditions and compliance.
- Container and reefer rent services can improve inventory management.
- Warehousing operations can enhance inventory tracking and order fulfillment.
- Container yard services can optimize movements and scheduling.
- Customs brokerage operations can ensure compliance and provide real-time updates.
- Cross-docking operations can reduce handling times.
- Inventory management can benefit from real-time updates and improved forecasting.
- Product labeling and packaging can boost traceability and compliance measures.

5.7.3 Criteria for Selecting Tracking and Tracing Mechanisms in Sri Lanka (Technical and Financial)

When considering tracking and tracing mechanisms in Sri Lanka, several key criteria come into play, encompassing both technical and financial aspects. From a technical perspective, customers place high importance on real-time tracking and timely updates. Integration capabilities with existing systems are highly valued to ensure a seamless flow of information.

User-friendly interfaces are considered essential for ease of use, making it accessible to a broader audience. The ability to provide multi-modal tracking across various transportation modes is favored to cater to the diverse needs of the logistics industry. Security and data privacy measures are non-negotiable to safeguard sensitive information.

On the financial front, cost-effectiveness and affordability stand as primary considerations. Decision-makers are influenced by the potential return on investment (ROI) when choosing tracking and tracing solutions. Transparent pricing structures are preferred, providing clarity on costs, and avoiding hidden charges. Scalability is another significant factor, ensuring that the selected mechanisms can adapt to the evolving needs of businesses as they grow.

This comprehensive set of criteria guides the selection process, helping logistics stakeholders make informed choices to enhance their tracking and tracing capabilities in Sri Lanka.

5.7.4 Expert Recommendations for Logistics Tracking and Tracing Solutions in Sri Lanka

Blockchain technology, with its secure and tamper-proof features, shows promise, although regulatory and expertise challenges must be addressed during implementation. RFID tags are gaining popularity, especially as costs decrease, and offer effective tracking solutions. Barcoding systems, although widely used, may lack the intricate detail required for complex logistics operations. GPS-enabled tracking devices are utilized but face limitations in areas with poor connectivity. Additionally, the adoption of electronic data interchange (EDI) systems for data exchange is on the rise, streamlining information flow within the logistics sector. These insights from experts

can guide Sri Lanka toward optimizing its tracking and tracing mechanisms for improved efficiency.

Based on the respondents' opinions, identified suitable Applications and Tools can be interpreted as,

- Blockchain technology
- Real-time GPS-connected ERP systems
- Temperature and humidity monitoring (Reefer Tracking)
- RFID and IoT-based tracking systems
- Multi-modal integrated tracking solutions
- Mobile apps and customer portals
- Electronic data interchange solutions

5.7.5 Challenges of Tracking and Tracing Implementations

Challenges of Tracking and Tracing Implementations can be summarized as below.

- High implementation costs
- Lack of technical expertise
- Fragmented IT systems
- Limited technology infrastructure
- Resistance to change
- Data security concerns
- Integration with stakeholders
- Regulatory and compliance issues
- Coverage and accuracy challenges
- Customization needs based on specific requirements

5.8 Reliability Analysis for Likert Scale

The reliability analysis demonstrates values exceeding 0.7, affirming that the outcomes derived from the Likert scale fall comfortably within and even surpass the acceptable threshold for internal consistency. Accordingly, these analysis results can be trusted as dependable and consistent outputs.

5.9 Chapter summary

This chapter break down the multifaceted dynamics of Sri Lanka's logistics landscape. In summary, we comprehend below.

- Respondent Suitability: The research confirms that the selected respondents are well-suited for our study, ensuring the credibility of our survey data.
- Logistics Potential in Sri Lanka: Both commercial customers and logistics service providers in Sri Lanka exhibit substantial potential in exploring a wide array of logistics needs and services.
- Demand-Driven Concerns: The positive demand for logistics services raises concerns among logistics service providers about areas that need further development and enhancement.
- Service Expectation vs. Experience: An apparent mismatch exists between the service expectations of customers and their actual experiences, primarily concerning logistics tracking and tracing capabilities.
- Information Sharing Challenges: Information sharing among stakeholders is suboptimal, characterized by issues related to visibility, timeliness, and modes of sharing information.
- Willingness to Improve: Despite these challenges, there is a shared willingness among both customers and logistics service providers to explore tracking and tracing solutions. This is driven by their awareness of industry trends and growth prospects.
- Recommendations for Improvement: The chapter concludes with valuable suggestions and recommendations aimed at empowering both parties to select suitable tools that can enhance logistics tracking and tracing capabilities, focusing on highly demanded services.

