# KEY DRIVERS TO THE GROWTH OF AIR CARGO DEMAND FOR COMBI-CARRIERS; BASED ON AIR NETWORK OF SRI LANKA

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## STATEMENT OF THE SUPERVISOR

The above candidate has carried out the research for the MSc degree on Transport and Logistics Management under my supervision.

Dr. Anuja Fernando

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## ABSTRACT

Today air transportation is vital for implementing best international business practices, including just-in-time inventory management and build-to-order production. Regardless of the geographical location, air cargo transportation enables regions and nations to connect distant markets and sustain the global supply chain efficiently and faster. According to the IATA reports, nearly 40 percent of the value of global trade is carried by air, where more than 50 percent of the air cargo is carried on passenger flights (Moving Air Cargo Globally, 2016) (IATA, 2020). Therefore, it is essential to identify the optimum route network coupling in both passenger and cargo demand-driven networks. Cargo demand-driven networks are dynamic upon the factors that affect the cargo demand in respective destinations. This study mainly focuses on identifying the key influencing factors and industries that could affect the growth of air cargo demand in the cargo and passenger demand-driven network.

Unfortunately, most airlines focus only on passenger demand, whereas cargo demand at the destination is often neglected. However, more than 98% of air cargo trades in Sri Lanka are happening through Combi carriers. As the first step to address this issue, it is necessary to understand air cargo generation and attraction at a destination. Sri Lanka will be a best-case study to analyze the Combi carriers. Hence, this study introduces preliminary criteria on how air cargo is generated and assigned to a particular demand.

Five years of export air cargo data, including more than five hundred thousand shipment details, have been used for the cluster analysis to identify similar commodity groups based on air cargo weight and value. Before the analysis, all the export air cargo was classified into 97 commodity groups (According to HS code classification) to get clear output from the analysis. Nine distinct clusters were identified below, showing apparent differences in air cargo behavior.

| **Cluster Number** | **HS Code** | | | | | | **Cluster Number** | **HS Code** |
|---|---|---|---|---|---|---|---|---|
| ***Cluster 01*** | 1 | 22 | 37 | 53 | 75 | 92 | ***Cluster 02*** | 3 |
| | 2 | 23 | 38 | 54 | 76 | 93 | | 6 |
| | 4 | 24 | 39 | 55 | 78 | 94 | ***Cluster 03*** | 7 |
| | 5 | 25 | 40 | 56 | 79 | 95 | | 8 |
| | 9 | 26 | 41 | 57 | 80 | 96 | ***Cluster 04*** | 14 |
| | 10 | 27 | 42 | 59 | 81 | 97 | ***Cluster 05*** | 21 |
| | 11 | 28 | 43 | 65 | 82 | | | 58 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 29 | 44 | 66 | 83 | | | 60 |
| | 13 | 30 | 45 | 67 | 84 | | | 63 |
| | 15 | 31 | 46 | 68 | 85 | | | 64 |
| | 16 | 32 | 47 | 69 | 86 | | ***Cluster 06*** | 49 |
| | 17 | 33 | 48 | 70 | 87 | | ***Cluster 07*** | 61 |
| | 18 | 34 | 50 | 72 | 89 | | ***Cluster 08*** | 62 |
| | 19 | 35 | 51 | 73 | 90 | | | 88 |
| | 20 | 36 | 52 | 74 | 91 | | ***Cluster 09*** | 71 |

Identified clusters were classified into four quadrants according to high-high, high-low, low-high and low-low value to weight ratio. In addition, the social and economic impact on cargo generation, the final destinations of the cargo, sub-commodity types, and characteristics are discussed. The findings will benefit airlines in strengthening their air route network and increasing global market access & traffic growth. Likewise, a country could implement the basement to enhance the overall level of productivity. It will help to boost exports and the competition in the home market.

Many research studies have been conducted using different factors and models to forecast air cargo demand, and those did not consider demand from Combi and All-cargo carriers together. More than 30 factors were identified through literature reviews and interviews with industry experts. The independent variables for the analysis were selected, covering different areas that would affect air cargo demand growth at a destination, like an airport and airline capabilities, economic, market, environmental, and human factors. The population of a country, Population Growth, GDP, GDP Growth, Total Passenger demand, Total Cargo Demand, Hub Connectivity, Employment rate, and CO2 emission due to the aviation industry are the selected factors under-considered areas. Regression analysis was conducted for the analysis, and the Connectivity index and the air cargo demand at the destination were identified as the key influencing factors for the growth of air cargo demand at a destination for Combi carriers. These derived factors can assist in assigning flight schedules, route development, and facility improvements of airports and airlines. Hence the outcomes of this research would benefit the airlines, airports, and freight forwarders in their strategic decision-making.

**Keywords – Air cargo, Cluster analysis, Regression analysis, HS code**

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## LIST OF ACRONYMS

| | |
|---|---|
| IATA | International Air Transportation Association |
| WTO | World Trade Organization |
| CTK | Cargo Tonne Kilometers |
| HS | Harmonized Commodity Description and Coding System |
| WCO | World Customs Organization |
| ANN | Artificial Nural Network |
| COP | Crude Oil Prices |
| UK | United Kingdom |
| USA | United States America |
| UAE | United Arab Emirates |
| GDP | Gross Domestic Products |
| GSP+ | Generalised Scheme of Preferences Plus |

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# CHAPTER 01 - INTRODUCTION

## 1.1 Background

Today the world has become one global village and continues the growth of globalization, performing a prominent role in fostering economic development and making countries more competitive and productive. According to the International Air Transport Association (IATA) reports, a share of global output trade is now at about three times the level it was in the early 1950s (IATA, 2020). Therefore, international freight transportation has become more evident and profound over time. As a result, freight transportation management has also become more complex and competitive. Therefore, the objective of the World Trade Organization (WTO) has been to facilitate the trading industry to grow to be smooth, fair, liberated, and knowable (Glenn Baxter, 2018).

Several methods could physically move cargo between two or more countries: by air, sea, road, rail, and pipeline, involving several stakeholders, including shippers, forwarders, carriers, third-party logistics services, and customs (Glenn Baxter, 2018). Out of those modes, the cost of air cargo transportation is high compared to the other mode of transportation. Air cargo services can be up to five times the cost of transporting goods by road and up to sixteen times the cost of sea transport (Feng Jin, 2020). Compared to other modes of transportation, more than 40% worth of value cargo is carried by air transportation (Moving Air Cargo Globally, 2016) (IATA, 2020). It is about one percent of the overall freight movements by weight. That freight includes a variety of goods like transfer high-value and low-volume products, consumer, heavy weighted and outsize goods, live animals, and temperature-sensitive. A high proportion of air freight is business-to-business. Furthermore, air cargo enhances the productivity of several industries by cutting costs for inventory, production, and storage, enhancing more flexibility and reliability of the service with minimum losses and damages (Daniel Y. Suh, 2019) (Shuojiang Xua, 2019).

According to the IATA reports statistics, Figure 1.1 shows the share percentage of international freight tonne-km in 2019 (Economic Development, Air Cargo 2017 Facts & Figures, 2018). Asia and the Pacific region have the highest share percentage, and China is the leading hub in this

region. Furthermore. East Asia-North America and East Asia-Europe have the busiest air trade routes (Economic Development, Air Cargo 2017 Facts & Figures, 2018).

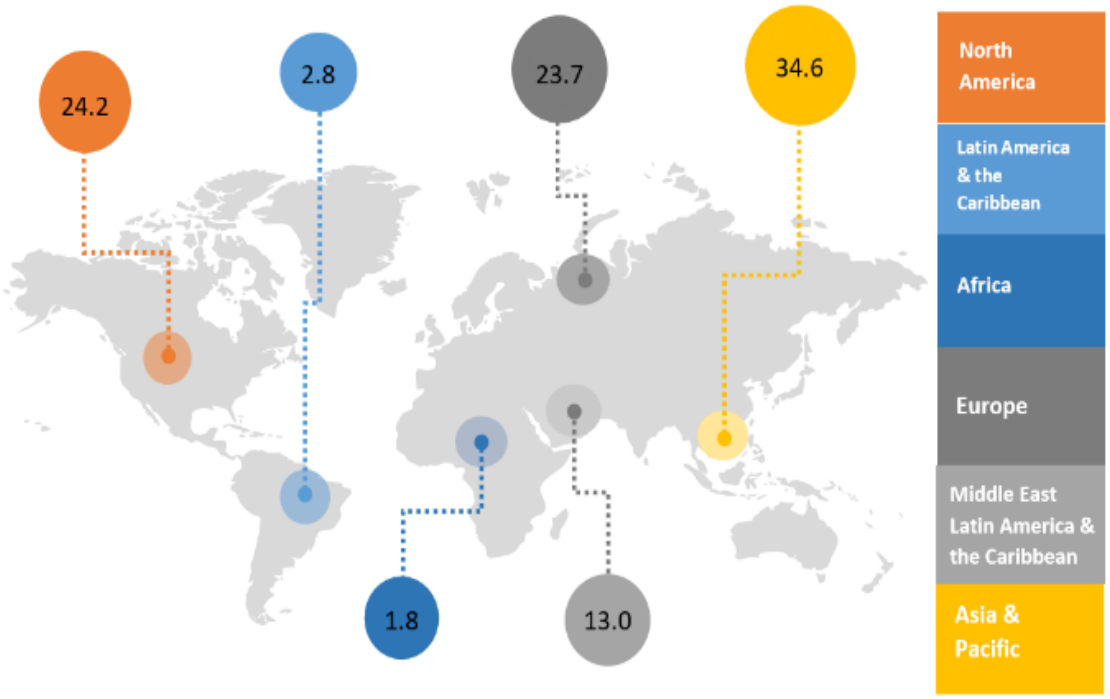


Figure 1.1 : Share percentage of international freight tonne-km (Economic Development, Air Cargo 2017 Facts & Figures, 2018)

The story of the air cargo in 2020 is different from other years. Due to the Covid 19 pandemic, cargo volumes were down to the lowest point in April. It was around a quarter-time reduction of Cargo tonnes kilometers (CTKs) compared to the previous year. However, by September, air cargo volumes had risen to just 8% below the prior year's figures. The IATA reports show that freighters have used their maximum capacity (IATA, 2020). Freighters have increased their capacity by 20%, increasing the average number of hours flown and adding new aircraft to the fleet (IATA, 2020). Airfreight transportation is essential to sustain global supply chains and transport medical equipment and pharmaceuticals. Hence, the demand for air cargo will never die, and it is an important area to be analyzed and discussed.

## 1.2 Introduction to air cargo transport methods

There are different market players in the air cargo industry, and approximately 2,500 aircraft are involved in the market (Globalgreenfreight.org, n.d.). Airfreight can be moved with various carriers, depending on the commodity or the customer's requirements. San Francisco International Airport has analyzed the usage of carrier types for air cargo transportation. The air cargo statistics by air cargo carriers have shown in Figure 1.2 (DataSF, 2021). The usage of Combi carriers has increased over the years for air cargo movements, while the usage of all-cargo carriers has been reduced. However, the Combination aircraft carriers had been retired from transporting air cargo by 2014.

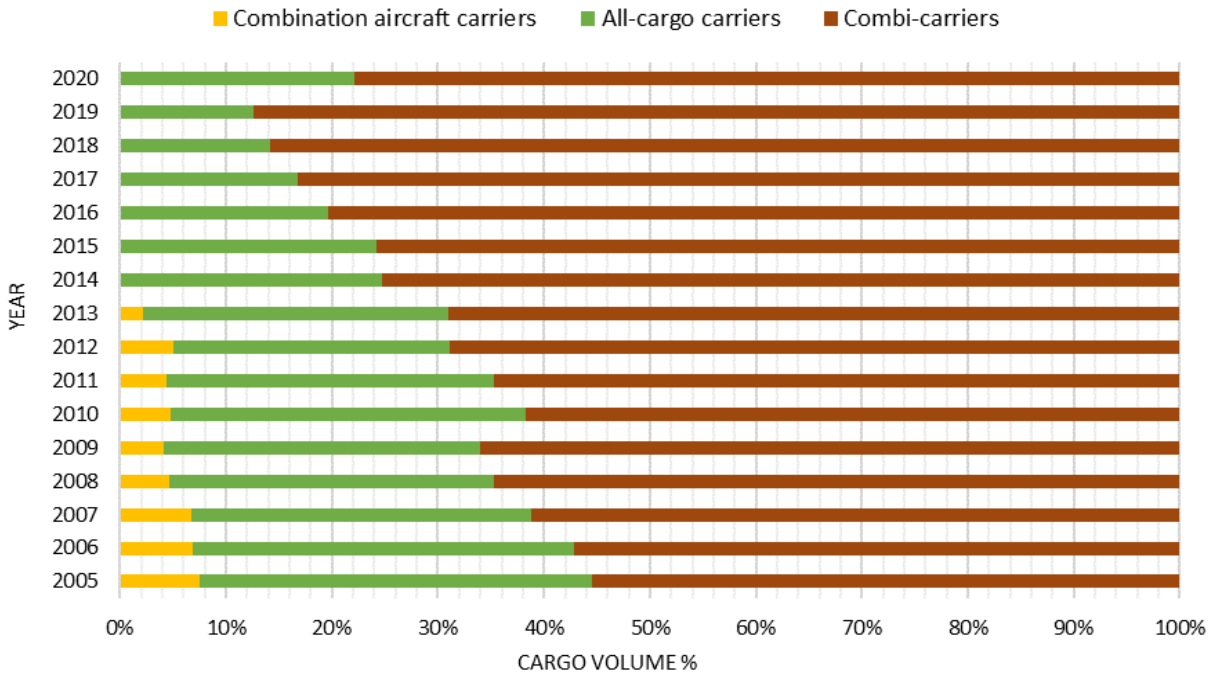


Figure 1.2 : Share percentage of international air cargo movement by carrier type (DataSF, 2021)

Today, most carriers operate with a hub-and-spoke network. Air cargo is first collected from the origin and then transported to a hub and will send the cargo to its destination through another aircraft. Two operational methods can be seen in a hub, where a small air cargo volume is transported to a hub, merged, and sent into another hub, or a bulk of air cargo is transported to the central hub, broken into a small volume, and distributed. Integrators who provide door-to-door services and freight forwarders who arrange the transportation chain and prepare the necessary

activities are playing a significant role while enhancing their operational activities within the hub-and-spoke network to provide a smooth, good service for their customers.

### 1.2.1 Combi Carriers

According to IATA reports, Combination carriers carry around half the global international air cargo, primarily focusing on passenger transport but reserving space for transporting cargo (IATA, 2020). However, passenger airlines are not considering air cargo at their crucial decision points. After introducing a new series of wide-body passenger aircraft with larger lower-hold capacity, most airlines combine air cargo transport with passenger operations to smoothen the cargo supply chain and take advantage of additional revenue operations. Furthermore, belly cargo space offers unique value on a non-cargo route by feeding dedicated freighter networks and providing new business opportunities for integrators. Nevertheless, IATA's introduction of different regulations and security standards has restricted the possible commodities shipped in passenger aircraft (Wadud, 2013).

### 1.2.2 All cargo carriers

All-Cargo carriers move air cargo and offer freight services but do not offer passenger services. These airlines, including All-Cargo Carriers and Integrated Express Carriers, transport cargo by dedicated freight aircraft (Paolo Malighetti & Scotti, 2019). Some of the Passenger Carrier aircraft were modified for cargo transportation. Further, All-Cargo carriers can be classified into Scheduled-Cargo Carriers and Charter-Cargo Carriers. Scheduled Cargo Carriers provide their services regularly, while Charter Carriers provide their services for specific deliveries at specific times. Due to weight and space availability, the limitations are minor on wide-body aircraft (Paolo Malighetti & Scotti, 2019). Most express carriers move cargo from the door at point A to point B by integrating aircraft. It is called integrated express carriers, mainly relying on their air cargo hubs; DHL, UPS, and FedEx are some of the most popular carriers.

### 1.2.3 Combination Aircraft Carriers

The Combi Carriers category can mislead Combination Aircraft Carriers. These carriers have passenger and freighter aircraft in their fleet, providing passenger and air cargo services separately. This type of business model is uncommon in modern aviation operation practices. Sometimes, Combi Carriers' services are also provided under their aircraft fleet. Lufthansa, Cathay Pacific, and Emirates are a few of them, now rare in operations (National Aviation Academy, 2022).

## 1.3 Introduction to HS Code

Due to the vast diversity of air cargo movements, they require different handling methods for air and sea freight transportation. Therefore, it is crucial to have a proper method of identifying cargo trading between countries. World Customs Organization (WCO) has developed a coding system called "Harmonized Commodity Description and Coding System (HS code)" to mitigate this issue. It is an internationally accepted product classification system that facilitates trading activities. More than 200 countries use this system as a basis to complete successful trade transactions (Harmonized System (HS) Codes, n.d.).

WCO has comprised more than 5000 commodity groups, and each can be identified by a six-digit code or more. The first two digits identify the chapter in which good has been classified, the next two digits identify headings in that chapter, and the last two digits identify the subheadings to be even more specific. The first six digits of HS codes are usually the same worldwide. Countries can add additional numbers for their purposes, and those more extended codes can differ among nations. There are eight digits included in the HS code in Sri Lanka. Figure 1.3 elaborates the classification properly (Harmonized System (HS) Codes, n.d.). The HS code number can be identified in Appendix 1.

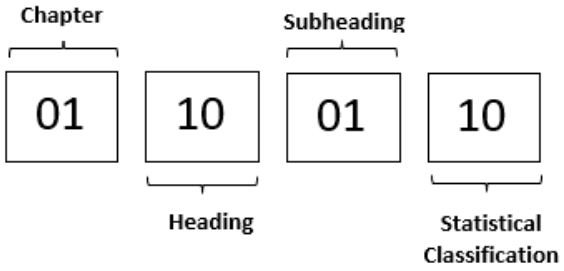


Figure 1.3 : HS Code structure

## 1.4 Research Gap

Due to the heterogeneous nature of air cargo, airline and airport operators need to keep changing their air cargo strategies. At the same time, when developing future strategies, most Combi-Carriers focus only on passenger demand, whereas cargo demand at the destinations is often neglected. Most algorithms have been developed to calculate passenger or cargo demand over the past few decades. During their research works, various factors were used for their models. Therefore, it is difficult to measure the cargo demand for Combi Carriers. Hence, it is essential to identify the influencing factors and a method to calculate the cargo demand at a destination for Combi Carriers. Surprisingly, the research on air cargo carried by Combi Carriers has not been comprehensively studied.

After the Covid 19 pandemic, global air cargo trends grown remarkably within the last two years. From the second half of 2020 until now, a robust upward trend can be seen in air cargo traffic, with the turn of businesses to air freight to restock inventories to meet rising demand. The air cargo demand has increased by 9.4% compared to the pre-crisis (2019) level (Air cargo demand continues strong growth trend in May 2021, Outline IATA data, 2021) (IATA Annual Report, 2021). However, international travel restrictions limit air cargo transport in belly space. Freight forwarders increased their capacity by 12% to mitigate capacity issues. Figure 1.4 shows the air passenger and cargo tonne kilometers flown over the last two decades (IATA Annual Report, 2021).

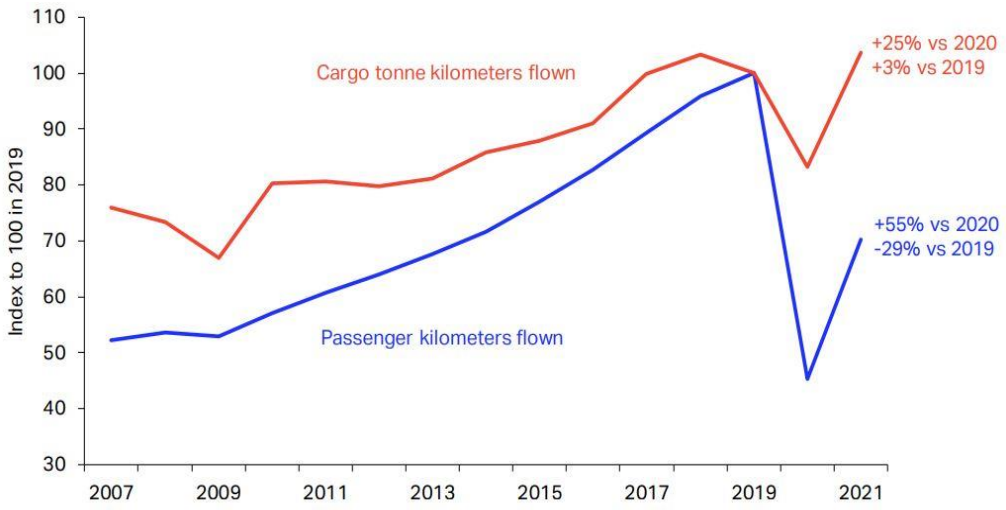


Figure 1.4 : Cargo vs. Passenger kilometers flown (Brett, 2020)

With the revolution after the Covid 19 pandemic, the air cargo industry has been taken to the next level. The freighters and the Combi Carriers focus on implementing and testing new strategies to face such incidents and minimize revenue losses. One of the best examples is that the PEMCO has launched a new aircraft to take half–passenger and a half–cargo services in 2020. This dual-use plane type is called "FlexCombi aircraft" (Kulisch, 2020). Therefore, studying the influencing factors for the growth of air cargo demand for Combi Carriers is essential to developing strategies in the aviation industry.

