CONTRIBUTION OF PORT LOGISTICS DEVELOPMENTS FOR THE MARITIME CONNECTIVITY OF A PORT

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ABSTRACT

Contribution of port logistics developments for the maritime connectivity of a port

Maritime connectivity of a port explains how well a port is connected to international maritime networks. When a container line selects a port of call, it takes into consideration maritime connectivity of the particular port. Therefore, port authorities strive to enhance the quality of services offered by ports with the assistance of suitable port logistics facilities.

This nature motivated to study the contribution of port logistics developments for the maritime connectivity of ports. The methodology adopted for the current study is comprised of two stages. First stage online mail survey based on the perception of senior managers attached to global container line agencies and local offices registered in Sri Lanka try to identify, which port logistics developments affect maritime connectivity of ports. The second stage quantitative data analysis was conducted using Pearson correlation method to validate the results of the mail survey. And simple linear regression analysis was performed to assess how significant is each port logistics development on the maritime connectivity of a ports.

Accordingly, port annual handling capacity, number of quay cranes available, number of reefer plugging facilities available, number of berths available, quay length and number of terminals are identified as significant port logistics developments to the maritime connectivity of a port. Due to the limitations in collecting required data the second stage analysis is limited only to the superstructure and infrastructure related port logistics developments.

This current study envisions new area on which port logistics developments affect maritime connectivity of a port. Therefore, this is beneficial for both port terminal operators and ship operators. Terminal operators will be benefited in identifying optimal development options to enhance port connectivity while container line network planners will be benefited in identifying which factors they should consider in identifying most connected hub ports for their container linear services.

Key words- Maritime connectivity, Port logistics, Intermediary ports, Container liner services, Hub ports

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Surandika Rupasinghe

LIST OF ACRONYMS

Abbreviation	Description
ASC	- Annualized Slot Capacity
TEU	- Twenty feet Equivalent Unit
ULCS	- Ultra Large Container Ship
EDI	- Electronic Data Interchange
SLR	- Simple Linear Regression
LSCI	- Liner Shipping Connectivity Index
JCT	- Jaya Container Terminal
SAGT	- South Asia Gateway Terminals
CICT	- Colombo International Container Terminal
UCT	- Unity Container Terminal
RORO	- Roll On Roll Out

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CHAPTER 1 – INTRODUCTION

1.1 Background

Technological advancements, globalization and economic internationalization across the globe have eased the day to day activities of humans. Today people are not willing to spend their valuable time on non-value adding activities like shopping and travelling. Everything is now at their fingertips as a result of e-commerce. Anyone can order anything they want using virtual shopping stores like Amazon, EBay and Ali Express, and goods are delivered on next day. Therefore, in achieving product flow and service level effectiveness and efficiencies to deliver maximum value to the customer, supply chain integration is highly demanded. Supply chain integration is an emerging concept whereby manufacturers strategically collaborate with supply chain partners in managing both intra and inter organization processes. As maritime transport plays a vital role in facilitating global supply chains and internationalization of economies, maritime logistics service providers should drive these systems well. Thus maritime transportation has become the backbone of both domestic and international trade while giving enormous contribution for supply chain enhancements. In addition, it could be considered as the clean, safe and the most economical and cost effective mode of transportation for international freight distribution.

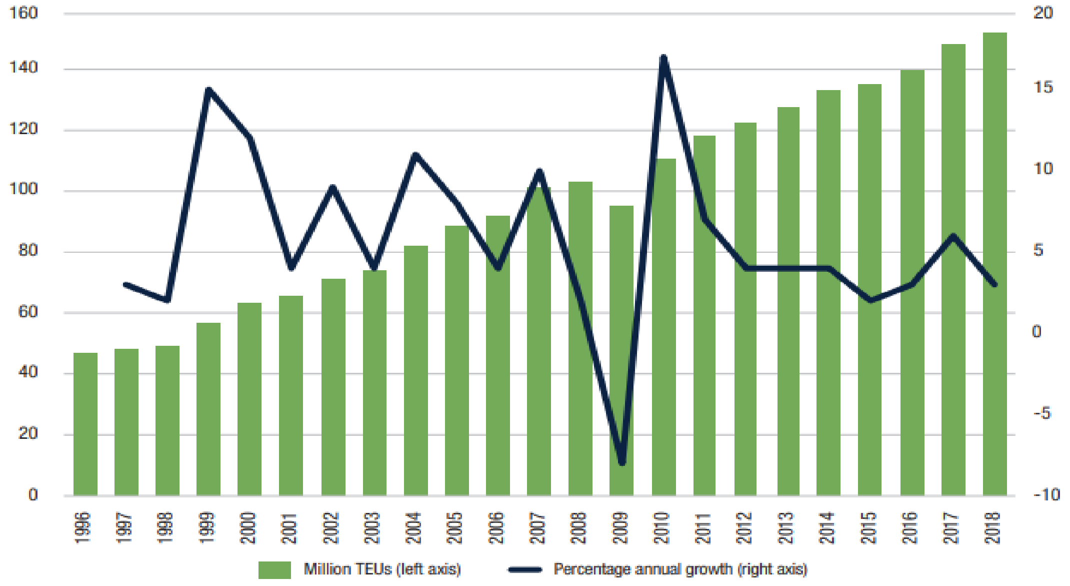

Figure 1-1 Global Containerized Trade- 1996-2018 (Millions of TEU and Percentage annual change) Source- Review of Maritime, 2019

The Figure 1-1 explains the growth of global containerised trade from 1996 to 2018. Thus, demand for maritime transport keeps on growing while world seaborne trade volumes are approximately accounted for 80 percent from total world merchandise trade. For an example, estimated world seaborne trade volumes as per the UNCTAD records has surpassed 10 billion tons in 2015.

In order to cater the rapidly increasing demand, the containerized trade is continuously faced with the need for bigger container ships to gain advantage from economies of scale. It has grown panamax vessels to post panamax vessels and mega container carriers during the last decade. The cumulative annual growth rate of the average ship size in the global fleet has increased at 1.9 per cent between 2001-2009 and 18.2 per cent between 2010 – 2015 (Davidson, 2016).

Further, when larger vessels were put into operations, single operator could not fill the vessel only from his cargo. As a strategic decision they have formed alliances between individual container lines to reap the benefit of economies of scale instead of calling several vessels for the same route by different container lines. At the same time, container lines attempt to reduce the numbers of port calls in their service networks due to high cost and time associated with ports operations. As a result, small scale liner companies tend to lose their competitive position in the market and large scale liners acquire them. According to the Figure 1-2, it is proved that when ship sizes are increased number of ships and liner companies have declined.

Further, this will reduce the number of vessels calling a particular port. Nevertheless, deployment of increasingly large vessels may outweigh the benefits of economies of scale involved due to disadvantages such as reduced service frequency, reduced options for shippers, double handling involved in intermediate ports, higher peaks in container traffic, higher pressure and the increased cost on the services related to cargo handling operations, increased costs of terminal capital and increased supply chain risk. Thus, total cost saving for whole shipping and port network will be relatively less. Therefore, it is important to select an optimal number of ports for a service to minimize the total cost and voyage time involved.

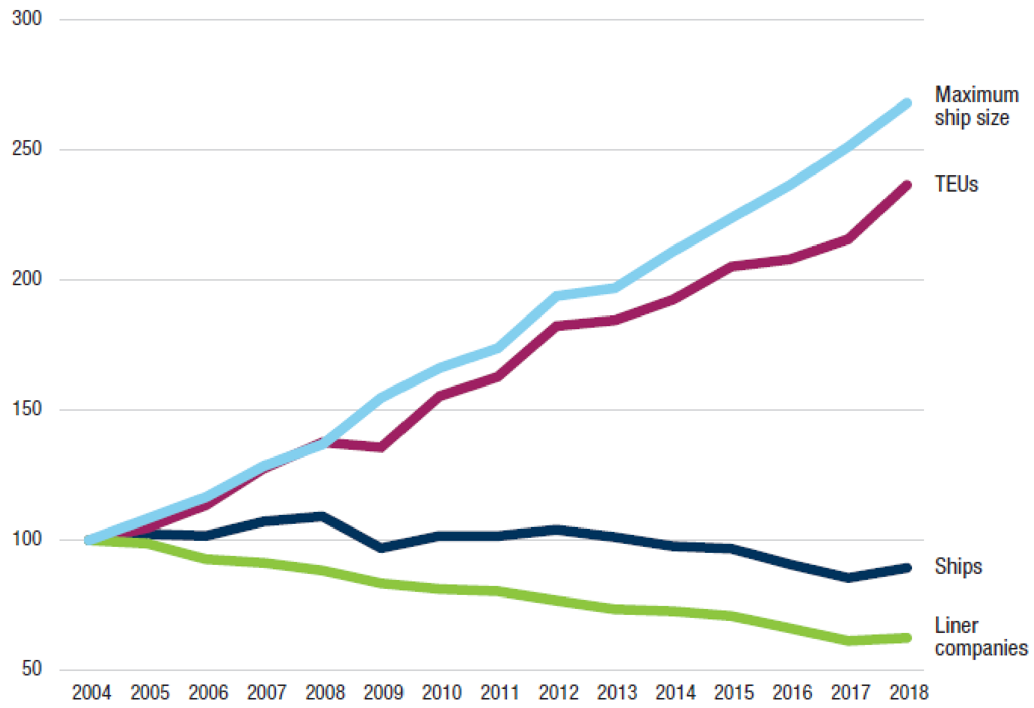

Figure 1-2 Container ship size Vs Number of liner shipping companies
Source- Review of Maritime, 2018

The significance of hub and spoke operation is mainly accelerated due to this continuous growth in vessel size while limiting the accessibility for minor ports due to infrastructure constrains in accommodating larger size vessels. Hub port is a common connection point for all the regional ports and container lines while spokes are all the connecting shipping routes in this system. For container service planners, hub and spoke network is the most popular network characterized by the network optimization effort with combining advantages of both larger capacity main line vessels and smaller capacity feeder vessels which are operated in an integrated manner to realize the transportation between origin and destination ports regardless of the infrastructure constrains associated with minor ports. Thus, demand for hub ports keeps on increasing. A hub port will always become a transhipment port when containers are constantly moved from one to another service which can be a feeder line or another connecting mainline. The strategically located hub ports increase efficiency in maritime transport by offering both higher number of route options for cargo transportation as well as reducing overall transport cost and travel time involved in total supply chain of a product (Jiang, Lee, Chew, & Gac, 2015). Therefore, selecting the optimal hub port is crucial in minimizing total freight cost. Further this has increased the competition among the hub ports.

Port competitiveness is largely associated with carriers' and shippers' port selection choices. While reliability, efficiency and availability of economical services of ports are key factors that determine the port attractiveness to both carriers and shippers (Jiang et al., 2015). In order to gain a competitive advantage over the rapidly increasing inter-port competition, port authorities and terminal operators should carefully develop strategies to promote attractiveness of ports. As a result, multiple infrastructure developments and expansion projects were undertaken in recent years. Majority of the port authorities and terminal operations across the world are undertaking significant investment in developing port logistics in order to improve port attractiveness, and thus the port competitiveness (Cullinane & Wang, 2009). A growing trend in the development of port logistics can be justified by improved infrastructural and technical capacity to attend mega vessels (Colombo South port development, One Belt, One Road Initiative in China, China investing in the United Republic Tanzania to develop the Bagamoyo port), at container logistic centres on main shipping lanes (port cities at Busan, Singapore), by increasing storage capacities to facilitate transhipment services and by the investments in inland access routes to expand in a way to facilitate hinterland connectivity by enabling trade and regional integration. Further some have reduced tariffs as a decision to attract more services while some are assuring quality services to port users.

More competitive a port is, more shipping lines are attracted to that port which results in more port calls and availability of increased options to reach that port and therefore enhancing its maritime connectivity. Maritime connectivity of a port is determined by how effectively a single port connects with the other ports in the shipping network and easiness of accessing a port by regular container services (Jiang et al., 2015). In other words, competitiveness of a port visualizes the connectivity of a port. At the same time, it captures the level of integration of the country into the existing container liner shipping network (Wilmsmeier, Martinez-Zarzoso, & Fies, 2010). Further, connectivity is one of the major factors, which is directly related to the ability to offer effective transhipment services from a particular port. Due to the increased transport volume and the availability of multiple transportation options to reduce cargo transportation time, planning optimal routes for a shipping network is highly regarded, as they are created based on a few selected strategic regional hubs. Therefore, for a port, maritime connectivity is important as same as having state of the art facilities and world class efficiency levels. Thus, if port managers are to promote their port, they should market maritime connectivity of their port and should develop strategies to improve connectivity level as the quality of transport networks depends on both the features and how the links are connected.

1.2 Rational of the study

Once mega container ships were put in to operation, container terminal with deeper drafts was highly demanded within South Asian region. Further one of the key objectives of the Sri-Lankan government was to develop Sri Lanka as a main maritime hub while promoting port of Colombo as the major transhipment hub for South Asian region. Therefore, Sri Lankan government has identified the importance of the Colombo port expansion to cater to this increasing international shipping demand and to facilitate mega container vessels, eliminating the bottlenecks in operation schedules. A port needs to constantly adapt itself to meet the frequently changing demands of its customers in a way that is superior to competing ports because the port industry is constantly at risks of losing important customers when carriers rationalize their shipping schedules (Notteboom & Winkelmans, 2001). Following the same strategy, Sri Lankan port authority also invested on Colombo South harbour development project, which is to build three new container terminals in a way to accommodate mega container vessels, expanding draft limitation up to 18 meter in order to enhance the position of transhipment hub port for the South Asian region as port of Colombo was handling in the range of 75% of transhipment containers from total container volume handled per year.

However according to Figure- 1-3, this percentage was bound to decline during 2011-2012. Bandara, Nguyen and Chen, 2013 pointed out that this is due to the recent developments of Indian ports which have resulted in more competition and transhipment cargo split between the Port of Colombo and Indian Ports.

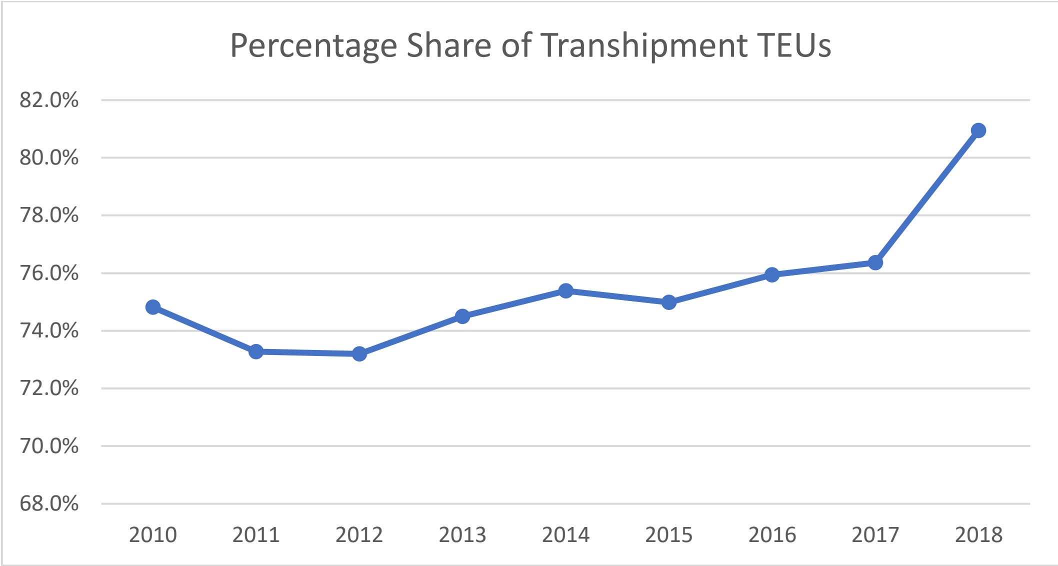

Figure 1-3 Percentage share of transshipment TEUs handled in Colombo port
Data Source- Central bank report, 2018

At present India has initiated few port development projects and port expansion projects to accommodate mega container ships, investing on state-of-the-art equipment and terminals with deeper drafts. Further, Bandara et al. (2013) mentioned that i-maritime (2003) has stated that Nhava Sheva port project has been crucial in minimizing transportation cost resulted in double handling of cargo from Indian feeder ports to main hub ports; Colombo and Dubai. Apart from that Jawaharlal Nehru port in India was identified as one of the Asian ports which have improved upon their connectivity (Low, Lam & Tang, 2009). Hence there is a possible threat to the Port of Colombo. But since 2013 percentage share of transhipment volume has increased while total transhipment volume keeps on increasing and the highest volume was reported in 2018.

According to the UNCTAD statistics, LSCI of Sri Lanka had been in the range of forty until up to 2013. But since then there is significant increase from 43 to 72.5 (Figure 1-4). When it is compared with all the South Asian countries, LSCI of Sri-Lanka has a significant increment since 2013 while it was recorded almost same to the India up until 2012. In 2018, Sri Lanka recorded the highest LSCI 72.46 being the most connected country in the South Asian region (Review of Maritime, 2018).

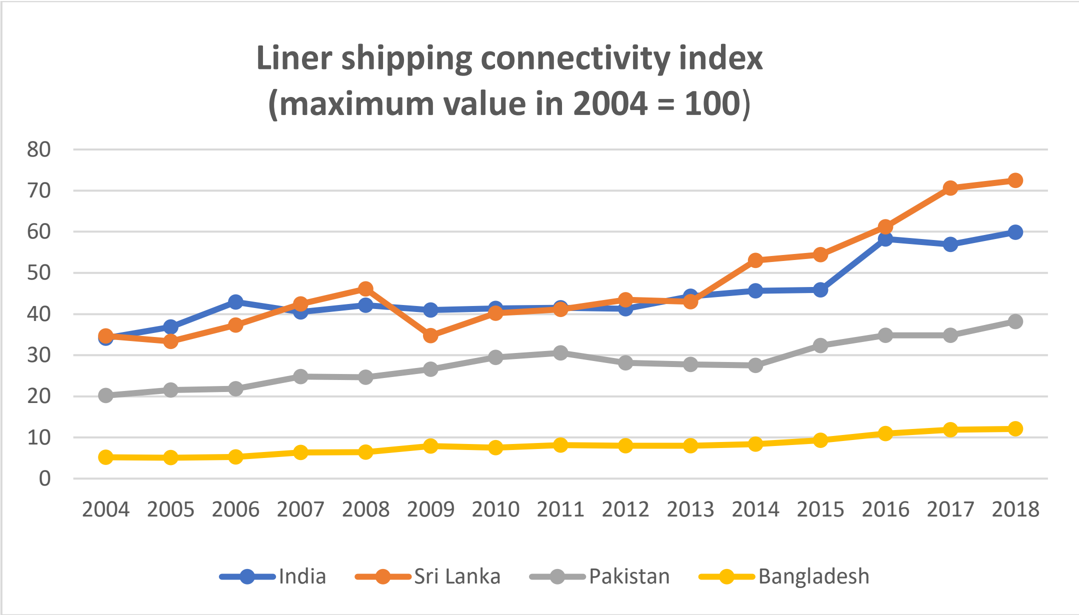

Figure 1-4 Liner shipping connectivity *index*
Data Source- UNCTAD LSCI

Further when number of vessel arrivals at port of Colombo is analysed over the period of time, results indicate that number of vessel arrivals has increased since 2014 in spite of vessel type and size though slight decrease is recorded in 2017.

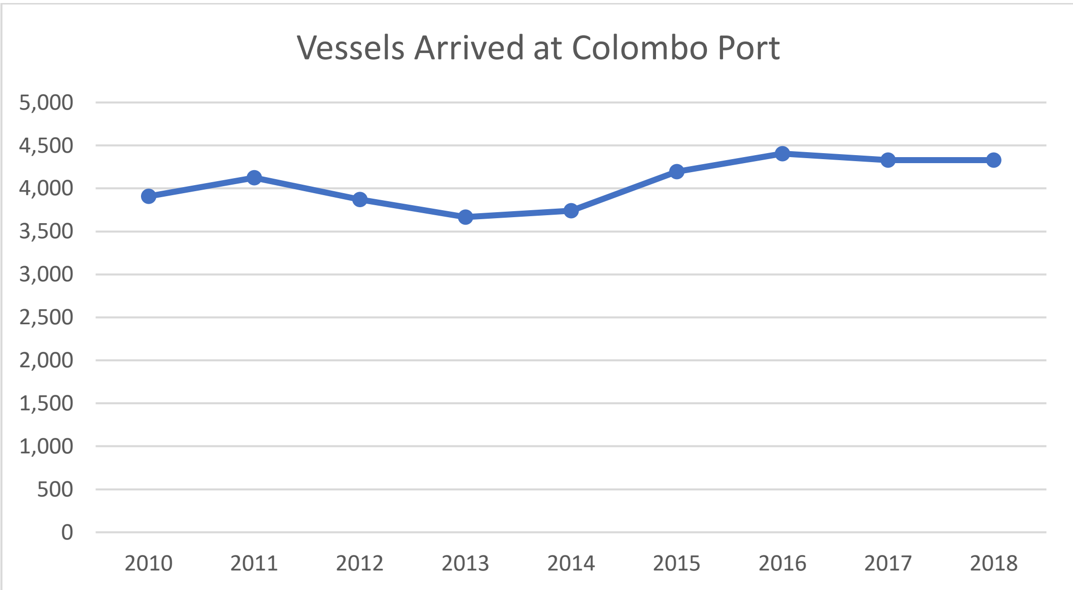

Figure 1-5 Percentage share of transhipment TEUs handled in Colombo port
Data Source- Central bank report, 2018

According to Figures 1-3, 1-4 and 1-5, it is clearly illustrated that liner shipping market in Sri Lanka underwent a significant reform since 2013. The major change in 2013 was that CICT terminal started its operation. Therefore, it is interesting to study whether new port development has an effect on maritime connectivity of port of Colombo. Most of the researchers have constructed port connectivity indexes and discussed how maritime connectivity and developments in port logistics have affected the freight rates. But only few research studies have evaluated how developments in port logistics have affected maritime connectivity. Thus, it is motivated to study "**How do developments in port logistics affect maritime connectivity of a port"**.

1.3 Port of Colombo

Port of Colombo is one of the leading port in South Asian region while being one of the rapidly growing maritime hubs in the region. It has been extending its service as the major transhipment hub port for the south Asian region since ancient times by being located in one of the most strategic locations in the East-West container route which is well known as the silk route. Port of Colombo currently caters to the demand for container movements operating four container terminals; Jaya Container Terminal (JCT), South Asian Gateway Terminal (SAGT) Colombo International Container Terminal (CICT) and Unity Container Terminal (UCT). In which SAGT, JCT and CICT are highly focusing on main lines while UCT is dedicated to accommodate feeder lines. CICT is the newly built container terminal which is in its growing stage. The original port had three container terminals located in 184 hectares. The construction of South port which is to accommodate the latest generation of mainline vessels with deeper draft started in 2008. The new harbour is served by a two-way access channel of 570m width, 20m depth basin and a turning circle of 800m. Under this development, a capacity increase of the Port of Colombo was undertaken in two separate phases whereby the existing capacity of 4.5 million TEUs will be approximately increased by another total capacity of 7.2 million TEUs. Once completing the developments in first phase, South harbour started its operations in 2013 with one terminal, Colombo International Container Terminals Limited (CICT).

Since 2008, it has been ranked among top thirty five busiest container ports in the world and it has upgraded its position to thirtieth busiest port in 2014 by handling 4.91

million TEUs (world Shipping Council). In the year 2018, the port became the number one container growth port among the top 30 container ports by handling 7 million TEUs for the first time with its three main liner terminals.

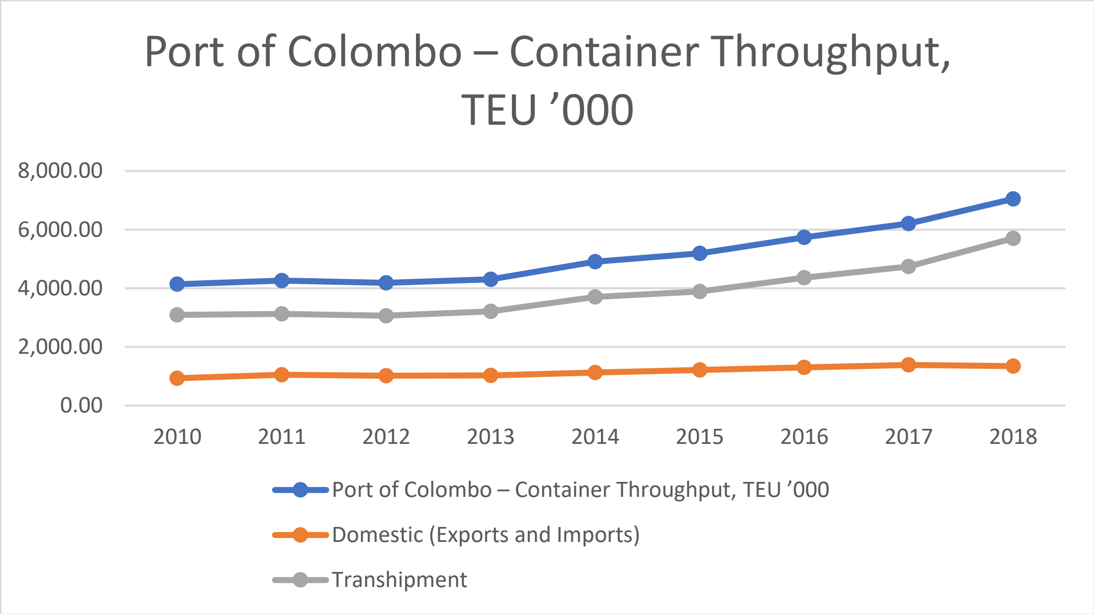

Figure 1-6 Port of Colombo throughput in 1000 TEUs
Data Source- Central bank report, 2018

From that, more than 75% comes from transhipment volume. The Port of Colombo expediently and efficiently connects cargo generating from and destined to Europe, East and South Asia, the Persian Gulf, and East Africa. Major competitive markets of Colombo port are Asia- Europe service, Asia- America, Asia-Mediterranean and Intra Asia.

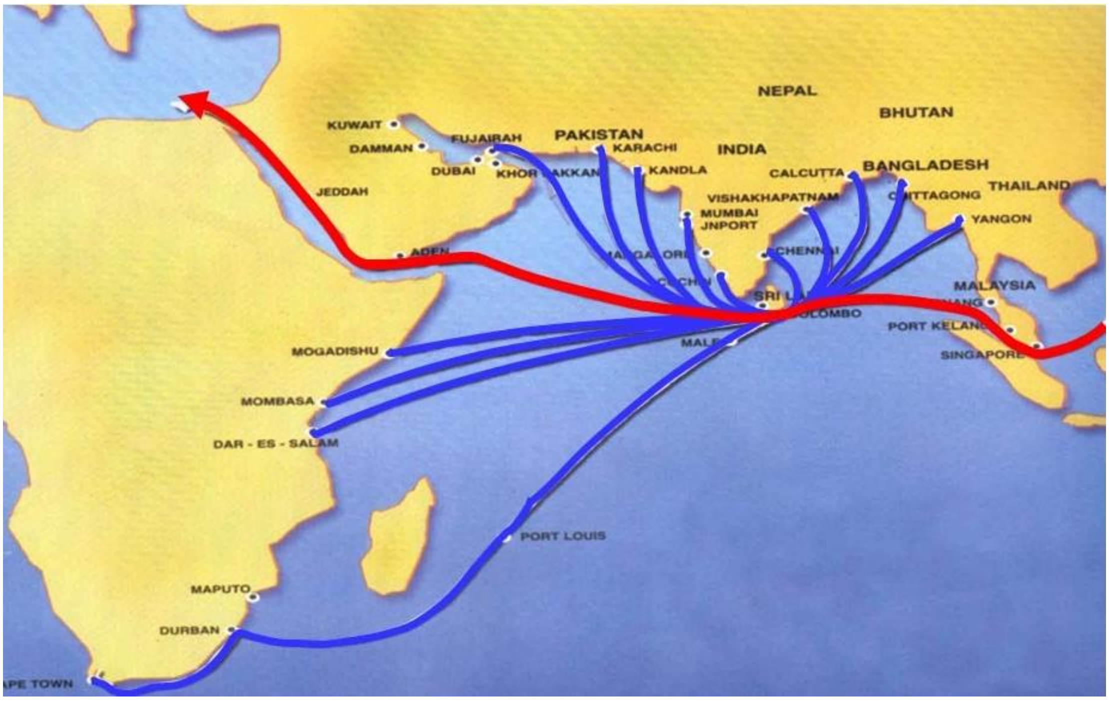

Figure 1-7 Demography of Colombo Port
Source- SLPA website

1.4 Research Questions and Objectives

Once the research problem was identified, research questions and objectives were identified to address through the research. This study is mainly designed to answer a currently important issue with regard to how maritime connectivity of a port is affected from developments in port logistics in the sense of port infrastructure, superstructure, location, and institutional and time management. Thus, the study aims to address the following primary research question;

> **PRQ- How do developments in port logistics affect maritime connectivity of a port?**

Accordingly, this is expected to address following secondary questions;

> **SRQ 1 –** Which port logistics developments affect maritime connectivity of a port?