Research underscores the suitability of the respondents, the diverse potential in logistics services, and the imperative need for addressing development areas.

While challenges exist, the willingness to adapt and improve bodes well for the industry's future. Results highlight the critical service expectation-experience mismatch and information sharing challenges while drawing attention to the shared determination to pursue solutions for traceability in logistics. Ultimately, provided recommendations serve as a roadmap to address these challenges and seize opportunities for enhancing logistics tracking and tracing capabilities. Organizational wise new solution offerings will enhance each LSP’s competitiveness, eventually contributing to the industry's growth and development.

6 CONCLUSION AND RESEARCH IMPLICATIONS

6.1 Introduction

This conclusion not only summarizes the essence of the research but also provides valuable recommendations and suggestions to achieve the research objectives. Guided by a rigorous analysis of data, and the ensuing discussion has shed light on the nuances of our findings. In addition to these crucial elements, the researcher also considers the inputs directly gathered from our survey participants, ensuring a holistic perspective.

Furthermore, the Delphi method, which harnessed the collective wisdom of industry experts, adds an extra layer of depth to the study. These suggestions, infused with industry knowledge and vision, enrich our understanding, and improve the avenues of exploration in this domain. The research delves into the implications of our research for various stakeholders, highlighting those poised to benefit most from study's findings. Additionally, it simply addresses the limitations encountered, acknowledging areas where this study can be further refined in the future.

As we venture into the conclusion, the study bridges the gap between research and practice, offering practical recommendations that emerge from the study. These recommendations pave the way for the integration of traceability solutions, potentially transforming the logistics landscape in Sri Lanka. Researcher believes that these insights will encourage industry players to embrace traceability as a tool for competitive advantage, ushering in an era of enhanced customer satisfaction and streamlined supply chain operations.

6.2 Recommendations

In light of this research findings, it is evident that Sri Lanka's logistics landscape presents opportunities for both logistics service providers and commercial customers. However, there exists a notable service mismatch caused by inadequate transparency and accuracy in traceability and tracking of goods. Both parties recognize the need for an upgraded, more sophisticated traceability systems, and they've even proposed potential solutions based on their insights. Additionally, the research has identified areas where traceability tools can bring about substantial operational improvements. To address these challenges and align with industry expert opinions, the study presents a set of recommendations aimed at achieving our research objectives.

6.2.1 Approaches and mechanisms for logistics tracking and traceability in Sri Lanka

Study explores into various approaches and mechanisms for enhancing logistics tracking and traceability in Sri Lanka. The study not only identifies global best practices but also examines the current applications and mechanisms within the Sri Lankan context. Through thorough analysis and evaluation based on multiple criteria, suitable tracking and tracing practices are proposed to enhance accuracy and efficiency. The resulting applications, tools, and mechanisms are presented in the following subsection. Based on the respondents' opinions, identified suitable Applications and Tools can be interpreted as,

- Blockchain technology
- Real-time GPS-connected ERP systems
- Temperature and humidity monitoring (Reefer Tracking)
- Electronic data interchange solutions
- RFID and IoT-based tracking systems
- Multi-modal integrated tracking solutions
- Mobile apps and customer portals

6.2.2 The 3PL operations that can leverage through logistics tracking & traceability

Implementation of advanced IT applications and RFID systems in Sri Lanka's 3PL logistics operations can significantly enhance efficiency, business performance, and stakeholder satisfaction. These technologies simplify supply chain operations, reduce complexity, and enhance real-time monitoring and traceability. Specific benefits include improved warehousing and inventory management, customized customer services, cost reduction, and increased order fulfillment rates. The adoption of tracking and tracing mechanisms benefit.

- Import and export sea freight,
- Land transport,
- Reefer plugins, container and reefer rent services,
- Warehousing, container yard services,
- customs brokerage operations,
- Cross-docking & inventory management,
- Product labeling and packaging.

Ultimately, these technologies lead to enhanced visibility, efficient logistics services, and improved transactions within supply chains and among trading partners in the market to achieve required competitive advantage.

6.3 Research implications

The research findings have important implications for various stakeholders, including logistics service providers and commercial customers in Sri Lanka. There is an opportunity to enhance their services and gain a competitive edge by implementing traceability solutions, for logistics service providers such as warehouse logistics service providers, other third-party logistics services, freight forwarders, Shipping & Air lines, Transporters, and courier services etc. These solutions can improve shipment tracking, enhance real-time monitoring, and streamline documentation processes. Additionally, they can lead to better customer satisfaction and reduced supply chain risks.