## 1.5 Purpose of the research

Today, air transportation is vital for implementing best international business practices, including just-in-time inventory management and build-to-order production. Regardless of the geographical location, air cargo transportation enables regions and nations to connect distant markets and sustain the global supply chain efficiently and faster. As a result, there has been significant growth in the impact of air freight transportation on the economy in both supply-side and demand-side markets over the past few years (Rico Merkert, 2017).

This study elaborates on the potential of improving cargo supply-side demand to grow air cargo operations in the aviation industry. Air cargo is attracted by traditional passenger aircraft due to profit maximization by capacity utilization, having great potential with the growth of the market, and providing a means of achieving economies of scale and scope (Rico Merkert, 2017). Since

more than half of air cargo is carried by Combi Carriers, it is essential to identify the key influencing factors for the growth of air cargo demand at a destination and to recognize the new opportunities in the industry.

## 1.6 Research Objective

There are three main objectives in this study work.

1. Assess the current outbound air cargo from Sri Lanka and its impact on the economy of Sri Lanka.
2. Identify the influencing factors for air cargo demand growth at a destination.
3. Develop a criterion to assess identified influencing factors.

This study identifies two directions in line with the above-described background, as shown in Table 1.1. The research objectives were set to continue in these directions, and the detailed objectives are depicted in the following session. Cluster analysis and regression analysis were the two analyses identified to support the three research directions.

Table 1.1 : Research direction

| Categories | Research Direction |
|---|---|
| Cluster Analysis | Assess the current outbound air cargo categories and the air cargo shipment value and weight behavior patterns. |
| Regression Analysis | Ascertain the relationship between identified factors for the growth of air cargo demand and the actual air cargo data uplifted by Combi Carriers for the past few years. |

Objective 01 – Assess the current outbound air cargo from Sri Lanka and its impact on the economy of Sri Lanka

As a result of globalization, countries have received the opportunity to specialize in activities with a competitive advantage in the global market. These activities have increased social-economic and

technological advantages by enabling companies to communicate with customers and suppliers worldwide and market their products. Similarly, the political circumstances have increased the number of potential trading partners worldwide. Air cargo is highly varied in its physical attributes and value. It can be finished products, raw materials, gifts, personal belongings, donations, equipment, and even live animals or human parts for business, professional activities, and events (Moving Air Cargo Globally, 2016). These products impact the economy of Sri Lanka in different manners. Therefore, the first objective of this research is to assess the current outbound air cargo going from Sri Lanka and identify its impact on the economy of the country.

Objective 02 – Identify the influencing factors for air cargo demand growth at a destination

Most of the cargo demand-driven networks are steady, unlike passenger demand-driven networks. However, more than 50% worth of shipments is carried by Combi Carriers. Therefore, it is essential to identify the optimum route network coupling in both passenger and cargo demand-driven networks. Hence, the second main objective of this section is to identify the key influencing factors for the growth of air passenger and cargo demand-driven networks at respective destinations. The factors that previous researchers used to forecast or develop models will be summarized in this section. Furthermore, the factors identified during the interviews will be discussed here.

Objective 03 – Develop a criterion to assess identified influencing factors

As per the previous explanation, air transport is a complex system that includes airports, aircraft, air traffic management systems, and flight routes. Air passenger and cargo demand forecasting values are vital for the airport, airline, and airfreight managers to make timely operation and decision-making plans (Wadud, 2013). Even though the models previously developed in other locations will not suit the situation in Sri Lanka. From this case study, we mainly focus on the impact of Combi Carriers on air cargo transportation. Therefore, after the influencing factors for air cargo demand at a destination were identified, a proper mechanism was developed to predict the air cargo demand at a destination.

## 1.7 Overview of the research

This section describes the five main chapters include in the thesis. The five sections will lead the path to accomplish the ultimate goals of the research, including the introduction, Literature review, Methodology, Data analysis, and conclusions. A brief introduction to the content of each chapter is below.

**Chapter 1**

The overview of the research background, research purpose, importance, influence, and contribution to filling the knowledge gap in the air cargo industry and the usage of Combi Carriers for air cargo transportation are discussed here.

**Chapter 2**

This chapter elaborates on the literature related to the research, the previous concepts and models for air cargo demand calculation developed and the key influencing factors identified by other researchers.

**Chapter 3**

This chapter expounds details on the research design process, the methods of data collection, and the analysis used for the research.

**Chapter 4**

The findings of the research study are discussed in this chapter. The outcomes of the interviewer's opinions and the secondary data analysis are included.

**Chapter 5**

This chapter concludes with some significant areas and conclusions identified through the study. Further, this chapter discusses the conclusion and the recommendation for the future.

# CHAPTER 02 – LITERATURE REVIEW

The literature review in this chapter has been divided into two main parts focusing on identifying the drivers that affect the growth of air cargo demand for Combi Carriers and the previously developed models. The first part of the literature focuses on the factors used to develop models. Secondly, the theoretical concepts and how these theories are applied to investigate the impact of different methods and the developed models to calculate or forecast air cargo demand will be elaborate.

## 2.1 Factors

Analyzing and modeling passenger and cargo demand is dynamic. The propositions taken by the management and the operation in the entire aviation industry seem to be a tough challenge (Feng Jin, 2020). Demand forecasting is a well-established research topic in the aviation industry in the same way as in many areas. However, forecasting passenger and air cargo demand are challenging due to its multiple characteristics, such as non-stationarity, high volatility, and irregularity (Feng Jin, 2020). Many research studies have been conducted using different factors and methods to forecast air cargo demand and those that did not consider the demand from passenger and cargo carriers together.

Researchers have used various explanatory factors in their previous research to develop models to identify cargo and passenger demand. These models include GDP value, household income level, population, export and import volume, ticket fare, exchange rates, travel time, aircraft movements, frequency of flights, connectivity, etc. IATA describes the most critical factors are income or GDP, representing the size of a country's economic activity. For developing countries, they represent the ability to purchase export items or people to fly. Further, they reveal that population is also an essential factor as it describes the prospective pool of air travelers and cargo (Moving Air Cargo Globally, 2016).

Raghavendra Totamane and his team (Raghavendra Totamane, 2014) have considered similar factors for their forecasting model, such as primary statistic functions, Cargo Market share of the airlines in a given route, industry growth rate, inflation rate, cargo demand on a specific air route,

etc. Further, they have analyzed other economic predictors, such as GDP, inflation, industrial growth, and import/export commercial activity.

Krishan Hamal has tried to develop a model to forecast international air freight movements through Australian airports. Per capita, real income in export destination countries, and actual export price index variables have been used for the model development. Both inbound and outbound freight movements have been considered for the analysis (Hamal, 2011).

Further factors were identified during the preliminary survey. Experts in the industry were highlighted as missing and rated as of relative importance. Including them, more than 30 possible influencing factors were identified through the literature review and interviews with industry experts. Identified factors are listed below.

1. Outbound flights (Glenn Baxter, 2018)
2. Load factor (Iman Mohammadian, 2019)
3. Number of low-cost carriers (Iman Mohammadian, 2019)
4. Airport Competition (Daniel Y. Suh, 2019) (Shuojiang Xua, 2019)
5. Avg. ticket price (Daniel Y. Suh, 2019)
6. Connecting Passenger share (Daniel Y. Suh, 2019)
7. Per Capita Income (GDP) (Daniel Y. Suh, 2019)
8. Exchange rate (Glenn Baxter, 2018)
9. National price level (Wadud, 2013)
19. Annual enplaned export air cargo tonnage (Glenn Baxter, 2018)
20. Population Domestic (Daniel Y. Suh, 2019) (Iman Mohammadian, 2019)
21. World population (Glenn Baxter, 2018)
22. World population growth (Glenn Baxter, 2018)
23. Passenger demand (Feng Jin, 2020) (Daniel Y. Suh, 2019) (Shuojiang Xua, 2019)
24. Passenger turnover (Shuojiang Xua, 2019)
25. Domestic total turnover (Shuojiang Xua, 2019)
26. International total turnover (Shuojiang Xua, 2019)
27. HHI - (Hirschman-Herfindahl Index) (Daniel Y. Suh, 2019) (Iman Mohammadian, 2019)

10. Industry growth (Raghavendra Totamane, 2014)
11. Monthly inflation rate (Raghavendra Totamane, 2014)
12. World airfreight yield
13. World jet fuel price (Glenn Baxter, 2018) (Iman Mohammadian, 2019) (Wadud, 2013)
14. Cargo demand (Wadud, 2013) (Raghavendra Totamane, 2014) (Shuojiang Xua, 2019)
15. Cargo demand growth rate (Raghavendra Totamane, 2014)
16. World merchandise exports (Glenn Baxter, 2018)
17. Pandemic
18. Legal Limitations
28. No. of connected airports (Chiara Morlotti, 2021) (Paolo Malighetti & Scotti, 2019)
29. No. of connected routes (Chiara Morlotti, 2021)
30. No. of flights between connections (Iman Mohammadian, 2019) (Chiara Morlotti, 2021) (Sameera Prasani, 2018)
31. Average time to travel between airports (Sameera Prasani, 2018)
32. All activity nodes in an air route network (Sameera Prasani, 2018)
33. The Employment rate (Iman Mohammadian, 2019)
34. Average distance between airports (Chiara Morlotti, 2021)
35. Emission & noise reduction
36. Geographical location

## 2.2 Models

### 2.2.1 Artificial Neural Network Modelling

The objective of an Artificial Neural Network is to predict the dependent variables accurately. This process does not require any formulation or a priori-developed model (Merkus & Meesters, 2013). ANN can be trained to perform a function by adjusting the value of connections between the model's elements (kunt et all, 2011). Further, complex relationships between the input and the output can be identified during the training of the sample data set. After training the sample data set through ANN, it can forecast or estimate similar patterns in other sets of data (BaFail, 2004). The following equation is commonly used for demand calculation or forecasting in ANN.

$$Y = F[H1(x), H2(x), ….., Hn(x)] + u$$

Where,

Y = Dependent Variable

X = Explanatory Variables

F & H = Network Function

U = Error Term

Glenn Baxter and Panarat Srisaeng have used ANN to develop a model to calculate annual enplaned export air cargo tonnage in Australia. The following variables are used as independent variables to develop the model. World population, World Merchandise exports, World air freight yield, Outbound flights, AUD / USD exchange rate, and World jet fuel price. The research also found that all the independent variables contribute to the dependent variable, and world population, world real merchandise exports, World air cargo yield, and world jet fuel price are identified as the essential variables.

### 2.2.2 Potluck Problem - The Weighted Majority Algorithm

Raghavendra Totamane et al. have selected the following predictors to predict the demand for the forthcoming days,

1) Essential statistical functions.
2) Airline's cargo market share in a given route.
3) GDP growth in the region.
4) Industry growth in a region or country.
5) Inflation rate in a region or country.
6) Imports or exports growth rate in a region or country.
7) Cargo supply during special occasion days.
8) Cargo supply (within first two quarters).
9) Cargo supply (within last two quarters).
10) Average demand over the last j days (where j is a tunable parameter, e.g. 15).
11) Cargo supply (maximum and minimum over the previous week).

The authors have addressed two main areas regarding air cargo demand prediction from this study. The first section describes how far accurately air cargo demand can be predicted. The second section identifies the influence of the economic and other factors on air cargo demand. The actual total cargo supply data of a selected route and airline for a year have been used for the simulation. The developed algorithms have performed with nearly 75% - 81% accuracy with a tolerance level of $\pm$ 25%. Furthermore, the study found that the GDP, inflation, industrial growth, and import/export commercial activities influence air cargo demand.

### 2.2.3 Simulation Modelling

Zia Wadud has tried to build up a model to predict the air cargo demand at the airport in Bangladesh. The GDP of the country and the crude oil prices (COP) have been used for the model development. The results show that the Seemingly Unrelated Regression (SUR) method is more efficient in terms of result estimation than the Ordinary Least Squares (OLS) method. Further, the paper discussed how the joint modeling approach would improve than individual modeling results.

$$\mathbf{CAR}_t = \alpha_f \, (\mathbf{GDP}_t)^{\beta f} \, (\mathbf{COP}_t)^{\gamma f}$$

CAR = Air cargo demand for a year

$GDP_t$ = Gross Domestic Production

### 2.2.4 Econometric model

To develop a long-term forecasting model, Krishna has used econometric models specified in population, real income, export-import prices, and exchange rates. Both outbound and inbound models have been developed to predict the future air cargo demand through Australian airports.

$$\ln X_t = \alpha_0 + \alpha_1 \ln Y_{1,t} + \alpha_2 \ln P_t + \alpha_3 AFC_t + u_t$$

$$\ln M_t = \beta_0 + \beta_1 \ln Y_{2,t} + \beta_2 \ln Q_t + \beta_3 GFCt + \varepsilon_t$$

where,

X = Outbound air freight movements from Australia (thousand tonnes)

$Y_{1,t}$ = Income of the air cargo exported destinations (in billion dollars)

P = Real export price index

AFC = Dummy variable (to identify the freight movement variation due to Asian economic crisis in 1998 -1999)

M = Inbound air freight movements to Australia (thousand tonnes)

$Y_2$ = Income in Australia (in billion dollars)

Q = Real import price index

GFC = Dummy variables (to identify the freight movement variation due to global economic crisis in 2008 – 2009)

u and ε = Error terms

α and β = Regression coefficients

t = Time subscript

## 2.3 Research Gap Identification

In conclusion, the literature review shows that many researchers have tried to identify the relationship between the air cargo demand of a country and many other variables to forecast future air cargo demand. Some studies have tried to develop models to forecast air passenger and cargo demand separately. However, it would be inappropriate to assume that the developed models can be used to forecast the air cargo demand for combi carriers at a destination. Therefore, there should be a proper mechanism to study the air cargo demand for combi carriers. This research work will take the first step to address this area. Hence, the factors that affect the growth of supply-side demand and the industries will identify and discuss in the following chapters.

# CHAPTER 03 – RESEARCH METHODOLOGY

Once identify the research objectives, it is necessary to develop a proper methodology to achieve them. This chapter provides a detailed description of the research development and design, the process of data collection, and the analysis methods.

## 3.1 Research Design

In this section, the procedure for achieving the objectives of the research will be discussed in detail, including the data collection and analysis methods. The research objectives could not be achieved through a single method. Therefore, qualitative and quantitative methods will utilize a different methodological approach in the literature survey, interviews, and primary and secondary data. Table 3.1 will elaborate on the objectives to be achieved in each method. Figure 3.1 represents the research workflow to achieve the following research objectives.

- Assess the current outbound air cargo from Sri Lanka and its impact on the economy of Sri Lanka.
- Identify the influencing factors for air cargo demand growth at a destination.
- Develop a criterion to assess identified influencing factors.

Table 3.1 : Data collection methods

| Data Collection Methods | Objectives |
|---|---|
| Interviews | • Obtaining background knowledge about the study.<br>• Identifying the main influencing factors that affect the growth of air cargo demand at a destination. |
| Literature Survey | • Identifying the key influencing factors that affect the growth of air cargo at a destination.<br>• Study of other similar cases around the world. |
| Primary Data | • To identify the Influencing factors for the growth of air cargo demand at a destination. |

| | |
|---|---|
| Secondary Data | • Identify the behavior of the air cargo categories.<br>• Identify the industries that need to be developed to grow air cargo.<br>• Develop a model to calculate the export air cargo demand. |

Figure 3.1 shows the bird's point of view of the research work.

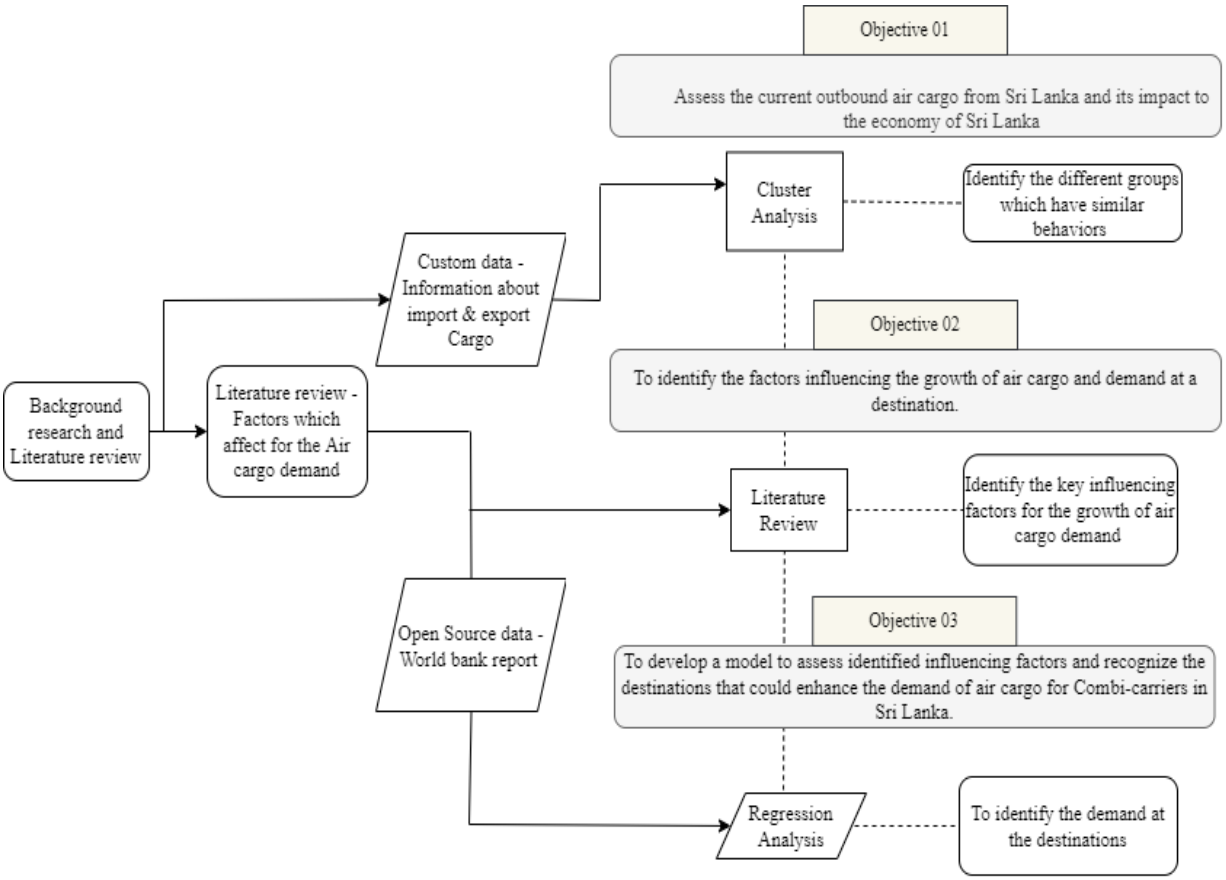


Figure 3.1 : Research methodology

## 3.2 Data Collection

Data collection methods utilized for this research include two approaches: primary data collection and secondary data collection. Data gathered from existing sources are identified as secondary data, while data collected for the research from the actual site of occurrence of events are identified as primary data.