> **SRQ 2 -** How significant is each port logistics development on the maritime connectivity of a port?

Research design deals with procedure to obtain answers to research questions fulfilling each objective. Following key objectives are established to answer the above research questions;

- Conduct online survey analysis to identify which port logistics developments have significant impact on the maritime connectivity based on the perception on industry experts attached to container lines.
- Conduct correlation analysis for the quantitative data collected from main container ports in different maritime regions to validate the results obtained in online survey.
- Develop simple linear regression models to identify how each factor affects to maritime connectivity of a port
- Develop a multiple linear regression model to identify how each factor collectively affect to maritime connectivity of a port
- Visualize how developments in port logistics in Colombo port have affected its maritime connectivity.
- Propose suggestions to increase maritime connectivity of port of Colombo.

1.5 Research contribution

There are number of existing research studies on port competitiveness, port selection criteria, port logistics developments and its influence on transport cost. Even though the maritime connectivity concept was introduced quite recently in the literature, it was significantly discussed in academia related to maritime field. An increasing number of studies have constructed port connectivity indexes to measure connectivity while some researchers studied the impact of maritime connectivity on maritime transport cost and freight rates. Measuring maritime connectivity with related to countries were focused on by very few studies. Furthermore, few scholars have focused on measuring the connectivity levels of ports. But no single research is done to identify how developments in port logistics affect the maritime connectivity of a port and subsequently how it has affected the maritime connectivity in port of Colombo. Hence, there is a visual gap to study how port logistics developments of a port will effect on maritime connectivity.

This study envisions new area on how port logistics developments affect the maritime connectivity of a port. The knowledge bring in to light from this study will support port operators and vessel operators in developing their strategies. Terminal operators will be benefited in identifying optimal investment options to enhance maritime connectivity of their ports. For example, port operators can use this knowledge as a guideline to improve their services and in developing their ports as a transshipment hub port. Further, terminal operators in port of Colombo will be able to identify how they can optimally use available resources. Shipping network planners will be benefited in evaluating most connected hub ports for their container liner services. For an example, container liner operators can utilize this knowledge in preparing selection criteria to select an optimal hub port in their shipping network.

CHAPTER 2 - MARITIME CONNECTIVITY OF PORTS

2.1 Introduction

Following a brief introduction on the current situation of the maritime industry, this chapter explains Liner Shipping Connectivity Index (LSCI), how researchers have perceived the importance of maritime connectivity of a port and how eventually a unique index is introduced to rank countries based on their relative connectivity. Then it continues discussing existing studies, illustrating their scopes and identifying the new research areas to fill the gap between existing studies and unrevealed titles. Finally, it is pointed out how this study bridges the gap between present available knowledge and the unrevealed knowledge.

Due to the globalization and the internationalization of the world economies, maritime transport is rapidly developing and has become the leading mode of transportation for domestic and international trade in many countries (Jiang et al., 2015). Containerization demonstrates a 75% to 100% increment in bilateral trade flows by being the driver of the current market growth (Bernhofen, El-Sahli, & Kneller, 2013). As a result, world sea freight volumes are increasing. United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP, 2011) stated that containerized trade has grown at a remarkable rate of 8.8% per annum while volumes of global maritime trade records a growth of 3.3% during 1985-2010. To accommodate this demand increment by optimizing cost efficiencies and economies of scale, container lines tend to develop Triple E new generation vessels which can carry more than 15,000 TEUs. Cullinane and Khanna (1999) stated that the container lines gain cost efficiencies through scale economies by deploying larger vessels on mainline and feeder services. At the same time this requires ports to be equipped with sound superstructure and infrastructure to accommodate mega ships. Further with the increasing demand for faster cost effective maritime transport services and mega container vessels with deeper draft and wider breadth, operating to a hub and spoke system is highly demanded rather than operating as a point to point service. In particular, when designing container services, planners select few ports representing regions which are located closer to main shipping trade routes and have higher throughput and physical capabilities of handling mega ships as hub ports. Low et al. (2009) mentioned that Wang (2005) has highlighted that international container movement is optimized through the hub-feeder network of mainline and fewer efficient ports (hub ports), which operate as gate ways to these countries or regions. Thus, the demand for transshipment hub ports has increased and shipping lines tend to select regional hubs with high container throughput.

Container lines are becoming increasingly focused on selecting the best port that has better access to global market in their hub-and-spoke networks as there is more than one port to select (Low et al., 2009). Notteboom (2011) explains that cost savings gained using the hub-and-spoke networks which minimize the number of mainline port calls is insufficient to offset the extra feeder costs and container lift charges. Hence selecting an economically viable regional hub port is crucial for a vessel operator. This creates inter port competition among ports, which have similar capacity to supply required services in the same shipping region. Cullinane and Wang (2009) argued that port-infrastructure users will face competition among ports when economically feasible options are available for same facilities. Furthermore, it is argued that by being an interface linking sea and land transport, the performance of a port will have a direct impact on the competitive advantage for its user (Lam & Yap, 2011). Therefore, a port should develop innovative strategies to attract more vessels in order to gain competitive advantage over others.

2.2 Liner Shipping Connectivity Index

The Liner Shipping Connectivity Index (LSCI) measures the connectivity level of countries to the global liner shipping networks and its accessibility by regular container liner services. Since 2004, maritime connectivity of countries has captured the attention of many authors such as Teng, Huang, and Huang, 2004; Bichou, (2004); Angeloudis, Bichou, and Bell, 2013; Wilmsmeier, Hoffmann, and Sanchez, 2006; Wilmsmeier and Hoffmann (2008); Yeo, Roe, and Dinwoodie, 2008; Low et al. (2009); Verhetsel and Sel (2009); Wilmsmeier and Sanchez (2009); Castillo-Manzano, Castro-Nuño, Laxe, López-Valpuesta, and Arévalo-Quijada, 2009; Wilmsmeier et al. (2010); Marquez et al. (2011); Yeo, Roe, and Dinwoodie, 2011; Hoffmann (2012);

Paflioti, Vitsounis, Tsamourgelis, and Bell, 2014; Tovar et al. (2015); Jiang et al. (2015). Hoffmann (2005) was first to develop an overall LSCI for 162 coastal countries combining nine factors of maritime transportation which is related to fleet assignment, liner services, vessel and fleet sizes. Later United Nations Conference on Trade and Development (UNCTAD, 2005) published LSCI which is based on five components of the maritime transport sector, number of ships, their container-carrying capacity, maximum vessel size, number of services, and number of companies that deploy container ships in a country's ports (UNCTAD, 2006). This was calculated by dividing the country's average value of five components from the maximum average value of five components in 2004 and then multiplied by 100. The country which recorded maximum average index was given the value of 100. Each of five components was given an equal weight though there is no justification for the equal weight given for each of the five components (Langen, Udenio, Fransoo & Helminen, 2016). For the land locked countries, LSCI is not calculated. Since then, UNCTAD annually publishes the LSCI and it illustrates the tendencies in maritime connectivity of countries (Haji and Hoffmann, 2007 and UNCTAD, 2011). Rodrigue (2017) pointed out that the LSCI is designed to capture the degree of integration of a country to the current liner network. Therefore, LSCI can be used as a proxy to represent the level of accessibility to global trade and is a vital factor in deciding freight rates and competitiveness of a port (UNESCAP, 2011). Furthermore, the degree of connectivity indicates the hub status of a port, either it is a regional hub or a global hub, wherein hub ports required sound accessibility and wide network coverage to achieve its maritime connectivity (Tongzon & Heng, 2005).

Having a higher index indicates that it is easier to access a high capacity and a frequent global container liner system and maritime freight transport system thereby enabling effective participation to international trade. For an example, in 2017 China; where the busiest container ports are located, records the highest LSCI, 158.76 while Singapore records second highest score of 115.07 and Korea being the third highest, 109.94 (UNCTAD stat, 2017). These are the countries with leading hub ports not only in South East Asia but also in the world. The land lock countries like Switzerland, Hungar and Austria. do not have a LSCI as those cannot be reached by any vessel where Logistics

Performance Index (LPI) explains the accessibility of those countries. In total, LSCI in 80 countries recorded an growth in LSCI index between 2016 and 2017 while LSCI of 77 countries has decreased (UNCTAD stat, 2017).

Although, the LSCI is a good indicator of the maritime connectivity level of a country where there are certain limitations. For an example, LSCI has been constructed on country level but not on port level. But in reality, container liner services are connected with ports rather than countries where adequacy and reliability will be increased with detailed disaggregation at a port level (Paflioti et al., 2014). Further, LSCI does not consider hub and spoke nature and adopts spontaneous but ad hoc approach in developing the index (Arvis & Shepherd, 2011). Another limitation is that the bigger nodes seem to be well connected therefore it is not considered as a global metric rooted in network modelling (Paflioti et al., 2014). Again, LSCI considers each country as one location compared to the rest of the world where the whole network is sized down to two vertices. Thus, LSCI is interpreted to measure the strength of the link between two vertices (Bartholdi, Jarumaneeroj & Ramudhin, 2016). Therefore, several different port connectivity indexes are increasingly discussed by several researchers considering origin destination links.

2.3 Port connectivity in a maritime network

For a port to become a regional hub, it should possess optimal cost efficiencies and operational efficiencies to minimize total voyage time of a vessel in addition to world class performance, capacity to handle mega ships and being located in major shipping routes. In designing container services, network planners tend to select optimal hub ports looking at their maritime connectivity in order to gain economies of scale, optimal cost efficiencies and to minimize total voyage time. Jiang et al. (2015) pointed out that the maritime connectivity contributes and indicates the ability of a port to provide effective transhipment services where port competitiveness is measured through the strength of transhipment services. As the accessibility of a port is an outcome of the container line’s port choice in their service networks, port maritime connectivity makes a significant contribution for the competitiveness of a port.

Langen et al. (2016) defined maritime connectivity of a port as an indicator of the degree of connectivity to other ports in a maritime network as well as to the hinterland links of the transportation network. Paflioti et al. (2014) defined container port connectivity as a multidimensional phenomenon which is a combination of various types of connections that exist from the foreland to the hinterland. It captures the linking patterns of nodes and the ability of reaching a destination from different origins and vice versa.

Jiang et al. (2015) pointed out that connectivity level of a port has impact on the attractiveness of the port, transport cost and time, and thus the competitiveness of a port. In addition to this connectivity, visualize the contribution of a port to the maritime transportation network and its capacity, whereas higher the maritime connectivity of a port, more option to ship cargo to and from the port which add more value to port users (Paflioti et al., 2014, Jiang et al., 2015 and Langen et al., 2016). On the other hand, as connectivity enhances competitiveness of a port and access to international markets, it is benefiting to countries' economy by attracting and developing skilled labour, increased capital investments, business agglomeration and increased productivities (Paflioti et al., 2014). Existence of global value chains, globalization and delocalization of productions has lead connectivity to be a critical element in maritime transport network in overcoming international trade barriers and improving competitiveness (Arvis and Shepherd, 2011). Thus connectivity can be identified as a measure of port competitiveness (Low et al., 2009). Low et al. (2009) pointed out that other than being an indication of the effectiveness of a port as a hub port, the connectivity index, which is constructed based on the number of origin and destination connections served by individual ports, also functions as a good indicator to identify the changes in competitiveness of ports compared to their competitors. Further Paflioti et al. (2014) explained that authorities of ports should act proactively to enhance connectivity of their port with the main global transportation networks. They should ensure ports are sufficiently equipped with superstructures, infrastructures, free trade agreements and custom procedures. Thus port connectivity has become an important measure for ports (Jia, Lampe, Solteszova & Strandenes, 2017) as well as policy makers (Langen et al., 2016) as it is correlated with the frequency of shipping services, port competitiveness and captures the quality of shipping networks. For an example, port of Antwerp, Singapore, Busan and Rotterdam. highlight connectivity as a selling point in the marketing campaigns on their port websites.

Thus the maritime connectivity of a port and availability of port logistics factors, such as port superstructure and infrastructure to facilitate mega vessels and an efficient service, are critical to a port in order to gain competitive advantage over the other competing ports.

An increasing number of studies have been designed to develop port connectivity indexes to assess the degree of connectivity of a port. The indexes as explained below shows how each port is positioned relative to its competitive ports.

2.4 Port connectivity indexes

With the development of standard LSCI, developing a port connectivity index has drawn the attention of more researches to overcome the above limitations entailed with the LSCI and an increasing number of studies can be seen in recent past with respect to container ports and ports in general.

Low et al. (2009) formulated a connectivity index and a cooperation index in order to propose a network-based hub port assessment (NHPA) model from a network perspective conducting three case studies of major carriers in the maritime industry. Port connectivity index is calculated considering a hub-and-spoke network built by two individual ports whereas cooperation index is the ratio of the number of origin and destination pairs. This model, specifically analyzes the degree of a port connectivity, which is an indicator for the particular port's potential to become a hub port, and can be used to analyze a port's likelihood of developing into a global or regional hub port as well as the sustainability of hub status for the exiting hub ports. Low et al. (2009) illustrated that hub ports record high connectivity indices and the sustainability depends upon their cooperation indices whereas ports with low connectivity indices but high cooperation indices are characterized as regional hub ports which have the potential to develop into global hub ports (Low et al., 2009).

Bartholdi et al. (2016) developed a Container Port Connectivity Index (CPCI) based on both network theory and economics, focusing on the container flow and assuming that shipping routes are designed to maximize profitability for the shipping company. As a result, connections represent not only distance but also the number of containers with their origin and destination details (Bartholdi et al., 2016). This index was developed on scheduled container services where a link exists in the presence of a main line; a scheduled container service travels directly from one port to another (Bartholdi et al., 2016). This index summarizes how individual ports are connected to others within the larger network and the specialty is, this expresses connectivity of a port to its neighbours-of-neighbours not limiting only to local connectivity to immediate neighbours where containers move not only from one port to a neighbouring port down the service but move along paths.

Wang, Zeng, Li, and Yang, 2016 captured port connectivity with respect to the external connections with other ports in the region. This provides an in-depth assessment of port connectivity in relation to the maritime networks of Dalian, Tianjin and Qingdao; three hub ports in Bohai Bay (wang et al., 2016). The study established an overall index measuring three criterias of port connectivity and accessibility which are (1) hinterland connectivity, (2) inner bay connectivity and (3) international connectivity from the perspective of liner shipping companies (wang et al., 2016). The multi-criteria decision analysis method was adopted in the study in developing the index.

Jia et al. (2017) constructed a port connectivity index to measure individual port connectivity of major Norwegian regional ports which are located at strong shipping nation due to its geographical location and long coastline. The index was constructed with respect to multiple shipping segments namely container, passenger, tanker and dry cargo. Port connectivity is evaluated empirically by the number of unique vessel visits, vessel sizes and cargo sizes for the data derived from the automated identification system (AIS) over a 7-year period. The specialty in this index is that they use actual vessel movement data and the actual transportation network between individual ports in a country to assess how well ports are connected to each other.

Examining past studies almost all the researchers have constructed connectivity indexes for container ports. Therefore not limiting to container port connectivity index, Langen et al. (2016) have presented a connectivity indicator for RORO shipping using route data of 23 shipping companies which connect European RORO ports. They have considered number of links (number of RORO destinations) and link quality (service frequencies, number of service providers and minimum number of intermediate stops) in developing the RORO connectivity indicator (Langen et al.,2016). This is more like to indicators which explain container shipping connectivity. The difference between their indicator and the LSCI is that they have introduced the concept of diminishing return which is the decrease in marginal output of the connectivity components considered while the LSCI is based on constant returns. Langen et al. 2016 mentioned that the method of diminishing returns is applicable for components like frequencies and number of service providers. This is measured as the average of the three scores for each of the individual factors that are measured between 0 and 1 giving more weight to number of destinations/links than the attributes of a link quality (Langen et al.,2016). Finally it is pointed out that both the number of links and the link quality jointly impact on the results of the proposed indicator.

In understanding the dynamics of port connectivity and inter-port relationships Lam and Yap (2011) examined the calling patterns of container shipping services in relation to four major ports in East Asia; Shanghai, Busan, Kaohsiung and Ningbo. Calling patterns were studied by identifying the shipping capacity, shipping lines involved, connected trade routes and geographical regions and nature of inter-port relationships. The annualized slot capacity (ASC) in terms of TEUs which is the sum of vessel capacities of liner services calling a particular port during a year is analysed to identify the shipping capacity and thus the connectivity. In calculating ASC they have analysed over 3000 container shipping services calling at above ports over a 12-years.

Paflioti et al. (2014) assessed and constructed a port's connectivity index using transport costs as the determinants of port’s connectivity. It is rooted not only on an integrated method grounded on network analysis, but also a understanding of connections between the nodes derived from gravity modelling (Paflioti et al., 2014). This analyse the different measures of transport costs; which are distance, time, infrastructural/ qualitative characteristics and intermodalism, and thus the connectivity. Findings suggest that as connectivity is impacted by the availability of sufficient capacity and readiness of carriers to connect, connectivity depends on characteristics like demand, the geographical location, the infrastructural technology and hinterland connections which have an influence on carriers' decisions (Paflioti et al., 2014).

Jiang et al. (2015) analyzed port connectivity from the perspective of an international container liner network which can be used to generate quantitative measures for the connectivity of ports. The framework is designed for the global network, not for the port itself and the actual transportation flow in the real world. It is defined in terms of the impact on the transportation network when the transshipment service is not available at the evaluated port. The framework introduces two models to capture connectivity with respect to transportation time which determine the average impact on the transportation time and capacity which aims to identify the average impact on the transportation capacity of one (O, D) pair. For this analysis they used a case study on the major ports in the Asia Pacific region. Compared to existing measures, the framework and models does not only provide scientific methods to compute port connectivity, but also it is able to capture a global effect on how port connectivity contributes to the overall network for given shipping services.

Tovar et al. (2015) assessed the connectivity of the main Canarian ports using graph theory focusing on degree, betweenness centrality and the port accessibility index which are complementary measures that characterize different aspects of the node connectivity and gives broader picture when considered together. Maritime degree represents the number of connections that a port has while betweenness centrality measures the importance of a node within a network, in terms of connectivity. This measure illustrates the competitiveness of the port and its potential to achieve or keep regional or global hub status. In accessing connectivity they have used a sub-network of 53 ports directly related with Las Palmas and Tenerife ports.

Lun and Hoffmann (2016) explored the concept of Connectivity and Trade Relativity (CTR) by developing a research model to illustrate the impact of maritime connectivity on the two types of trade flows which are intra trade and extra trade, and the mediating effect of intra-trade in governing the relationship between maritime connectivity and extra-trade. They used a multi-method approach to investigate CTR by testing three hypotheses: 1. Maritime connectivity is positively correlated with intra-trade, 2. Maritime connectivity is positively correlated with extra-trade and 3.Intra-trade mediates the relationship between maritime connectivity and extra-trade. The developed research model was validated using a three-step approach. First correlation and regression analyses were used to examine the relationships among the variables of maritime connectivity, intra-trade and extra-trade. Then CTR was examined with formulated equations and finally the mediating effect of intra-trade was tested on the relationship between maritime connectivity and extra-trade with three regression equations. In assessing CTR, they used the case of ten ASEAN member countries such as Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. Finally, the results showed that maritime connectivity is positively correlated with the intra-trade and extra-trade. Further it is proposed that intra-trade has a mediating effect in governing the relationship between shipping connectivity and extra-trade.

Fugazza and Hoffmann (2017) assessed the effects of maritime connectivity on bilateral exports using a revised index of bilateral liner shipping connectivity (LSBCI) where as LSBCI is computed by taking the simple average of the five normalized components (number of transshipments required to get from one country to other, the number of common direct connections, geometric mean of the number of direct connections that belong to each country, level of competition on services that connect country pairs and the size of the largest ships on the weakest route) against dependent variable, exports in goods by value. They have used the standard gravity model of international trade which is improved by the inclusion of maritime connection variables for the data collected on 138 non landlocked countries corresponding to 9453 country pairs between 2006 and 2013. This model presents a revised version of the LSBCI which provides an overall view of maritime connectivity and its impact is assessed using a comprehensive set of country pairs observed for 8 years.

2.5 Different aspects on maritime connectivity

In addition to the above studies an increasing number of studies discuss connectivity from different viewpoints. For an example Bichou, (2004) and Angeloudis et al. (2013) examined connectivity from the perspective of maritime security. Wang and Cullinane, (2008), Yeo et al. (2008), Verhetsel and Sel, (2009), Yeo et al. (2011) analysed the influence of maritime connectivity on port/regional competitiveness. Further Lee, Wan, Shi, and Li, 2014; Laird, Nellthorp, and Mackie, 2005 mentioned that significant levels of connectivity contribute to the competitiveness of ports and generate network effects that contribute to the economy. Again, Notteboom (2004); Kronbak and Cullinane (2011) discussed that maritime connectivity has an influence on logistics connectivity of a county.

Some researchers have studied how port connectivity affects transport cost. For example, Marquez-Ramos, Martinez-Zarzoso, Perez-Garcia, and Wilmsmeier, 2005) developed three complex connectivity component variables and analysed the determinants of maritime transport costs of Spanish exports and their effect on international trade flows using principle component analysis (PCA) methodology. Wilmsmeier et al. (2006) revealed that inter-port connectivity has significant impact on international maritime transport costs considering maritime trade among 16 Latin-American countries. Port connectivity was assessed by the monthly frequency of direct liner services between the ports in origin and destination countries. The findings illustrated that increasing the frequency of liner services between a pair of ports by 1 per cent leads to a reduction of freight by 0.113 percent. In other words, if two ports increase their connectivity by 150 per cent, the freight between them can be expected to go down by almost 10 percent. This shows that connectivity has quite a high impact on freight. Zarzoso and Hoffmann (2007) pointed out that connectivity is one of the main determinants of international transport costs, accordingly improving port connectivity is crucial for keeping transport costs under control. Further, Wilmsmeier and Hoffmann (2008) studied the impacts of liner shipping connectivity on intra-Caribbean freight rates and the relationships between the structure of liner services, port infrastructure and liner shipping freight rates. The principal component analysis considering parameters like number of carriers, level of deployed TEU, number of vessels, vessel sizes, number of shipping possibilities and the number of services was used to access above and found out that an increase of connectivity by one, decreases freight rates by 287USD and concluded the number of liner shipping companies providing direct services between pairs of countries appears to have a stronger impact on the freight rate.

Wilmsmeier and Sanchez (2009) studied about transshipment connectivity index considering the impact on food prices for South American imports. Wilmsmeier and Sanchez (2009) measured the centrality of a country within the global shipping network taking transshipment requirements into accounts. Centrality represents the more critical nodes having a major impact to the network operations. And explained that if a country can double its centrality in the network which is a significant increase in direct linear services to a wider range of countries, transport costs can be reduced up to 15.4%.

LSCI is discussed in an empirical study on trade costs, a recent research project done by Economic and Social Commission for Asia and the Pacific [ESCAP] 2011, and concluded that about 25 per cent of the changes in non-tariff policy-related trade costs can be explained by the liner shipping connectivity index. Marquez-Ramos et al. (2011) have done principal component analysis considering structure of liner services, maritime route structure and characteristics of ships deployed for all Spanish exports to 17 countries. They concluded that the explanatory power of the transport cost model increases when connectivity and service quality measures are included in the model with the expected negative sign.

Thus several recent empirical studies have found strong correlations between maritime connectivity and trade costs, in particular transport costs. Despite increasing interest in constructing port connectivity indexes and assessing the degree of connectivity of a port in the context of transport networks, a model that takes into account the determinants of maritime connectivity with regard to port logistics developments is still missing. Instead, available researches mention only about the port logistics developments which have potential impact on the port maritime connectivity. There are no in-depth analysis on the impact of each developments to maritime connectivity of a port.

2.6 Port logistics as a key determinant of maritime connectivity of a port

Port logistics is an indicator of economies of scale, superstructure, infrastructure and supporting services as ports require adequate equipment and services in order to deal with certain vessel sizes. Thus, port logistics developments include developments in berths, quay length, terminal draft, access channel width and draft, container yard stacking capacity in TEUs, reefer pluggins, quayside container cranes, yard cranes, availability of sophisticated IT systems, management structures etc. at ports.

Hoffmann (2012) pointed out that connectivity positively depends on demand for ships which can be deployed where they are needed, but also on infrastructure, geographical location and efficient trade supporting services, such as customs procedures or port governance. Hoffmann (2001) also bought in to notice that not only infrastructure, but also institutional, administrative and political factors are influencing international transport costs and consequently maritime connectivity. Further it is discussed that geography, trade volumes and port characteristics are the key determinants of maritime connectivity (UNCTAD, 2014). Therefore, port infrastructure, geographical location, custom procedures, port governance and characteristics are selected to further study how significant they are on maritime connectivity of a port. A good quality of infrastructure of ports is required to attract more services by liner shipping companies and is likely to be positively related to trade volumes (Hoogenhuizen 2013, Limao and Venables 2001, Wood et al., 2003). Further, Calatayud, Mangan & Palacin, 2017 mentioned that Annual Summit of the International Transport forum [ITF], 2012 also has pointed out that enhancing infrastructure, increasing information sharing and providing the harmonization and standardization as the main recommendations to increase “connectivity across borders”.

Low et al. (2009) identified that number of port calls, draught, national trade volume, port cargo traffic, turnaround time, total annual operating hours, average port charge per vessel, and inter-modal transport capabilities in ports as the main factors which have a potentially significant effect on maritime connectivity of a port. Further, it is illustrated that Singapore port is one of the global hub ports by exhibiting relatively high connectivity in the analysis done on the assessment of hub status among Asian ports from a network perspective (Low et al., 2009). The identified reasons for this position is encouraging business environments and well-developed infrastructures, quick turnaround time, presence of year-round deep harbour and supporting landside facilities such as distribution parks and sophisticated logistics centres which draw transshipment volumes (Low et al., 2009). Further, Lun and Hoffmann (2016) have identified a large number of ship calls, higher throughput, a large number of shipping companies servicing, comprehensive range of liner shipping services and an infrastructure that is capable of handling mega ships as the characteristics of economies with excellent shipping connectivity.

Paflioti et al. (2014) identified geographical position of port, trade volumes and port characteristics, the infrastructural technology and hinterland connections as the key determinants of maritime connectivity which is able to affect carriers' decisions. Further it is pointed out that the quality of port infrastructure services (draught, berths and storage facilities) is increasingly seen as a determinant of the trade performance for both developing and developed counties. Shipping companies are trying to reap benefit from economies of scale by deploying a new generation of ships. If a port is not in a position to accommodate those ships, container lines direct cargo to other competitive ports by leading a port in to a downturn. Thus, the relative efficiency of a port declines with respect to capacity. Therefore, in order to attract those services, ports should be equipped with and be able to accommodate mega ships with higher draft and other physical constraints. This will finally influence the connectivity of the port. Supporting this, Paflioti et al. (2014) illustrated that the costs incurred by shipping lines will be higher due to inadequate physical infrastructure or its operational inefficiency which influence the port’s connectivity and in turn the regional economic growth.