Commercial customers, representing a range of industries and businesses, can benefit from the improved traceability and tracking efficiency offered by logistics service providers. Outsourcing logistics services becomes more attractive when providers offer robust traceability solutions. This research serves as a guide for both logistics service providers and commercial customers to address existing challenges related to logistics traceability and tracking efficiency.

Furthermore, the study's recommendations and insights can inform policy and regulatory considerations & Trade associations in Sri Lanka's logistics industry. Policymakers and regulatory bodies can explore ways to incentivize the adoption of traceability technologies and ensure data security and privacy. These implications underscore the potential for traceability to not only enhance competitiveness but also contribute to the growth and efficiency of the logistics sector in Sri Lanka.

6.4 Research Limitations

While the study provides valuable insights, it is important to acknowledge its limitations. Firstly, the research focused on the perspectives of logistics service providers and commercial customers in Sri Lanka. Other stakeholders such as government agencies, industry associations, and technology providers were not directly included. Future studies could benefit from a more comprehensive examination of the ecosystem.

Secondly, the data collection primarily relied on surveys and interviews. Despite efforts to ensure representativeness, the sample size and geographical coverage could be expanded for a more holistic view.

Thirdly, the research context is specific to Sri Lanka, and the findings may not be entirely generalizable to other regions or countries with different logistics landscapes and regulatory environments. Moreover, time limitations constrained the ability to track long-term impacts of traceability solutions, and the rapidly evolving nature of technology may impact the relevance of the findings over time.

Lastly, the study primarily examined the potential benefits of traceability solutions, but the practical challenges of implementation, including cost, infrastructure, and regulatory compliance, require further investigation.

In summary, while the research offers valuable insights, these limitations suggest the need for future studies with broader stakeholder representation, larger samples, cross-country comparisons, a deeper exploration of implementation challenges, and consideration of the evolving nature of technology and its long-term impacts on the logistics industry.

6.5 Future Research Areas

This study could lead to many research areas, and the importance of Logistics Traceability application in practice is significant. Potential, future research areas could be as follows.

- Cross-Country Comparative Studies: Conduct comparative studies with logistics service providers and customers in different countries to understand how traceability impacts competitive advantage in various regulatory and market contexts.
- Environmental Sustainability: Explore how traceability can be leveraged to enhance the environmental sustainability of logistics operations, such as reducing carbon emissions through optimized routing.
- Technology Trends: Stay updated on emerging technologies (e.g., blockchain, IoT) and assess their applicability and benefits for enhancing traceability in logistics operations.

- Long-Term Impact Analysis: Explore the long-term effects of traceability implementation on logistics firms, including its influence on operational efficiency, customer retention, and financial performance.
- Cost-Benefit Analysis: Investigate the cost-effectiveness of different traceability technologies and systems, considering factors such as implementation costs, maintenance, and the return on investment over time.
- Regulatory Frameworks: Examine the role of government regulations and policies in promoting or hindering the adoption of traceability solutions within the logistics industry.
- Supply Chain Resilience: Investigate how traceability contributes to supply chain resilience and the ability to respond to disruptions, especially in the wake of global events like the COVID-19 pandemic.
- Small and Medium-Sized Enterprises (SMEs): Study how traceability solutions can be tailored and made accessible to SME logistics providers, who may face unique challenges and opportunities.
- Customer Behavior: Analyze how traceability influences customer behavior, satisfaction, and loyalty, and whether it can be a competitive differentiator in customer-centric logistics services.

These future research areas can provide valuable insights into the evolving landscape of logistics traceability and its role in enhancing the competitive advantage of logistics firms, both in Sri Lanka and on a broader global scale.

6.6 Chapter Summary

In summary, the research underscores the transformative potential of traceability for logistics firms in Sri Lanka. The evidence gathered supports the notion that traceability can indeed be leveraged as a potent tool for gaining a competitive edge in the fiercely competitive 3PL market of Sri Lanka.

Research findings reveal that embracing advanced traceability mechanisms, such as RFID, GPS tracking, and blockchain, empowers logistics service providers to optimize operations, enhance customer satisfaction, and streamline supply chains. In this dynamic industry, traceability emerges not only as a tool for immediate competitive advantage but also as a means to achieve broader sustainable objectives.

As Sri Lanka's 3PL market continues to evolve, the integration of these traceability solutions offers a pathway to not only surviving but thriving. It fosters efficiency, transparency, and adaptability, positioning logistics firms to meet the ever-changing demands of the modern business landscape.

In conclusion, this study points to traceability as a linchpin for success, a bridge to sustainable growth, and a dynamic tool for logistics providers navigating the challenging terrain of Sri Lanka's 3PL market.

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