### 3.2.1 Primary Data

One method of collecting primary data is through interviews with industry experts. Interviews were crucial in the research as they were used to obtain background knowledge regarding the study. The top management experts from the air cargo export industry that has expert knowledge were the target population for the interview. To attain good sound knowledge about the background of the research, the opinions of the top management are crucial. Therefore, interviews were conducted with managers from the export sector in different industries, such as freight forwarders (DHL, FedEx, and Sri Lankan airlines) and academia, to have background knowledge from different perspectives and reduce the biases of the interviews.

The convenience sampling method was used to collect data via interviews. Due to the covid 19 pandemic, it was not easy to conduct face-to-face interviews. Therefore, the discussions were conducted online (Zoom) and via telephone. The main objective of the interviews was to get the opinion on the identified factors through literature reviews and to collect missing variables to the list. Opened-ended questions were carried out through the discussions.

### 3.2.2 Secondary data

The required qualitative and statistical data needed for the research work were collected through the findings of the literature review and interviews. The following secondary data requirements were identified from the literature review and interviews.

- Air cargo volume export from Sri Lanka
- Value of the air cargo exported from Sri Lanka.
- Destinations of the export air cargo going out from Sri Lanka.

- Statistical values of other countries relevant to the identified factors.

The secondary data from Custom of Sri Lanka has been used for the analysis in this research. Every item going out or coming in should need to be clear from the custom. Therefore, details of every shipment have been recorded in the custom database. Five years of data from 2016 to 2020 consist of the shipment's HS code number, description, year, month, weight, value, and the final destination details. Furthermore, the statistical values of the other countries were obtained from the websites and the reports.

## 3.3 Analysis Method

Cluster analysis and regression analysis were used to analyze the data in terms of achieving the objectives of the study. Following Figure 3.2 describes the overall flow of the analysis.

### 3.3.1 Cluster Analysis

Cluster analysis is commonly used in airport classification in the air transport research area. Clustering means unsupervised classification, where cluster analysis groups a set of data into clusters. Two characteristics can be seen in the developed clusters; the data objects within the clusters are similar and dissimilar to the objects in other clusters. Hierarchical and K-mean clustering methods are the most popular methods among researchers. The main disadvantage of K-mean clustering is that it requires the number of clusters beforehand. The advantage of hierarchical clustering is that it does not require the number of clusters beforehand, is easy to implement, and has a good visualization capacity. In hierarchical clustering, data are not separated into a specific number of groups at a single phase, like in k-mean clustering. Depending on the decomposition process, two types of approach can be seen in hierarchical clustering. They are an agglomerative approach and a divisive approach. An agglomerative approach considers each data point as n groups and merges data points that have similarities with each other until all the data points are merged into one group. The divisive approach classification procedure includes a series of separations from one group of individuals to am *n* group of a single individual (Tien-Chin Wang, 2020) (Tomar, 2013). The pros and cons of these two clustering methods are summarized in the below table.

Table 3. 2 : Pros and cons of clustering methods

| Clustering Method | Pros | Cons |
|---|---|---|
| Hierarchical Clustering Method | 1. No need to identify the number of clusters beforehand.<br>2. Easy to implement.<br>3. Easy to understand (Good visualization). | 1. Not suitable for data sets that have outliers and noise.<br>2. Processing time is high.<br>3. Once the merge or split point is decided, it cannot be revised. |
| K-mean Clustering Method | 1. Simple process.<br>2. Efficient. | 1. Need to identify the number of clusters beforehand.<br>2. Results can be different when there are outliers in the data set.<br>3. It cannot handle categorical variables. |

The first objective was fulfilled through the cluster analysis by identifying the behavior of the air cargo commodity types and the industries that will impact the air cargo export demand. Then the developed four-quadrant matrix elaborates on the most crucial commodity categories that need to focus on rapid development.

### 3.3.2 Regression Analysis

Regression analysis is commonly used in scenarios where we need to find criteria that explain the correlation among different variables. Based on the type of independent variables, there are two types of regression models, linear and non-linear regression models. The linear regression model finds the relation between numerical or continuous data, and the non-linear regression model finds the relation between numerical and categorical data. At the same time, the non-linear regression model is called a logistics regression model. This study's selected dependent and independent variables consist of numerical or continuous data (Tomar, 2013). Hence linear regression analysis was conducted to develop a model to calculate air cargo demand for Combi Carriers using Sri Lanka as a case study to fulfill the third objective of the study. The factors were identified through the literature review, and the interviews were used for the analysis. The methodology of the regression is shown in chapter 04.

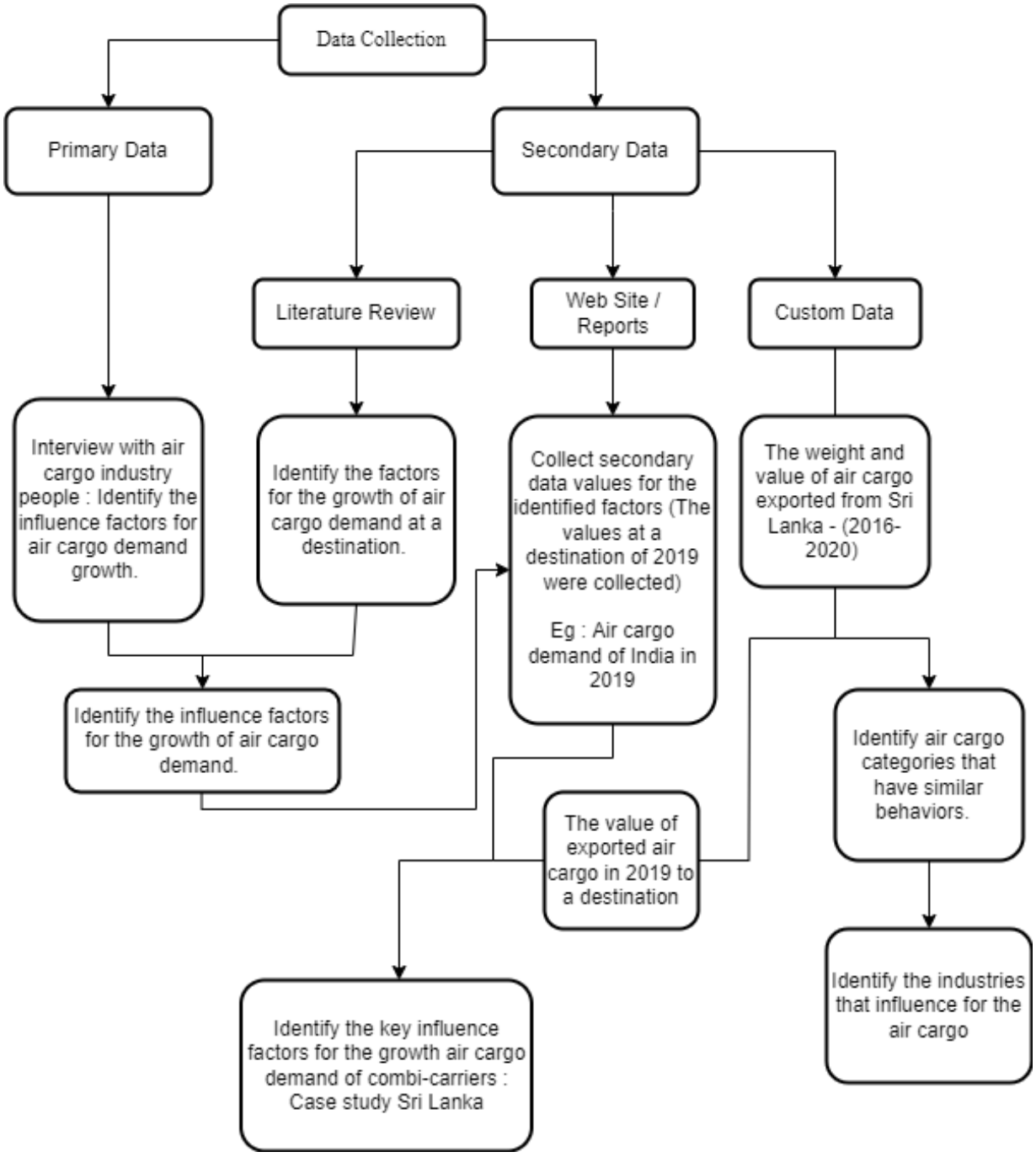


Figure 3.2 : Conceptual framework of the research work

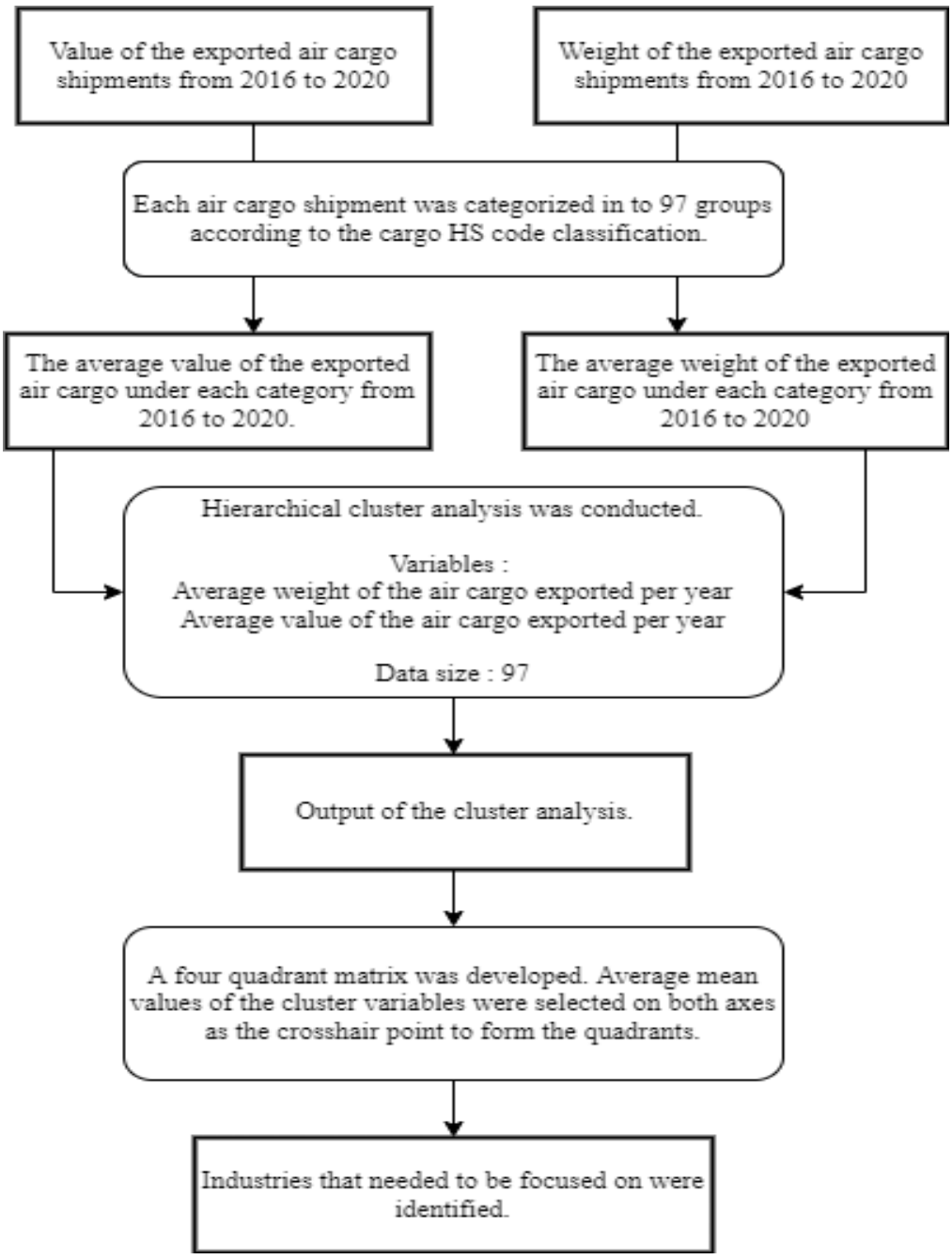


Figure 3.3 : Overall methodology of Cluster analysis

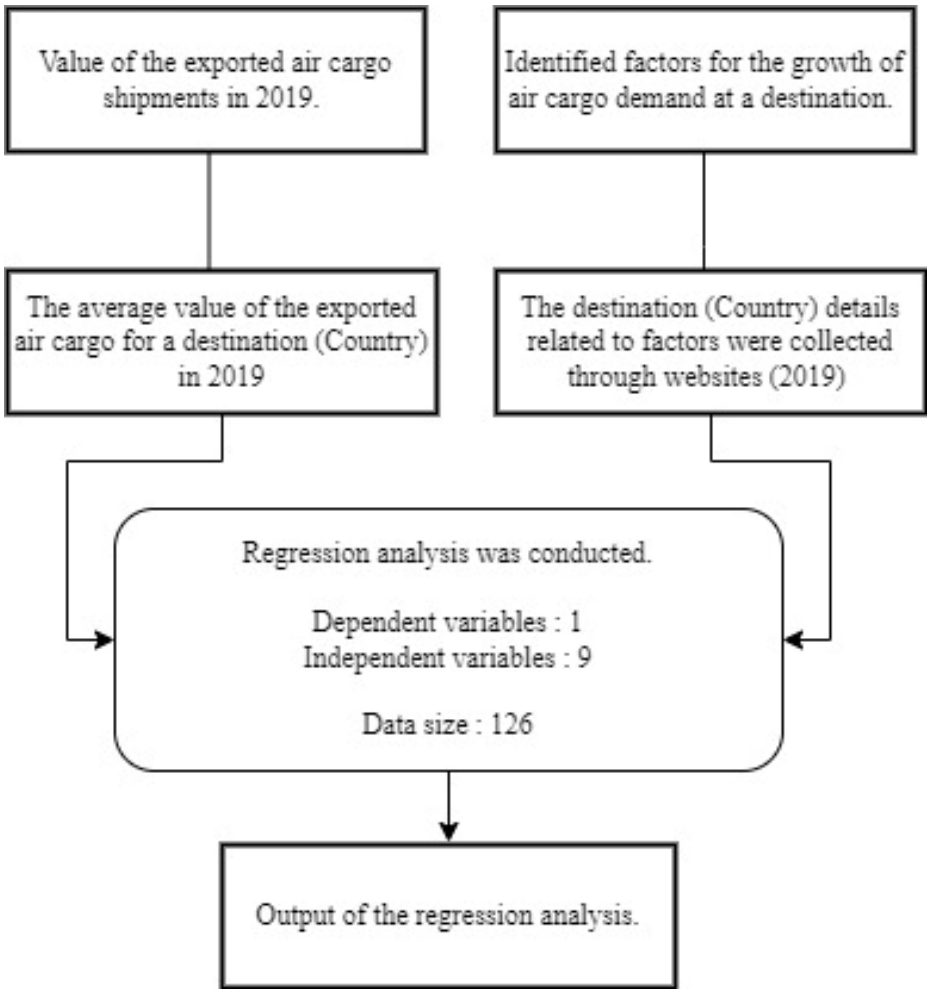


Figure 3.4 : Overall methodology of Regression analysis

# CHAPTER 04 – DATA ANALYSIS

This chapter describes the analysis and findings of the research work. The analysis is done according to the methodology described in Chapter 3. The findings of the literature survey, interviews, statistics, and customs data on the growth of air cargo demand at a destination are discussed here.

The chapter starts with a descriptive analysis of the secondary data collected from customs which portrays the current air cargo industry in Sri Lanka. Then the cluster analysis elaborates on the behavior of export commodities in terms of shipment weight and volume. Finally, the focus is to develop a model through regression analysis.

## 4.1 Descriptive analysis

### 4.1.1 Export Air Cargo Summary

With the policy change towards foreign trade, the exports of Sri Lanka play a significant role in strengthening the economy of the country. The aviation industry gives the right hand by providing efficient and fast transport services for the export industries to fortify their business practices. According to Figure 4.1, air cargo weight increased in 2017, and strong consumer confidence in e-commerce was the key driver of the growing industry. Unfortunately, after 2018 the weight handled in Sri Lanka has been reduced. However, the value of the export commodities has increased over the years (Figure 4.2).

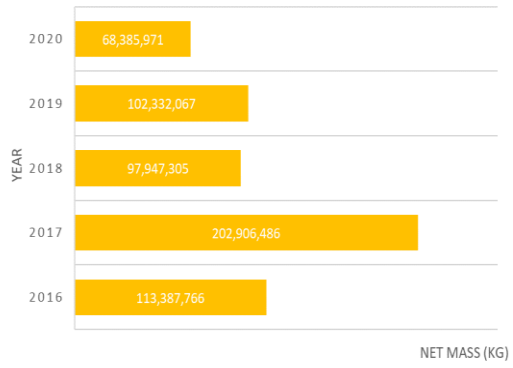


Figure 4.1 : Export air cargo weight (Kg)

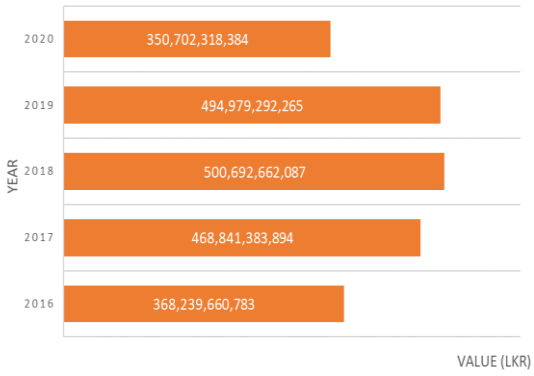


Figure 4.2 : Export air cargo value (LKR)

Figure 4.2 : Export air cargo value (LKR)

The distribution of every exported shipment's weight and value are shown in Figure 4.3 and Figure 4.4. The average weight of air cargo shipment is around 1400Kg. Meanwhile, the average value of a shipment is around 6 million rupees. Apparently, high-value one-off shipments can be seen almost every year. Most of these shipments are related to currency.

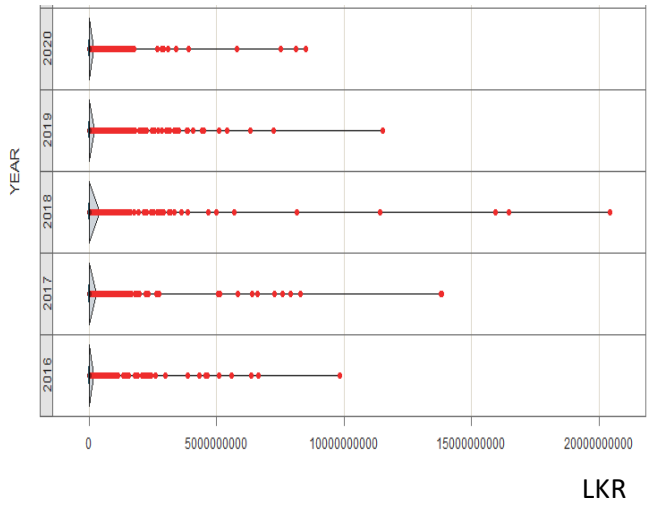


Figure 4.3 : Value per shipment

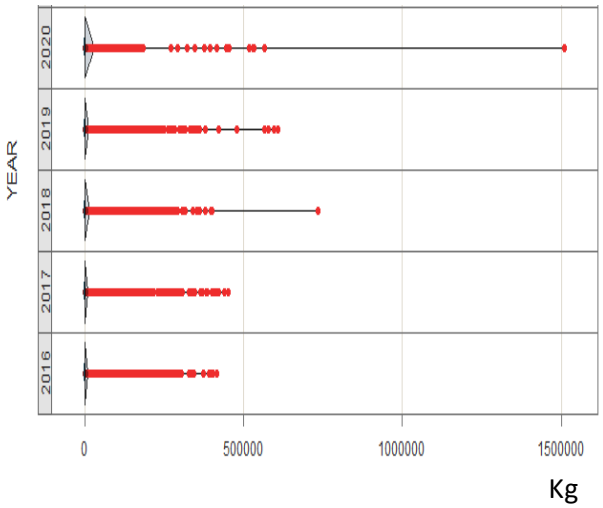


Figure 4.4 : Weight per Shipment

Figure 4.4 : Weight per Shipment

Figure 4.5 shows the value of air cargo exported monthly-wise each year. Most of the export shipments happen in March every year. Moreover, at the same time, minimum exports are happening in April. Due to most factories closing their work in April to celebrate the new year, exporters are sending their orders in March.