Tovar et al. (2015) assessed the connectivity considering the sample of the main Canarian ports by means of graph theory and studied the infrastructure and superstructure endowment of those ports and their accessibility, by evaluating site and situation factors. Further, Paflioti et al. (2014) mentioned that infrastructural characteristics of ports and their connections to hinterland have a direct impact on transport costs and indirectly on its connectivity. The challenges to ASEAN-India maritime connectivity include shortage of port capacity, very few direct calls, high port handling charges, lack of skilled human resources, and absence of an institutional mechanism (ASEAN-India Maritime Connectivity Report, 2014).

Despite increasing discussions about the influencing factors for maritime connectivity of a port, a very few researches were found which was done to comprehensively assess the determinants of the maritime connectivity of a port. For an example, Calatayud et al. (2017) provided a comprehensive assessment of the influencing variables to a country's degree of connectivity to international markets using graph theory and network analysis. They evaluated infrastructure, transport services, and trade facilitation performance as the influencing variables. In the evaluation process they first build a containerized international trade network (ITN) in the Americas using network analysis to analyse the connectivity to international markets. Then developed a support network (SN) which was defined as the network of liner shipping services, port infrastructure, and trade facilitation procedures which enable connection to international markets. Finally it is pointed out that it is critical to understand port infrastructure quality at origin, intermediate and destination countries, country's position within the maritime shipping network, its level of dependency and trade facilitation processes at origin and destination countries in understanding a country's degree of connectivity to international markets.

In addition, there are an increasing number of researches discussing port logistics developments with respect to today's rapidly developing maritime industry. As discussed above, demand for ports and transhipment services keeps on increasing due to the increased containerization, operation of mega container ships and the associated economies of scale (Meng & Wang, 2011; Jiang et al., 2015). This rapid growth has led to port logistics developments at intermediate ports and at the crossing points of trade lanes. Further, the increase in competition has also led to investments in port installations in an attempt to improve efficiency levels (Ugboma et al, 2006).

Felicioet al. (2012) argued that container traffic growth has led to high demand for container terminals, resulting in port congestion, a need for investment in new terminals and greater competition between terminals within and between ports. Cullinane and Wang (2009) pointed out that to enhance the attractiveness and, therefore, the competitiveness of a port, most port authorities and managers worldwide are making significant investments in infrastructure with the objective of reducing operating costs, improving service quality and capacity to attend vessels, increasing storage and transport capacity.

Table 2-1 Literature review summary on port logistics development factors

Affecting Factor	**Study**
Infrastructure	Hoffmann (2012), UNCTAD (2014), Paflioti et al. (2014), Tovar et al. (2015), Low et al. (2009), Lun and Hoffmann (2016), Limao and Venables (2001), Wood et al. (2003), Calatayud et al. (2017)
Geographical location	Hoffmann (2012), UNCTAD (2014), Paflioti et al. (2014)
Trade supporting services- Customs procedures, port governance	Hoffmann (2012), UNCTAD (2014), (ASEAN-India Maritime Connectivity Report, 2014)
Port Characteristics	UNCTAD (2014), Paflioti et al. (2014)
Trade volume	Low et al. (2009), UNCTAD (2014), Paflioti et al. (2014)
Number of port calls	Low et al. (2009), (ASEAN-India Maritime Connectivity Report, 2014), Lun and Hoffmann (2016)
Draft	Low et al. (2009)
Turnaround Time	Low et al. (2009)
Operating hour	Low et al. (2009)
Port Charges	Low et al. (2009), (ASEAN-India Maritime Connectivity Report, 2014)
Intermodal transport capability/ Hinterland connectivity	Low et al. (2009), Paflioti et al. (2014)
Superstructure	Tovar et al. (2015)
Skilful human resources	ASEAN-India Maritime Connectivity Report (2014)

Although, many researchers have identified above factors are having direct impact on the port maritime connectivity, no single research is designed to assess maritime connectivity of a port with respect to port logistics development factors and no model was developed to capture how each development in port logistics effects on the maritime connectivity of a port

2.7 Summary

Considering the above literature, there are number of existing research studies on port competitiveness, port logistics developments and its influence on transport cost. Although the introduction of the maritime connectivity concept is relatively recent in the literature, it has rapidly gained popularity. An increasing number of studies discuss LSCI while some analyze the influence of maritime connectivity on maritime transport cost. There are some studies which have focused on quantifying the connectivity level of ports. Few studies construct connectivity indexes for ports not limiting to country level. But no single research is done to identify how developments in port logistics affect maritime connectivity of a port and subsequently how it has affected maritime connectivity in port of Colombo. Hence there is a visual gap to study how the developments in port logistics impact maritime connectivity of a port.

CHAPTER 3- METHODOLOGY

3.1 Introduction

Chapter Two explained the importance of conducting an empirical study to find out how developments in port logistics affect maritime connectivity of a port. Thus, the purpose of this chapter is to explain the development and implementation of a two-stage data gathering process suitable for the study. The research design explains two-stage data gathering, which includes firstly an exploratory online mail survey and secondly an in-depth quantitative data analysis, which were developed to address the primary research question (PRQ) and two subsidiary research questions (SRQ1 and SRQ2). The chapter continues explaining sample design, selection of the respondents and questionnaire development for online survey. Furthermore, chapter explains the processes used for the pre-testing, the process of administering survey and importantly the error control processes that were adopted. Then Chapter three continues the illustration of methods and techniques used in second stage data gathering, identification of population and sample and finally the sources where data was extracted.

3.2 Research design

The main objective of the current study is to understand the effect of port logistics development for maritime connectivity of a port. Thus, the study aims to address the following primary research question

> **PRQ - How do developments in port logistics affect maritime connectivity of a port?**

Accordingly, this is expected to address through following secondary questions

> **SRQ 1 -** Which port logistics developments affect maritime connectivity of a port?
>
> **SRQ 2 -** How significant is each port logistics development on the maritime connectivity of a port?

As mentioned above, the objective of the current study is to identify how developments in port logistics facilities affect the maritime connectivity of a port. In order to answer this primary research question two subsidiary questions were designed. The objective of the first subsidiary research question is to identify, which port logistics developments significantly effect to maritime connectivity of a port. In order to answer first subsidiary research question, an online questionnaire survey was developed based on the port logistics factors identified through the literature review.

The respondents were selected from managerial level employees attached to global container lines operating in Sri Lanka and questionnaires were circulated through emails. The data will be analyzed using sample mean and one sample proportion test to identify which factors significantly affect the maritime connectivity of ports. Questionnaire design will be discussed in detail in section 3.3. Then, data collected through port/terminal websites and online publications are analyzed to address the second subsidiary research question; How significant is each port logistics development on the maritime connectivity of a port. The data will be analyzed using Pearson correlation analysis and simple linear regression analysis. Furthermore, it will be used as a tool to validate the results obtained from online survey analysis. Then results will be compared and interpreted using both first stage and second stage data analysis. The detailed process for obtaining answers to above mentioned primary and secondary research questions and process of data analysis are explained in this section.

3.3 Online Survey- First stage data gathering

3.3.1 Methods of data gathering

It was a challenging task to select the best data gathering method, which is suitable to achieve research objectives (Neuman, 2014; Oishi, 2003). There are several data gathering options available such as self-administered surveys via mail/email, fax and social media, interviews (telephone and in-person), participant observation and visual and audio materials to identify the perceptions of the respondents (Fahy, 2002; De Vaus, 2002; Duffy, Smith, Terhanian and Bremer, 2005; Lu, 2007; Cameron and Price, 2009; Wilson, 2014; Zikmund, 2010; Creswell and Clark, 2011; Creswell, 2014). Having their own advantages and disadvantages for all these methods (Oishi, 2003:

De Vaus, 2002 and Zikmund, 2010), the mail/email survey method has more advantages compared to others. For example, it captures a large number of respondents within a short period of time, relatively quick to complete, easy to analyze, cost effective and economical, convenient for respondents and the ability to respond anonymously (De Vaus, 2002; Zikmund, 2010; Creswell and Clark, 2011; Neuman, 2014). Burns et al. (2008) has revealed that response rate of mail surveys is higher compared to other administered survey techniques. At the same time there are some disadvantages and limitations also entailed in mail survey questionnaires such as researcher does not physically observe the respondent's reactions, how respondent perceived the question and under which conditions did the respondent complete the mail survey (Neuman, 2014). These disadvantages can be minimized by doing a pre-test for survey questionnaire, which is a cognitive interview, conducted either by face to face /in-person or telephone interview, before the mail survey.

Galbreath (2002) has used the mail survey method to capture the perceptions of senior managers about the contribution of resources to the success of a firm. Further Lu (2007) has used the mail survey method to gather the perceptions of senior managers on the selection of container lines by customers. Further Sigera, (2012) has also used mail survey method to capture the perception of senior managers in container line agencies and regional offices on the contribution of intangible resources to the post strategic co-operation success of container lines. Kavirathna, Kawasaki and Hanaoka, 2018 also have used mail survey method to gather perception of senior level employees of global container line agencies and local offices registered at port of Colombo about the competitive dynamics among cross regional hub ports for the container transshipments. When considering above studies it shows that mail survey is a suitable method to capture the perception of industry experts.

Accordingly, current study has selected online mail survey method to assess the perception of senior managers attached to global container line agencies and local offices registered in Port of Colombo. With the technical development of the world, emails are more used than normal mails in container liner companies in day to day communication. Further, the respondents selected for the primary data collection are managerial level employees who use and are familiar with emails; attached to global container liner agencies. Therefore, online email survey method was selected as the mode for the survey. Thus, first subsidiary question, “Which port logistics developments affect maritime connectivity of a port” would be answered through the data collected from this survey.

3.3.2 Population and sample design for mail survey

Container liner companies are the main customers of ports who are directly utilizing port facilities. Further, they have the decision making power on the feeder and hub ports selection that have facilities to accommodate container liner services regularly. Therefore, they consider these facilities prior to selecting ports. Thus, the questionnaire survey was designed to capture a maximum number of diverse perceptions of decision makers in global container lines. Therefore, the target population of this study is the managerial level employees attached to regional offices of global container line agencies. When considering difficulties in contacting and collecting data from the whole population, time and funding constrains entailed in the study, a sample which represents the target population was selected (Sekaran, 2000; De Vaus, 2002; Wimmer and Dominick, 2006 and Zikmund, 2010).

Global container lines are locally represented by their agencies and regional offices registered in each individual country. They perform administrative and operational duties on behalf of container line prior to and at the time of vessel arrival to local port. Further they are responsible for marketing of container services to shippers and consignees. Thus, these offices are directly engaged with the customers and their conduct has an impact on the services offered by container lines. Due to these reasons, Sigera, (2012) and Kavirathna et al., (2018) have selected global container line agencies and local offices registered at port of Colombo as the sample which represent the container lines for their studies.

Being the main container port in Sri Lanka, port of Colombo is specially selected as it plays a major role serving as the main transshipment hub port for the Indian subcontinent. UNCTAD statistics shows the fast growth of Sri Lanka in LSCI since 2013, where earlier it was in the range of 40 and now it has increased beyond 70. It is significantly higher than other competitive ports in the region especially higher than that of India. Further, Sri Lanka has been identified as one of the best connected countries (UNCTAD, 2016). Sigera, (2012) pointed out (as cited in Fossey, 2010) that Colombo South port development has strengthened regional transshipment hub port status of Colombo by attracting leading container lines to set up their operations in port of Colombo. Therefore, managerial level employees attached to all the global container line agencies and local offices registered at port of Colombo have a good understanding on how maritime connectivity of a port is impacted from port logistics developments.

Most of the container lines selected for the survey ranked within top leading 25 liner shipping companies by market share. The market share, number of ships operating and total shipboard capacity deployed in twenty-foot equivalent units and their average vessel size are presented in Table 3-1. (UNCTAD, 2017) to give an overview of the container lines selected.

Table 3-1 Leading container liner shipping companies by number of ships and total shipboard capacity deployed

Operator	**Rank**	**Market share %**	**TEU**	**# Vessels**	**Average vessel size**
Maersk Line	1	13.45	2,526,490	478	5,286
Mediterranean Shipping Company (MSC)	2	13.22	2,483,979	451	5,508
CMA CGM	3	8.00	1,502,417	375	4,006
Evergreen Marine Corporation (Taiwan) Limited (Evergreen Line)	4	5.08	954,280	204	4,678
COSCO Container Lines Limited (COSCON)	5	4.55	854,171	158	5,406
China Shipping Container Lines Company Limited	6	4	751,507	136	5,526
Hapag-Lloyd	7	3.9	732,656	145	5,053
Hanjin Shipping Company Limited	8	3.41	640,490	104	6,159
Mitsui O.S.K. Lines Limited (MOL)	9	3.19	599,772	111	5,403
APL Limited	10	2.91	545,850	96	5,686
Orient Overseas Container Line Limited (OOCL)	11	2.77	520,328	103	5,052

Nippon Yusen Kabushiki Kaisha (NYK)	13	2.63	494,953	104	4,759
Yang Ming Marine Transport Corporation	14	2.6	487,771	103	4,736
Hyundai Merchant Marine Company Limited (HMM)	15	2.13	399,791	65	6,151
Kawasaki Kisen Kaisha Limited ('K' Line)	16	2.12	397,623	77	5,164
Pacific International Lines (Private) Limited (PIL)	17	1.99	374,849	139	2,697
Zim Integrated Shipping Services Limited	19	1.58	296,554	66	4,493
Wan Hai Lines Limited	21	1.07	200,970	88	2,284
Safmarine Container Lines N.V	33	0.28	52,638	23	2,289
Regional Container Lines Public Company Limited	38	0.23	43,371	29	1 496
Total		**79.11**	**14,860,460**	**3,055**	

Source: Review of Maritime, 2017

All these agencies and regional offices have been in operation for more than ten years in port of Colombo. Therefore, employees in these container line agencies have been exposed to performance of port of Colombo and how the maritime connectivity has changed over the period of last ten years (UNCTAD stat) Thus, senior level employees attached to all container line agencies and local offices registered at port of Colombo are identified as the best sample, which can clearly explain on which port logistics developments affect to maritime connectivity of a port.

Identifying ideal respondents and suitable sample size is vital for the accuracy of the study. Ninety five senior level employees attached to leading container line agencies have been identified as the sample to collect data through Ceylon Association of Ship Agents (CASA, 2017) directory, an annual directory which provides contact details of all the container line agencies registered in Sri Lanka. In addition, Sri Lanka Ports Authority shipping directory was used to verify the contact number and the details of container line agents registered in CASA directory. Further websites of all the container lines were referred to verify the updated contact details obtained from CASA directory.

3.3.3 Selection of respondents

Selecting most suitable respondents is vital for the success of the research as the results obtained from data analysis is dependent on the responses of the participated respondents. Thus it is highly important to select most knowledgeable respondents rather than selecting a larger number of respondents. Surveying is a useful method of data gathering only if data is collected from suitable respondents who can provide accurate responses to the questions (Sekeran, 2016 and Cavena et al., 2001). In this research the stage one data gathering is important for the success of the whole research because the second stage data analysis is designed as a verification tool for the results obtained from first stage findings. And also, the data which are targeted to answer the questionnaire requires respondents who have in depth knowledge on the maritime connectivity of a port. Therefore, it is important to capture the data from senior level employees attached to container liner agencies and local offices. Sigera (2012) has selected CEO, General Manager, Managing Director, Director, Vice Chairman or a Senior Manager responsible for a particular division from each regional office or agency for the survey. Following the same target sample, this questionnaire also disseminated among Chairmen, CEOs, COOs, General Managers, Managing Directors, Directors or Senior Managers attached to container line agencies or local offices. Then next question is whether to select single respondent from each container line agency or to select multiple respondents from the same container line. Phillips (1981) and Bagozzi, Yi, and Phillips, 1991 argued that single respondents will bias the results while Shortell and Zajac (1990), Huber and Power (1985) and Gatignon, Tushman, Smith and Anderson, 2002 argued that selecting a single knowledgeable respondent is suitable for gathering strategic information rather than collecting multiple responses from different knowledgeable respondents as bias can be negligible compared to lower accuracy level in average responses. But when considering the minimum sample size requirement and the number of active main container line agencies registered in Sri Lanka, current study will collect primary data from four respondents belonging to separate divisions i.e. Operations, Commercials and Marketing at each container line agency. In total 95 managerial level employees attached to global container line agencies registered in Sri Lanka are selected to conduct questionnaire survey.

3.3.4 Development of online survey questionnaire

The objective of the online survey is to answer the first subsidiary research question: "which port logistics developments affect maritime connectivity" and the findings will also be used to develop the second stage quantitative data gathering. Accordingly, questions were designed under two sections selecting ideal question types to be included. To maintain clarity and the flow of the questionnaire, questions are segregated into two sections. Each section was given a label (Oishi, 2003, Sigera, 2012; Kavirathna.et al., 2018) followed by an alphabetical letter to create a background picture about the questions that are going to be asked. Further each question is given an alpha-numerical label to make sure respondents will not miss a single question. For example, first question in first section is named as A-1. Section A is designed to identify significant levels of the port logistics factors affecting the port connectivity on the perception of container line experts. Finally, Section B is designed to capture demographic information about the respondents. The demographic information collected will be used to identify how well the respondent is suitable to represent decision of each container line.

The mail survey questionnaire was designed in an attractive, respondent friendly manner in order to obtain maximum attention and to encourage them to answer the questions (Hair et al., 2011, Zikmund, 2010). Therefore, the following strategies were adopted in designing the questionnaire.

- A simple language was used in writing questions enabling a clear understanding to the respondents (Cameron and Price, 2009; Frazer and Lawly, 2000; Zikmund, 2010).
- Double-barrel and loaded questions were avoided- Respondent may misunderstand and get confused if they do not perceive what the researcher intends in a particular question (De Vaus, 2002; Cameron and Price, 2009; Zikmund, 2010).

- The length of the mail survey questionnaire was kept to a maximum of three pages as lengthy questionnaires tend to de-motivate respondents to answer and it leads to low response rate (De Vaus, 2002; Zikmund, 2010).
- Adequate space was provided in open ended questions to write down the answer (Cahoon, 2004; Oishi, 2003) eliminating congested appearance.
- The online questionnaire form is designed in a way such that the respondent cannot proceed if he/she does not answer a particular question. But in the normal questionnaire it is impossible to set such a limitation.

3.3.4.1 *Question types and measurement scale*

As indicated in the below table three types of questions, open-ended, forced choice and Likert style were included to retrieve different information from the respondents. Visser, Krosnick and Lavrakas, 2000 pointed out that different question types facilitate retrieving different depths of information from respondents.

Table 3-2 Question dimensions

Section	Dimensions discussed	# Questions	Types of Questions		
			Likert	**Forced Choice**	**Open**
A	**Significance of the port logistics factors**	27	27		
B	**Demographic information**	6		2	4
	Total number of questions	33	27	2	4

Comparatively a low number of open-ended questions were used in the questionnaire as Hair et al. (2011) and Krosnick (1999) have found that respondents may be less motivated to answer open ended questions in mail surveys without the presence of an interviewer to encourage them. From question types used, the Likert scale questions are highly important to extract views of respondents easily within a short period of time during their busy schedules (De Vaus, 2002) and Zikmund, 2010). Thus Fahy (2002), Galbreath (2004), Sigera (2012) and Kavirathna.et al. (2018) also used Likert scale questions in their mail surveys to extract views of respondents. Thus Likert scale was used to obtain answers for Section A. Respondents were asked to rate the perceived significance of the 27 items affecting maritime connectivity in a five scale rating starting from 1 as ‘‘Not significant at all’’ to 5 as “Highly significant”. A five point Likert scale was used especially because it provides 5 options to rank the perception of the respondents giving opportunity to include unsure option if the respondent is doubtful about the mentioned factor. The option “Not significant at all” is included to express the zero impact from the requested factor to maritime connectivity. As suggested by De Vaus (2002) and Zikmund (2010), higher numbers were assigned to positive responses while lower numbers were assigned to negative responses.

3.3.4.2 Pretesting of mail survey questionnaire

It is very important that survey instruments like online questionnaires, interview questionnaires are designed in such a way that they gather accurate information. Today some of the online survey questionnaires do not allow respondents to proceed if they do not answer a question, but it does not address the issue of incorrect answering, because still respondents could provide an incorrect answer if they are unable to comprehend the wording of the question or recall the accurate information (Hofmeyer, Sheingold, & Taylor, 2015). Therefore, considerable effort has to be put into the process of developing a survey questionnaire (Drennan, 2003; Collins, 2003).

There are several methods to validate and ensure relevance of study instruments like pre testing questionnaires, cognitive interview methods, computer-assisted telephone interviewing, computer-assisted personal interviewing, and computer-assisted self-interviewing (Couper and Nicholls, 1998; Collins, 2003; Drennan, 2003; Sigera, 2012; Haeger, Lambert, Kinzie, and Gieser, 2012; Hurst et al., 2015; Hofmeyer et al., 2015).

Two methods that could be used to identify issues or unclear questions of the questionnaire are the Pre-testing and cognitive interviewing. They identify whether a questionnaire raises issues for respondents before it is disseminated among them (Presser et al., 2004; Haeger et al., 2012; Hofmeyer et al., 2015). Accordingly, pre testing helps to identify issues such as problematic questions that do not produce expected responses, to identify questions which respondents find difficult to understand and to identify questions that can be understood in a different manner than what the researcher intended. Further pre testing reveals issues such as questions with unfamiliar wording. Furthermore pre testing helps to get an understanding on how respondents react to open ended questions (Visser et al., 2000; Cycyota and Harrison, 2006; Rattray and Jones, 2007; Burns et al., 2008; Arnon and Reichel, 2009; Zikmund, 2010; Hair et al., 2011; Haeger et al., 2012: Hurst et al., 2015; Hofmeyer et al., 2015).

Current study uses cognitive interview method to pre test the questionnaire because a pilot test may not provide the reasons why the question is problematic or suggestions improve the wording (Hofmeyer et al., 2015). For an example during a pre-testing, respondents are not met in person during the survey and because of it, they cannot understand the real issues/concerns the respondent felt when he or she was answering a particular survey questionnaire unless if they mentioned it clearly. From available three cognitive interview techniques which are think-aloud/read-aloud, cognitive verbal probing and observing (Hofmeyer et al., 2015) "think-aloud/read-aloud" technique was selected to test the questionnaire. Think-aloud/read-aloud is a technique, which asks respondents to read the survey questions aloud, verbalize what they understand and their views aloud and then ask to answer the question as per their understanding (Hurst et al., 2015; Collins, 2003; Drennan, 2003). The cognitive interview was conducted with two groups; the two groups included five academics and ten employees from shipping industry who are having expertise industrial knowledge. First cognitive interview was conducted with five academics that have a maritime background to capture the reviews on wording, language used to develop questions, clarity, the relevance of questionnaire and the structure of the questionnaire to ensure that the questionnaire is academically sound and suitable to distribute among managerial employees of the shipping agencies and regional offices of container lines. Then cognitive interview was conducted with ten personnel from container lines to get a feedback on the coverage of the knowledge and the suitability of the questionnaire from the industry perspective. Further pretesting helped to understand how the questions were perceived and interpreted by the respondents and also to estimate the time required to complete the survey by a respondent.

First of all, the respondents were explained the background, purpose and the sequence of the questionnaire along with guidelines and then asked the respondents to express their view of each survey question and provide an answer to the question as they understand it. The answers given for the pre testing survey helped to understand the issues that they had when answering the survey. Their main concerns were on question wordings, the necessity for additional questions to be included and the clarity of some questions. After editing the necessary changes, the questionnaire was circulated among the respondents.

3.3.4.3 Administering the Mail Survey

Stage one data gathering and analysis was conducted based on the perspective of managerial level employees attached to global container line agencies and local offices. In order to mitigate the replication of responses and to maintain minimum sample size, only four respondents from each container line who represent different departments were selected. Thus, the responses from all the sample respondents are highly important for the success of the survey. The major concern in mail surveys is the low response rate (Hansen, 2006). In order to address this issue, different strategies like conducting meetings with respondents, emailing the questionnaire document, online form of questionnaires, sending covering letters and sending reminders were used.

First of all, the selected respondents were contacted over the phone and were given a brief introduction about the researcher and the research. Then a meeting was fixed with them if they were free and interested to discuss about the questionnaire. After briefing, questionnaires along with covering letters were distributed via email considering the respondent’s convenience. Further questionnaire was created as an online form to facilitate easy access and form link was mentioned in the covering letter enabling them to directly access. During first three weeks only three responses were received, one returned as a hardcopy at the initial meeting conducted with the respondent. Three weeks after the questionnaires were distributed, reminders were sent through emails or phone conversations.

3.3.4.4 Cover Letter

In a self-administered survey, there is no one to encourage the respondents to answer the questions. Therefore, a covering letter is the most important instrument to encourage participant to answer the questionnaire (Kelley, Clark, Brown, and Sitzia, 2003; Ross, 2005). Cover letter provides a first impression (Burns et al., 2008) about the research to the respondents by demonstrating an overview, which contains the background of the researcher, details of how and why the respondent was selected, the objective of the study, importance of the responses, a guarantee to the data provided, potential benefits, contact details of the principal researcher, estimate time of completion and appreciation for participating in the questionnaire (Kelley et al., 2003; Ross, 2005; Burnset al., 2008).

The target sample of the research is managers attached to global container line agencies and local offices who are busy. Therefore, the estimated time required to complete the questionnaire (15 minutes) and the importance of their participation to the success of the survey were mentioned in the covering letter to encourage them to participate (Sigera, 2012). These measures were included to increase the response rate (Burns et al., 2008). It is clearly mentioned that the information collected will only be used for data analysis purpose as the respondent may be reluctant to provide his/her container line information. Further the covering letter is printed in university letterhead mentioning contact details of the department to assure that the data is collected only for the academic references (Burns et al., 2008). To add a personalize outlook, cover letter is individually addressed for each and every respondent along with the personal salutation and the date (Sigera, 2012). Edwards et al. (2002) indicated that personalized questionnaires and covering letters increases response rate.

In order to assure participants are also benefited by completing the questionnaire, it is promised that the results of the questionnaire will be disseminated among the participants for their information if requested. This will further motivate them to participate (Sigera, 2012).

3.3.5 Data analysis method

The one-sample (single proportion) binomial test which compares whether the sample proportion is significantly different from a hypothesized value was used as the analytical method to select significant port logistics development parameters on port maritime connectivity. Generally one-sample proportion test compares the proportion found in an observed sample to a hypothetically assumed value which is typically the population proportion or some other theoretically derived value. As the study assesses, whether a selected variable is significant or not based on the perception of the majority of the respondents, 50% is considered as the threshold proportion to compare sample proportion against the decision of whether the considered parameter actually has a significant impact on port maritime connectivity. Though the questionnaire is measured to five point Likert style, in running one-sample (single proportion) binomial test, the decision of "Significant" and "Highly Significant" are considered as the decision of success to compare proportions whereas other decisions (Neutral, Not Significant and Not significant at all) are considered as the decision of not success. Thus, the sample proportion of each identified variable is compared with respect to proportion value "0.5" to identify the significant variables for port maritime connectivity.

3.4 Second stage data gathering

3.4.1 Methods of Data Gathering

There are several quantitative data gathering methods and sources available such as online databases, online publications, online magazines, websites, annual reports of organizations and documentaries (Wang and Cullinane, 2011; Laxe, Seoane, & Montes, 2012; Tovar et al., 2015). The primary data extracted from above mentioned sources provide valuable information for new research studies although they are gathered and recorded by someone else (Zikmund, 2010).

Low et al. (2009) used Containerization International Yearbook, Lloyd's Register Fairplay Ports Guide and World Competitiveness Yearbook to collect data on port cargo traffic, number of port calls, draft, cargo volume, turnaround time, hinterland connectivity, port operating hours and port charges. Sigera (2012) used Containerization International , Review of Maritime and Alphaliner Monthly Monitor as main data sources to collect details about container lines (market share with regard to TEU capacity, cargo volumes and number of vessels), information on strategic co-operations (types of strategic co-operations, dates of their occurrences, members of the strategic co-operations and changes in the members and types) and volumes of resources integrated or acquired through the strategic co-operations.

The transportation capacity between a pair of ports, which represent the actual traffic flow in the network, was quantified by using data collected from the Alphaliner database (Tovar et al., 2015). Jiang et al. (2015) collected data such as shipping routes, arrival/departure/ waiting time at a port, travelling time in a link and service capacity from CI-Online to calculate capacity of a link which connects two ports, the waiting time for transfer from one service to another, the waiting time of one shipment at its origin port. Further Mohamed-Chérif and Ducruet (2016) extracted vessel movement data from the Lloyd's Shipping Index published by Lloyd's List and port throughputs data from port authorities and Ministry of Transport. In addition to above, Kavirathna.et al. (2018) collected container handling data, transshipment volume and information about port facilities from official websites of ports and online data bases. Further MDS was used as the source to collect information on container shipping services. Thus, current study also uses a combination of following sources to collect required data.

3.4.1.1 Online Publication

Online publications provide reliable secondary data which are published by reputed organizations like World Bank, Lloyd's register, UNCTAD and port authorities. Accordingly, Review of Maritime, World Bank reports, annual reports of the selected port authorities, Lloyd's Register Fair Play Ports and Terminal guide and Sri Lanka Central Bank reports were used to collect data on performances of the selected ports, details of port infrastructure and superstructure, turnaround times and operational capabilities of ports.

3.4.1.2 Online databases

Online databases are also one of the best secondary data sources. Databases such as Alphaliner database, Drewery Maritime, AIS and CI-online and Lloyd's Marine Intelligence were used to collect port traffic data, services calling to each port and their vessel capacities, port infrastructure data and port operational parameter. McCalla, Slack, and Comtois, 2005; Cullinane and Wang (2009); Cullinane and Wang (2012); Wang and Cullinane (2014) used Containerization International while Ducruet, Rozenblat, and Zaidi, 2010; Kaluza, Kölzsch, Gastner, and Blasius, 2010; Laxe et al. (2012) used Lloyd's Marine Intelligence Unit to collect required quantitative data for their study.

3.4.1.3 Port websites

Infrastructure related data such as number of terminals and berths, quay length, terminal draft, width and draft of entrance cannel, terminal capacity in TEUs, number of reefer plug-ins, specification of equipment that a port is using and quantity of terminal equipment were collected for each selected port using web sites of each selected container ports.

The process of data collection will be discussed in detail in the section 3.4.3 (data sources).

3.4.2 Population and sample design

The objective of second stage data analysis is to identify the quantitative data collected for the affecting factors identified through qualitative data analysis. Once data collecting sources are identified, next step is to correctly identify the target population for the study. In order to bring a better understanding on which port logistics developments affect maritime connectivity, it is better to do a census on identified factors for all the container ports in the world. But it is not practical as there are a lot of limitations entailed in accessing whole population of container ports such as unavailability of all the required data for all the container ports, difficulties in collecting data, time consumed and cost. Therefore, it is decided to select a sample which represents the target population.

One of the objectives of stage two data gathering and data analysis is to answer second subsidiary question (Quantify how significant is each port logistics development on the maritime connectivity?). Therefore, selecting most appropriate sample is highly critical as it represents the result for whole population.

3.4.3 Sample port selection

Low, et al (2009) used a sample of 11 ports to assess the connectivity of them. This sample includes ports such as Singapore, Hong Kong, Kaohsiung, Shanghai, Pusan, Port Klang, Yokohama, Tokyo, Tanjung Priok, Laem Chabang and Jawaharlal Nehru for the period of one year. Then Lam and Yap (2011) calculated annualize slot capacities which represent connectivity of 3000 container shipping services on an annual basis over a 12-year period from year 1995 to 2006 selecting four major ports in East Asia, namely Shanghai, Busan, Kaohsiung and Ningbo. Again Tovar et al. (2015) selected a sample made up of 53 ports, representing 36 countries and covering twelve different geographical areas to measure port connectivity. Bartholdi et al. (2016) studied connectivity considering links of 457 ports belong to communities such as Asia-Pacific and Trans-Pacific, Trans-Atlantic, South Asia and Mideast, West and South Africa, Gulf of Mexico-Caribbean-Pacific-South America, South-eastern Latin America, New Zealand and Mediterranean-Europe. Jiang et al. (2015) studied port connectivity considering 34 ports including 16 major ports and 17 super ports. Major ports were selected from Asia Pacific region namely Singapore, Shanghai, Hong Kong, Shenzhen, Busan, Ningbo, Guangzhou, Qingdao, Kaohsiung, Tianjin, Dalian, Port Klang, Laem Chabang, Tanjung Pelepas, Yokohama and Yingkou, while ports in other regions except Asia Pacific region were selected as single super port. Super port is a representative port which was formed combining major ports in a particular region. For an example super port called Africa is formed combining all major ports in Africa while all ports in Europe are combined to form super port of Europe. Calatayud et al. (2017) analyzed the structure of the network that enables connectivity to international markets selecting one geographic region which includes 34 countries showing high intensity of intra-regional trade floors in North, Central and South America and the Caribbean.

Considering all above sample selections, availability of data and scope of the current study, a sample of 34 highly connected ports were selected using stratified sampling method where the whole population of container ports segmented in to small port groups based on the maritime region they located. Maritime regions considered are West Coast America, East Coast America, Africa, Europe, Mediterranean, Middle East, South Asia, South-East Asia and Eastern Asia. The number of ports which should be selected from each maritime region was decided in proportional to the size of each stratum which is the total number of container ports that belonged to each maritime region. Once the number is decided, the ports which should be considered were selected based on the following criteria.

- The ports ranked in top 50 busiest container ports (Lloyd's List Top 100 Container Ports,2017)
- Ports that belonged to countries which are ranked among top 50 connected countries with respect to the LSCI.
- Ports located in busiest routes (Asia Europe, Asian America, Asia-Mediterranean and Asia Middle east)
- Ports which can accommodate new generation ships
- Ports where recent port logistics developments were occurred

Accordingly, the sample that was selected for the second stage data analysis is as follows,

Table- 3-4 Sample- Container port

Geographical region	Port	Country	Port Rank ASC
East Asia	Shanghai	China	**1**
	Hong Kong	Hong Kong	**3**
	Busan	South Korea	**4**
	Tokyo	Japan	**18**
	Dalian	China	**22**
South East Asia	Singapore	Singapore	**2**
	Port Klang	Malaysia	**5**
	Tanjung Pelepas	Malaysia	**11**
	Laem Chabang	Thailand	**19**
South Asia	Colombo	Sri Lanka	**10**
	Nhawa Shiva	India	**16**

Middle East	Jebel Ali (Dubai)	UAE	**8**
	Jeddah	Saudi Arabia	**20**
	Port Said	Egypt	**24**
	Khor Fakkan	UAE	**32**
Europe	Rotterdam	Netherlands	**6**
	Antwerp	Belgium	**7**
	Hamburg	Germany	**9**
	Felixstowe	UK	**12**
	Bremen/Bremerhaven	Germany	**13**
Mediterranean	Valencia	Spain	**14**
	Algeciras	Spain	**15**
	Tanger-Med	Morocco	**23**
	Piraeus	Greece	**27**
	Ambarli (Istanbul)	Turkey	**28**
	GioiaTauro	Italy	**31**
America	New York/New Jersey	United States	**17**
	Savannah	United States	**21**
	Los Angeles	United States	**25**
	Seattle/Tacoma	United States	**26**
	Long Beach	United States	**29**
	Balboa	Panama	**30**
	Vancouver	Canada	**33**
Africa	Durban	South Africa	**34**

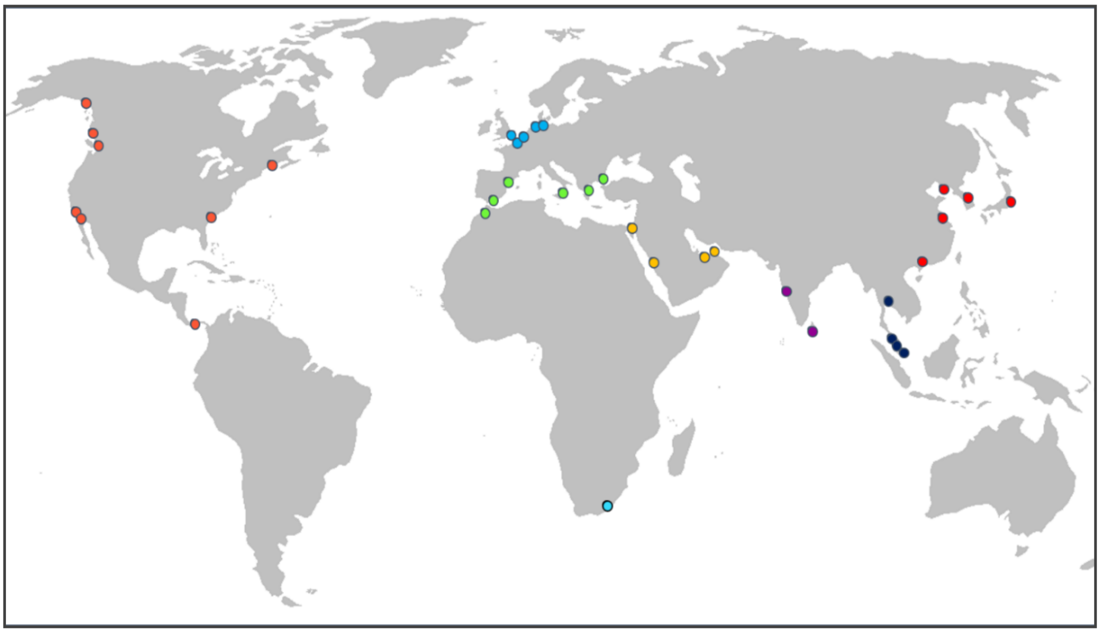

Figure 3-1 Sample Port map

Calatayud et al. (2017) collected required data for one point of time only, pointing out that the analysis is not performing to identify trends and evolution of the network. Given the purpose of second stage data analysis is to validate the results obtained from the first stage data analysis and develop a model/s to quantify how port logistics development factors affect the maritime connectivity of a port, the period one year was considered for data collection. Following the data availability, validity of all the required data and availability of latest information on ports, it is selected to collect data for the year 2016.

3.4.4 Data sources

3.4.4.1 Maritime connectivity of a port

Maritime connectivity of a port implies the easiness of connecting a port to the global shipping network. Easiness can be perceived as the number of options available to reach cargo from origin port to destination port and their cargo carrying capacities. However, measuring port maritime connectivity is highly challenging as it cannot be measured directly through published statistics (Paflioti et al., 2014). LSCI can be used as the measure for maritime connectivity. But LSCI measures the connectivity of a country not ports. Therefore, LSCI cannot be used as the measure for port maritime connectivity. Lam and Yap (2011), has used Annualized Slot Capacity as an alternate to quantify maritime connectivity of major ports in East Asia, namely Shanghai, Busan, Kaohsiung and Ningbo. Annualized Slot Capacity (ASC) can be defined as the multiplication of average vessel capacity in container liner services calling a port by frequency of calls in a year. Further Lam and Yap (2008) have also used ASC in their studies on container port competition in East Asia. Therefore, ASC can be used as the best parameter to represent maritime connectivity of a port and was selected to use as the dependent variable, which quantify port maritime connectivity. Though ASC, as a proxy for maritime connectivity, is widely calculated using average ship capacity and their frequency per annum, it will give a good insight if it can incorporate other factors like number of shipping companies registered at a particular port, liner services calling a port, number of vessels per company and maximum size of vessel calling a port. However due to the limitations in obtaining required data the study was limited only to ASC derived from multiplication of average vessel capacity in container liner services calling a port by frequency of calls in a year.

Although the online maritime databases like Alphaliner database, Drewery Maritime, AIS and CI-online were contacted to obtain required data, a large sum has to be paid. Therefore the required data (slot capacities of all the calling vessels, number of vessel calls and average TEU capacity of vessels calling) are compiled by collecting available data on terminal websites and other sources such as annual reports of all the terminal operators and port statistics published.

3.4.4.2 Operational and superstructure factor

Operational and superstructure factor is designed to measure following parameters; port annual handling capacity, number of container handling equipment, availability of ship and yard planning systems, availability of EDI system, number of reefer plugging facilities, efficiency in navigation services and warehousing capacity. However, data on efficiency levels in navigation services are not available on port websites whereas ports have only mentioned that they have efficient navigation services. Further, it is qualitative and complicated to develop a unique measurement as it depends on several other variables like availability of on time berthing windows, efficiency in tugboats and service level of harbour communication system, and as there is no predefined criteria to quantify. Therefore, efficiency in navigation services is disregarded from the quantitative analysis. In addition, warehousing capacity was also removed from the study due to the unavailability of data for all the sample ports. The remaining variables were factored in the quantitative data analysis

Port annual handling capacity - Annual handling capacity of a port is the designed handling volume which is capable of handling during an annum from all the terminals operating in a port. This is measured in terms of number of TEUs. This is highly dependent on the berth productivities, vessel turnaround time and productivities of equipment especially crane productivity and its specifications. Further, this is a capacity measure of a particular port and visualizes the traffic level it can handle. Therefore, port handling capacity is selected to study whether it has an impact on port connectivity. Data is collected referring the published data in terminal websites and their e-brochures.

Number of container handling equipment

Quay cranes, rubber tyre gantry cranes (RTGs), rail mounted gantry cranes (RMGs), terminal tractors and trailers and top lifters are the key container handling equipment deployed in a port container operation. All these are important for an efficient port operation while quay cranes play a critical role in how quickly a container vessel completes its operation as it is the only equipment used in ship to shore transfer operation. Therefore, number of quay cranes is selected to consider in spite of all the equipment when considering the availability of all the data and limitations in obtaining all required information. Port websites and terminal websites were selected to collect the above data.

Availability of ship and yard panning systems

Having sophisticated ship and yard planning systems, improve efficiencies in every single movement associated with the container vessel operation in a port. Today terminal operators has invested not only on ship planning systems but extended up to the automated crane management systems and automated gate management systems linking every single movement in to one platform. Therefore it was selected to assess how it has impacted the port connectivity. It is a highly challenging task to quantify how advanced the systems are. However it is not meaningful to consider the count of the system modules available. Therefore, it is selected to assess only the availability of the advanced ship and yard planning system. This is measured in binary form where as if a ship and yard planning system is available it is given one otherwise zero. Data published in terminals were selected as the data source.

Availability of EDI system

Electronic Data Interchange facility is highly important for a port and to container lines as it can share real time information which leads to more clarity and faster information compilation. This impacts the faster turnarounds eliminating unnecessary delays, which attracts container lines to a particular port. Therefore availability of EDI systems is selected to assess whether it has an impact on the maritime connectivity of a port. This is also measured in binary form where as if an EDI system is available it is given one otherwise zero. Data published in port and terminal websites were selected as the data sources.

3.4.4.3 Location related factors

Location of a port is important as it attracts container lines to call a particular port. Hoffmann (2012) also has identified geographical location of a port as one of the determinant factors on maritime connectivity of a port. Under location related factors, deviation distance from main shipping routes, close proximity to regional ports, hinterland connectivity and the number of connecting feeder services were selected as the main parameters. However, the data on deviation distance from main shipping routes to each port is not published in port websites or any maritime related database. Therefore, due to the limitation of obtaining data, this particular variable has to be eliminated from the second stage data analysis. Feeder connectivity was designed to quantify by number of feeder services available at selected port. But unfortunately, information on number of feeder services available at each port, was not able to collect for all the port in the sample. Therefore, feeder connectivity also has to be discounted from the quantitative data analysis. Finally, from remaining two variables, both variables have to be removed from the quantitative analysis due to the unavailability of required data.

3.4.4.4 Infrastructure related factors

Low et al. (2009); Hoffmann (2001); Hoffmann (2012); Hoogenhuizen (2013) have identified that port infrastructure has an impact on the port maritime connectivity. Number of terminals, number of berths, quay length, access channel draft, accessibility constraints and terminal draft were selected to study whether maritime connectivity of ports are impacted by them.

Number of terminals

A terminal is an interface between sea and the land and it is a quay which handles and stores containers. Generally, different terminals at a port are handled by different operators and in other words it is a mere indicator how many different operators/ options are available at a port to be considered in vessel route scheduling. Terminals are important in connecting a port to global network as it is the shelter for the ships, which are calling to load and unload cargo. Therefore, the number of terminals is selected as one of the variables which are going to be assessed whether it has an impact on the maritime connectivity. The above data is collected from the port websites and World Port Source (WPS) website.

Number of berths

Berth is a designated location where a ship is moored for the purposes of loading and unloading cargo. For a terminal there can be a number of berths. Availability of berths has a direct impact on the vessel turnaround time and thus the port competitiveness. If more berths are available, the waiting time for a berth would be lesser due to the lower congestion. Therefore, number of berths is selected as one of the variables to assess whether it has an impact on the maritime connectivity. The data is collected from the port and terminal websites and World Port Source (WPS) website.

Quay length

Quay length is the total length of berths located at a terminal and decides how many berths or ships can be handled at a time. Longer quay length is important in accommodating new generation of ships with higher LOA. Thus total quay length of a port measured in meters is selected as a variable to study whether it has an impact on the maritime connectivity of a port. Port websites and terminal websites were selected to collect the above data.

Access channel draft

Access channel is the entry point to a port and it should be able to facilitate extents of the biggest vessels. Therefore its width and draft (air and water) plays an important role in attracting vessels to a port. Data on the width of access channel is not available for all the ports. Hence access channel draft in meters is selected as a variable to study whether it has an impact on the maritime connectivity of a port.

Terminal draft

As explained above, terminal is the interface between sea and land and is directly involved in ship to shore operation. Further it should be capable of accommodating new generation of ships with deeper drafts. Therefore, it impacts on the port selection decision of the network planners. Thus maximum terminal draft is selected to study as different berths have different drafts. The port and terminal websites were selected to collect data.

Accessibility constraints

Ship operations of a port are highly impacted by natural features like swell, tidal water and ice. If any of these exists, a vessel will not be able to access the port and start its operation. Therefore, it has an impact on the port competitiveness and port's efficiency. Thus, Accessibility constraints were selected to study. Then the issue is how to quantify the level of the constraint. As there are no standard criteria to quantify, it was decided to measure whether any one of constraints existed (Yes/ No) assuming that each constraint has same disturbance effect on operation. The data is collected from the port and terminal websites and World Port Source (WPS) website. As this was measured in binary form whereas any of accessibility constraints like swell, tide and ice prevails, it was counted as one else zero.

3.4.4.5 Institutional Factors

Institutional factors are related to the ports structural characteristics such as custom policies, port policies, government policies, port tariff and skill levels of employees. Connectivity depends on port's structural characteristics not limiting to only on hinterland or foreland conditions and locational characteristics (Yeo et al., 2008). When it comes to custom policies, port policies, government policies (free trade agreements) and skill levels of employees, it is very tough to quantify and there are no unique scales to assign values. For an example, if port policies are assessed with respect to operation time, all the ports operate to a 24/7 time frame. Thus it is hard to quantify the impact on maritime connectivity from this variable. With respect to the port tariff, it is also a combination of different cost parameters. Such as handling is charged on TEU basis while pilotage and dockage are charged on the basis of GRT whereas GRT differs from ship to ship. Therefore it is hard to select a unique measurement. Thus institutional factors are excluded from the second stage analysis.

3.4.4.6 Time Factors

Kara and Tansel (2001) pointed out that cargo transport time is a combination of travelling time and waiting time, which is the transit time at a port and it is related to the frequency of liner services deployed at the intermediate ports. Thus both travelling time and waiting time are affected by the connectivity. Wilmsmeier and Hoffman (2008) examined that transit time of a vessel has a greater impact on freight rates than distance and thus the connectivity. Transit time at a port is decided by waiting time for a berthing window and vessel turnaround time. These are affected by availability of on-time berthing windows, waiting for connecting vessels, time taken for documentation process. Therefore, availability of berthing windows, dwell time for local containers, vessel turnaround time, time taken for documentation duties and dwell time for connecting vessels were selected to study. However, these data are not published and not available on port websites or any maritime database. Due to the limitations entailed in collecting required data, time factor is excluded from second stage data analysis.

Table 3-3 Second stage data gathering sources

Data	Measurement	Data Source
Port connectivity	Number of vessel arrivals	Annual reports of port authorities, port websites
Operational and superstructure factors	Capacity in TEUs, Number of gantry cranes, Reefer plugs, IT systems, Availability of ship and yard planning systems, Availability of EDI system	Port and terminal websites, online publications and databases
Infrastructure related factors	Number of terminals, Number of berths, Quay length, Terminal Draft, Accessibility constraints, Access channel draft	Port and terminal websites

3.4.5 Data analysis method

The correlation analysis will be performed to understand whether the selected variables from the first stage online survey analysis have a significant impact on the port maritime connectivity. Generally, in academic researches, significant level of 0.05 is widely used rather than 0.1 or 0.01 to identify the significance of each variable. This study uses 0.05 significant level as both hub and gateway ports in different maritime regions are considered in the analysis. Thus, the Pearson correlation analysis will be used to analyze the significance ($P<=0.05$) of the correlation of each variable.

Then simple linear regression (SLR) analysis will be conducted to identify the strength of each individual port logistics development parameter (independent variables) on the port maritime connectivity (dependent variable) and the variability of dependent variable to changes in independent variable (univariate correlation). The hypothesis tests will be conducted at 95% confident level, by assigning $\alpha=0.05$ significant level. Hypothesis will be accepted when port logistics factor is statistically significant unless otherwise null hypothesis is accepted.

3.5 Summary

This chapter explained why two stage data gathering was selected and how it was organized to answer primary research question followed by two subsidiary questions. Online mail survey was used to identify the perception of managerial level employees at container lines on how port logistics developments affect maritime connectivity of a port. The selection of sample and respondents was discussed and in total 95managerial level employees attached to global container line agencies registered in Sri Lanka were selected to conduct the online mail survey. Then the chapter discussed how second stage quantitative data gathering was conducted to validate the results obtained from perception based study and to quantify how significant each port logistics development is on the maritime connectivity of a port. The methods and techniques used in second stage data gathering, identification of population and sample and data sources from where data was extracted were discussed in detail. Considering the availability and limitations in obtaining data, thirty four (34) highly connected container ports which represent regions of West Coast America, East Coast America, Africa, Europe, Mediterranean, Middle East, South Asia, South-East Asia and Eastern Asia were selected as the sample using stratified sampling method. The next two chapters discuss the findings of the stage one mail survey followed by findings of the second stage quantitative analysis.

CHAPTER 4 - FIRST STAGE ONLINE SURVEY

4.1 Introduction

This chapter discusses the findings of the mail survey. The objective of the survey was to identify which port logistics developments affect maritime connectivity of a port. The chapter begins with explaining the profiles of respondents. Then it continues with explaining the significance of the 27 parameters identified based on the perception of industry experts attached to container lines. The parameters are categorized under operational and superstructure factors, location related factors, infrastructure related factors, institutional factors and time factors. The parameters in each factor will be ranked based on their mean significance score and the one sample proportion test P values to proceed secondary data analysis. The section concludes with the details of significant parameters and non significant parameters.

4.2 Demography of the mail survey

In total, questionnaires were emailed to 95 managerial level employees attached to global container line agencies registered in Sri Lanka and only 40 responses were received with completed information. This represents a 42.1 percent response rate. Initially, the response rate was very low. Then follow up emails and frequent reminder calls were made in order to encourage respondents to complete questionnaires.

4.2.1 The respondents' profile

The respondents are classified in to three main categories based on their designations. The designations such as Chairman, Vice President, Director, Chief Executive Officer and Chief Operating Officer are categorized under top management level employees and then designations such as General Manager, Assistant General Manager and Deputy General Manager are categorized under middle management while Senior Managers, Managers and Assistant Managers are categorized under junior management. From 40 respondents, 17 percent responses were received from top level management while 40 percent responses were received from middle level management. The remaining 43 percent of responses were received from junior level management (see Figure 4-1). The sample represents the perception of experts in all the levels and it is a good mix to identify different levels of experiences.

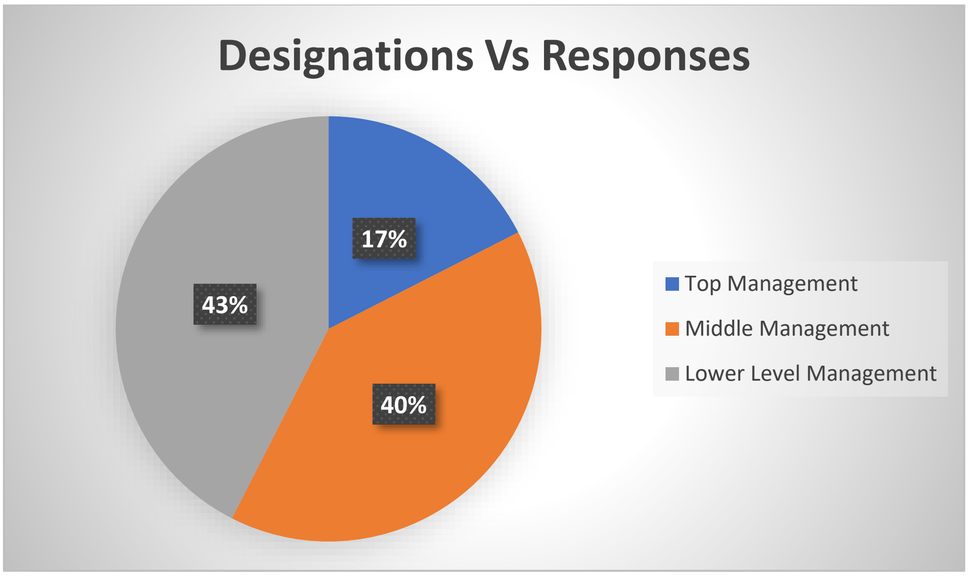

Figure 4-1 Respondents' profile

In order to ascertain how well the respondents understand the container line industry and how reliable their views are, the respondents were asked to indicate their total years of experience in shipping industry. Based on their responses the respondents were categorized into three categories. The three categories are industry experts with experience more than 10 years, 5-10 years and below 5 years.

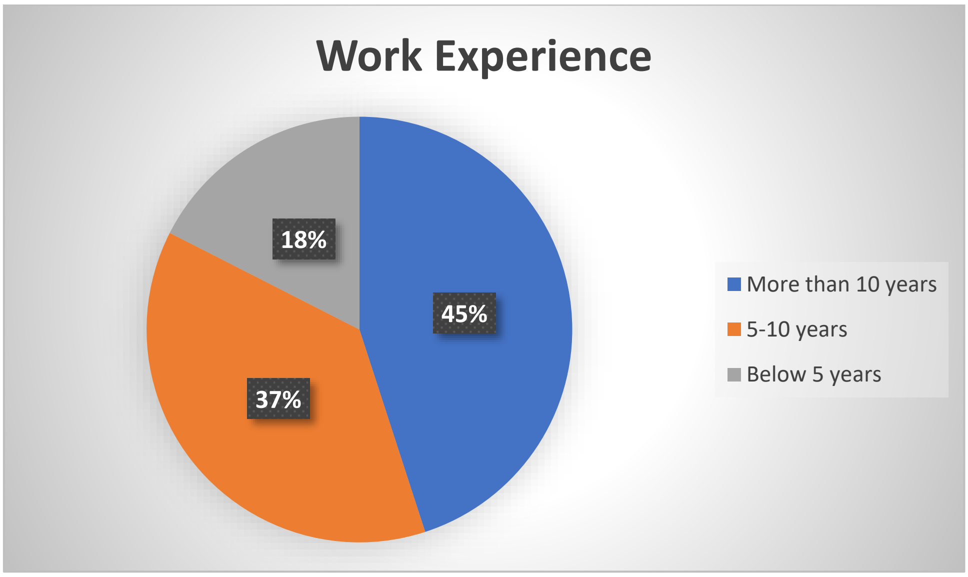

Figure 4-2 Work Experience

As shown in Figure 4-2, 45 percent of respondents have experience more than 10 years while 37 percent of the respondents have experience between 5-10 years. Only the remaining 18 percent have experience below 5 years. Altogether, 82 percent of the respondents have experience for more than 5 years. Therefore, this gives an indication that the respondents have thorough knowledge and experience on this domain and thus the study can rely on the perception of the respondents to do the analysis.