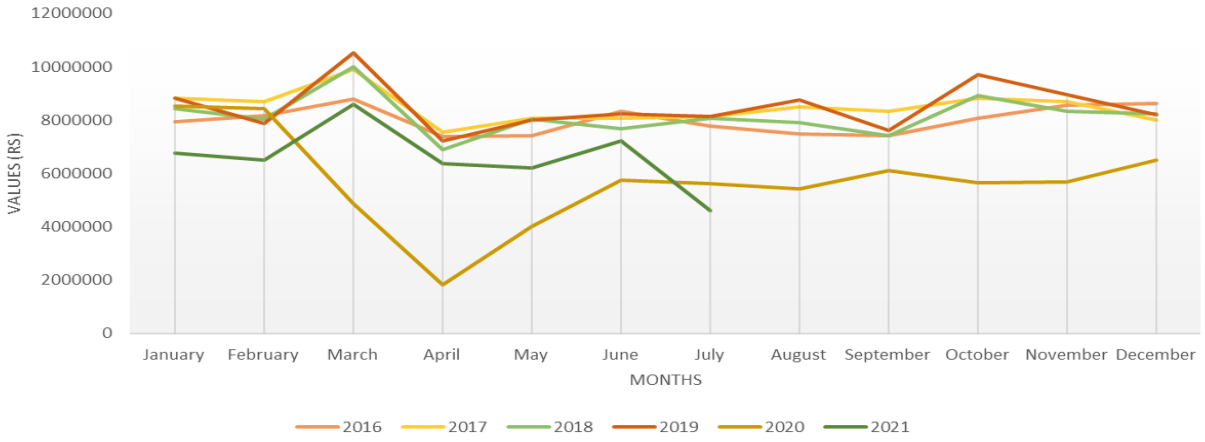


Figure 4.5 : Export air cargo value over the months

Figure 4.6 shows the destination distribution of the outbound air cargo. Nearly 36% of shipments have shifted from the total output to the North American region. Meanwhile, 31% worth of shipment has shifted to Asia & Pacific region by average per year. Apart from that, air cargo is uplifted to Europe, South America, the Middle East, Africa, and the Arab States by 29%, 1%, 2%, 1%, and 1%, respectively. The top five Sri Lankan product trade countries are the USA, Singapore, United Kingdom, Switzerland, and Italy. The following diagram (Figure 4.7) shows the top 10 destinations in terms of value-wise.

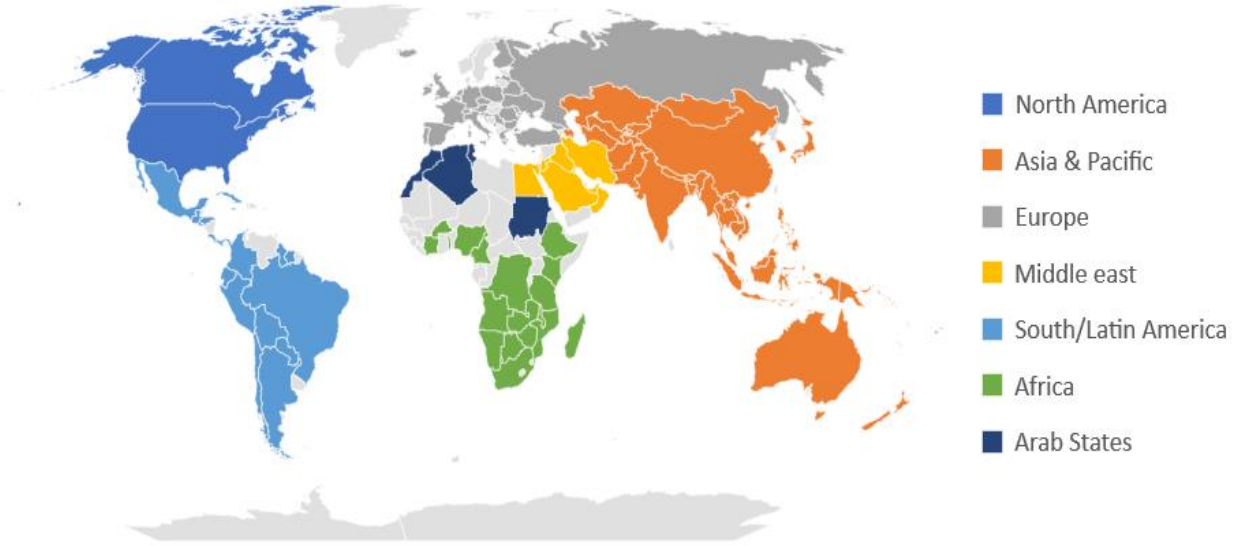


Figure 4.6 : Country distribution of the export air cargo around the world

The end destination of most of the air cargo uplifted from Sri Lanka is to the USA. According to the weight exported, nearly 26% of cargo weight is shipped to the USA annually from the total output. Maldives, UK, UAE, and Pakistan are some of the other top destinations. It is pretty much challenging to operate a direct long-haul flight to the USA. However, direct flights are operated to other top destinations. The top 10 export destinations by weight are shown in Figure 4.8.

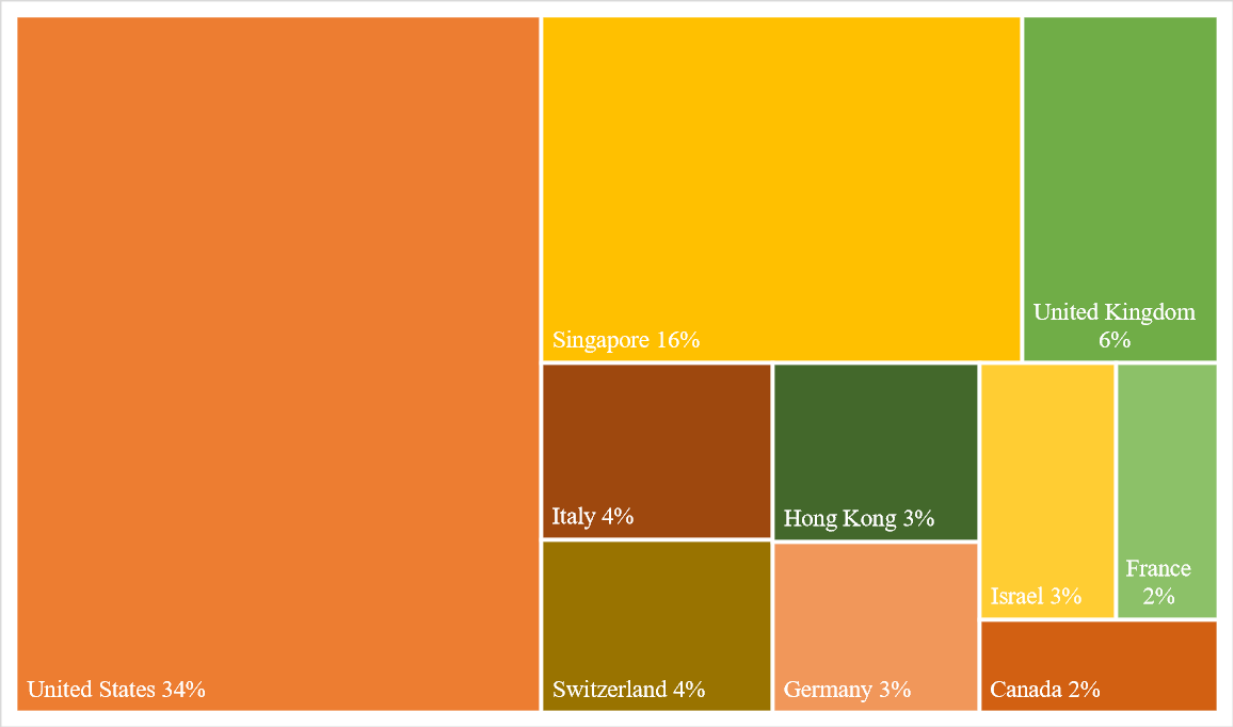


Figure 4.7 : Top 10 export air cargo destinations (Value LKR)

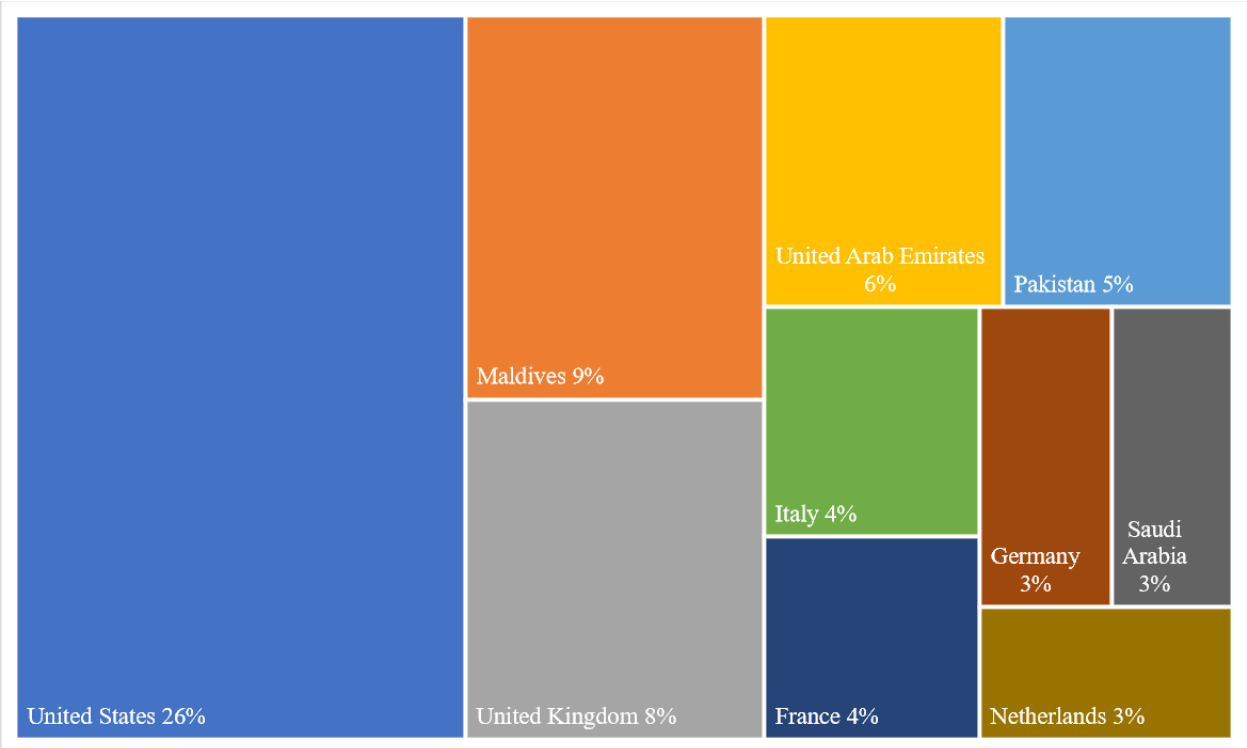


Figure 4.8 : Top 10 export air cargo destinations (Weight Kg)

### 4.1.2 Export Commodity Category wise

Every item has an HS code under specific chapters, as mentioned in chapter 01. Table 4.1 shows the minimum number of sections that cargo can be categorized according to the Sri Lanka custom classification. The document of HS code classification is attached in Appendix 1.

Table 4.1 : Cargo classification according to HS code section-wise

| Index | Category |
|---|---|
| 1 | Live animals, animal products |
| 2 | Vegetable products |
| 3 | Animal or vegetable fats, oils, and waxes |
| 4 | Prepared foodstuff, beverages, spirits, and tobacco substitution |
| 5 | Mineral products |
| 6 | Products of the chemical or allied industries |
| 7 | Plastic and rubber thereof |
| 8 | Raw hides, skins, and leather |
| 9 | Wood, cork, and straw product |
| 10 | Paper and paperboard products |
| 11 | Textile and textile articles |
| 12 | Footwear, headgear, umbrella, and artificial flower |
| 13 | stones, cement, glass, and ceramic product |
| 14 | Precious stones and jewelers |
| 15 | Base metals |
| 16 | Electrical machinery, equipment, and parts |
| 17 | Vehicles, aircraft, spacecraft, ships, and parts |
| 18 | Medical or surgical instruments, Musical instruments, and clock parts |
| 19 | Arms and ammunition |
| 20 | Miscellaneous products, toys, and furniture |
| 21 | Works of art, collectors' pieces, and antiques |

Figure 4.9 and Figure 4.10 illustrate the exported air cargo weight-wise and volume-wise that have been exported from 2016 to 2020. According to Figure 4.9, from the total outbound shipments, more than half of the volume of shipments has fallen under four categories. Live animals and animal products (Index 1), vegetable products (Index 2), textile and textile articles (Index 11), and electric machinery, equipment, and parts (Index 16) are the industries that export high-weight shipments. Besides the electric machinery, equipment, and part industry, there has been a persistent export volume from other industries over the years. Due to the covid 19 pandemic, the export volume falls of each industry can be seen in 2020. Apparently, Prepared foodstuff, beverage,

spirits, and tobacco substitution (Index 4), and plastic and rubber industries (Index 7) are also exporting a reasonable volume of their products through air transportation.

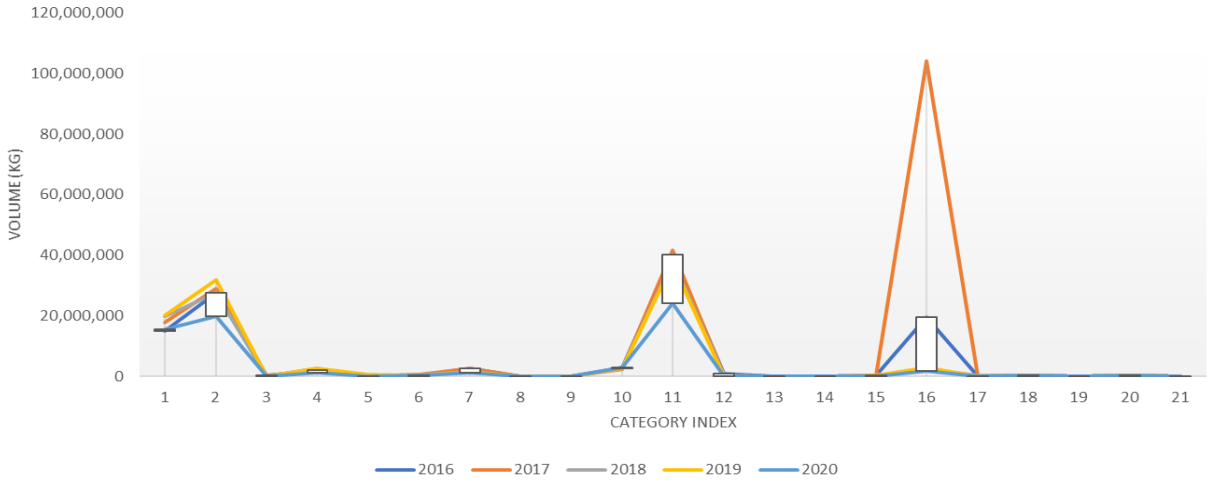


Figure 4.9 : Export air cargo weight over the years (Hs code section classification)

As shown in Figure 4.10, Sri Lanka's major outbound products by value are Textile and textile articles (Index 11), paper and paperboard products (Index 10), precious stones and jewelers (Index 14), live animals and animal products (Index 1), and electrical machinery equipment and parts (Index 16). At the same time, Vegetable products (Index 2), Prepared foodstuff, beverages, spirits, and tobacco substitution (Index 4), Vehicles, aircraft, spacecraft, ships, and parts (Index 17) and Medical or surgical instruments, Musical instruments, and clock parts (Index 18) industries are also using air cargo transportation to bring down the economy of the country.

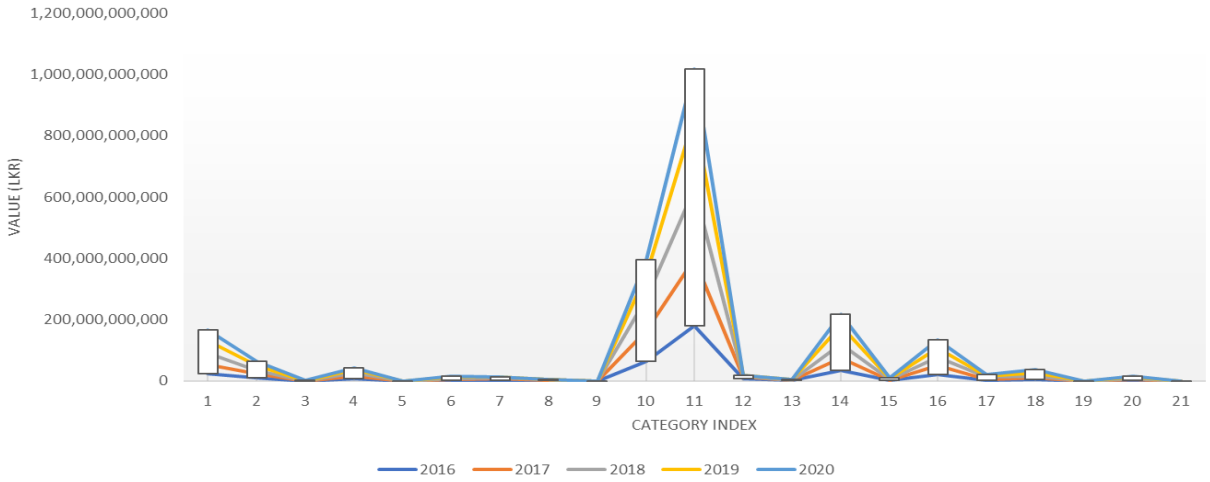


Figure 4.10 : Export air cargo value over the years. (Hs code section classification)

## 4.2 Import Summary

From 1977 onwards, Sri Lanka became the leading country in the policies toward economic liberalization. The changed policies highly impact the import industry in Sri Lanka. Figure 4.11 and Figure 4.12 presents the import commodities by value and weight from 2016 to 2020. According to Figure 4.11, the volume imported by air transportation has drastically dropped over the years. The impact of the Covid 19 pandemic has further reduced the import air cargo volume by 2020. The value of the air cargo imported over these five years has not decreased as the weight of the air cargo. However, high-value cargo has been imported throughout these years. Figure 4.13 shows the value of air cargo imported monthly wise.

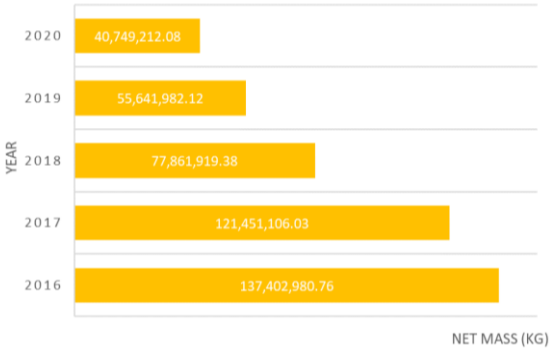


Figure 4.11 : Import air cargo weight

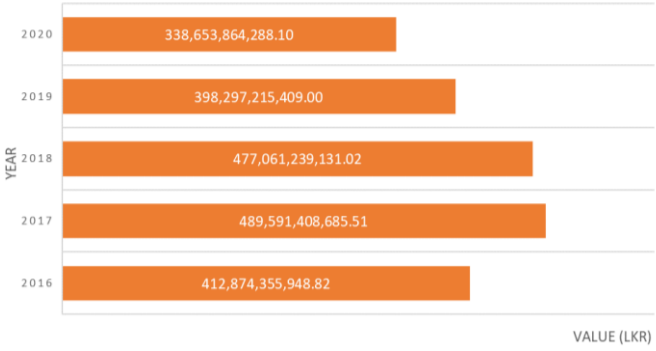


Figure 4.12 : Import air cargo value

Figure 4.12 : Import air cargo value

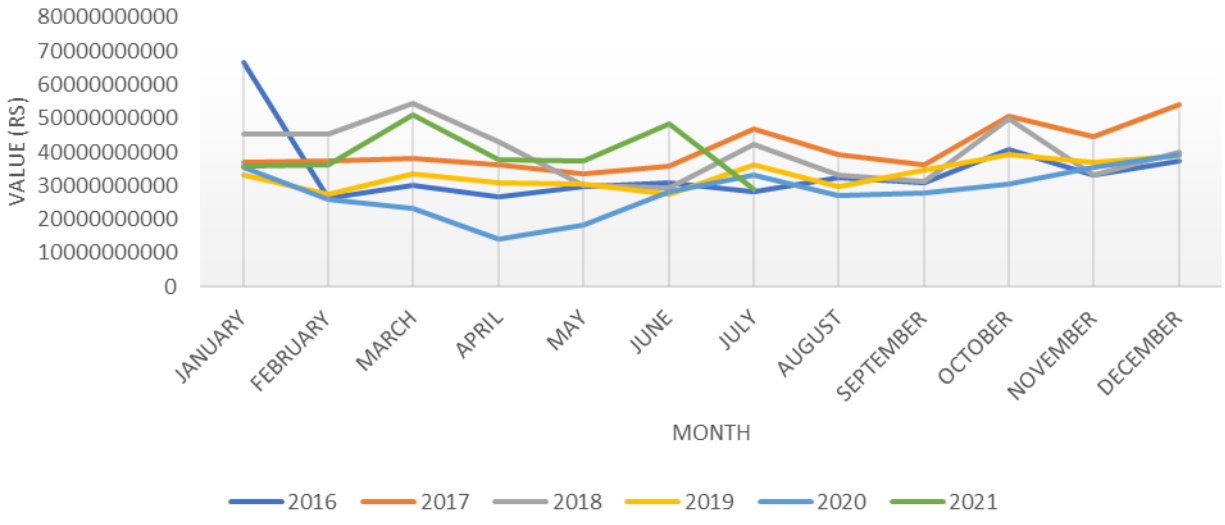


Figure 4.13 : Import air cargo value over the months

The origin distribution of the inbound air cargo differs from outbound destination distribution. Nearly 51% worth of shipments have been brought down from Asia & Pacific region from the total output. Meanwhile, on average, 32% worth of shipments are brought down from Europe each year. Air cargo from North America, the Middle East, and Africa are 12%, 5%, and 1%, respectively. The top five inbound trade countries of Sri Lanka are China, the United States, India, Switzerland, and Hong Kong. The following diagram (Figure 4.16) shows the top 10 origins in values-wise.

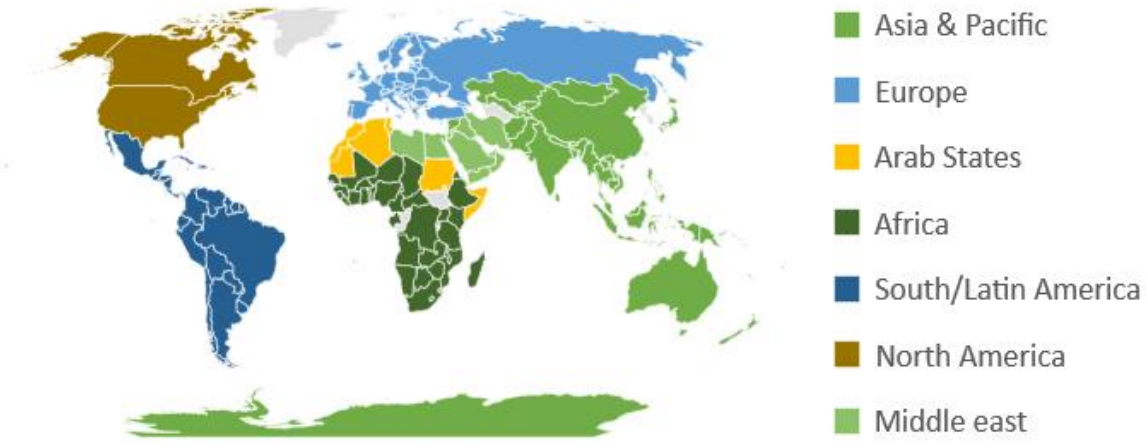


Figure 4.14 : Country distribution of the imported air cargo around the world

Figure 4.16 reveals the top 10 origins where air cargo is imported weight-wise. The total weight imported to Sri Lanka from China is nearly 26% of cargo weight per year. India, Hong Kong, Taiwan, and Germany are the other top origins. As most of the origins are located in the Asia Pacific region, where Sri Lankan flights are directly operated, this will be an excellent opportunity to capture new markets.

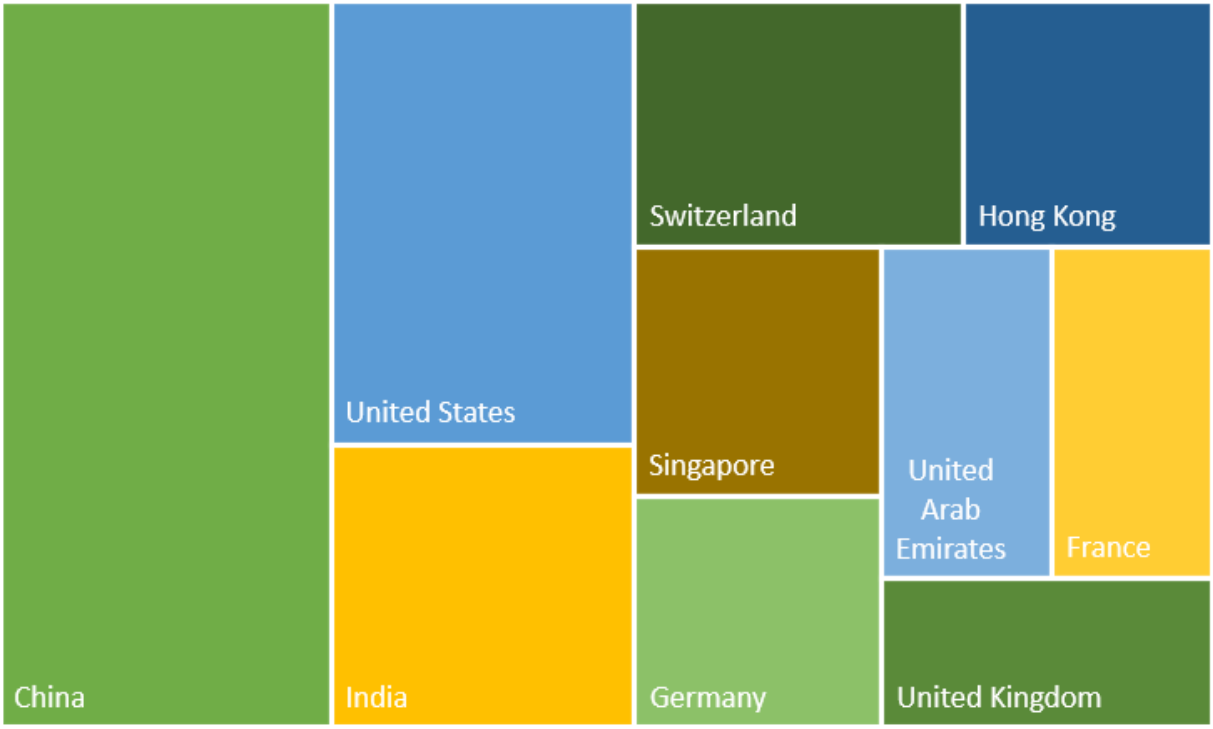


Figure 4.15 : Top 10 import air cargo destinations (Value LKR)

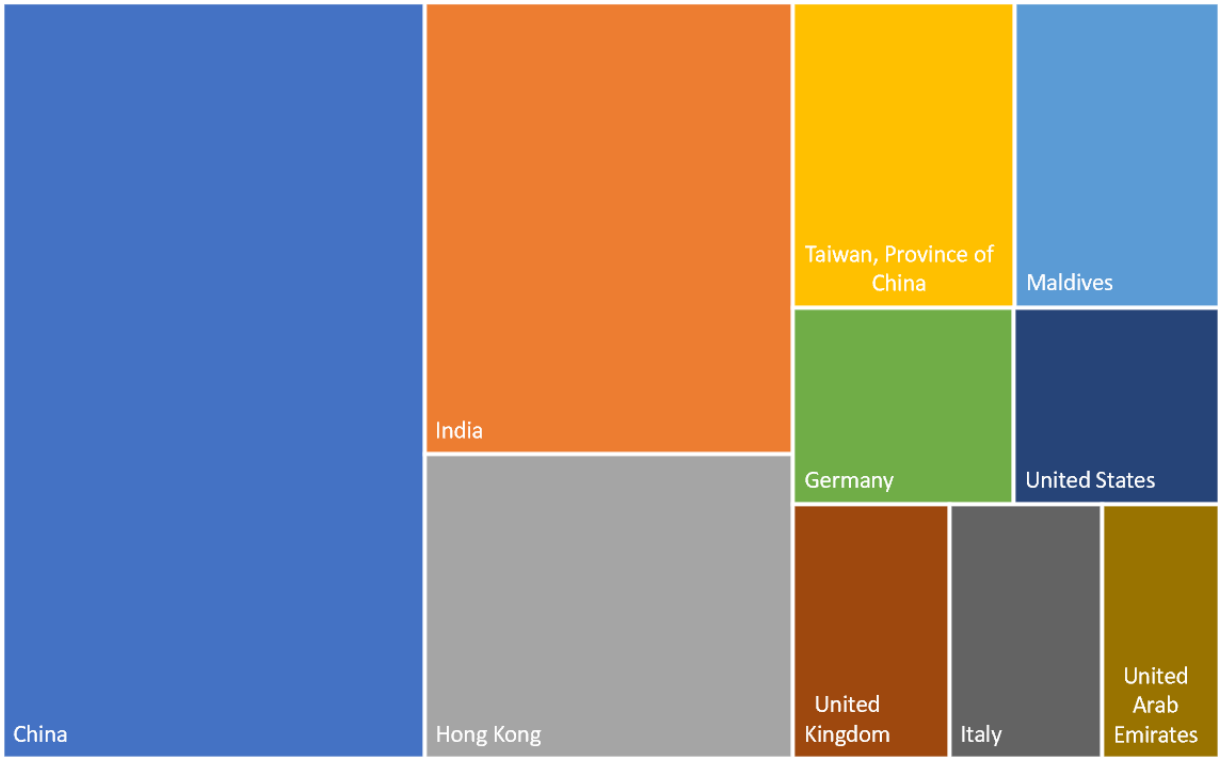


Figure 4.16 : Top 10 import air cargo destinations (Weight Kg)

### 4.2.1 Commodity category wise

Figures 4.17 and 4.18 illustrate the imported air cargo weight-wise and volume-wise imported from 2016 to 2020. According to Figure 4.17, from the total inbound shipments, more than half of the volume of shipments has fallen under two categories. Textile and textile articles (Index 11) and electric machinery, equipment, and parts (Index 16) are the industries that import high-volume shipments. However, a decrease in the air cargo volume imported can be seen throughout the years.

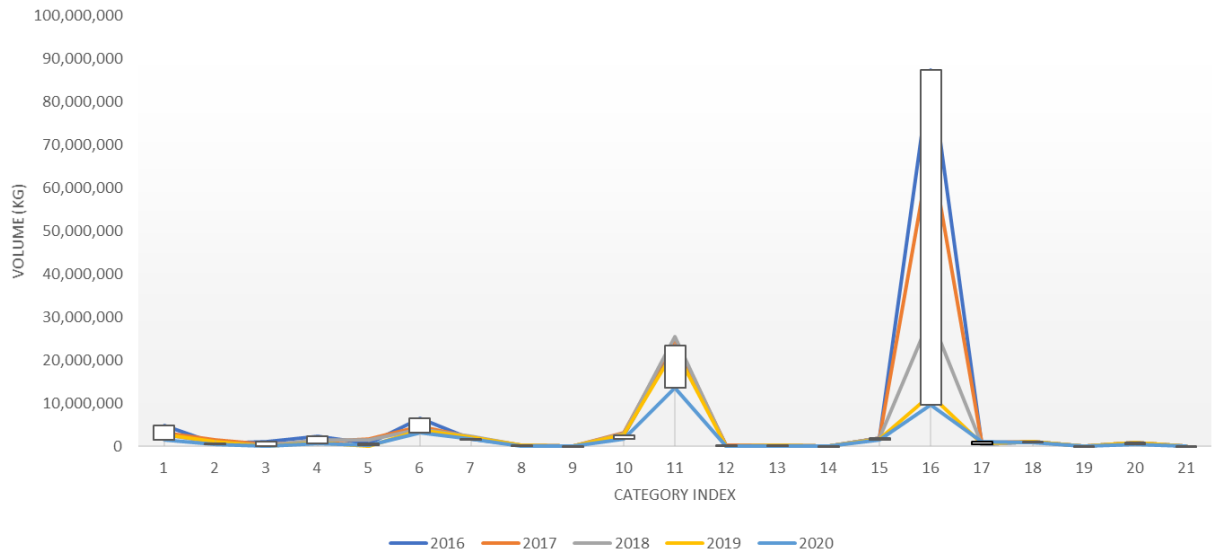


Figure 4.17 : Import air cargo weight over the years. (Hs code section classification)

Sri Lanka highly spends on the import items like Electrical machinery, equipment, and parts (Index 16), Textile and textile articles (Index 11), Products from the chemical or allied industries (Index 6), Precious stones and jewelers (Index 14), Medical or surgical instruments, Musical instruments and clock parts (Index 18), and Vehicles, aircraft spacecraft ships, and parts (Index 17). Even though the weight of the imported items has decreased over the years, the value of the imported items has increased. As shown in Figure 4.18, Sri Lanka spends more money importing electronic machinery equipment and parts (Index 16).

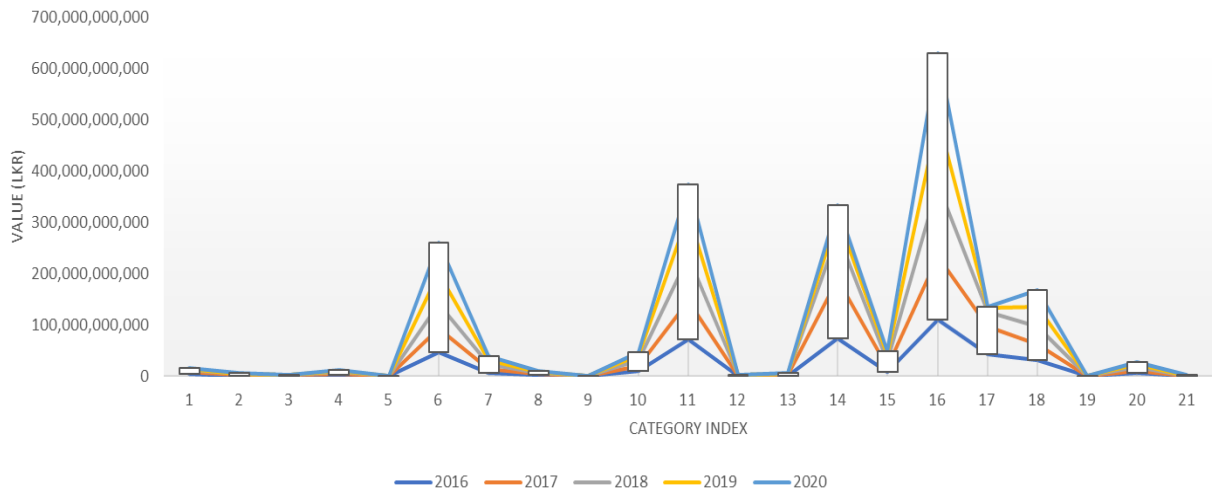


Figure 4.18 : Import air cargo value over the years. (Hs code section classification)

### 4.2.2 Aircraft Assignment in Sri Lanka

The Sri Lankan airline network serves as the national carrier for more than 40 direct destinations in over 20 countries. To gain more comprehensive coverage, in collaboration with codeshare partners, the airline offers 109 destinations for passengers across the worldwide, including North America, Canada, Europe, Africa, Central Asia, and Australia (Sri Lankan Airlines Annual Report, 2021). Table 4.2 shows the air cargo demand for the destinations operated by Sri Lankan Airlines from 2016 to 2020. The Maldives has the highest number of shipments per year and the highest weight exported. However, the table shows that heavy items have been exported to Pakistan. High-value air cargo has been transported to Singapore. Table 4.3 shows the inbound air cargo demand from the destinations operated by Sri Lankan Airlines.

Table 4.2 : Air cargo outbound demand for the destinations operated by Sri Lankan Airlines

| Country | Volume/ Year (Kg) | Value/ Year (Rs.) | Shipments/ Year | Value/ kg | Volume/ Shipment (Kg) |
|---|---|---|---|---|---|
| Maldives | 9500514.26 | 5832839429.50 | 10868.00 | 613.95 | 874.17 |
| United Kingdom | 8383391.52 | 30543841586.03 | 4124.20 | 3643.38 | 2032.73 |
| India | 2393933.04 | 9663554903.12 | 2905.60 | 4036.69 | 823.90 |
| Japan | 1592764.39 | 5190045573.02 | 2578.00 | 3258.51 | 617.83 |
| Australia | 849334.20 | 5162082737.60 | 2445.40 | 6077.80 | 347.32 |
| China | 1298792.38 | 6808889343.79 | 1967.20 | 5242.48 | 660.22 |
| France | 3615641.75 | 11811892812.19 | 1861.80 | 3266.89 | 1942.01 |
| United Arab Emirates | 5774327.02 | 5617505525.39 | 1819.00 | 972.84 | 3174.45 |
| Hong Kong | 1773528.06 | 16665530496.59 | 1783.80 | 9396.82 | 994.24 |
| Singapore | 901446.83 | 75233466622.89 | 1442.40 | 83458.57 | 624.96 |
| Bangladesh | 802965.23 | 1943395355.40 | 983.60 | 2420.27 | 816.35 |
| Qatar | 2481296.07 | 1180175800.41 | 929.80 | 475.63 | 2668.63 |
| Indonesia | 544609.87 | 2089288240.83 | 915.80 | 3836.30 | 594.68 |
| Korea | 359045.15 | 1433438805.60 | 892.00 | 3992.36 | 402.52 |
| Thailand | 587867.86 | 6364023663.54 | 816.20 | 10825.60 | 720.25 |
| Saudi Arabia | 3003472.27 | 2055195786.20 | 796.20 | 684.27 | 3772.26 |
| Malaysia | 258334.47 | 1525952598.05 | 692.20 | 5906.89 | 373.21 |
| Seychelles | 150601.24 | 149151757.21 | 600.20 | 990.38 | 250.92 |
| Bahrain | 507750.31 | 665305611.30 | 599.20 | 1310.30 | 847.38 |
| Russia | 262333.70 | 685195200.97 | 599.20 | 2611.92 | 437.81 |
| Oman | 471085.93 | 525381056.38 | 483.40 | 1115.26 | 974.53 |
| Pakistan | 5542540.45 | 5191829848.64 | 461.20 | 936.72 | 12017.65 |
| Kuwait | 1275999.72 | 1162051475.60 | 454.00 | 910.70 | 2810.57 |
| Kenya | 116211.88 | 246064327.60 | 251.40 | 2117.38 | 462.26 |

Table 4.3 : Air cargo inbound demand for the destinations operated by Sri Lankan Airlines

| Country | Volume/Year (Kg) | Value/ Year (Rs.) | Shipments/ Year | Value/kg | Volume / Shipment (Kg) |
|---|---|---|---|---|---|
| India | 7477184.70 | 34131294675.90 | 15592.00 | 4564.70 | 479.60 |
| China | 14685090.80 | 101681894303.30 | 14688.00 | 6924.20 | 999.80 |
| United Kingdom | 1821651.40 | 19564928587.80 | 11036.00 | 10740.20 | 165.10 |
| Singapore | 1151227.60 | 22486383439.30 | 10553.00 | 19532.50 | 109.10 |
| Hong Kong | 4974259.00 | 23326844153.50 | 10306.00 | 4689.50 | 482.70 |
| United Arab Emirates | 1454439.20 | 22238140754.30 | 8985.00 | 15289.80 | 161.90 |
| Japan | 578672.50 | 9418957574.10 | 6485.00 | 16276.80 | 89.20 |
| France | 812641.80 | 20021657833.30 | 4336.00 | 24637.70 | 187.40 |
| Korea | 1052282.70 | 6338436194.90 | 4075.00 | 6023.50 | 258.30 |
| Thailand | 1098087.10 | 4357316398.30 | 3337.00 | 3968.10 | 329.00 |
| Malaysia | 376121.60 | 3974394426.30 | 3319.00 | 10566.80 | 113.30 |
| Australia | 408804.50 | 1841244180.50 | 2732.00 | 4504.00 | 149.70 |
| Pakistan | 863662.50 | 2168104807.50 | 1433.00 | 2510.40 | 602.80 |
| Indonesia | 311146.00 | 1522076934.30 | 1197.00 | 4891.80 | 259.90 |
| Bangladesh | 322591.80 | 1219604058.70 | 727.00 | 3780.60 | 443.70 |
| Maldives | 2802132.20 | 2207878888.60 | 655.00 | 787.90 | 4275.50 |
| Saudi Arabia | 93277.00 | 86533504.00 | 367.00 | 927.70 | 253.90 |
| Russia | 23940.40 | 1803453388.00 | 190.00 | 75331.10 | 125.70 |
| Qatar | 227750.40 | 20458330.00 | 159.00 | 89.80 | 1428.80 |
| Oman | 43997.00 | 58872400.20 | 146.00 | 1338.10 | 301.30 |
| Kenya | 31606.10 | 46232265.20 | 116.00 | 1462.80 | 271.50 |
| Kuwait | 34853.30 | 2720405.20 | 110.00 | 78.10 | 316.30 |
| Bahrain | 9916.60 | 23705669.60 | 76.00 | 2390.50 | 129.80 |
| Seychelles | 9349.90 | 20710562.20 | 51.00 | 2215.10 | 182.60 |

Having an idea about the export cargo volume value of the cargo for those destinations might not be sufficient to implement strategies to capture or increase air cargo operations. Therefore, Figure 4.19 will compare outbound and inbound shipments from the destinations operated by Sri Lankan

Airlines. According to the comparison, the highest number of shipments are going to the Maldives. However, the inbound shipments from the Maldives are pretty much low. Considering the number of shipments, the highest number of inbound shipments is coming from India. However, there are fewer outbound shipments to India than inbound shipments. The same scenario can be seen in many destinations like China, the United Kingdom (UK), Singapore, Hong Kong, United Arab Emirates (UAE), and Japan. Therefore, proper strategies should be implemented to capture the air cargo demand at those destinations and gain profits without losses.