4.3 Significant port logistics developments

The main focus of the stage one mail survey is to identify the significant port logistics factors that affect maritime connectivity of a port. The analysis is done based on the responses received from managerial level employees attached to global container lines operating in Sri Lanka. The findings of this section address first subsidiary research question of the study:

"Which port logistics developments affect maritime connectivity of a port?"

Furthermore, the first stage data analysis is an exploratory study, which was done with the objective of empirically confirming the significance of each logistics factors identified through the literature survey to maritime connectivity of a port. And the findings in stage one online survey facilitate second stage analysis; where data is extracted from secondary data sources such as port annual reports and websites, which is the quantification of how significant each port logistics development is on the maritime connectivity of a port.

The one-sample (single proportion) binomial test issued to assess whether a selected variable is significant or not by taking 50 percent as the threshold proportion to compare sample proportion against the decision of whether the considered parameter actually has a significant impact on maritime connectivity of a port. Accordingly, sample proportion of the each identified variable is compared with respect to proportion value "0.5" to identify the significant variables for maritime connectivity of a port. Thus each variable was tested against a common hypothesis of;

H_0 : Variable A has no significant impact on the maritime connectivity of a container port
H_1 : Variable A has significant impact on the maritime connectivity of a container port

where alternate hypothesis is accepted when sample true proportion is greater than test value 50 percent and if one sample proportion test P value lesser than 0.05 under 0.05 significant level. Generally, in academic researches, significant level of 0.05 is widely used rather than 0.1 or 0.01 to identify the significance of each variable. This study also adapts 0.05 significant level to identify significant variables.

Before testing the significance of port logistics development parameters, first of all it is important to check the internal consistency (reliability) of all the parameters. Cronbach's alpha is the most common measure to check the reliability of multiple Likert style surveys. Thus, the reliability analysis (Cronbach's alpha) was run to understand whether the questions in this questionnaire are reliable.

Table 4-1 Reliability analysis

Reliability Statistics		
Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**N of Items**
.824	.809	27

According to Table 4-1, Cronbach's alpha is 0.824 which is more than 0.8. This indicates a high level of inter-correlations among parameters with respect to the sample of the study. Therefore, the data set is suitable for the significant analysis.

4.2.1 Superstructure and its operation related factors

The impact of superstructure and its operation related factor on maritime connectivity of a port is assessed under seven parameters. They are availability of suitable gantry cranes and yard cranes to handle new generation container ships, availability of state of the art ship and yard planning systems, availability of EDI system, availability of reefer plugging facilities, warehousing capacity (for local and MCC cargo), port annual handling capacity in TEUs and efficiency in navigation services. According to the mean values of the seven parameters stated in Table 4-2, availability of suitable gantry cranes and yard cranes records the highest mean value (4.73) while lowest mean value (3.28) is recorded for warehousing capacity. When the variables are prioritized according to the mean values, the senior managers attached to container lines perceive that availability of suitable gantry cranes and yard cranes (4.73) to handle the new generation ULCs as the most important variable that contributes to maritime connectivity of a port. Furthermore, availability of EDI system (4.6), port annual handling capacity in TEUs (4.45), efficiency in navigation services (4.45) and availability of state of the art ship and yard panning systems (4.40) respectively important to maritime connectivity of a port. When the statistical mode of the responses received from the industry experts is carefully analyzed, most of the respondents have perceived that availability of suitable gantry cranes and yard cranes, availability of EDI system and availability of state of the art ship and yard planning systems are "highly significant (5)" to maritime connectivity of a port, while efficiency in navigation systems, port handling capacity and number of reefer plugging facilities are perceived as "significant (4)".

Most of the industry experts perceive either warehousing capacity (for local and MCC cargo) has no impact on maritime connectivity of a port or they are not sure whether it has an impact or not. Forty five percent of the respondents have given the answer of "Not sure" while eighteen percent perceive that it does not have significant impact. This has resulted on a lower mean (3.28). This may be due to port warehousing capacities are highly important to the Multi Country Consolidation operation and import and export cargo traffic rather than the transhipment traffic. Further, this may be due to the lower volume of LCL cargo being handled at Port of Colombo.

Table 4-2 One-Sample Statistics-Superstructure and its operation related factors

One-Sample Statistics	**Mode**	**Mean**	**Std. Dev**	**Hypothesis proportion = 0.5**		
				True Proportion	**Sig.(1-sided)**	**Decision**
Availability of suitable gantry cranes and yard cranes	5	4.73	.55	95%	0.000	Reject the null hypothesis
Availability of EDI system	5	4.60	.55	98%	0.000	Reject the null hypothesis
Efficiency in navigation services	4	4.45	.504	100%	0.000	Reject the null hypothesis
Port annual handling capacity in TEUs	4	4.45	.504	100%	0.000	Reject the null hypothesis
Availability of state of the art ship and yard panning systems	5	4.40	.67	90%	0.000	Reject the null hypothesis
Number of reefer plugging facilities	4	4.18	.747	80%	0.000	Reject the null hypothesis
Warehousing capacity (for local and MCC cargo)	3	3.28	1.012	33%	0.040	Retain the null hypothesis

According to the one sample proportion test results depicted in Table 4-2, all of the above variables except warehousing capacity record higher sample true proportion than the hypothesis proportion of 50 percent. This implies that majority of respondents have perceived that these variables have a significant influence on maritime connectivity of a port. The one sample proportion test p value confirms this decision by having P value less than 0.05. Thus, the alternate hypothesis is accepted under 0.05 significant levels which shipping line experts perceive that;

- ✓ *Availability of suitable gantry cranes and yard cranes has significant impact on the maritime connectivity of a port*
- ✓ *Availability of EDI system has significant impact on the maritime connectivity of a port*
- ✓ *Efficiency in navigation services has significant impact on the maritime connectivity of a port*
- ✓ *Port annual handling capacity in TEUs has significant impact on the maritime connectivity of a port*
- ✓ *Availability of state of the art ship and yard panning systems facilities significantly impact on the maritime connectivity of a port*

- ✓ *Number of reefer plugging facilities significantly impact on the maritime connectivity of a port*

This is mainly due to the fact that competitiveness, productivity and efficiency of a port depend highly on the performances of its superstructure such as container handling equipment, ship and yard planning systems, EDI systems and navigation services. These are highly important in facilitating faster ship operations and competitiveness of a port which finally represent the connectivity (Low et al., 2009).

Some practitioners may not see the need of developing reefer plugging facilities due to the low volume of reefer cargo handled at Port of Colombo. Thus the lower volumes of reefer cargo handled at port of Colombo and lower emphasis to develop these facilities may be the reasons for comparatively lower proportion for the decision of significant.

Warehousing capacity (for local and MCC cargo) - Though the mean score records 3.28 which is less than the decision of significant (4), the highest standard deviation of 1.012 implies that a reasonable share of respondents believe that warehouse facilities contribute to maritime connectivity of a port. This could be due to the reason that low volume of LCL cargo and MCC operations happen at port of Colombo. According to the proportion test, only 33 percent of the respondents perceive that warehousing capacity significantly impact on maritime connectivity of a port wherein majority does not perceive. Although $p < 0.05$, null hypothesis is accepted due to majority of the industry experts perceiving that warehousing capacity has a no significant bearing on maritime connectivity of a port.

4.2.2 Location related factors

The location related factors, which affect maritime connectivity of a port, are assessed under four sub parameters; deviation distance from main shipping routes, location of port (proximity to other ports in the region), hinterland connectivity and adequate feeder connectivity. As per Table 4-3, the highest mean score is given for the adequate feeder connectivity (4.63) followed by deviation distance from main shipping routes (4.58). Further statistical mode for both variables records 5 (highly significant for maritime connectivity of a port). This indicates that most of the respondents perceive that both parameters significantly contribute to maritime connectivity of a port. Further hinterland connectivity records the lowest mean score (3.23) followed by location of the port (proximity to other ports in the region) which records 3.95. When considering the mode of the answers, most of the respondents have given that they are "not sure (3)" whether these variables have an impact on maritime connectivity of a port. Port of Colombo is less dependent on import and export cargo, accordingly the port is less dependent on hinterland connectivity. Further, being located in a strategic location in East-West shipping route, the port of Colombo is selected by most of the container lines usually as the transhipment hub for the South Asian sub-continent. Thus, for Colombo port, location of the port (proximity to other ports in the region) is less important. This scenario might be the reason why industry experts are not sure whether these two variables have any impact on maritime connectivity of a port.

Table 4-3 One-Sample Statistics -Location related factors

One-Sample Statistics	**Mode**	**Mean**	**Std. Dev**	**Hypothesis proportion = 0.5**		
				True Proportion	**Sig.(1-sided)**	**Decision**
Adequate feeder connectivity	5	4.63	.540	98%	0.000	Reject the null hypothesis
Deviation distance from main shipping routes	5	4.58	.594	95%	0.000	Reject the null hypothesis
Location-proximity to other ports in the region	3	**3.95**	**.845**	63%	0.155	Retain the null hypothesis
Hinterland connectivity	3	3.23	.862	40%	0.268	Retain the null hypothesis

Adequate feeder connectivity and Deviation distance from main shipping routes – 98 percent and 95 percent of the total respondents respectively perceive that adequate feeder connectivity and deviation distance from main shipping routes have significant impact on the maritime connectivity of a port. This is higher than the hypothesis proportion of 50 percent and also the proportion test P value records less than 0.05 under 95 percent CI. This indicates that the null hypothesis is rejected where industry experts perceive that;

- ✓ *Deviation distance from main shipping routes and Adequate feeder connectivity have significant impact on the status of the maritime connectivity of a container port*

This could be due to the deviation distance and feeder connectivity impact on total voyage time and the transport cost of a container, which in return impact on the connectivity (Paflioti et al., 2014, Jiang et al., 2015).

Location-proximity to other ports in the region and Hinterland connectivity - According to the responses given, only 63 percent perceive location proximity to other ports in the region has significant impact on maritime connectivity of a port. However, having fairly higher standard deviation (0.845) implies that there are more responses against the decision of "Significant". However, the proportion test P value records greater than 0.05, though the majority of responses perceive that location proximity to other ports in the region has significant impact. This retains the null hypothesis where Location-proximity to other ports in the region has no significant impact on the maritime connectivity of a port.

With respect to hinterland connectivity only 40 percent perceive hinterland connectivity impact on maritime connectivity of a port, violating hypothesis proportion which is below the 50% level. Considering the proportion test P value (0.268) and lesser proportion than hypothesis proportion, it accepts the null hypothesis. Thus, industry experts perceive that hinterland connectivity have no significant impact on the maritime connectivity of ports. Colombo port does not depend on import and export volumes and it is a transhipment dependent port. Therefore, the experts' decision could be biased to Sri Lankan contest and this may be the reason for the lower mean value derived for hinterland connectivity.

4.2.3 Infrastructure related factors

How industry experts perceive the impact of infrastructure related factor on maritime connectivity of a port is discussed under six criteria. They are number of terminals, number of berths, quay length, access channel width and draft, accessibility constraints (tidal water) and deeper terminal draft. As shown in the Table 4-4 when the parameters are prioritized according to mean values, the highest mean value is recorded for deeper terminal drafts (4.93) followed by access channel width and draft (4.90), number of berths (4.68) and quay length (4.38) while the number of terminals (3.80) received the lowest mean followed by accessibility constraints like tide, swell and ice (4.03).In analyzing the responses, most of the respondents have perceived that deeper terminal draft, access channel width and draft and number of berths are “highly significant” on maritime connectivity of a port. In addition to above, most of the responses are assigned quay length, accessibility constraints and number of terminals have “significant (4)” impact on the maritime connectivity of a port.

Table 4-4 One-Sample Statistics - Infrastructure related factors

One-Sample Statistics	**Mode**	**Mean**	**Std. Dev**	**Hypothesis proportion = 0.5**		
				True Proportion	**Sig.(1-sided)**	**Decision**
Deeper terminal draft	5	4.93	.27	100%	0.000	Reject the null hypothesis
Access channel width and draft	5	4.90	.30	100%t	0.000	Reject the null hypothesis
Number of berths	5	4.68	.47	100%	0.000	Reject the null hypothesis
Quay length	4	4.38	.49	100%	0.000	Reject the null hypothesis
Accessibility constraints	4	**4.03**	**.89**	80%	0.000	Reject the null hypothesis
Number of terminals	4	**3.80**	**.88**	68%	0.040	Reject the null hypothesis

Deeper terminal draft, access channel width and draft, number of berths and quay length have received mean values higher than 4 with a lower standard deviation, which indicates the uniformity of experts’ views about the significance of the contribution of above mentioned factors to maritime connectivity of ports. Further true proposition records as 100 percent and one sample proportion test P value is lesser than 0.05. This confirms that these variables reject null hypothesis under 0.05 significant level. Therefore,

- ✓ *Deeper terminal draft, Access channel width and draft, Number of berths and Quay length, have significant impact on maritime connectivity.*

This is because the number of berths available decides the number of ships which can be handled at a time. Further quay length, terminal draft and access channel width and draft decide the capability of handling larger new generation of vessels.

Accessibility constraints - Most of the respondents have given the score of "significant (4)" for accessibility constraints while 80 percent of the responses are given the decision of either "highly significant" or "significant". Mean score slightly higher than 4 (4.025) implies that there are few experts who perceive accessibility constraint is not significant on maritime connectivity of a port. The proportion test P value lesser than 0.05 (P=0.00) and higher proportion indicates that it rejects null hypothesis,

- ✓ *Accessibility constraints significantly impact on the maritime connectivity of a port*

This is because if a port frequently gets affected by the tidal water, swell, air draft and ice, this results in the lower productivity and efficiency. Then the vessels are reluctant to call the particular port and thus the maritime connectivity of the port is affected. Even though ports get affected by these issues, port of Colombo does not get exposed to these natural hazards very frequently. Few respondents might think with respect to the Sri Lankan contest and that could be the reason for high standard deviation.

Number of terminals - The mean value records 3.8 and only 68 percent of the total respondents perceive that number of terminals operating at a port has "significant" or "highly significant" impact on maritime connectivity of a port. Though 68 percent have given either 4 or 5, higher standard deviation with lesser mean value implies that there are few respondents who perceive that number of terminals is not significant. Compared to the hypothesis proportion value of 50 percent this is higher than the acceptable range and one sample proportion $P<0.05$, this rejects null hypothesis. Therefore, it can be concluded that,

- ✓ *Number of terminals has significant impact on maritime connectivity*

This may be because terminals are a fair indication of how many different operators are operating port facilities at a port and when there are more terminals, liner services have more selection options to call based on their productivities and efficiencies. Further, a terminal being operated by global terminal operators like PSA terminals, DP world terminals, APM terminals etc, most of the liner services will be motivated to call as they have liner specific agreements with those terminal operators. This will impact on maritime connectivity of a port.

4.2.4 Institutional factors

The institutional factors which affect maritime connectivity of a port are assessed under five sub parameters; port tariff structure, customs policies, port policies (operation time), government policies (trade agreements) and availability of skilled employees. As per Table 4-5, the highest mean score is recorded from the port tariff structure (4.48) followed by port policies (4.10) while government policies record the lowest mean score (3.50) followed by the availability of skilled employees (3.58) and customs policies (3.88). However, the higher standard deviations of customs policies, availability of skilled employees and government policies (0.883, 1.083 and 0.934) are because some of the industry experts perceive that these three parameters significantly impact on the maritime connectivity while others perceive no significant impact.

Table 4-5 One-Sample Statistics -Institutional factors

One-Sample Statistics	Mode	Mean	Std. Dev	Hypothesis proportion = 0.81		
				True Proportion	Sig.(1-sided)	Decision
Port tariff structure	5	4.48	.599	95%	0.000	Reject the null hypothesis
Port policies	4	4.10	.632	85%	0.000	Reject the null hypothesis
Customs policies	4	3.88	.883	80%	0.000	Reject the null hypothesis
Availability of skilled employees	4	3.58	1.083	60%	0.268	Retain the null hypothesis
Government policies	3	3.50	.934	43%	0.429	Retain the null hypothesis

According to the statistical mode of the responses received most of the respondents perceived port tariff structure is “highly significant” while port policies, customs policies and availability of skilled employees are perceived as “significant”.

Port tariff structure, Port policies and Customs policies – According to the true proportion percentage 95 percent, 85 percent and 80 percent of the respondents respectively perceive port tariff structure, port policies and customs policies either “highly significant” or “significant” on the maritime connectivity of a port. Thus, majority accept that these variables are significant. However, true percentage is higher than the hypothesis proportion of 50 percent and one sample proportion P value lesser than 0.05, implies that the null hypothesis is rejected. Thus, it is perceived that,

- ✓ *There is a significant impact on maritime connectivity from the port tariff structure, port policies and customs policies*

This might be because, when selecting ports of call, container lines consider quality of service and cost of calling. Thus, offering cost and time effective services is highly important in achieving maritime connectivity by attracting more liners. In achieving cost efficiencies, charges incurred at ports is one of the key cost components in total voyage cost. In addition, port policies and custom policies mainly impact on the vessel turnaround time and waiting time at the anchorage. For an example, if a port is not operating 24*7 or if customs are not visiting a vessel on arrival, vessels get delayed in berthing letting longer voyage time.

Availability of skilled employees - Though majority of respondents (60 percent) perceive availability of skilled employees as either “highly significant” or “significant”, the lower mean value and the higher standard deviation of 1.083 implies that there might be a few respondents for the decision of non-significant. However by having one sample proportion P=0.268, this accept null hypothesis where availability of skilled employees do not have significant impact on maritime connectivity of a port.

Government policies - The proportion test P greater than 0.05 (0.429) with lesser true proportion accept the null hypothesis. It can be concluded that industry experts perceive that government policies do not have a significant impact on maritime connectivity of a port.

4.2.5 Time Factor

The time factor gives an indication of how connectivity depends on each time consuming activity which are inevitable at a port. Accordingly, industry experts' perception on availability of on time berthing windows, dwell time for local containers, vessel turnaround time, time taken for documentation and waiting time for connecting vessels are assessed under the time factor. According to the Table 4-6, the highest importance (mean score) is given for the vessel turnaround time (4.83) followed by availability of berthing windows (4.60) and waiting time for connecting vessels (4.30). All three scores are higher than 4 which is the decision of significant. Further most of the respondents have stated that vessel turnaround time and availability of berthing windows as "highly significant" while waiting time for connecting vessels are stated as "significant". This indicates that industry experts perceive that these three parameters have an impact on the maritime connectivity of a port on average. The time taken for documentation records the lowest mean (3.35) score followed by dwell time for local containers (3.43).

Table 4-6 One-Sample Statistics - Time Factor

One-Sample Statistics	**Mode**	**Mean**	**Std. Dev**	**Hypothesis proportion = 0.81**		
				True Proportion	**Sig.(1-sided)**	**Decision**
Vessel turnaround time	5	4.83	.385	100%	0.000	Reject the null hypothesis
Availability of on time berthing windows	5	4.60	.496	100%	0.000	Reject the null hypothesis
Waiting time for connecting vessels	4	4.30	.648	90%	0.000	Reject the null hypothesis
Dwell time for local containers	4	3.43	**.958**	55%	0.635	Retain the null hypothesis
Time taken for documentation	3	3.35	**.893**	38%	0.155	Retain the null hypothesis

When all these parameters are prioritized, industry experts perceive that the first three parameters have a significant impact on the maritime connectivity of a port while the other two parameters show a moderate significance.

Vessel turnaround time (VTT), Availability of on time berthing windows – All the respondents have assigned either “highly significant” or “significant” score to both of these variables letting true proportion of 100 percent where hypothesis proportion is only 50 percent. Therefore majority of the respondents perceive VTT and availability of on time berthing windows are significant on achieving maritime connectivity of a port. The proportion test P value further confirms this by having P value lesser than 0.05 under 95 percent CI. Thus, alternate hypothesis is confirmed where industry experts perceive that;

- ✓ *Vessel turnaround time and availability of berthing windows have a significantly higher impact on maritime connectivity.*

This is because berthing delays, VTT impact on the total voyage time of a vessel and ultimately the total voyage cost. Therefore these are important in attracting more liners and thus the connectivity.

Waiting time for connecting vessels – In total 90 percent of the respondents have indicated that waiting time for connecting vessels significantly impact maritime connectivity of a port while only 10 percent feel that it has neutral effect or not significant. From those 90 percent, most of them have given the score of “significant (4)”. Further one sample proportion P value lesser than 0.05 rejects null hypothesis which is

- ✓ *Dwell time for connecting vessel has significant impact on maritime connectivity of a port*

This is because dwell time for connecting vessel is highly important for hub ports as they should tranship containers to its ultimate destination faster. Therefore, in selecting hubs, liner services are concerned on dwell time for connecting vessel. More the connectivity, more options are available to tranship containers quicker. Hence, this will have an impact on the maritime connectivity of the port.

Time taken for documentation and Dwell time for local containers – The sample proportion record a lesser proportion of 55 percent and 38 percent respectively. According to the one sample proportion P value it is greater than significant level 0.05. Therefore, null hypothesis is accepted where it can be concluded that time taken for documentation duties and dwell time for local containers have no significantly higher impact on the container port.

Accordingly, the following can be summarized as the key findings of the First stage online survey analysis.

Table 4-7 Significant variables

Port logistics Factor	Variable
Operational and superstructure factors	Availability of suitable gantry cranes and yard cranes
	Availability of EDI system
	Efficiency in navigation services
	Port annual handling capacity in TEUs
	Availability of state of the art ship and yard panning systems
	Number of reefer plugging facilities
Location related factors	Adequate feeder connectivity
	Deviation distance from main shipping routes
Infrastructure related factors	Deeper terminal draft
	Access channel width and draft
	Number of berths
	Quay length
	Accessibility constraint
	Number of terminals
Institutional factors	Port tariff structure
	Port policies
	Customs policies
Time factors	Vessel turnaround time
	Availability of on time berthing windows
	Waiting time for connecting vessels

Variables in Table 4-8 were rejected based the perception of industry experts as they perceived that those parameters have no significantly higher impact on the maritime connectivity.

Table 4-8 Insignificant variables

Port logistics Factor	Variable
Operational and superstructure factors	Warehousing capacity (for local and MCC cargo)
Location related factors	Location-proximity to other ports in the region
	Hinterland connectivity
Institutional factors	Availability of skilled employees
	Government policies
Time factors	Dwell time for local containers
	Time taken for documentation

The findings of the qualitative analysis confirm some of the findings in past literature, which are port infrastructure, superstructure, geographical location, port characteristics, draft, turnaround time, port charges, customs procedures/policies and port policies (operating hours), have a significant impact on the maritime connectivity of a port. Nevertheless, this analysis disconfirms that hinterland connectivity and skilful human resources have a significant impact on the maritime connectivity of a port. In addition, this study further reveals some new significant and insignificant variables.

4.4 Summary

The chapter assessed the perception of managerial level employees attached to global container lines registered in Sri Lanka on how each port logistics development factors impact the maritime connectivity of a port. Based on their perception, 27 parameters identified through literature survey validated as either significant variables or insignificant variables using one sample proportionate test.

CHAPTER 5- SECOND STAGE ANALYSIS

5.1 Introduction

This chapter discusses the findings of the second stage data analysis. The objective of second stage analysis is to identify how significant each port logistics development is on maritime connectivity of ports. The chapter begins with the correlation analysis between maritime connectivity of ports and the port logistics development parameters followed by the correlation analysis between each port logistics parameters. And then the chapter identifies the level of impact on maritime connectivity from each port logistics development parameter conducting a simple linear regression analysis.

As one of the objectives of the second stage data analysis is to verify the results obtained from mail survey analysis, all the variables considered in mail survey were initially selected for second stage analysis. However, due to the unavailability of the relevant data for all the sample ports and difficulties in quantifying data, only superstructure and infrastructure related variables were selected.

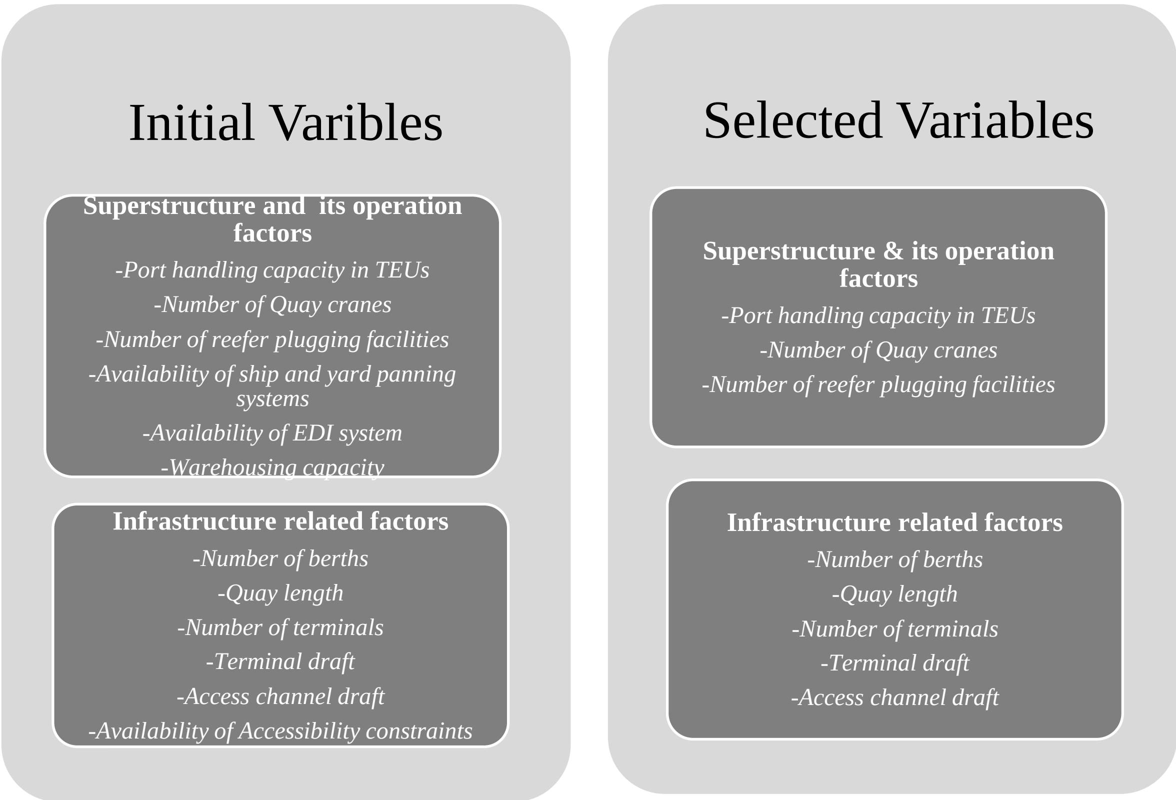

Figure 5-1 Variables for second stage data analysis

From those variables, availability of ship and yard panning systems, Availability of EDI system and availability of accessibility constraints were removed as they are measured in binary form (one is assigned if available otherwise zero) wherein binary data violates main assumptions in correlation analysis and simple linear regression analysis. Further, warehousing capacity was also removed from second stage quantitative analysis due to the unavailability of adequate number of data for analysis. Figure 5-1 show the both short listed and subsequently selected variables.

Accordingly, the variables that were selected for second stage data gathering are, port handling capacity, available number of quay cranes, number of berths, quay length, number of reefer plugging facilities, number of terminals, terminal draft and access channel draft.

5.2 Description of selected ports

Considering the availability and limitations in obtaining data, thirty four (34) highly connected container ports were considered as the sample for the second stage quantitative analysis. The 34 container ports that were selected using stratified sampling method represent regions of West Coast America, East Coast America, Africa, Europe, Mediterranean, Middle East, South Asia, South-East Asia and Eastern Asia. The criteria that were used for selecting ports are shown in the Figure 5-2.

- **The ports ranked in top 50 busiest container ports**
- **Ports are located in countries that are ranked among top 50 connected countries according to LSCI.**
- **Ports which are located in busiest routes (Asia Europe, Asian America, Asia-Mediterranean and Asia Middle east)**
- **Ports which can accommodate large supper Post Panamax ships**
- **Ports which have developed logistics facilities**

Figure 5-2 Sample Selection Criteria

Maritime connectivity of ports is explained using annualized slot capacity (ASC). Annualized slot capacity (ASC) is the multiplication of average vessel capacity (in TEUs) in container liner services calling a port by frequency of ship calls in a year. This is measured in million TEUs. The Table 5.1 indicates the sample of ports, which are ranked according to ASC in million TEUs. All these ports are segregated as per the geographical region they are located in and port type whether it is hub port or gateway port. In this study, “Hub port” is defined as a port where the transhipment volume out of its total volume is at least more than 25 percent. The “Gateway port” is defined as a port where majority of its handling volume is related to the hinterland volume-export and import volume while transhipment volume lesser than 25 percent (Rodrigue, J.P et al., 2016). The Liner Shipping Connectivity Index (LSCI) of each country that the particular port belongs to is also indicated. LSCI is an index that measures the connectivity level of countries to the global liner shipping networks and its accessibility by regular liner services.

Table 5-1 Ports considered for analysis

Port Rank _ASC	Port	Country	Geographical region	Port Type	ASC In Mn	2018 Rank - LSCI
1	Shanghai	China	East Asia	Hub port	59.57	1
2	Singapore	Singapore	South East Asia	Hub port	48.43	2
3	Hong Kong	Hong Kong	East Asia	Hub port	39.96	4
4	Busan	South Korea	East Asia	Hub port	39.18	3
5	Port Klang	Malaysia	South East Asia	Hub port	27.13	5
6	Rotterdam	Netherlands	Europe	Hub port	25.71	6
7	Antwerp	Belgium	Europe	Hub port	22.67	10
8	Jebel Ali (Dubai)	UAE	Middle East	Hub port	21.19	13
9	Hamburg	Germany	Europe	Hub port	19.11	7
10	Colombo	Sri Lanka	South Asia	Hub port	16.02	16
11	Tanjung Pelepas	Malaysia	South East Asia	Hub port	15.25	5
12	Felixstowe	UK	Europe	Gateway Port	12.81	9
13	Bremen/Bremerhaven	Germany	Europe	Gateway Port	12.27	7
14	Valencia	Spain	Mediterranean	Gateway Port	12.25	11
15	Algeciras	Spain	Mediterranean	Hub port	12.06	11
16	Nhawa Shiva	India	South Asia	Gateway Port	10.83	25
17	New York/New Jersey	United States	America	Gateway Port	10.66	8
18	Tokyo	Japan	East Asia	Gateway Port	10.51	15
19	Laem Chabang	Thailand	South East Asia	Gateway Port	10.40	35
20	Jeddah	Saudi Arabia	Middle East	Gateway Port	10.27	13

21	Savannah	United States	America	Gateway Port	10.22	8
22	Dalian	China	East Asia	Gateway Port	10.11	1
23	Tanger-Med	Morocco	Mediterranean	Hub port	9.35	17
24	Port Said	Egypt	Middle East	Gateway Port	9.31	18
25	Los Angeles	United States	America	Gateway Port	7.69	8
26	Seattle/Tacoma	United States	America	Gateway Port	7.33	8
27	Piraeus	Greece	Mediterranean	Gateway Port	6.97	28
28	Ambarli (Istanbul)	Turkey	Mediterranean	Gateway Port	5.60	27
29	Long Beach	United States	America	Gateway Port	5.49	8
30	Balboa	Panama	America	Hub Port	5.12	30
31	Gioia Tauro	Italy	Mediterranean	Hub port	4.89	20
32	Khor Fakkan	UAE	Middle East	Hub Port	4.81	13
33	Vancouver	Canada	America	Gateway Port	4.66	32
34	Durban	South Africa	Africa	Gateway Port	3.31	44

5.2.1 Details of port sample

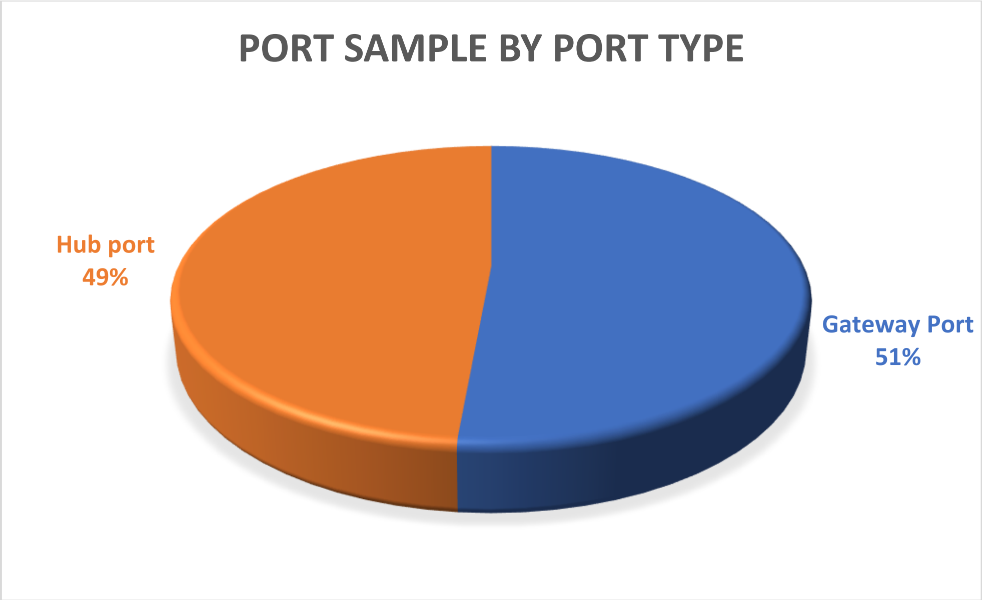

Figure 5-3 Sample Overview by port type

The sample of ports considered for the second stage analysis consisted of both hub and gateway ports. As shown in the Figure 5-3, 49 percent of the sample consisted of hub ports. These are either pure transhipment ports or regional hub ports, which connect regional and global shipping networks through long distance container liner ships and short distance feeder ships. The remaining 51 percent of the ports represent gateway ports. These ports facilitate intermodal transfers while import and export volume share in these ports are higher than transhipment volumes. These gateway ports are basically situated in either major cargo importing or exporting countries such as Japan, America, United Kingdom, India, Thailand, Canada, Turkey.

As shown in Figure 5-4, the ports sample represents all the main regions such as Asia, Middle East, Mediterranean, Europe, America and Africa. From all the regions, thirty three percent of the ports represent Asian shipping region, for clarity Asian region is further subdivided into three sub regions, East Asia, South East Asia and South Asia considering the simplicity of understanding the trends.

Furthermore, twenty percent of ports in the sample represent American region while seventeen percent and fifteen percent of the ports respectively represent Mediterranean and European regions. Twelve percent of the sample is consisted of ports located in Middle East region while only three percent of the sample belongs to African region. African region is less represented due to the fewer number of ports in African region are ranked among top 50 ports.

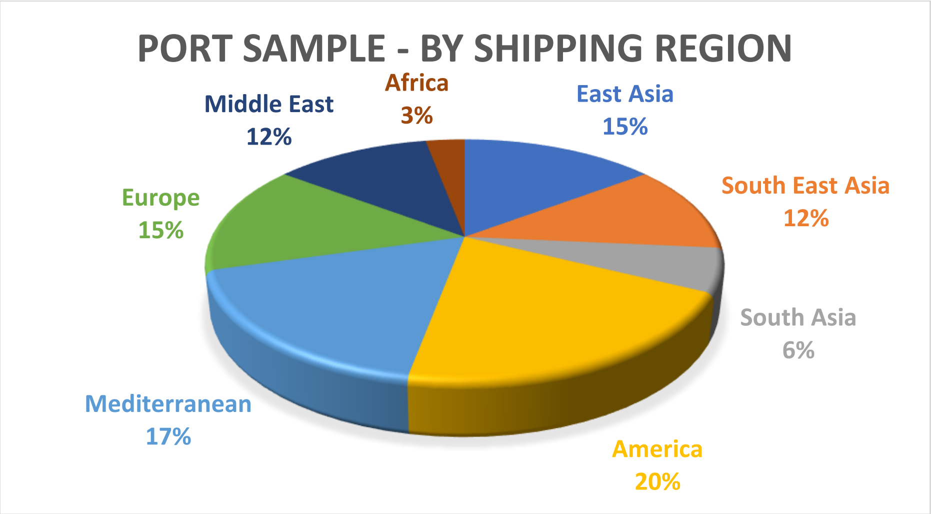

Figure 5-4 Sample overview by shipping region

As shown in Figure 5-5, port of Shanghai records the highest maritime connectivity among the ports in the above sample followed by the port of Singapore.

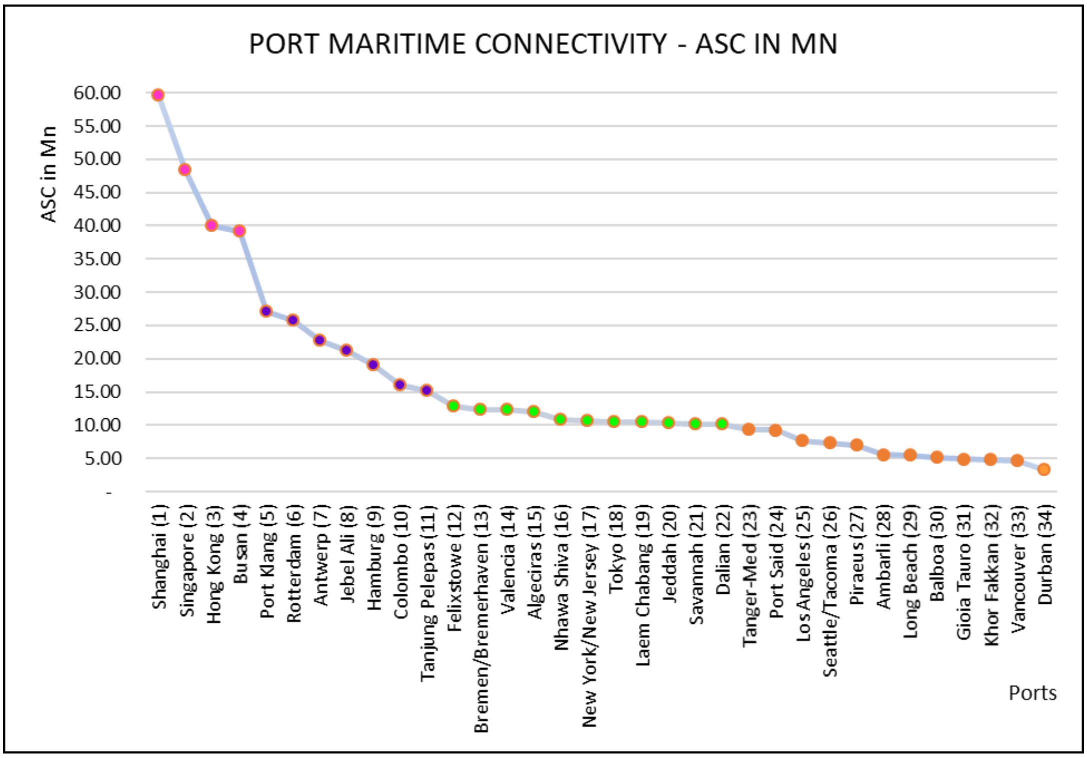

Figure 5-5 Port Maritime connectivity

Port of Shanghai is the major hub port located in the East Asia with both transhipment and gateway container volume while port of Singapore is a pure transhipment port. Ports could be clustered into four groups as per ASC, (see Figure 5-5). The four groups are ASC above 30 million, ASC between 30 million and 15 million, ASC between 15 million and 10 million and ASC below 10 million. Port of Shanghai, port of Singapore, port of Hong Kong and port of Busan are positioned in first cluster of ports (above 30 million ASC) by operating as the mega hub ports in Asian region with superior port infrastructure and cargo throughputs. Furthermore, port of Shanghai, port of Hong Kong and port of Busan are located in major production oriented countries. All of these ports are located in countries, which are in first four ranks of LSCI. Port Klang, port of Rotterdam, port of Antwerp, port of Jebel Ali, port of Hamburg and port of Colombo are ranked in the second cluster of ports, in which ASC value is between 30 million and 15 million. These are mainly regional hub ports located in East-West route which connects Far East to Europe (Review of Maritime, 2018). The common feature in these ports is the transhipment volume mainly dominates the throughput of theses ports.

Most of the ports which belong to cluster 3 and 4 are gateway ports which are mainly located in cargo importing and exporting regions like Japan, Thailand, United Kingdom, America, Canada, India and Africa. For example, port of Tokyo, port of Felixstowe, port of Savannah, port of Seattle/Tacoma, port of Vancouver, port of Nhawa Shiva and port of Durban are the main ports which record a lower ASC. However, there are few regional hub ports also recorded in the 3rd and 4th cluster like port of Algeciras, port of Tanger-Med, port of Balboa, port of Gioia Tauro and port of Khor Fakkan. All these ports are regional hubs operated in low cargo volume regions like America, Mediterranean and Middle East.

5.3 Correlation Analysis between Maritime connectivity of ports and Port Logistics Factors

The correlation analysis was performed to understand whether the selected variables from the first stage online survey analysis have a significant impact on the maritime connectivity of a port. Generally, in academic researches, significant level of 0.05 is widely used rather than 0.1 or 0.01 to identify the significance of each variable.

Table 5-2 Correlation analysis between maritime connectivity of ports and port logistics factors

Port logistics Factor	Pearson Correlation	Sig. (2-tailed)	N	Remarks
Port handling capacity in TEUs	.929	.000	34	Correlation is significant at 0.05 level
Number of quay cranes	.867	.000	34	Correlation is significant at 0.05 level
Number of berths	.842	.000	34	Correlation is significant at 0.05 level
Quay length	.767	.000	34	Correlation is significant at 0.05 level
Number of reefer plugging facilities	.689	.000	28	Correlation is significant at 0.05 level
Number of terminals	.608	.000	34	Correlation is significant at 0.05 level
Terminal draft	.365	.034	34	Correlation is significant at 0.05 level
Access channel draft	.134	.448	34	Correlation is not significant

This study uses 0.05 significant level as both hub and gateway ports in different maritime regions are considered in the analysis. The Pearson correlation analysis was used to analyze the significance ($P<=0.05$) of the correlation of each variable.

5.3.1 Port handling capacity in TEUs

As shown in table 5-2, correlation between maritime connectivity of a port and port handling capacity is 0.929, which illustrates a significantly strong relationship by having P value less than 0.05. The senior managers who responded for the online survey also indicated a very similar view related to port handling capacity, which is port annual handling capacity has significant relationship on the maritime connectivity of a port. Thus, port handling capacity can be considered as a significant variable which contributes to maritime connectivity of ports.

According to Figure 5-6, port number 1 and 2 which respectively represent port of Shanghai, and port of Singapore are highly connected while ports represented by numbers 3, 4, 5, 6, 7, 8, 9, 10 and 11 (port of Hong Kong, port of Busan, port of Klang, port of Rotterdam, port of Antwerp, port of Jebel Ali, port of Hamburg, port of Colombo and port of Tanjung Pelepas) are moderately connected.

It is clear that, ports with high handling capacities are provided with high ASCs by container lines, reflected by a strong correlation between them. However, Shanghai port (handling capacity per annum - 40 Mn TEUs) receives the highest ASC although it has a slightly lower capacity than Singapore (Port Singapore handling capacity per annum - 42 Mn TEUs). This could be due its strategic location in the Yangtze River Delta region, which has considerable high volumes of gateway traffic as well. Being a transshipment dependent country, liner shipping consolidation and growing alliances during 2016 has become a treat to port of Singapore and this could be the reason for slightly lower ASC (Nightingale, 2017).

Ports such as port of Hong Kong, port of Busan, port Klang and port of Tanjung Pelepas have shown moderate connectivity, because these ports are competing with above mentioned two highly connected ports for market share in their respective regions for container volumes. Specifically, moderate connectivity records in port of Busan may be due to the bankruptcy of Hanjin shipping line. Hanjin container line being the key customer of port of Busan and the world's seventh largest container line, it was challenging to bring back the same transshipment volume in short term to port of Busan and thus the vessel traffic (Nightingale, 2018). This might have impacted on the moderate ASC value of Port of Busan.

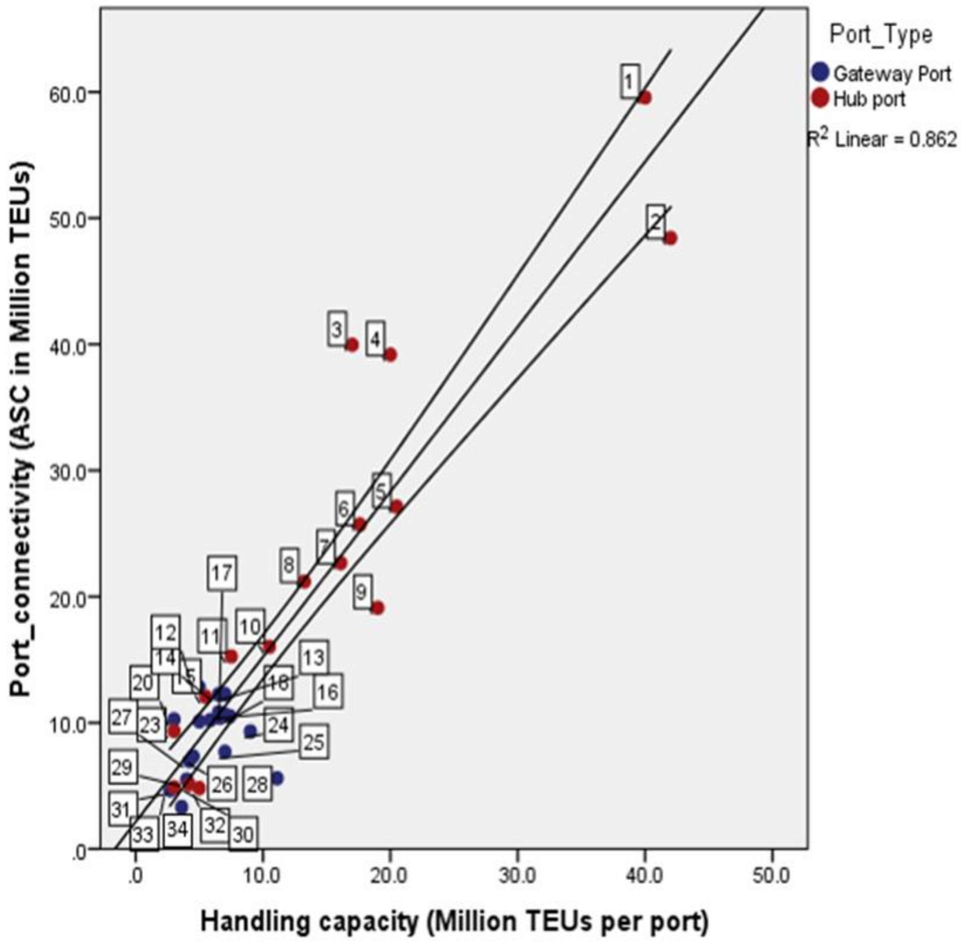

Figure 5-6 Scatter plot- Port handling capacity by port type

Moreover, when comparing to other ports, port of Hong Kong (3) and port of Busan (4) are placed towards left side from the trend line, indicating comparatively higher ASCs than the relative mean connectivity for their designed port handling capacity, which is possibly due to the presence of their national container carriers with prioritizing calling at these ports. This implies that these ports are operating to its maximum efficiency and thus more volumes of cargo are handled. Port of Busan (4) has constructed the new port development to alleviate cargo congestion and four of the five terminals in new port are also operated by global operators like Singapore's PSA International and the UAE's DP World who have proven records of world class efficiencies. Moderate connectivity in European ports such as port of Rotterdam (6), port of Antwerp (7), and port of Hamburg (9) could be due to the comparatively lower container traffic in European region compared to East Asia and South East Asia. And these are the economies with more imports than exports (see Figure 5-7).

Moreover, regional hub ports located in South Asia and Middle East such as port of Colombo (10) and port of Jebel Ali (9) also indicate moderate connectivity mainly due to the moderate container volumes traffic associated with these regions and also due to the competition between these hub ports with each other to attract more transshipment cargo, owing to their close proximity. However, during 2016 both of these ports are operating to their optimal capacity and there is a room to attract more traffic to increase their maritime connectivity. Therefore, they have accelerated the construction of new deeper terminals and fixed more state of the art ship-to-shore gantry cranes and terminal handling equipment to facilitate ULCs which will attract more vessel traffic and thus the higher maritime connectivity (Nightingale, 2017).

It is reasonable for most gateway ports have deviated to right from the trend line showing a lower connectivity although some of them (port Said (28) and Los Angeles (25)) have considerable high port capacities than several hub ports, especially located in hub and spoke networks with multiple feeder connections. All these ports have developed more capacity than current demand. The ports Ambarli-Istanbul (28), Long Beach (29), Balboa (30), Gioia Tauro (31), Khor Fakkan (32), Vancouver (33) and Durban (34) record lower maritime connectivity. All these ports are located in the countries which inherit lower cargo volumes as they are mainly cargo importing counties. Further, economic downturn in the world also has impacted in lower demand for containerized cargo in these countries. Among all the lower connected ports, port of Durban is the least connected port. Though it is located in an ideal location to serve as a hub for Indian Ocean Islands, Middle East, Far East and Australia, lower draft in the port has hindered attracting larger ships and transshipment volumes (Nightingale, 2017). This might have impacted on the lower ASC and thus the maritime connectivity.

As per Figure 5-7, the common feature in all the highly (ASC 30 above) and moderately (ASC 30-15) connected ports is that they are major hub ports or regional hub ports in maritime regions like East Asia, South East Asia, South Asia, Middle East and Europe (Figure 5-7). The less connected ports are gateway ports which are located in Africa and even in America catering to a major portion of import cargo rather than transshipment cargo.

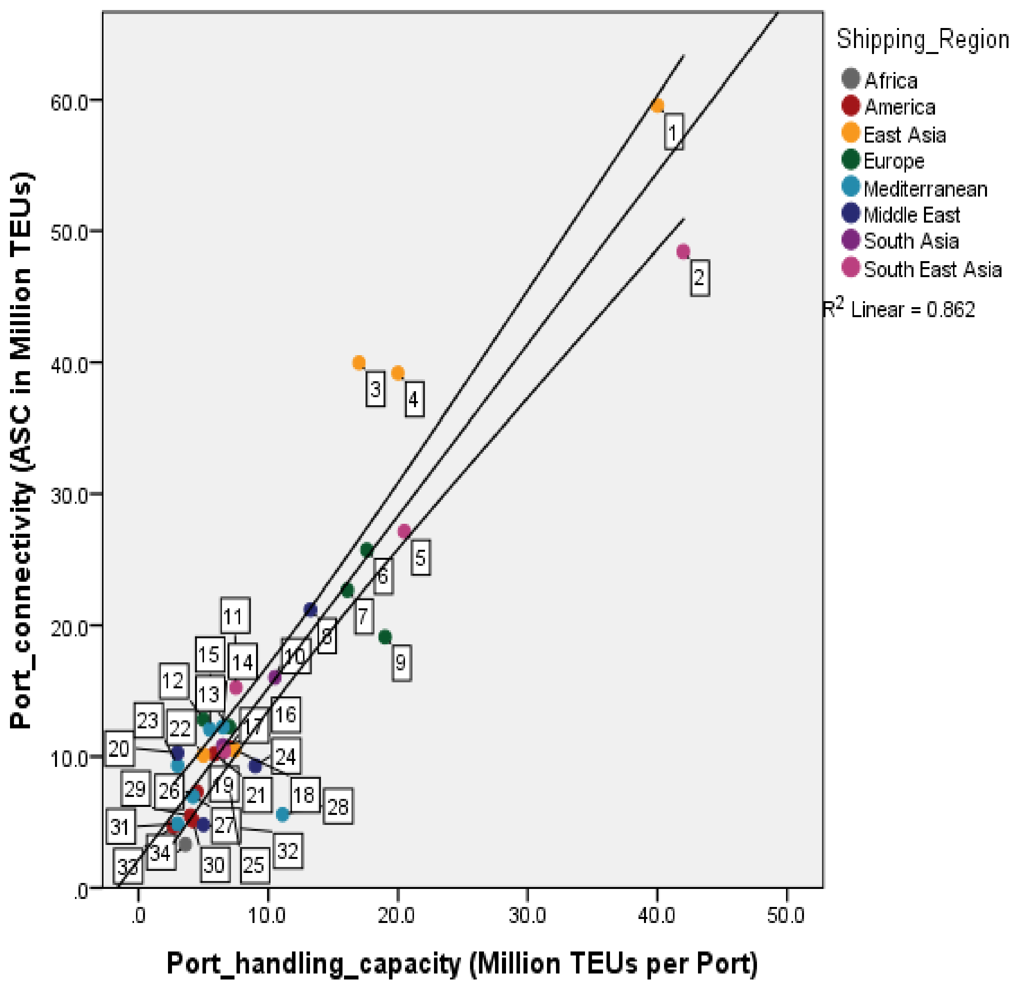

Figure 5-7 Scatter plot- Port handling capacity by shipping region

5.3.2 Number of quay cranes

As explained in methodology chapter, only number of quay cranes that are used for container handing is considered for this particular analysis. The number of quay cranes used shows a significantly higher relationship to maritime connectivity of ports by having P value <0.05 and correlation value - 0.867 under 0.05 significant level (see Table 5-2). This is further illustrated in the Figure 5-8 by showing a linear relationship. Hence, this confirms the results obtained from online survey analysis, which is that gantry cranes have a significant relationship on Port maritime connectivity.

Figure 5-8 depicts how maritime connectivity of each port is positioned against quay cranes operating at port. Among the highly connected ports (Figure 5-8), port of Shanghai (1), port of Hong Kong (3) and port of Busan (4) are positioned to left side of the trend line indicating significantly higher connectivity than relative mean connectivity which is equivalent to their number of quay cranes in operation. This implies that connectivity of these ports is higher than what it should be to currently operating quay cranes. Higher crane occupancy in these ports should be the reason for relatively higher maritime connectivity of these ports with respect to the available resources. Moreover all these ports are major hub ports in East Asian maritime region which are located in major cargo originating counties to globe as well as transshipment volume off these ports are considerably higher than other ports (Figure 5-9).

Port of Singapore, being the major giant in South East Asian region, is positioned towards the right side of the trend line indicating comparatively lower maritime connectivity to its current quay cranes operating. When analyzing crane occupancy port of Singapore shows relatively lower crane occupancy indicating that port of Singapore is not operating to its maximum. Commencing operation at Pasir Panjang Terminal Phases 3 and 4 in 2015 and facing a challenge due to various container line alliances, mergers and acquisitions, port of Singapore could not achieve its target vessel volume by 2016 (this study is conducted based on 2016 figures). This would result in the overcapacity of the cranes and lower ASC.

In contrast, port of Colombo is positioned to the left side of the trend line indicating higher ASC to existing number of quay cranes. Being located in a strategic geographical location ideal for a hub port, having its natural deeper terminal drafts and recent developments of Colombo South port, more number of ULCSs, post panamax, panamax and feeder vessels are attracted to the port of Colombo. This results in huge vessel traffic and optimum utilization of existing cranes.