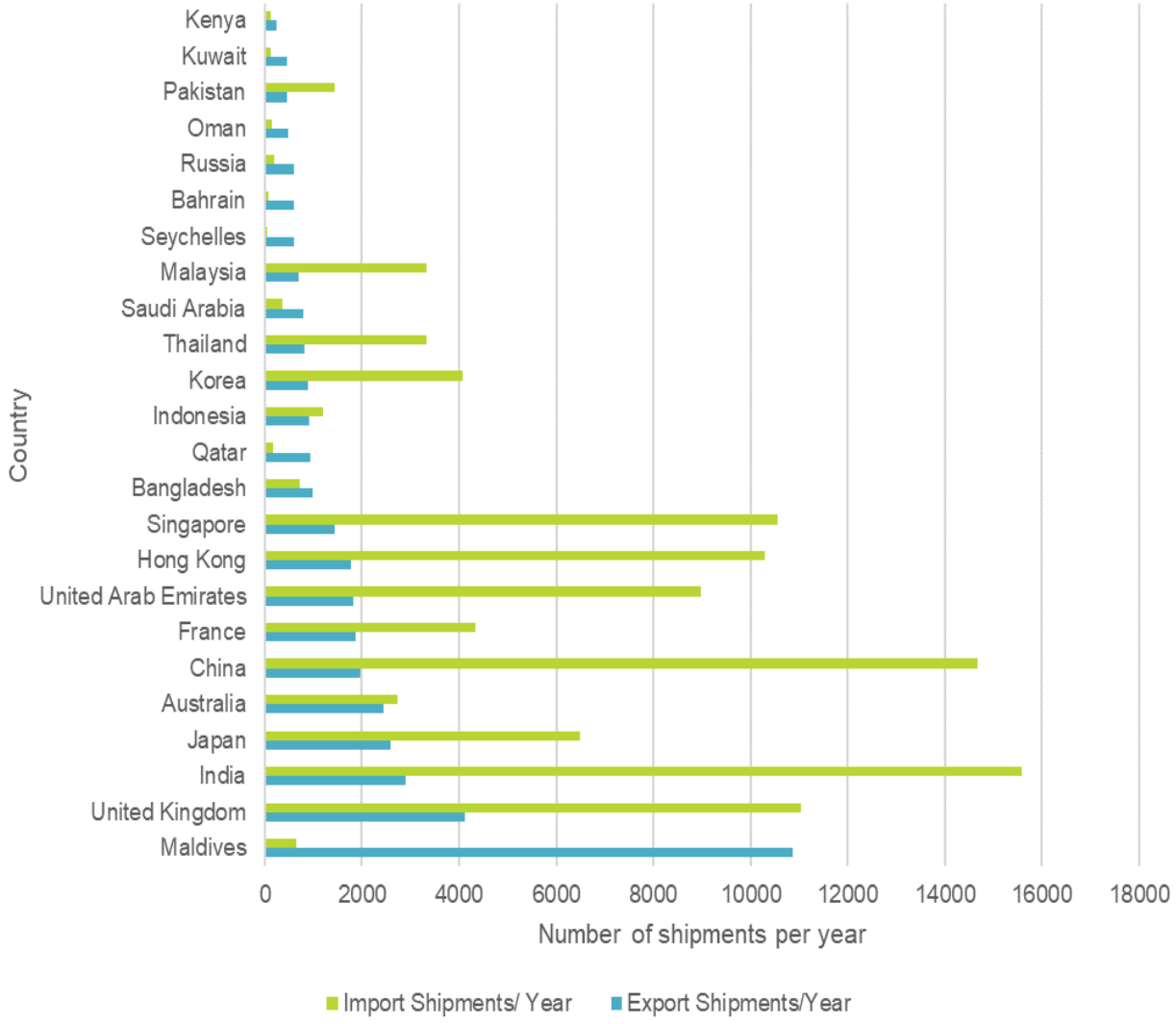


Figure 4.19 : Comparison between outbound and inbound shipments per year

## 4.3 Cluster Analysis

One of the main objectives of this research is to cluster the air cargo types with similar behaviors and study how to generate the air cargo, which will highly impact the growth of the economy of Sri Lanka. Therefore, one of the critical sub-objectives is to identify the air cargo types or commodity groups that have similar behavior in terms of weight and the value of the air cargo. HS code system used to group the shipments, which could easily apply to the cluster analysis. Cluster analysis was carried out chapter-wise, as discussed in chapter 01, using the key variables: the shipment's value and weight. The analysis identified that nearly 5000 different commodities had been exported as air cargo from Sri Lanka to the rest of the world.

The cluster analysis method is widely available and used in many investigational studies in the aviation industry. Surprisingly, air cargo classification has not yet been extensively studied. R. Mayer et al. have done airport classification based on air cargo characteristics. They have used Total cargo output (in metric tonnes) per annum, Cargo workload units, freight aircraft movements, and international cargo as percentage variables for the study. The other researchers also have used the hierarchical clustering method (Paolo Malighetti S. P., 2009) (Mayer, 2016) and the k-mean clustering method (V. Adikariwattage, 2012) for airport classification. These classifications are mainly based on passenger-related variables, like the size of the airports, connectivity, geographic location, nature of traffic, and ownership (V. Adikariwattage, 2012) (Paolo Malighetti S. P., 2009).

Based on the aim of this study, two variables relating to the air cargo output from a destination are chosen to be included in the cluster analysis; those are:

- Annual air cargo weight (Kg)(According to the HS code chapter-wise)
- Annual air cargo value (Rs.)(According to the HS code chapter-wise)

### 4.3.1 Analysis Method

The hierarchical cluster method generates a dendrogram that calculates the distance from each object to all other objects. Then groups are created by the process of agglomeration or division. The agglomeration process starts where all objects start by being alone and then gradually merge

with close objects and groups till all objects are in a single group. The division starts where all the objects are in a single group and then split into groups until they become their own.

R software was used to conduct the cluster analysis (R software is a statistical computer program freely available through the internet). The fact that R is based on a formal computer language gives it tremendous flexibility for data analytics (Guy Brock, 2008).

As the first step, using the clValid function, internal validation is conducted by comparing hierarchical, k-means, and PAM clustering methods to identify the most suitable clustering method for the data set. Three values generate from this function: Connectivity value, Silhouette width, and Dunn index (Guy Brock, 2008). It was identified that the hierarchical clustering method was the most suitable method for data analysis.

The Linkage method for cluster analysis is defined using the agglomerative coefficient value, which measures the strength of the clusters. Ward's linkage method was identified as the most suitable, and the results suggested that the population can be divided into nine clusters based on the average shipment's weight and the value (Figure 4.20) shows the results of the optimum cluster identification. Additionally, a dendrogram Figure 4.20 identifies the possible clusters Table 4.4 shows the cluster profiles, and Table 4.5 summarizes the cluster analysis.

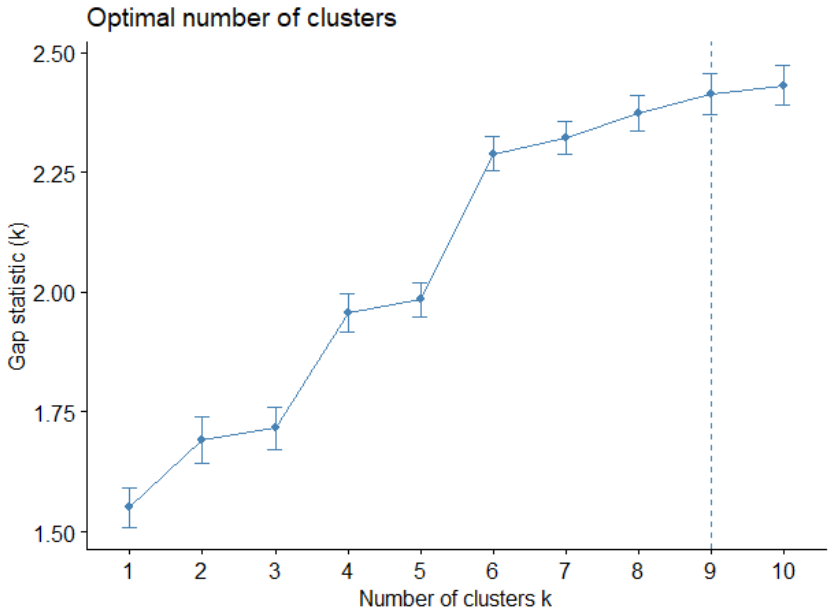


Figure 4.20 : Optimum number of clusters

Table 4.4 : Cluster profile

| Data Size | Linkage method | | Clusters | | Weight | | Value | |
|---|---|---|---|---|---|---|---|---|
| | | | Count | Size | Mean | SD | Mean | SD |
| 97 | Average | 0.97189 | 1 | 82 | 2015.03 | 2773 | 8063692 | 15353172 |
| | | | 2 | 2 | 134769 | 27422 | 172119010 | 69692556 |
| | Single | 0.96411 | 3 | 2 | 104982 | 6234 | 32510373 | 3577426 |
| | | | 4 | 1 | 424808 | - | 284312376 | - |
| | Complete | 0.97417 | 5 | 5 | 29383 | 17923 | 133894156 | 29004969 |
| | | | 6 | 1 | 49326 | - | 1739213787 | - |
| | Ward | 0.98308 | 7 | 1 | 186502 | - | 1029483098 | - |
| | | | 8 | 2 | 33434 | 33192 | 351438486 | 11751643 |
| | | | 9 | 1 | 681 | - | 1315685863 | - |

Table 4.5 : Summary of the clusters

| **Group Number** | **HS Code** | | | | | | **Group Number** | **HS Code** |
|---|---|---|---|---|---|---|---|---|
| ***Group 01*** | 1 | 22 | 37 | 53 | 75 | 92 | ***Group 02*** | 3 |
| | 2 | 23 | 38 | 54 | 76 | 93 | | 6 |
| | 4 | 24 | 39 | 55 | 78 | 94 | ***Group 03*** | 7 |
| | 5 | 25 | 40 | 56 | 79 | 95 | | 8 |
| | 9 | 26 | 41 | 57 | 80 | 96 | ***Group 04*** | 14 |
| | 10 | 27 | 42 | 59 | 81 | 97 | ***Group 05*** | 21 |
| | 11 | 28 | 43 | 65 | 82 | | | 58 |
| | 12 | 29 | 44 | 66 | 83 | | | 60 |
| | 13 | 30 | 45 | 67 | 84 | | | 63 |
| | 15 | 31 | 46 | 68 | 85 | | | 64 |
| | 16 | 32 | 47 | 69 | 86 | | ***Group 06*** | 49 |
| | 17 | 33 | 48 | 70 | 87 | | ***Group 07*** | 61 |
| | 18 | 34 | 50 | 72 | 89 | | ***Group 08*** | 62 |
| | 19 | 35 | 51 | 73 | 90 | | | 88 |
| | 20 | 36 | 52 | 74 | 91 | | ***Group 09*** | 71 |

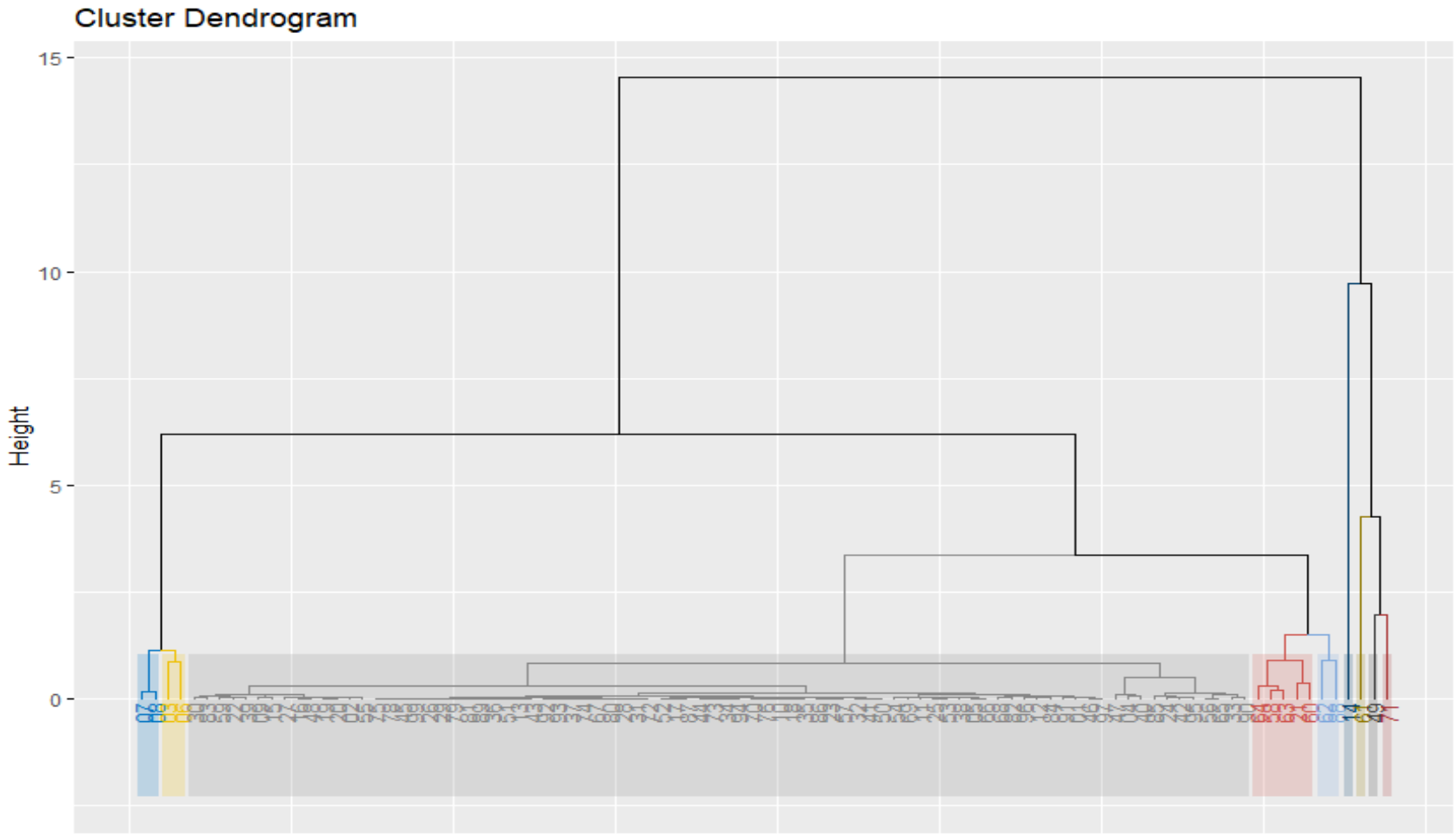


Figure 4.21 : Dendrogram diagram

According to the analysis, out of 97 categories, 82 categories have fallen into one cluster, representing nearly 85% of Cargo commodities. The rest of the 15 categories have been divided into 8 clusters. Four types of interactions between the two variables are based on the quadrants formed by splitting the X and Y axis into high and low categories. Locations where the X and Y axis are split act as reference points defining high and low values. The average values of two variables were chosen on both axes as the crosshair point to form the quadrants. Identified nine clusters have fallen into four quadrants, as shown in Figure 4.22.

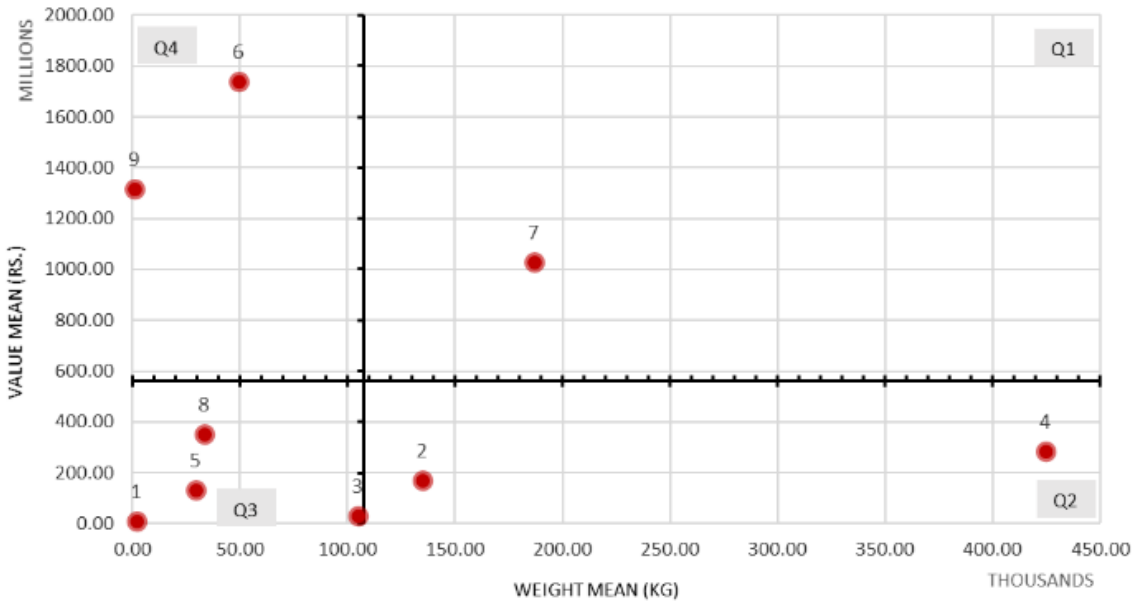


Figure 4.22 : Four Quadrant Metrix

The interaction within each quadrant can be defined as follows:

Quadrant-1(QI) (High weight / High value) is labeled “Benefits to both airline and the country”. Commodities under clusters that fall into this quadrant represent vital areas that need improvement.

Quadrant-2(Q2) (High weight / Low value) is labeled “Hight benefits for the airline compared to the country”. All commodities under clusters that fall into this quadrant are the strengths and pillars of the organizations. These commodities are related to increasing the revenue of the organization.

Quadrant-3(Q3) (Low weight / Low value) is labeled “Low benefits to both airline and the country”. Any commodity items that fall into this quadrant have less impact on the revenue of the organization or the economy of the country.

Quadrant-4(QIV) (Low weight / High value) is labeled as “High benefits to the country compared to the airline”. It denotes commodities under clusters that may be given high priority in allocating scarce resources.

Under the findings and discussion section, identified quadrants will be elaborated. The clusters under each quadrant and the industries under each cluster will be identified. Furthermore, the impact of the industries and their impact on the air cargo industry economy of the country will be discussed.

### 4.3.2 Findings & Discussion

#### *4.3.2.1 Quadrant 01*

- Cluster 7;

HS Code 61 – Articles of apparel and clothing accessories that are knitted or crocheted.

After the liberalization of the economy, multinational firms have invested in the apparel industry, seeking opportunities in Sri Lanka. Due to the ability to buy skilled labor and land space at a low cost, clothing manufacturers have shifted from East Asia to Sri Lanka. Furthermore, the easy access to Western markets through Multi Fibre Agreement (MFA) quotas is another reason for expanding the apparel industry in Sri Lanka. Around 300 manufacturing companies have provided 0.3 million direct employment opportunities and 0.6 million substantial jobs for women. Compared to the worth of total export value, nearly 25% worth of shipments are happening from the products that have fallen under cluster 7, and the annual growth will be around 13.26%. Finished apparel is exported to the Western European markets through air and sea transport modes. From the total trade, 13.8% worth of finished products is carried by air transportation to the main markets like the United States of America (USA), United Kingdom (UK), France, Switzerland, Maldives, United Arab Emirates (UAE), and Qatar are the main markets (Jayawickrama, 2013) (Board, 2020) (Sri Lanka Export Development Board, n.d.).

#### *4.3.2.2 Quadrant 02*

- Cluster 2;

HS Code 03 – Fish and crustaceans, mollusks, and other aquatic invertebrates.

The fishing industry plays a significant role in a larger community that resides along the coastline by creating 2.4 direct and indirect job opportunities and contributing 2.7% to Sri Lanka's Gross Domestic Product (GDP). Having a 1340 km coastline and 21500 km2 territorial sea area have been blessed for around 1700 fisheries boats. Compared to the total trade, 1% worth of value shipments are in this category and have 1.66% annual growth. Restoration of the GSP+ concession in 2017 and lifted the ban on Sri Lankan fish exports to the European Union in 2016. Processed or unprocessed Cuttlefish, Squid, lobsters, crabs, shark fin, shrimps, and tuna are exported to the USA, UK, Japan, France, Italy, Hong Kong, Singapore, Germany, and the Netherlands. From that trade, 50% of cargo is carried through air transportation (Sri Lanka Export Development Board, n.d.).

HS Code 06 – Live trees and other plants; bulbs, roots, and the like; cut flowers and ornamental foliage.

The beauty of Sri Lanka is the varying climatic regions within a small area and the rich biodiversity. The key success for the different varieties of stunning quality flowering plant species is due to the mix of lowland tropical climate and cool hill country temperatures. Meanwhile, the availability of a skilled and knowledgeable workforce has led to success. With an industry growth of 1.2%, this sector generates job opportunities for people in rural and sub-urban areas in Sri Lanka. From the total output, 50% worth of cargo is carried by air transportation to leading buyers like the Netherlands, Japan, Saudi Arabia, UAE, UK, Germany, and Australia (Board, 2020) (Sri Lanka Export Development Board, n.d.).

- Cluster 4 ;

HS Code 14 – Vegetable plaiting materials; vegetable products not elsewhere specified or included.

The main export items under this category are Betel leaves and coconut husk chips. Betel leaves have a higher economic and medicinal value. Value-added products like mosquito repellent coils and cream, mouthwash, toothpaste, shampoo, and face cream have been made from the betel leaves, providing thousands of stakeholders, including the farmers, and bringing foreign exchange. More than 95% of Sri Lankan betel leaves buy from Pakistan and have an annual growth of 12.64%. Similarly, Sir Lanka is one of the global's top five coconut and coconut product exporters. Fresh & desiccated coconuts, coconut water, Suga, oil, and fiber are the main exporting products. The climate around Sri Lanka guarantees harvesting around the year, providing thousands of job opportunities, mainly in Kurunegala, Kegalle, Gampaha, and Puttalam districts. The average annual growth of this sector is about 6.24%. Both air and sea transport modes are used to distribute and out from the total harvest of 20% worth of cargo carried by air. UK, France, Saudi Arabia, and Switzerland are the other main destinations for betel leaves, while Singapore, Canada, the UK, Germany, and Japan are the leading destination for coconut products (Crops, n.d.) (Sri Lanka Export Development Board, n.d.).

#### *4.3.2.3 Quadrant 03*

The commodity groups belonging to clusters 1, 3, 5, and 8 have come under Quadrant 03. (Out of 97 commodity categories, 91 categories have fallen under this).

- Cluster 1;

The behavior of 82 Commodity groups is elaborate in this cluster. Most of the time, air transportation is used to transport Live animals (3.82% Industry growth) and meat & meat edible offal (7.24% industry growth) commodity items for the international markets. Ceylon Tea, Food, feed & beverages, Spices, essential oils & oleoresins, Tobacco, Chemical & plastic products, Electric & electronic items, Ceramic & plastic products, Wood & wooden products, Ayurveda & herbals, Giftware toys, Boats & ship, and Rubber & rubber-based products are other main exports industries in the central cluster. Nearly 20% of trade is happening through air transport, and Switzerland, USA, Germany, UK, India, Hong Kong, China, and the Maldives are the main destinations. Sri Lanka is an island with rich natural resources and a skilled, knowledgeable labor force, which are the critical drivers for the growth of industries (Board, 2020).

- Cluster 3;

HS Code 7 & 8 – Edible vegetables and certain roots and tubers & Edible fruit and nuts; peel of citrus fruit or melons.

The revenue gained by exporting fruits and vegetable products has boosted the national GDP over the past years. Due to the different climate regions in Sri Lanka, farmers benefit from selecting any item from a wide range of fruits and vegetables for their cultivation. The highly technical irrigation system and new technology, pest and disease control, postharvest management, quality packaging, best supply chain management practices, and easy access to the airport are key success factors for the growth of the fruits and vegetable exporting industry (7.24% industry growth). Averagely 80% of the trade is happening through air transportation, and the Maldives, UAE, Qatar, Switzerland, Canada, and the UK are the main destinations (Board, 2020).

- Cluster 5;

Fabrics, Footwear & leather products are the primary commodities under cluster 05. The availability of high-quality raw materials like natural rubber for sole crepe and leather, sustainable production procedures, and creative designs are the competitive advantages of Sri Lankan footwear manufacturers. Apart from footwear bags, wallets, purses, and gloves, some other products are included in the leather industry. More than 20000 people are working under around 4000 companies. After 2018 we can see a decline in the footwear industry. Around 30% worth of cargo is carried by air mode to the main destinations like the USA, India, Vietnam, UK, Hong Kong, Pakistan, and China (Board, 2020) (Sri Lanka Export Development Board, n.d.).

- Cluster 8;

HS Code 61 & 88 – Articles of apparel and clothing accessories that are not knitted or crocheted & aircraft, spacecraft, and parts thereof.

Not only for the knitted or crocheted apparel sector, a considerable amount of not knitted or crocheted garments are also exported from Sri Lanka. As the regional supply chain logistic hub in Sri Lanka, several European and Asian fabric suppliers store their fabric in Sri Lanka to support fast fashion and grow by 2.22% in this sector. We have the advantage of fast regional shipping times and clearing in less than 24 hours. USA, UK, Italy, Germany, and Netherlands are the main

destinations through air transportation. Meanwhile, we could see a 2.22% growth in aircraft, spacecraft, and parts exports from Sri Lanka. Singapore, Germany, France, Austria, and the USA are the main destinations exported via air transportation (Board, 2020).

#### *4.3.2.4 Quadrant 04*

- Cluster 6;

HS Code 49 – Printed books, newspapers, pictures, and other products of the printing industry; manuscripts, typescripts, and plans.

It is rare to hear that the printing, prepress and packaging industry provides significant support for the export sector with more than 50 years of history in Sri Lanka. Tea cartons, garment tags, labels, printed books, pictures, newspapers, manuscripts, paper, or paperboards are some of the exported items in this sector. Today, the industry has adapted to the new technology, best practices, and customer requirements according to world standards. More than 40000 employees are working under more than 4000 manufacturers and supporting improving the economy in Sri Lanka. The printing industry made a 5.61% growth in the past few years. According to the total exports, 90% worth of printing items is carried by air transport mode to the primary markets like Singapore, the USA, the UK, Vietnam, and India (Board, 2020) (Sri Lanka Export Development Board, n.d.).

- Cluster 9;

HS Code 71 – Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles thereof; imitation, jewelry; coin.

Sri Lanka Was referred to as the "Pearl in the Indian Ocean" and "Rathna Deepa" many centuries ago as the island is blessed with gems and precious stones. Even today, Sri Lanka has remarked on the international market as one of the world's top five gem-bearing nations. Including the miners, cutters, polishers, dealers, and designers, nearly 600000 employers are dependent on this industry. They have refined their genetic skills, ancient knowledge, and traditional designs over the years and combined new technologies to produce some of the best jewelry in the global market. Unfortunately, we can see a shrink in the gem and jewelry export industry over the past few years. More than 70% worth of precious products are transported by air, and Israel, Hong Kong, USA,

Switzerland, Thailand, Belgium, and France are the leading destinations (Board, 2020) (Sri Lanka Export Development Board, n.d.).

#### *4.3.2.5 Global Demand Trends for Sri Lanka Production*

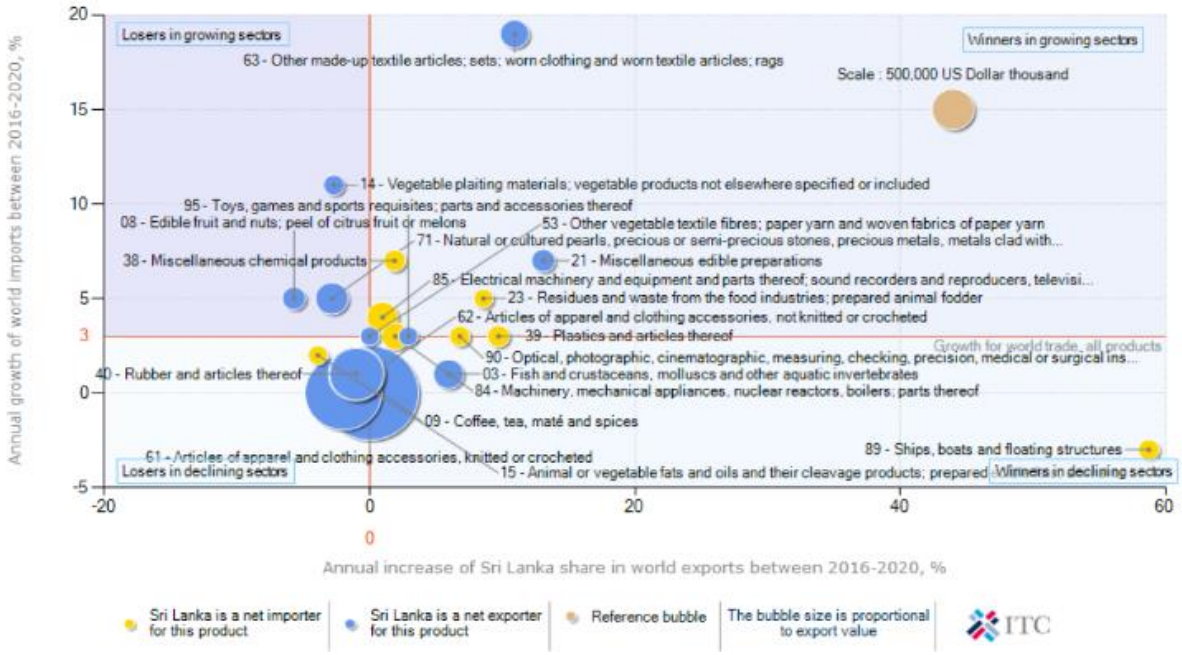


Figure 4.23 : Growth of global demand trend and growth of Sri Lanka production (Board, 2020)

Winners in growing sectors – Referring to the industries which have grown in global demand and the growth in Sri Lanka production. Mechanical appliances, Machinery, Electrical, electronic equipment, Miscellaneous chemical products, Plastics & articles, Miscellaneous edible preparations, Residues & waste from food are industries that fall into this category. According to our matrix, these industries have come under quadrant 3. It means that the portion of the commodities exported through air transportation is less than other commodities. Hence, aviation strategies should be implemented to expand the supply capacity and capture the market destinations with increasing demand.

Losers in growing sectors – Industries under this category have the world demand. However, industry growth in Sri Lanka is falling. Edible fruit and nuts, Toys, games and sports requisites, Vegetable planting materials, Natural or cultured pearls, Miscellaneous chemical products, precious or semi-precious stones, and precious metals industries come under this section.

In our matrix, the precious and semi-precious stones industry has come under quadrant 4. Unfortunately, the growth of this industry has declined over the past few years. Further rest of the industries have come under quadrant 3. Fortunately, there is still potential to enhance the sectors like edible fruit, nuts, and vegetable planting material as Sri Lanka is blessed with natural resources. Therefore, there should be a proper mechanism to enhance these industries, strengthening the aviation industry and the economy of the country.

Losers in declining sectors – it means that both Sri Lanka's share of that products in world exports and world demand for the products are declining. Industries like Rubber and articles, Animal or vegetable fats and oils, Articles of apparel, accessories, knit, not knit, or crochet are fallen into this category. Still, more than 25% volume of export air cargo is from the articles of the apparel and accessories industry. Therefore, there should be a proper strategy to overcome these issues: integrating with other potential industries, overall cost leadership, and differentiation.

Winners in declining sectors -These are the industries that grow the industry in Sri Lanka but decline in demand worldwide. Fish, crustaceans, mollusks, aquatic invertebrates, and Ships, Boats & floating structures industries are coming under this category. Fish, crustaceans, mollusks, and other aquatic invertebrates highly contribute to the air cargo transportation industry. Therefore, there should be a proper plan to protect the demand side with the best decisions: end-game decisions like niche market strategies, leadership strategies, or overall cost leadership (Board, 2020).

### 4.4 Regression Analysis

Typically, air transportation plays a significant role in social and economic development. Furthermore, air transport is a complex system that includes airports, aircraft, air traffic management systems, and flight routes. In the airline industry, air passenger and cargo demand forecasting values are a vital element for the airport, airline, and airfreight managers to make timely operation and decision-making plans (Daniel Y. Suh, 2019) (Shuojiang Xua, 2019). Hence, the main objective of this section is to identify the key influencing factors for the growth of air cargo demand and understand the factors needed to focus on when developing models to identify the air cargo demand.

Analyzing and modeling passenger and cargo demand is dynamic. The propositions taken by the management and the operation in the entire aviation industry seem to be a tough challenge (Shuojiang Xua, 2019). Demand forecasting is a well-established research topic in the aviation industry in the same way as in many areas. However, it is challenging to forecast passenger and air cargo demand due to its multiple characteristics, such as irregularity, high volatility, and non-stationarity (Feng Jin, 2020). As discussed in chapter 02, many research studies have been conducted using different factors and methods to forecast air cargo demand and those that did not consider the demand from passenger and cargo carriers together.

### 4.4.1 Variables

#### *4.4.1.1 Dependent variable*

The ultimate motivation for exporting cargo is to strengthen the country's economy by the financial benefits for the people of the country and the airlines. The impact of the value of air cargo shipments on revenue management in the aviation industry has not been studied yet. However, Soufiane Daher points out that when the value of air cargo is high, it will mainly impact the economy of a country or region. That will improve local industries and broader logistics (Daher, 2021). Therefore, the dependent variable for the analysis was selected as the total value of export air cargo for each destination from Sri Lanka. Only 2019 export air cargo data were considered for the regression analysis.

#### *4.4.1.2 Independent Variables*

The factors mentioned in the 2.1 section were used to develop the models for demand calculations and predictions. The brainstorming sessions and opinion surveys were conducted with expertise from the airline industry, freight forwarding industry, and academia. These experts have more than ten (10) years of experience in the aviation industry. Hence, with having great background and experience, they were asked to categorize the factors identified into groups according to similarity and relationship. By considering interconnection and relationships, all the factors were pooled into seven (7) categories. These seven (7) categories are airport capability, airline capabilities, aircraft capabilities, economic, market, environmental, and human factors. The population of a country,

Population Growth, GDP, GDP Growth, Total Passenger demand, Total Cargo Demand, Hub Connectivity, Employment rate, and CO2 emission due to the aviation industry are the selected factors under-considered seven categories. The historical data in 2019 was considered, and the data was collected from World Bank Reports, IATA reports, and Our world in data sources.

Glenn Baxter and Panarat developed a model in 2018 to identify the export air cargo demand from Australia to the world with six variables, including world population growth, air freight yields, and world. However, this study aims to identify the air cargo demand for different destinations. Therefore, the population and population growth at a destination and cargo demand at a destination were considered for this study. When the population is high, there is a possibility of high usage of cargo. GDP is considered the measurement of the economic level of the country. Since economic activities at a destination are the primary driver of air cargo movements, GDP and GDP growth appear to be explanatory factors in most cargo demand models. Hub connectivity or connectivity index indicates the ability to participate in the global markets and facilitate global production and supply chain. The employment rate of a country represents the ability to supply cargo demand accordingly. At the same time, it is better to understand the impact of CO2 emission due to the aviation industry, which indicates the aircraft operations at a destination.

### 4.4.2 Conceptual model

This section aims to identify the factors that will affect the air cargo demand at a destination from the chosen independent variables and develop a model to predict the future air cargo demand. The regression analysis method was used to achieve the goals.

#### *4.4.2.1 Regression model 01*

All air cargo volumes going from Sri Lanka were considered for the regression model. There is nearly 200 destination that represents the destination of air cargo going from Sri Lanka. Even though only 126 destinations were considered for the analysis with the availability of independent variable's value at the destinations.

There are nine main hypotheses are analyzed,

1. The population impacts the growth of air cargo demand at a destination.

2. Population growth impacts the growth of air cargo demand at a destination.
3. GDP impacts the growth of air cargo demand at a destination.
4. GDP growth impacts the growth of air cargo demand at a destination.
5. Passenger Capacity impacts the growth of air cargo demand at a destination.
6. Cargo Capacity impacts the growth of air cargo demand at a destination.
7. The connectivity Index impacts the growth of air cargo demand at a destination.
8. CO2 emissions due to aviation impact the growth of air cargo demand at a destination.
9. The employment rate impacts the growth of air cargo demand at a destination.

The first linear model is as below (Model 01). This linear model estimated the statistical relationship the between dependent variables (Export value) and the independent variables.

Model 01

$$Y = \beta_0 + \beta_1 (\text{Population}) + \beta_2 (\text{Population Growth}) + \beta_3 (\text{GDP}) + \beta_4 (\text{GDP Growth}) + \beta_5 (\text{Passenger Capacity}) + \beta_6 (\text{Cargo Capacity}) + \beta_7 (\text{Connectivity Index}) + \beta_8 (CO_2 \text{ Emission}) + \beta_9 (\text{Employment Rate}) + \mu$$

Where,

Y : Potential Air Cargo Value
μ : Standard error

As first data set splits into two sets, one is to train the mode; and the other set is to validate purposes. Typically, 80% is used for training the model, and 20% is used to evaluate the model's performance. After splitting the data set, all variables' significance values were studied. From the results, it was identified that out of nine independent variables, only three variables have a significant relationship with the dependent variable.

Table 4. 6 : Relationship between the dependent variable and independent variables

| Residuals | | | | | |
|---|---|---|---|---|---|
| Min | 1Q | Median | 3Q | Max | |
| -1.78E+09 | -3.47E+08 | 5.59E+07 | 1.92E+08 | 8.02E+09 | |
| | | | | | |
| Coefficients: | | | | | |
| | Estimate | Std. Error | t value | Pr(>\|t\|) | |

| | | | | | |
|---|---|---|---|---|---|
| (Intercept) | -2.39E+08 | 3.15E+08 | -0.759 | 0.44966 | |
| Population | 5.03E-01 | 7.73E-01 | 0.651 | 0.51684 | |
| Population Growth | 3.37E+07 | 1.06E+08 | 0.319 | 0.75028 | |
| GDP | 1.51E+04 | 5.50E+03 | 2.749 | 0.723 | |
| GDP Growth | -7.78E+06 | 4.55E+07 | -0.171 | 0.86452 | |
| Passenger Capacity | -6.13E+00 | 4.68E+00 | -1.309 | 0.19382 | |
| Cargo Capacity | 6.08E+07 | 2.65E+07 | 2.29 | 0.0244 | * |
| Connectivity Index | 5.90E+01 | 2.13E+01 | 2.766 | 0.00689 | ** |
| CO2 Emission | -4.32E+03 | 4.45E+04 | -0.097 | 0.9229 | |
| Employment Rate | -1.17E+07 | 2.35E+07 | -0.496 | 6.21E-01 | |
| | | | | | |
| Signif. Codes: | 0 * | 0.001 ** | 0.01 * | | |
| | | | | | |
| Residual standard error : 492800000 on 89 degrees of freedom | | | | | |
| Multiple R-squared : 0.531 , | | Adjusted R-squared : 0.484 | | | |
| F - statistic : 11.2 on 9 and 89 DF, p-value: <1.632e-11 | | | | | |

Out of the nine independent variables, three independent variables have a statistical relationship with the dependent variables. The variables that do have any relationship are cargo capacity and connectivity index. In the second step, the multicollinearity of these variables was examined. Before running the regression analysis, removing the variables with interrelationships among independent variables is necessary. The test result shows that cargo capacity at a destination and connectivity index is not correlated with other variables.