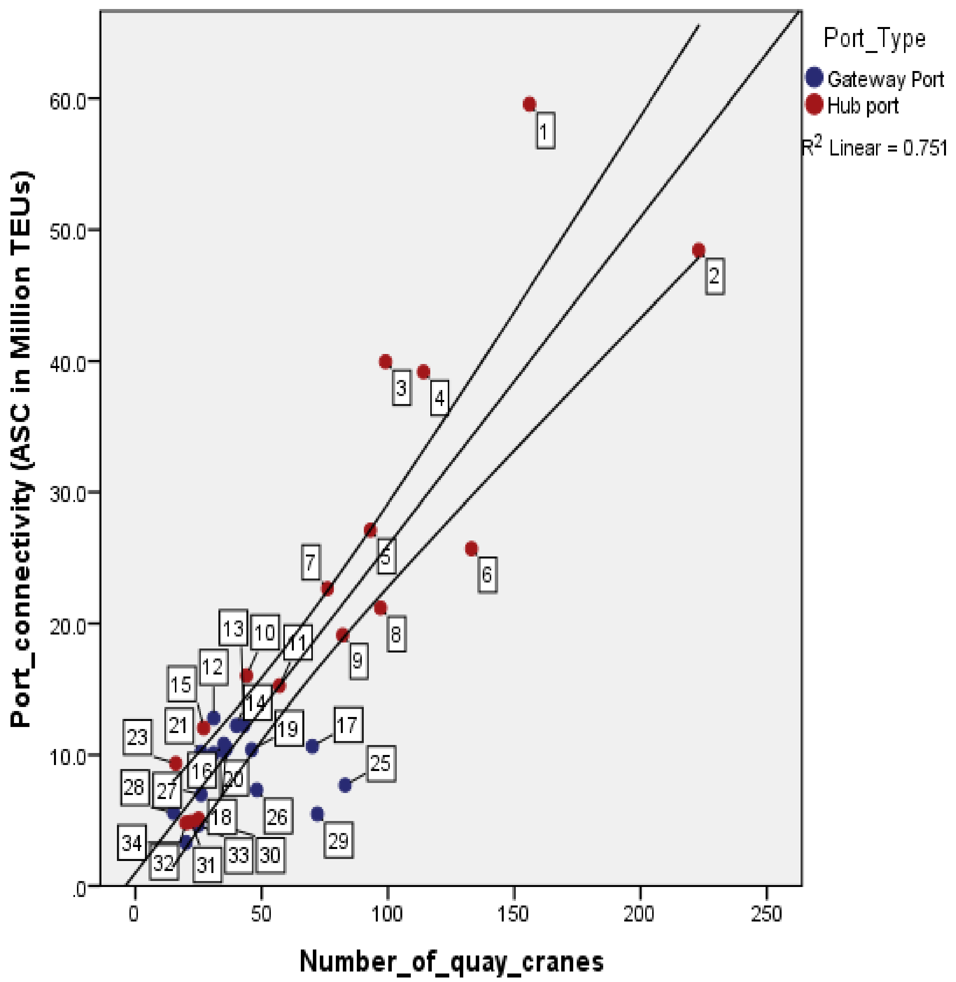

Figure 5-8 Scatter plot- Quay cranes by port type

Further, it shows the necessity of investing on more and advanced quay cranes to cater existing traffic and to attract more vessels. For example, one of the terminals operates cranes to the bare minimum and their crane specifications does not have potential to operate new generation ships though terminal can accommodate those vessels. As a result, port of Colombo has decided to fix more state of the art ship-to-shore gantry cranes and terminal handling equipment to facilitate ULCSs which will attract more vessel traffic and thus the higher maritime connectivity (Nightingale, 2017).

Furthermore, port of Hong Kong (3), port of Felixstowe (12), port of Algeriras (15) and port of Tanger med (23) are also positioned to the left showing very high occupancy which results in higher ASC and congestion at port. This could be due to several reasons like seasonal demand variation, lack of timely developments or maintenance.

Figure 5-9 illustrates that connectivity of most of the ports located in American continent is comparatively less than the equivalent connectivity of trend line which should be to their current quay cranes operating. Port of New York/New Jersey (17), port of Los Angeles (25), port of Seattle/Tacoma (26) and port of Long Beach (29) from American region and port of Rotterdam (6) from Europe are the ports which show comparatively lesser connectivity to its resources. This could be due to low economic growth/ trade growth in these regions during this period. Further, all these ports are in well developed countries and they are the main cargo importing economies. Thus, the number of vessel calls for these ports are comparatively less due to lower demand with compared to ports in cargo originating economies.

However, being well developed economies, they have over invested than current requirement which results in lower utilization of the quay cranes. For an example, ports of New York/New Jersey (17), Los Angeles (25), Seattle/Tacoma (26) and Long Beach (29) have respectively invested in 70, 83, 48 and 72 ship-to-show gantry cranes where regional hubs like ports of Colombo (10) and Tanjung Pelepas (11) operate with only 44 and 57 cranes. Furthermore, port of Rotterdam (6), port of Los Angeles (25) and port of Long Beach (29) are showing relatively lower quay crane occupancy.

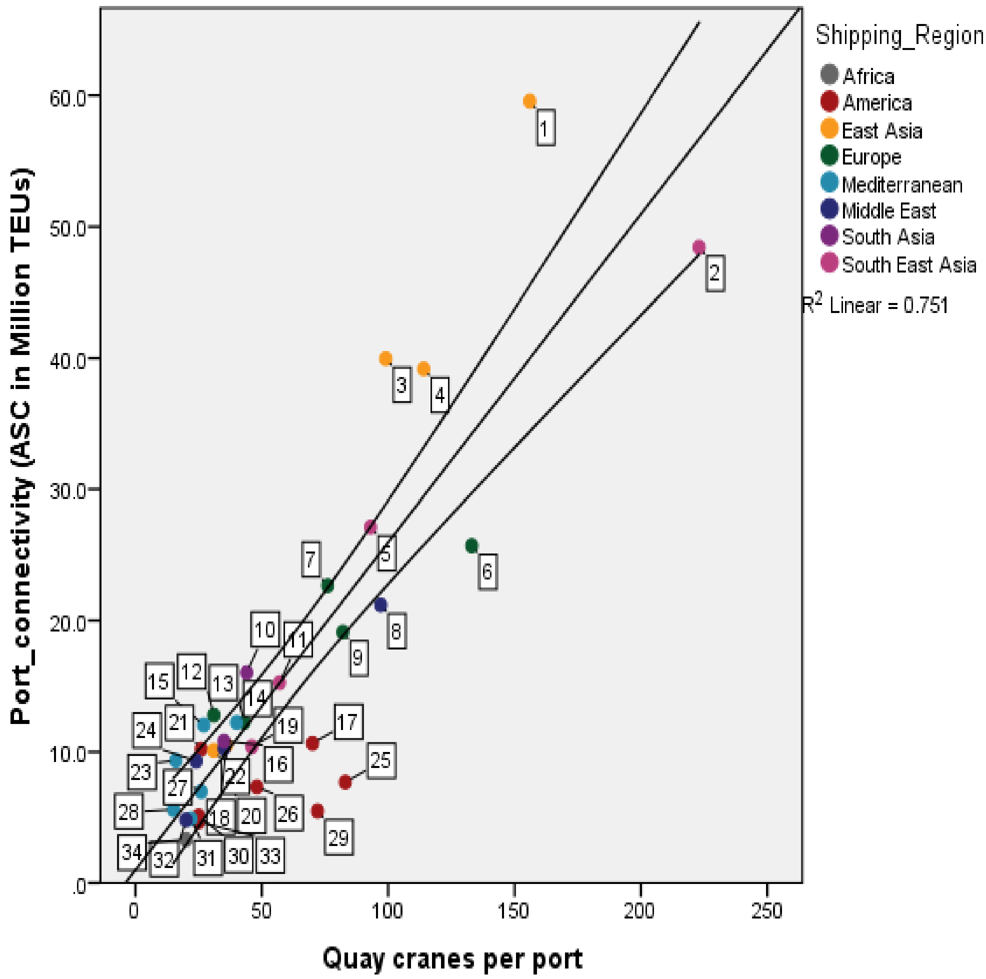

Figure 5-9 Scatter plot- Quay cranes by shipping region

5.3.3 Number of berths

Number of berths indicates how many ships, either mainline or feeder ships, can be operated in a port at a given time. The number of ships handled at a port is one of the key variables, which decides LSCI of a country also. As Table 5-2 depicts, number of berths shows a significant relationship on maritime connectivity of ports recording a higher correlation value 0.84 and P<0.05. The scatter plot in Figure 5-10 visualizes the higher association by locating most of the ports along the mean line and within the 95% confident interval. This confirms the results of online survey analysis where industry experts perceived that the number of berths has a significant relationship on the maritime connectivity of a port.

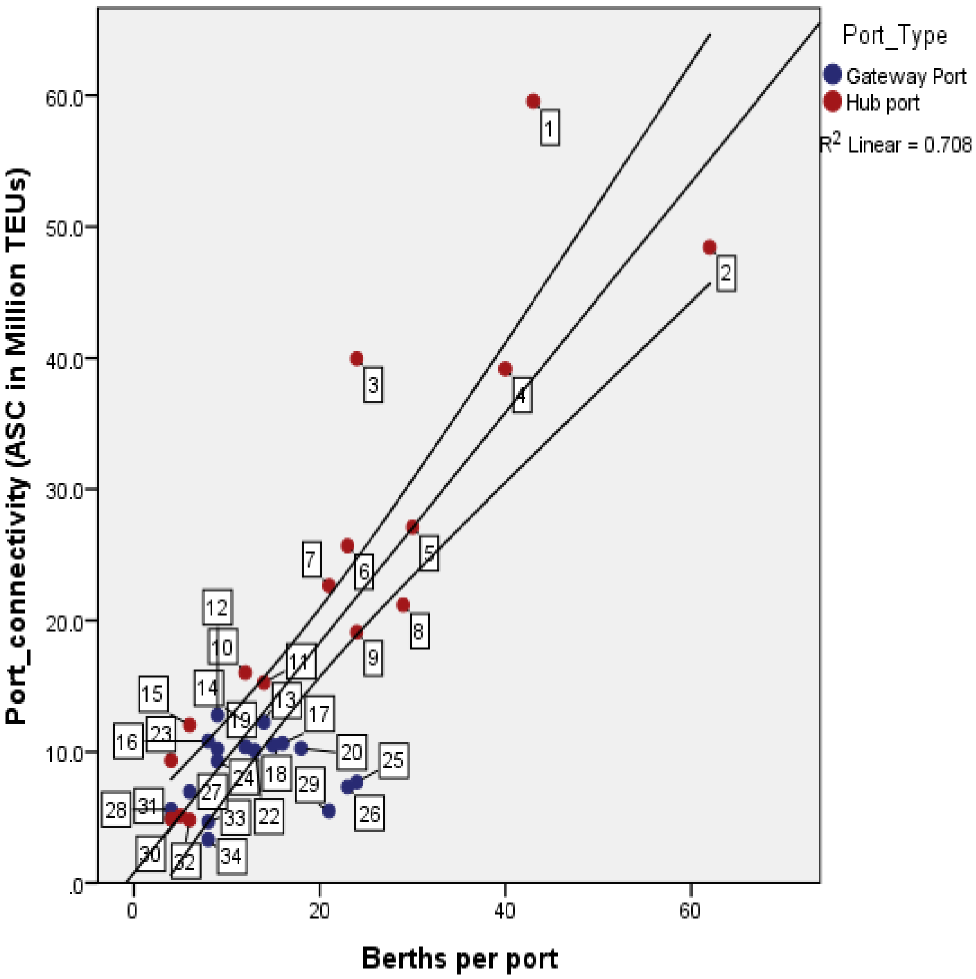

Figure 5-10 Scatter plot- Berths by port type

Figure 5-10 depicts that most of the gateway ports (in blue) have relatively lesser number of berths and their connectivity is also low accordingly which records ASC even below 15 Million TEUs per annum. From all the gateway ports port of Jeddah (20), port of Los Angeles (25), port of Seattle/Tacoma (26) and port of Long Beach (29) shift to right side from trend line recording relatively lesser connectivity with higher number of berths. All these ports respectively operate 18, 24, 23 and 21 berths whereas the ports in the same range of connectivity operate only around 4 to 9 berths. Lesser connectivity recorded in these ports is due to the lesser number of port calls and the size of the vessels calling these ports are comparatively lesser than the other major ports in Asian maritime region. This is confirmed by comparatively lower berth occupancy rates recorded in these ports.

However, most of the hub ports are positioned to the left side of the trend line. This implies that their connectivity is higher than the relative mean connectivity which should be to existing number of berths. According to the Figure 5-11, the ports which show significantly higher and moderate connectivity belong to Asian and European shipping regions which generate the highest containerized volume compared to all the regions, from which port of Shanghai (1), port of Hong Kong (3), pprt of Colombo (10) and Port of Algeciras (15) are showing a higher connectivity to their current operating berths. Out of them highly deviating ports to the left side are port of Shanghai (1) and port of Hong Kong (3) which belong to East Asian region and ranked in the top 5 busiest ports in 2018 while port of Shanghai being the first. All these ports are reaping the maximum out of available berths. Therefore, all these ports need infrastructure developments to maintain current connectivity levels, otherwise cargo will be shifted to competing regional ports due to congestion.

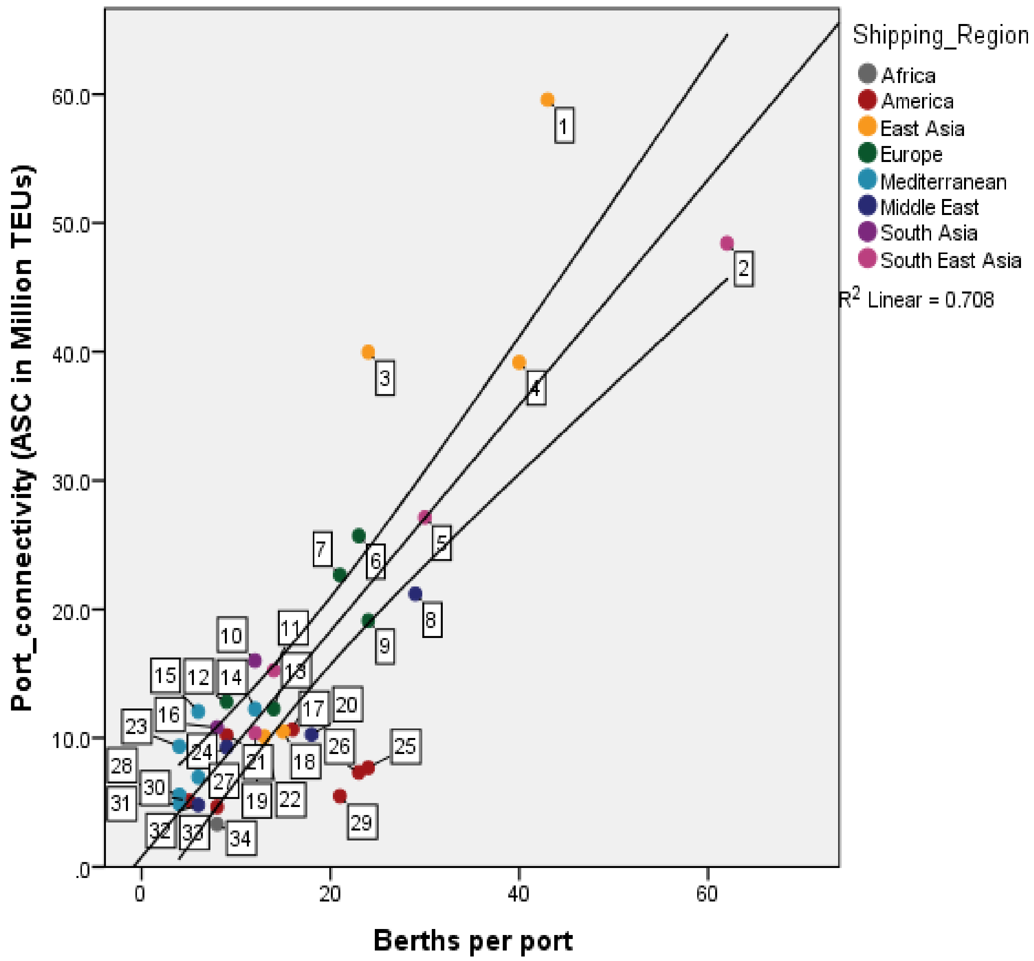

Figure 5-11 Scatter plot- Berths by shipping region

The ports located along the trend line indicate that they operate optimal number of berths which is adequate to handle the vessel traffic in those ports. Port of Bremen/Bremerhaven (13) from Europe, ports of Valencia (14), Piraeus (27), Ambarli (28) and Gioia Tauro (31) from Mediterranean maritime region, port of Said (24) and port of Khor Fakkan (32) from Middle East maritime region and port of Laem Chabang (19) from South East Asian maritime region are the ports mainly positioned on the trend line. All these ports except Gioia Tauro (31) and Khor Fakkan (32) are gateway ports and handle lesser number of traffic and berths which are respectively12, 12, 9, 6 and 4.

5.3.4 Quay length (m)

Quay length is the total length of berths located at terminals operating in a port and it decides how many ships and the size of the ships that could be accommodated at the port at a particular time. As industry experts perceived that quay length has a significant impact on the maritime connectivity of ports, it was selected for further analysis by using quantitative data. The results of the analysis show a correlation of 0.76 with a $P<0.05$ (see Table 5-2). This implies that quay length has a significant relationship with the maritime connectivity of a port, which further confirms the results obtained from the online survey. The maximum vessel size is one of the variables that are taken into consideration when calculating Liner Shipping Connectivity Index (LSCI). LSCI is the index which explains maritime connectivity of countries. In this analysis, quay length also implies how large and how many ships can be operated in a port. Thus, the higher relationship between maritime connectivity of ports and quay length can be justified. Further, the scatter plot diagram shows a linear distribution with outlier ports like ports of Shanghai (1), Hong Kong (3), Klang (5), Rotterdam (6), New York/New Jersey (17), Los Angeles (25), Seattle/Tacoma (26) and Long Beach (29). This is due to either quay length not being fully occupied or inadequate quay length to facilitate larger ULCSs.

From highly connected ports, port of Shanghai (1), port of Hong Kong (3) and port of Busan (4) are positioned towards the left side from the trend line, which indicate maritime connectivity of these ports are relatively higher compared to their quay lengths (respective quay lengths 13,000m, 19,170m and 12,523m).These are the top three mega hub ports in East Asia (Figure 5-13) and also in the world. These ports serve both transshipment and gateway traffic and accommodate higher number of both feeders and main liners, which are panamax, post panamax and super post panamax. As the number of ship calls are high and the capacities of the vessels are higher, this results in higher ASC and thus the higher maritime connectivity as shown in Figure 5-12.

When moderately connected ports are considered, port of Klang (5) and port of Colombo (10) are positioned to the left side of the trend line while port of Rotterdam (6) is poisoned to the right side respectively having quay lengths of 8,100m, 4,372m and 16,685m.

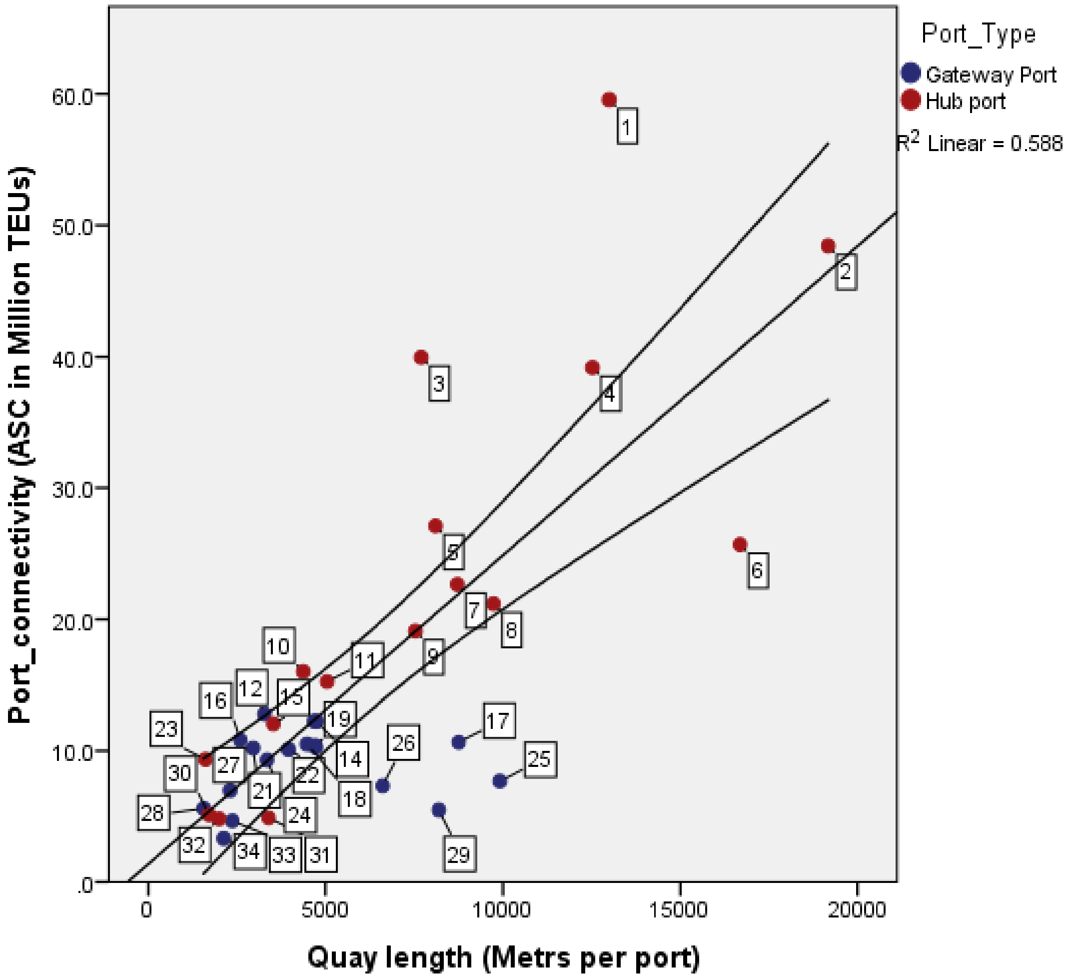

Figure 5-12 Scatter plot- Quay length by port type

Both, port of Klang and port of Colombo are pure transhipment hubs located in the South East Asian and South Asian shipping regions connecting Eastern and Western regions of the world. Operating as regional hubs for routes connecting all the shipping regions, these ports handle a significant number of both feeder and mainliner ships with limited quay lengths. These ports struggle with existing quay lengths and they should enhance quay lengths. The maritime connectivity of these ports is considerably higher than the other ports with same quay length. With respect to port of Rotterdam located in European shipping region, though it is a hub port, it handles only Europe bound cargo whereas ports in Asia handle cargo transporting all over the world. Therefore, the sizes of the vessels calling at port of Rotterdam are comparatively lower. This results in lower ASC, though the number of vessel calls are slightly higher than that of the American ports and longer quay lengths are developed to facilitate larger and higher number of vessels. Further regional competition also might have impacted on lower ASC. Thus, the maritime connectivity is lower with respect to quay length.

When considering less connected ports, ports of New York and New Jersey (17), Los Angeles (25), Seattle/Tacoma (26) and Long Beach (29) are positioned towards the right side of the trend line showing underutilization of the existing quay length. Being located in American shipping region (Figure 5-13), these ports generally handle medium size (panamax) vessels and relatively lesser number of ships due to the lower cargo volume inherent in the region. This results in lower maritime connectivity though they have longer quays. Therefore, they should design strategies to attract more number of ships and larger sized ships than investing on the terminal quays. However, port of Tanager-med (23) is positioned to the left side of the trend line showing a higher connectivity compared to other med ports. This is because, being a hub port in Mediterranean maritime region, it handles quite a large number of vessels with its available quay length.

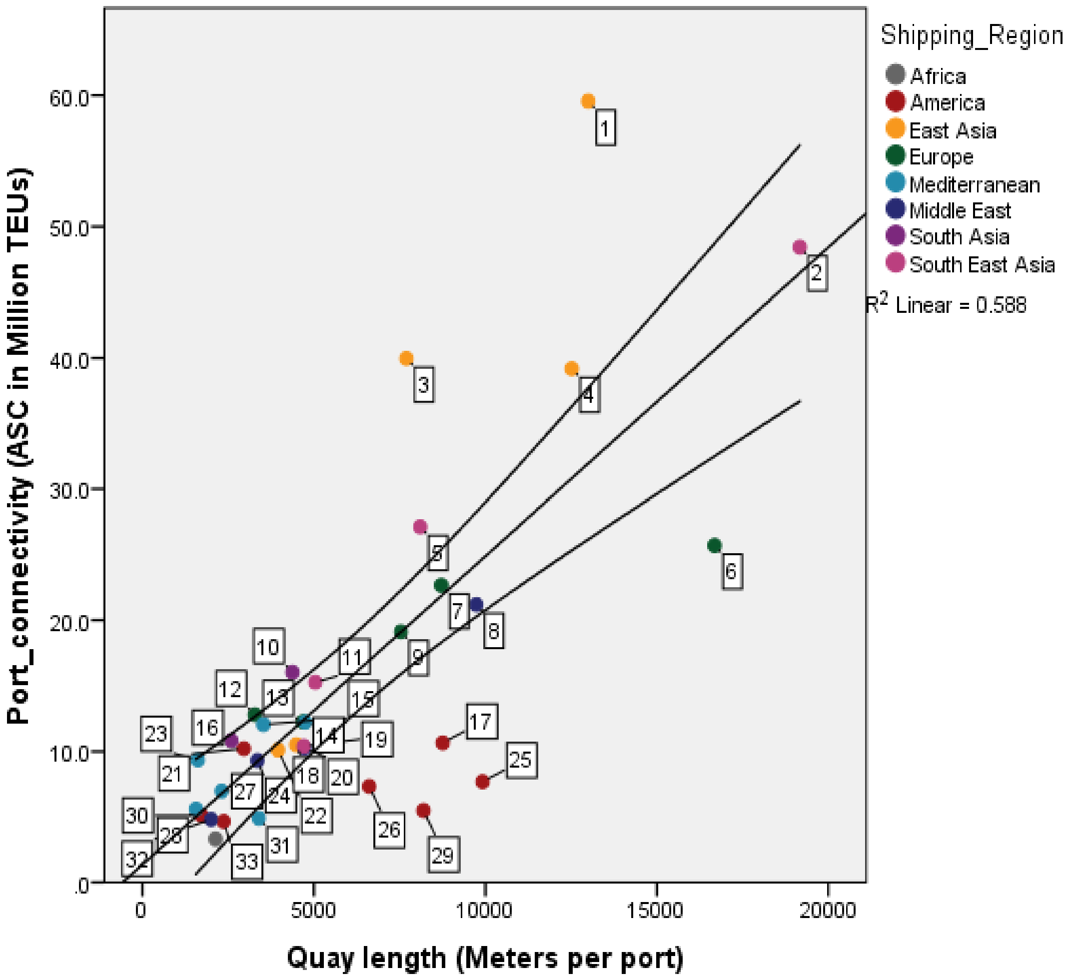

Figure 5-13 Scatter plot- Quay length by shipping region

The ports positioned along the trend line indicate that they operate current vessel traffic with the existing dimensions of the quays. In other words, currently they are using its quays optimally. If they are to improve their maritime connectivity, they might need longer quays than at present to facilitate larger and more vessels.

5.3.5 Number of reefer plugging facilities

The number of data points available to analyze is considerably lesser than for the other variables (28 ports). According to the second stage analysis number of reefer plugging facilities record a moderate relationship on the maritime connectivity of a port by having $P<0.05$ (correlation- 0.689 and $P=0.00$) whereas the first stage online survey also illustrated that industry experts perceive number of reefer plugging facilities show significantly higher impact on maritime connectivity of a port (Sample mean-4.18 and

P=0.00). The Figurer 5-14 illustrates a dense distribution of ports along the mean. Therefore, number of reefer plugging facility records a significant relationship under 0.05 significant level. Most of the ports have 2500-7500 number of reefer plugs.