Table 4.7 : Summary of the regression analysis

| | | | | | |
|---|---|---|---|---|---|
| Residuals | | | | | |
| Min | 1Q | Median | 3Q | Max | |
| -2.040e+09 | -1.293e+08 | 4.988e+07 | 1.288e+08 | 2.411e+09 | |
| | | | | | |
| Coefficients : | | | | | |
| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
| (Intercept) | -1.410e+08 | 8.085e+07 | -1.744 | 0.0844 | * |
| Cargo Demand | 7.126e+04 | 1.543e+04 | 4.619 | 1.22e-05 | *** |
| Connectivity Index | 6.636e+01 | 9.567e+00 | 6.936 | 5.07e-10 | *** |
| | | | | | |
| Signif. Codes: | 0 * | 0.001 ** | 0.01 * | | |
| | | | | | |
| Residual standard error : 5.54e+08 on 89 degrees of freedom | | | | | |
| Multiple R-squared : 0.7507 , | | Adjusted R-squared : 0.7428 | | | |
| F - statistic : 94.37 on 3 and 89 DF, p-value: <2.2e-16 | | | | | |

The derived model for the calculation can be shown as below.

Potential Air Cargo Demand = $\beta_0 + \beta_1 *$ Cargo Capacity + $\beta_2 *$ Connectivity Index

$\beta_0 = -1.41 * 10^8$

$\beta_1 = 7.12 * 10^4$

$\beta_2 = 6.63 * 10^1$

The K-fold cross validation method was used to validate the model as the available data set is small. The results are as below.

```
Linear Regression

124 samples
  2 predictor

No pre-processing
Resampling: Cross-Validated (10 fold, repeated 3 times)
Summary of sample sizes: 110, 112, 112, 112, 112, 112, ...
Resampling results:

  RMSE       Rsquared   MAE
  753266238  0.6635332  370330407

Tuning parameter 'intercept' was held constant at a value of TRUE
```

Several researchers have different opinions on the identified factors influencing air cargo demand at a destination. The results of this study also have different outputs than the other research works.

# CHAPTER 05 – SUMMARY & CONCLUSIONS.

As a result of globalization, logistics has become the leading sector globally. Air, sea, land, and rail are the fundamental modes of transportation that facilitate trade, distribution, or logistics activities. Sri Lanka is an island in a strategic geographical location; there is a high potential to become one of the busiest logistic hubs in the world. Therefore, air and sea transportation are the fundamental modes that could enhance trade activities in Sri Lanka. Unfortunately, the relevant authorities and parties have failed to implement a proper plan and policies to gain the gold out of it. The findings of this research will help identify the areas that need to be focused on implementing strategies to improve the air cargo trade activities in Sri Lanka.

This chapter summarized the finding of the study in two directions. The methodological framework of using historical (secondary) data and studying the export air cargo market has been discussed in the first sector. Identifying the key influencing factors for the growth of air cargo demand for Combi carriers has been discussed in the second sector.

## 5.1 Cluster analysis

The first part of the study analyses assessed the outbound air cargo and categorized them according to the behavior patterns. Export air cargo data were considered for the analysis. Five years of data were taken from Sri Lanka Customs, including more than five hundred thousand shipment details. All the commodities were grouped into 97 groups using the HS code classification. Shipment's weight and value were considered as the variables for the cluster analysis to categorize the identified groups. Through the cluster analysis, 9 clusters showed an apparent difference in air cargo behavior. Out of 97 commodity groups, 82 groups have fallen into one cluster, and the rest of the 15 groups have been divided into 8 clusters. Further classification is done (Four quadrant matrix was built) according to high-high, high-low, low-high and low-low value to weight ratio.

- It was identified that 25% worth of export shipments are from Articles of apparel and clothing accessories that are knitted or crocheted (HS Code 61).
    - Furthermore, from the developed quadrant matrix, it was identified that there is an advantage for both economy of the country and the airlines.

- However, world demand for articles of apparel and clothing accessories and Sri Lanka's share in world exports are declining.
- Therefore, a proper mechanism should be implemented to overcome this challenge. Overall cost leadership and differentiation are some strategies to win the market and enhance cargo demand in the aviation industry.

- Fish and crustaceans, mollusks, and other aquatic invertebrates (HS code 3), live trees and other plants, bulbs, roots, cut flowers and ornaments (HS Code 6) and vegetables plaiting materials, and vegetable products not elsewhere specified or included (HS Code 14) industries identified as the industries which give economically advantage to the airlines compared to the country.
  - More than 50% worth of products in each sector are exported through the aviation industry.
  - Unfortunately, the demand growth for the vegetable planting materials industry in Sri Lanka is decreasing, whereas industry demand growth in the world is increasing.
  - As Sri Lanka is blessed with natural resources, there is an opportunity to enhance the vegetable products industry.
  - The world demand for fish and other aquatic invertebrates has been declining over the years, while the industry in Sri Lanka has been growing.
  - Niche market, leadership, and overall cost leadership strategies can be implemented to protect and sustain the fishery industry.

- Printed books, newspapers, pictures, and other products of the printing industry; manuscripts, typescripts and plans (HS Code 49) and natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal, and articles thereof; imitation, jewelry; coin (HS Code 71) industries were identified as the industries which are highly influenced the economy of the country compared to the airlines.
  - Word demand for precious stones, metals, and jewelry has increased over the years, and Sri Lanka has a high market share globally.
  - Nearly 70% of trade is happening through air transportation, and unfortunately, the growth of the export industry has been declining over the past few years.

    - Therefore, other strategies should be implemented to increase the share percentage of the industry and the usage of air transportation.
- Out of 97 air cargo groups, nearly 90% have fallen into one category. It was identified that the influence level of these products on the economy of the country and airlines is low compared to other industries.
    - Nevertheless, the industries like Electronical machinery and equipment (HS Code 85), Residues and waste from the food industries (HS Code 23), Miscellaneous edible preparation, and plastic industries (HS Code 21) have a high demand growth globally. At the same time, Sri Lanka has a high share market worldwide.
    - The industries like Toys, games, sports, parts, and accessories (HS Code 95) and Miscellaneous chemical products (HS Code 38) have a high demand growth but declining Sri Lanka's market share worldwide.
    - Therefore, new strategies and policies should introduce to improve the export industry and the usage of air transportation for distribution activities.

## 5.2 Regression Analysis

Recently, changes in social, economic, and environmental behaviors have impacted the usage of Combi carriers for air cargo transportation. Therefore, it is necessary to identify the key influence factors for the growth of air cargo demand of Combi Carriers. More than 98% of air cargo trades in Sri Lanka are happening through Combi Carriers. Hence, Sri Lanka will be a best-case study to analyze the Combi carriers. Regression analysis was conducted to identify the key factors influencing air cargo demand growth for the Combi Carriers. The factors for the analysis were selected from previous research works on air cargo transportation and discussions held with industry experts.

- Out of nine factors, two factors were identified as influencing factors for air cargo demand growth at a destination. Those are total air cargo demand and the connectivity index at a destination.
- According to the results, it was found that air cargo demand at a destination and the connectivity index at a destination affect the growth of air cargo demand for Combi

Carriers at those destinations. Therefore, airlines (Sri Lankan Airlines) should focus on those areas when developing air route networks and strategies.

## 5.3 Recommendation

The same scenario can be applied to Sri Lanka as well. Increasing the air cargo capacity and the country's connectivity will attract other aircraft or Combi Carriers. These activities will open the path for many job opportunities. These activities will open the path for many job opportunities, and it will help to strengthen the economy of the country.

- The identified industries through cluster analysis affect for improvement of Air cargo capacity in Sri Lanka.
    - Nearly 25% worth of export shipments are from Articles of apparel and clothing accessories that are knitted or crocheted. Furthermore, from the developed quadrant matrix, it was identified that there is an advantage for both economy of the country and the airlines.
    - Word demand for precious stones, metals, and jewelry has increased over the years, and unfortunately, the growth of the export industry in Sri Lanka has been declining over the past few years.
    - Fish & seafood, Live plants, fresh flowers, and vegetable-related industries were identified as the other main industries that will highly impact the air cargo industry in Sri Lanka.
- To improve the Air connectivity in Sri Lanka.
    - Improve the facilities at the airport to enhance the air cargo handling capacity
    - The policies and agreements needed to be implemented to enhance air connectivity at the airports. USA, UK, Italy, Germany, France, UAE, Netherlands, Maldives, and Pakistan are some of the leading air cargo export destinations. The agreements will help for smooth cargo operations.

- Finally, the following are some identified strengths that will be reasons for improving the identified factors in Sri Lanka.
    - The natural advantage of the central location of Sri Lanka

- Land availability in the region to expand the capacity and facilities
- Availability of Human professional resource
- Availability of labor - Human resource

## 5.4 Limitations of the study

It is rare to find research d on the air cargo demand for Combi Carriers. After the Covid 19 outbreak, airlines and people tend to find solutions to utilize air transportation for cargo and passengers. However, it was challenging to identify the influencing factors for the air cargo demand for Combi Carriers through a literature review. At the same time, finding the values of identified factors at each destination through websites was another challenge. Finally, from nearly 200 destinations, only 126 destinations were selected for the regression analysis. Country selection will lead to the accuracy of the model.

Collecting the data on all single shipments over the past years was another challenge as it was a large sum of data set. The covid pandemic also blocked the chances to meet the relevant parties physically and explain myself and the research work. Therefore, it took more than five months to collect the data from Sri Lanka Customs by communicating only through emails and telephone calls.

The data collection period from Sri Lanka Customs for the analysis was pre covid 19 pandemic period. Therefore, the data should be validated with the post covid pandemic as the behavior of the trade patterns might have changed accordingly.

## 5.5 Future Research

There are many opportunities to extend this research further. Analyzing the presence patterns and exploring the areas that need to be developed is the initial step in future cargo transportation. Different directions in which the research can further be extended are,

- The factors identified here are mainly related to the current situation in Sri Lanka. Applying this methodology to other economic zones will add new factors related to their economic

contexts and could generalize the influencing factors for the growth of air cargo demand for Combi Carriers by finding more results.

- The factors selected for this study were used by other researchers to develop models to forecast air cargo demand. The result of the study identified that only two factors have a relationship with air cargo demand. Therefore, further study can identify the reasons for not having a relationship with other factors.
- The challenges faced, and the social, economic, and environmental changes that happened due to the covid 19 pandemic cannot be neglected when developing a model to forecast the future. Therefore, identifying the differences between pre-pandemic and post-pandemic periods is essential.
- When conducting market analysis in the aviation industry, it should focus on outbound and inbound market share to maximize revenue and reduce any losses. Therefore, a proper mechanism to analyze import air cargo demand can be developed.
- This study focuses on maximizing the profits of the Combi carriers by enhancing the air cargo demand. Therefore, identifying the passenger demand for other destinations cannot be ignored.

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## APPENDIX 1

SECTION I

**LIVE ANIMALS; ANIMAL PRODUCTS**

**Section Notes**.

01 Live animals.
02 Meat and edible meat offal.
03 Fish and crustaceans, molluscs and other aquatic invertebrates.
04 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included.
05 Products of animal origin, not elsewhere specified or included.

SECTION II

**VEGETABLE PRODUCTS**

**Section Notes**.

06 Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage.
07 Edible vegetables and certain roots and tubers.
08 Edible fruit and nuts; peel of citrus fruit or melons.
09 Coffee, tea, mate and spices.
10 Cereals.
11 Products of the milling industry; malt; starches; inulin; wheat gluten.
12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder.
13 Lac; gums, resins and other vegetable saps and extracts.
14 Vegetable plaiting materials; vegetable products not elsewhere specified or included.

SECTION III

**ANIMAL OR VEGETABLE FATS AND OILS AND THEIR CLEAVAGE**

**PRODUCTS; PREPARED EDIBLE FATS;ANIMAL OR VEGETABLE WAXES**

15 Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes.

SECTION IV

**PREPARED FOODSTUFFS;**
**BEVERAGES, SPIRITS AND VINEGAR; TOBACCO**
**AND MANUFACTURED TOBACCO SUBSTITUTES**

**Section Notes**.

16 Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates.
17 Sugars and sugar confectionery.
18 Cocoa and cocoa preparations.
19 Preparations of cereals, flour, starch or milk; pastrycooks' products.
20 Preparations of vegetables, fruit, nuts or other parts of plants.
21 Miscellaneous edible preparations.
22 Beverages, spirits and vinegar.
23 Residues and waste from the food industries; prepared animal fodder.
24 Tobacco and manufactured tobacco substitutes.

SECTION V

## MINERAL PRODUCTS

25 Salt; sulphur; earths and stone; plastering materials, lime and cement.
26 Ores, slag and ash.
27 Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes.

SECTION VI

## PRODUCTS OF THE CHEMICAL OR ALLIED INDUSTRIES

**Section Notes**.
28 Inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, of radioactive elements or of isotopes.
29 Organic chemicals.
30 Pharmaceutical products.
31 Fertilisers.
32 Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring matter; paints and varnishes; putty and other mastics; inks.
33 Essential oils and resinoids; perfumery, cosmetic or toilet preparations.
34 Soap, organic surface-active agents, washing preparations, lubricating preparations, artificial waxes, prepared waxes, polishing or scouring preparations, candles and similar articles, modelling pastes, "dental waxes" and dental preparations with a basis of plaster.
35 Albuminoidal substances; modified starches; glues; enzymes.
36 Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations.
37 Photographic or cinematographic goods.
38 Miscellaneous chemical products.

SECTION VII

## PLASTICS AND ARTICLES THEREOF; RUBBER AND ARTICLES THEREOF

**Section Notes**,
39 Plastics and articles thereof
40 Rubber and articles thereof

SECTION VIII

## RAW HIDES AND SKINS, LEATHER, FURSKINS AND ARTICLES THEREOF; SADDLERY AND HARNESS; TRAVEL GOODS, HANDBAGS AND SIMILAR CONTAINERS; ARTICLES OF ANIMAL GUT (OTHER THAN SILK-WORM GUT)

41 Raw hides and skins (other than furskins) and leather.
42 Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut).
43 Furskins and artificial fur; manufactures thereof.

SECTION IX

## WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL; CORK AND ARTICLES OF CORK; MANUFACTURES OF STRAW, OF ESPARTO OR OF OTHER PLAITING MATERIALS; BASKETWARE AND WICKERWORK

44 Wood and articles of wood; wood charcoal,

45 Cork and articles of cork.
46 Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork.

SECTION X

**PULP OF WOOD OR OF OTHER FIBROUS CELLULOSIC MATERIAL; RECOVERED (WASTE AND SCRAP) PAPER OR PAPERBOARD; PAPER AND PAPERBOARD AND ARTICLES THEREOF**

47 Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard.
48 Paper and paperboard; articles of paper pulp, of paper or of paperboard.
49 Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans.

SECTION XI

**TEXTILES AND TEXTILE ARTICLES**

**Section Notes**.
50 Silk.
51 Wool, fine or coarse animal hair; horsehair yarn and woven fabric.
52 Cotton,
53 Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn.
54 Man-made filaments.
55 Man-made staple fibres.
56 Wadding, felt and nonwovens; special yarns; twine, cordage, ropes and cables and articles thereof
57 Carpets and other textile floor coverings.
58 Special woven fabrics; tufted textile fabrics; lace; tapestries; trimmings; embroidery.
59 Impregnated, coated, covered or laminated textile fabrics; textile articles of a kind suitable for industrial use.
60 Knitted or crocheted fabrics.
61 Articles of apparel and clothing accessories, knitted or crocheted.
62 Articles of apparel and clothing accessories, not knitted or crocheted.
63 Other made up textile articles; sets; worn clothing and worn textile articles; rags.

SECTION XII

**FOOTWEAR, HEADGEAR, UMBRELLAS, SUN UMBRELLAS, WALKING-STICKS, SEAT-STICKS, WHIPS, RIDING-CROPS AND PARTS THEREOF; PREPARED FEATHERS AND ARTICLES MADE THEREWITH; ARTIFICIAL FLOWERS; ARTICLES OF HUMAN HAIR**

64 Footwear, gaiters and the like; parts of such articles,
65 Headgear and parts thereof
66 Umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof
67 Prepared feathers and down and articles made of feathers or of down; artificial flowers; articles of human hair.

SECTION XIII

**ARTICLES OF STONE, PLASTER, CEMENT, ASBESTOS, MICA OR SIMILAR MATERIALS; CERAMIC PRODUCTS; GLASS AND GLASSWARE**

68 Articles of stone, plaster, cement, asbestos, mica or similar materials.
69 Ceramic products.
70 Glass and glassware.

SECTION XIV

**NATURAL OR CULTURED PEARLS, PRECIOUS OR SEMI-PRECIOUS STONES, PRECIOUS METALS, METALS CLAD WITH PRECIOUS METAL AND ARTICLES THEREOF; IMITATION JEWELLERY; COIN**

71 Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles thereof; imitation, jewellery; coin.

SECTION XV

**BASE METALS AND ARTICLES OF BASE METAL**

**Section Notes**.

72 Iron and steel.
73 Articles of iron or steel.
74 Copper and articles thereof
75 Nickel and articles thereof.
76 Aluminium and articles thereof
77 *(Reserved for possible future use in the Harmonized System)*
78 Lead and articles thereof
79 Zinc and articles thereof.
80 Tin and articles thereof.
81 Other base metals; cermets; articles thereof.
82 Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal.
83 Miscellaneous articles of base metal.

SECTION XVI

**MACHINERY AND MECHANICAL APPLIANCES; ELECTRICAL EQUIPMENT; PARTS THEREOF; SOUND RECORDERS AND REPRODUCERS, TELEVISION IMAGE AND SOUND RECORDERS AND REPRODUCERS, AND PARTS AND ACCESSORIES OF SUCH ARTICLES**

**Section Notes**.

84 Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof
85 Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles,

SECTION XVII

**VEHICLES, AIRCRAFT, VESSELS AND ASSOCIATED TRANSPORT EQUIPMENT**

**Section Notes**.

86 Railway or tramway locomotives, rolling-stock and parts thereat railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro-mechanical) traffic signalling equipment of all kinds.
87 Vehicles other than railway or tramway rolling-stock, and parts and accessories thereof.
88 Aircraft, spacecraft, and parts thereof.
89 Ships, boats and floating structures.

SECTION XVIII

**OPTICAL, PHOTOGRAPHIC, CINEMATOGRAPHIC, MEASURING, CHECKING, PRECISION, MEDICAL OR SURGICAL INSTRUMENTS AND APPARATUS; CLOCKS AND WATCHES; MUSICAL INSTRUMENTS;**

**PARTS AND ACCESSORIES THEREOF**

90 Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof

91 Clocks and watches and parts thereof.

92 Musical instruments; parts and accessories of such articles.

SECTION XIX

**ARMS AND AMMUNITION; PARTS AND ACCESSORIES THEREOF**

93 Arms and ammunition; parts and accessories thereof.

SECTION XX

**MISCELLANEOUS MANUFACTURED ARTICLES**

94 Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated nameplates and the like; prefabricated buildings.

95 Toys, games and sports requisites; parts and accessories thereof

96 Miscellaneous manufactured articles.

SECTION XXI

**WORKS OF ART, COLLECTORS' PIECES AND ANTIQUES**

97 Works of art, collectors' pieces and antiques.

98 *(Reserved for special uses by Contracting Parties)* 99 *(Reserved for special uses by Contracting Parties)*