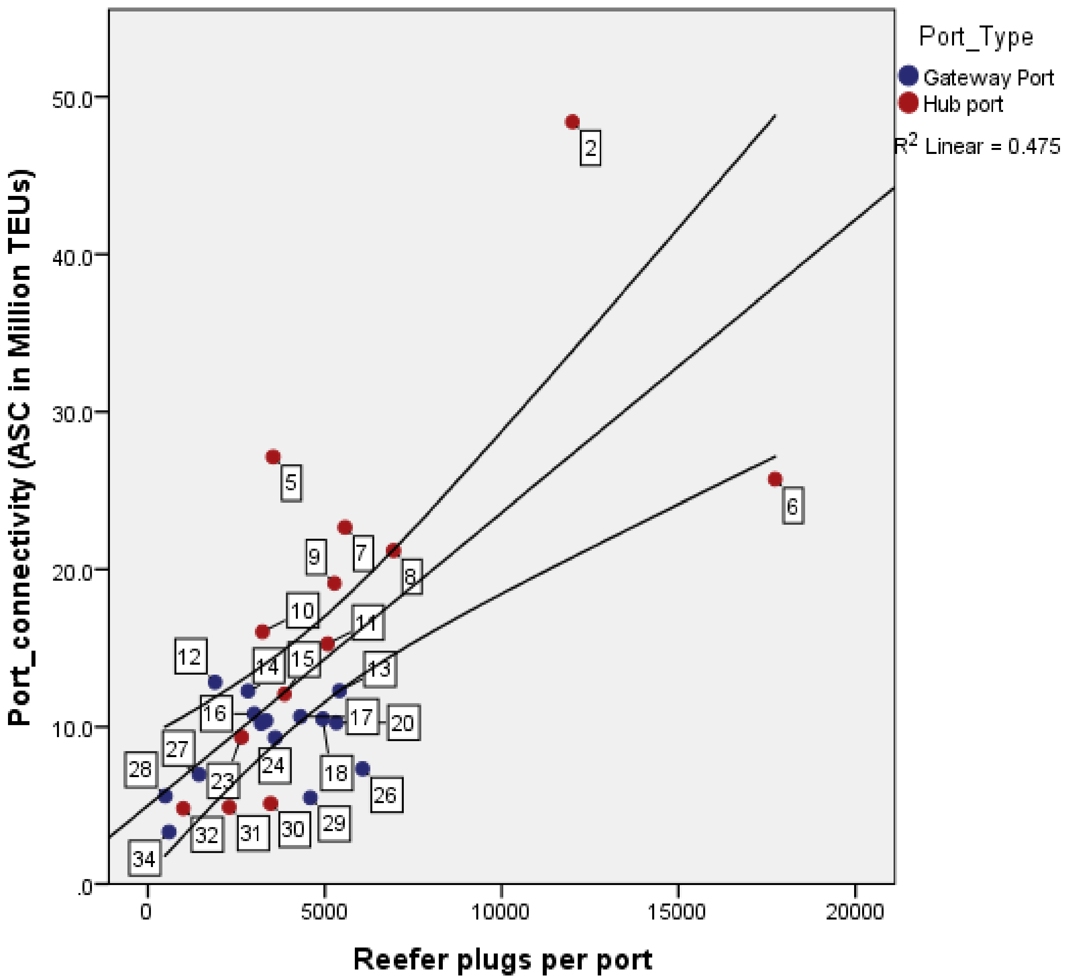

Figure 5-14 Scatter plot- Reefer plugging facilities by port type

From highly connected ports, data on reefer plugs could only be collected for port of Singapore (2) and it is also positioned to left side of the mean trend line having 12,000 units. This implies that maritime connectivity of port of Singapore is significantly higher than the relative mean connectivity which is equivalent to its number of reefer plugs. Though more reefer containers are transshipped via port of Singapore, having relatively lower number of reefer plugs does not make an issue as there are more frequent connecting vessels. Therefore, port of Singapore manages existing reefer plugs while achieving its higher maritime connectivity.

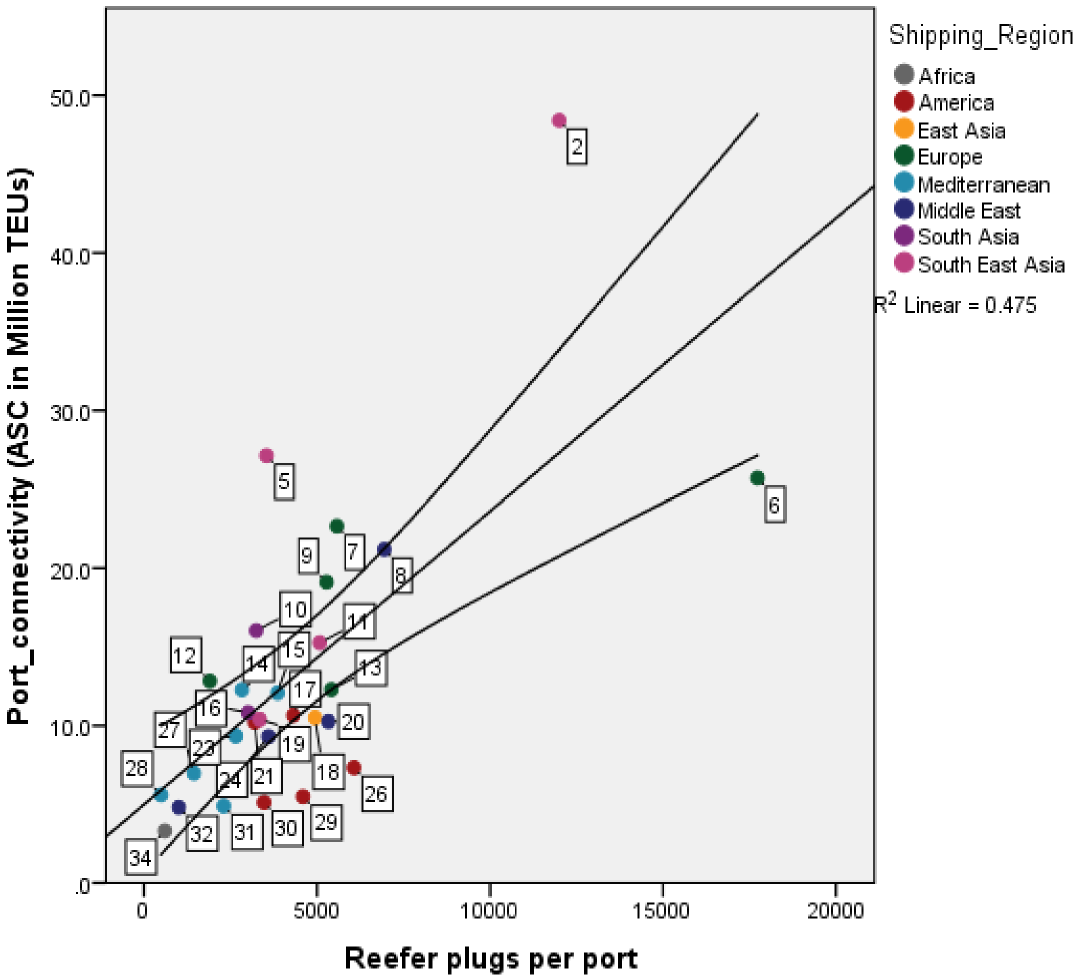

Figure 5-15 Scatter plot- Reefer plugging facilities by shipping region

When moderately connected ports are considered, ports of Klang (5), Antwerp (7) Hamburg (9) and Colombo (10) are positioned to the left of the trend line while Rotterdam (6) is positioned to the right. Being regional hubs, the reefer plugs of these ports are in the range of 5000 except at the port of Rotterdam (6). Port of Klang is extremely shifted to left and it implies more reefer cargo is transhipped via port of Klang than the other Malaysian port, Tanjun Pelepas. Thus, port of Klang may be highly congested for reefer containers and more developments might be needed. In addition, there is an increasing trend in refrigerated containers and perishable good volumes in Antwerp and Hamburg ports whereas most of the reefer cargo imports and exports also are transhipped via port Antwerp and Hamburg.

Further, port of Felixstowe (12) is also positioned to left of the trend line implying inadequate reefer plugs to cater to its demand. This is because reefer cargo to United Kingdom seems to be moving through the port of Felixstowe. Thus, the number of reefer points available in these ports may not be sufficient to cater to the demand which could result in congestion. Though, there are lesser number of reefer plugs in these ports, ASC is higher due the higher container vessel traffic and the sizes of the vessels calling in these ports. Thus, a higher maritime connectivity is reported.

However, when the ports positioned to the right side of the trend line are considered, most of the ports with lower maritime connectivity are recorded from American shipping region (Seattle/Tacoma (26), Long Beach (29) and Balboa (30)) though they have higher number of reefer plugs. As the demand for reefer cargo in these ports are high, the number of reefer plugs in these ports is also higher. But due to generally lower demand inherent in these ports number and sizes of the vessels are lesser and thus the maritime connectivity is lesser.

Port of Tanjung Pelepas (11), port of Algeciras (15), port of Nhawa Shiva (16), port of Laem Chabang (19), port of Savannah (21), port of Tanger-Med (23), port of Piraeus (27) and port of Ambarli (28) are positioned on the trend line indicating that they operate optimal number of reefer plugs required to cater to their vessel traffic. However, this illustrates the necessity of investing on more reefers if they are to cater to more reefer containers and to attract more vessel traffic over competing ports.

5.3.6 Number of terminals

A terminal is an interface between sea and the land and it is demarcated to particular type of cargo (e.g. container, bulk cargo, oil). Each terminal is comprised of several berths with shore handling equipment to handle ships. Further, a terminal consists of few berths, which may have different berth dimensions (draft, length) and ship-to - shore gantry cranes with different performance specifications. These terminals are operated by different operators and there are world class terminal operators who handle terminals in several ports like PSA International, DP world, APM Terminals, Hutchison Port. According to the table 5-2, number of terminals shows a moderate correlation of 0.608 on the Port maritime connectivity. This is proved by having a dispersed scatter plot (Figure 5-16). These findings are similar to experts' views received for first stage online survey.

As per the Figure 5-16, port of Shanghai (1), port of Singapore (2), port of Hong Kong (3) and port of Busan (4) are positioned left to the trend line and they are the major hub ports which handle both transshipment and gateway traffic in East Asian and South East Asian region. These ports operate more container terminals and most of those terminals are operated by leading terminal operators like DP world, PSA Terminals, COSCO and Shanghai International Port Group. For an example four of five terminals in new port of Busan are operated by global operators like Singapore's PSA International and the UAE's DP. Efficiency levels of terminal operators help to gain higher ASC by attracting more ships. Accordingly, maritime connectivity increases with the higher efficiency levels of these operators.

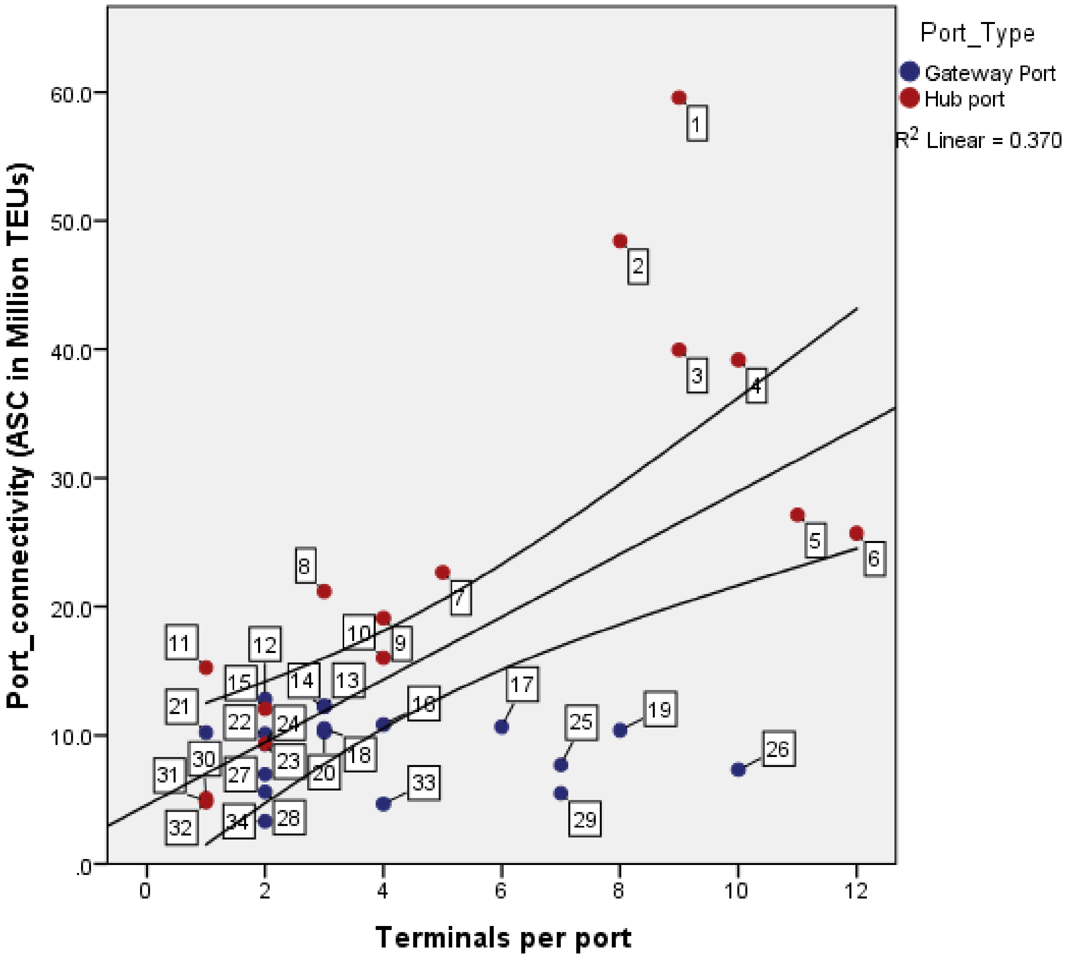

Figure 5-16 Scatter plot- Terminals by port type

From moderately connected ports, the ports of Antwerp (7), Jebel Ali (8), Hamburg (9) and Tanjung Pelepas (11) are positioned to the left of the trend line. Even though comparatively a lesser number of terminals are operated at these ports, they record moderate connectivity by being hub ports which handle both feeder and mainliner vessels and these are operated by world class terminal operators like DP world and APM terminals. This results in more ship calls and thus the higher maritime connectivity. For example, port of Tanjung Pelepas (11) is solely operated by APM terminals (Maersk terminals), where Maersk ships are committing more ASC. In addition, port of Jebel Ali is mainly operated by DP world which results in most of container vessels are connected via Jebel Ali.

The ports of Bremerhaven (13), Tanger-Med (23) and Said (24) are located on the trend line indicating that these ports operate optimal number of terminals required to cater to vessel demand in these particular ports. The numbers of terminals of these ports are respectively 3, 2 and 2. Most of these terminals are also operated by efficient terminal operators like, Eurogate, APM and MSC.

All the American ports except the port of Savannah (21) are positioned to right of the trend line indicating lower maritime connectivity and underutilization of terminals. Though port of New York/New Jersey (17), port of Los Angeles (25), port of Seattle/Tacoma (26) and port of Long Beach (29) operate 6,7,10 and 7 terminals respectively, cargo volume and ship calls of these ports are low as they handle only the ships that are calling America. This results in lesser ship calls and smaller vessels and finally a lower connectivity.

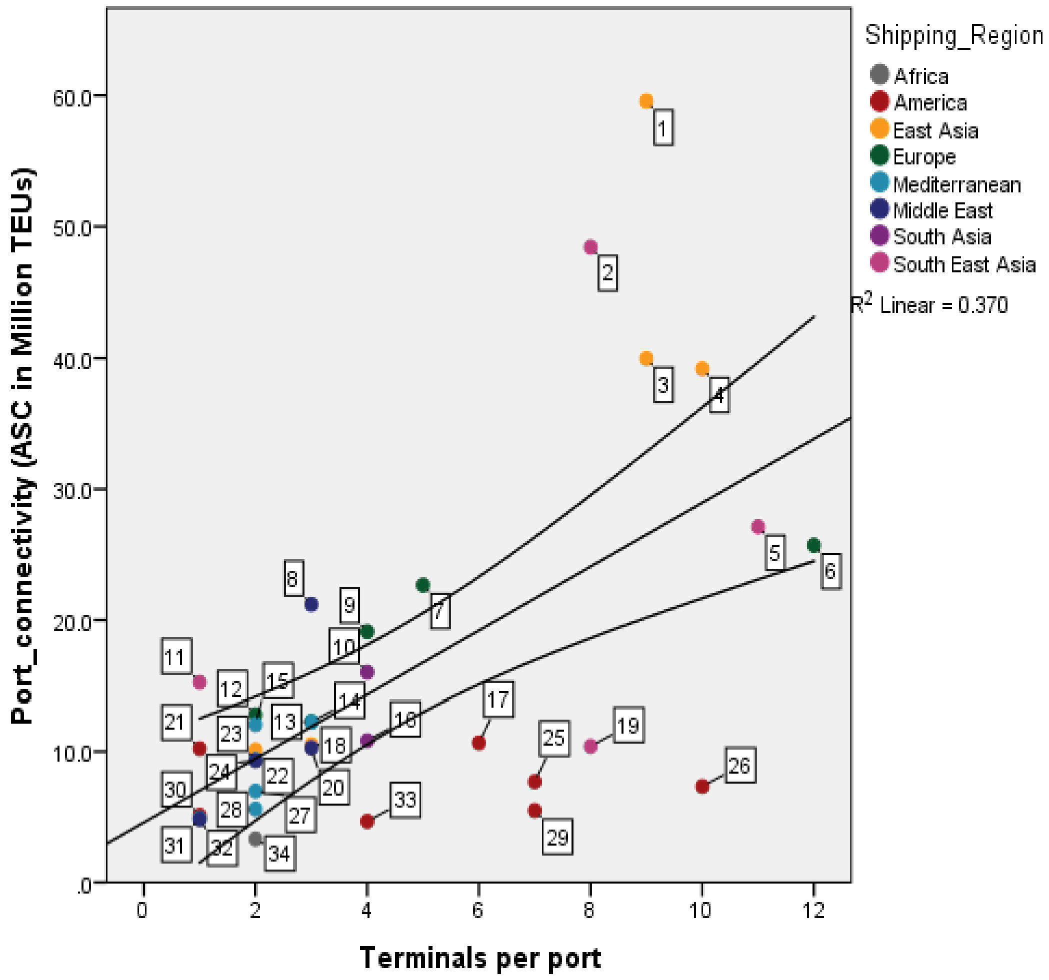

Figure 5-17 Scatter plot- Terminals by shipping region

Both online survey and quantitative analysis explain that the relationship between number of terminals and maritime connectivity of ports is less significant than the relationship between number of berths and maritime connectivity of ports by illustrating lower correlation and higher P value for number of terminals. This may be because the number of berths available decides the number of ships which could be handled at a particular time at a port, whereas number of terminals explains how many different operators are operating container terminal facilities at a port.

It can be concluded that terminal efficiency matters more on port connectivity rather than the number of terminals operating at a port.

5.3.7 Terminal draft (m)

Table 5-2 illustrates that terminal draft records a lower correlation (0.36) with a considerably higher p value (P=0.034). Nevertheless, the correlation analysis accepts that terminal draft has a significant relationship under 0.05 significant level by having P<0.05. However, results of the online survey analysis point out that terminal draft, out of all the infrastructure related variables, records the highest correlation on the maritime connectivity of ports. Thus, there is a conflict between what industry experts perceived and the results of second stage analysis. The perception of industry experts is reasoned out by them "that there is no point of having state of the art equipment and longer berths to handle new generation ships, if a terminal is unable to accommodate ships with deeper draft". Further, the largest vessel size that a particular port can accommodate is also factored in when calculating LSCI.

The lower correlation indicated in the second stage analysis may be due to the limitation in the dependent variable. As the maritime connectivity is calculated by the multiplication of average vessel capacity (in TEUs) in container liner services calling a port by the frequency of ship calls in a year. Therefore ASC may not provide a clear explanation on how terminal draft affect on maritime connectivity. Moreover, if a port has adequate terminal draft to accommodate the largest vessel that visits the particular port, maritime connectivity will not be increased though the draft is deepened further. For example, if a port has lesser cargo demand and only panamax vessels are calling to that port due to lower demand, it requires terminal draft only up to 15m. Though the port deepens the terminal draft up to 18m, it will not increase the maritime connectivity further due to the lack of demand of either post panamax or super post panamax vessels. Therefore, ASC does not give clear interpretation on how terminal draft impact on the maritime connectivity. However, if the significance analysis is run for more ports with lesser terminal draft than the ports covered in this sample, it may provide a better picture than this.

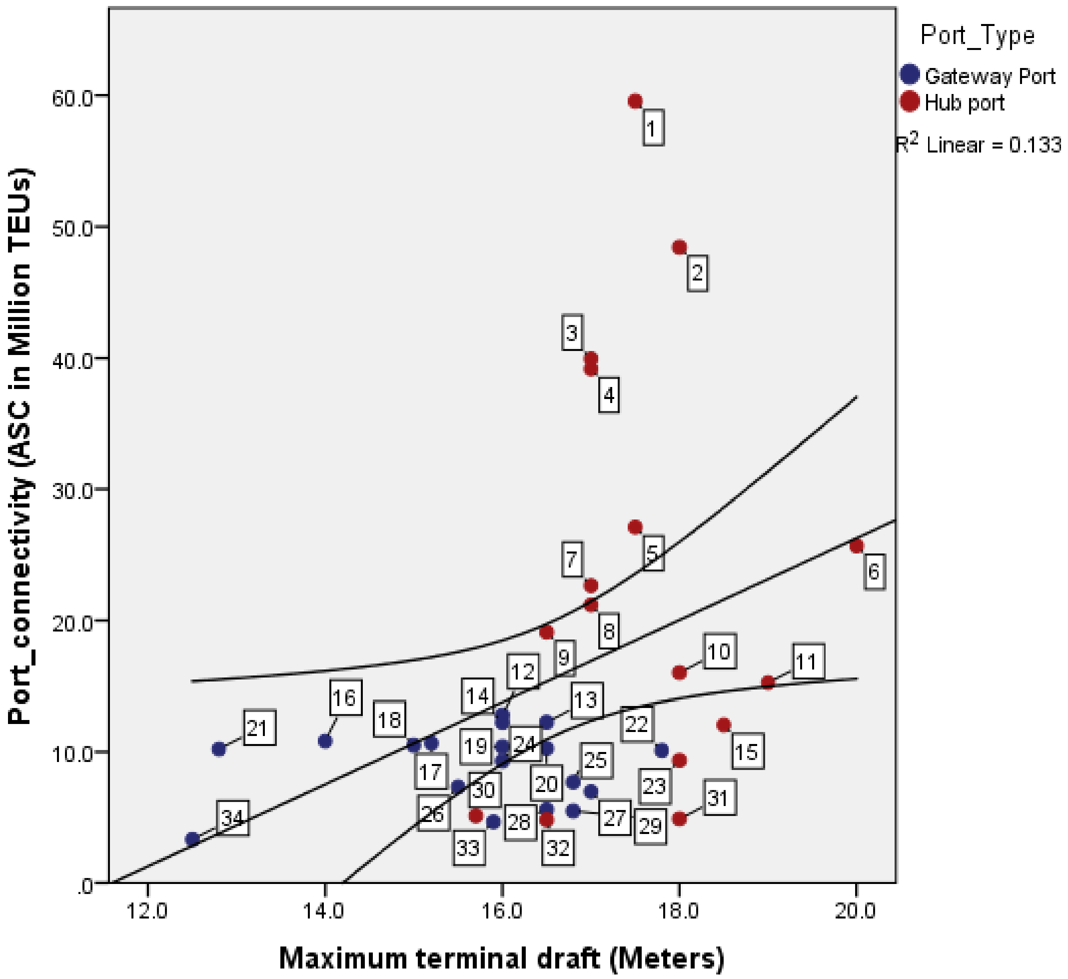

Figure 5-18 Scatter plot- Terminal draft by port type

Figure 5-18 illustrates that terminal draft in most of the hub ports are above 17m while terminal draft in gateway ports is below 17m. All the highly connected ports of Shanghai (1), Singapore (2), Hong Kong (3) and Busan (4) with a terminal draft of 17m- 18m are positioned above the trend line indicating that they are operating optimum to the available draft.

Most of the Mediterranean and American ports (Figure 5-19) are positioned below the trend line implying that the maritime connectivity of those ports are quite lower though they have deeper terminal drafts of 16m-18m. This is due to the lower vessel calls and relatively smaller size of container ships deployed in these ports due to lower cargo volume inherent in these shipping regions.

Port of Durban is the least connected port with the lowest terminal draft. Though it is located ideally to serve as a hub for Indian Ocean Islands, Middle East, Far East and Australia, lower draft in the port has hindered attracting larger ships and transhipment volumes (Nightingale, 2017). This might have impacted the lower ASC and thus the maritime connectivity.

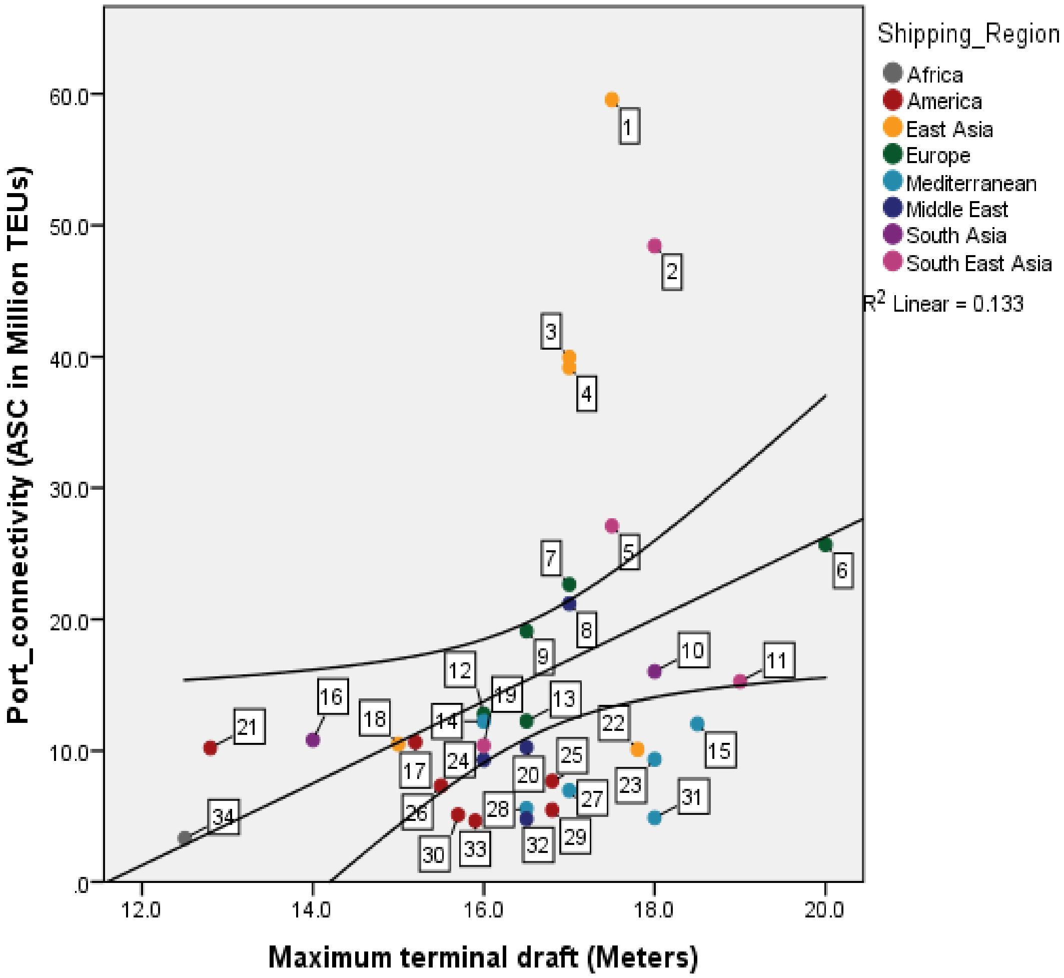

Figure 5-19 Scatter plot- Terminal draft by shipping region

5.3.8 Access channel draft (m)

As discussed under methodology chapter, only the access channel draft measurement was selected to consider in quantifying the relationship with maritime connectivity of ports due to the limitations in obtaining data. Table 5-2 points out that when access channel draft is considered individually, it shows lower correlation (0.13) and it does not show direct significant relationship on the maritime connectivity of ports by having a correlation P=0.45. Thus, this disconfirms the results obtained from the online survey analysis where industry experts perceived that access channel dimensions (width and draft) have a significant relationship with the port maritime connectivity. The lower correlation indicated in the second stage analysis may be due to the limitation in dependent variable.

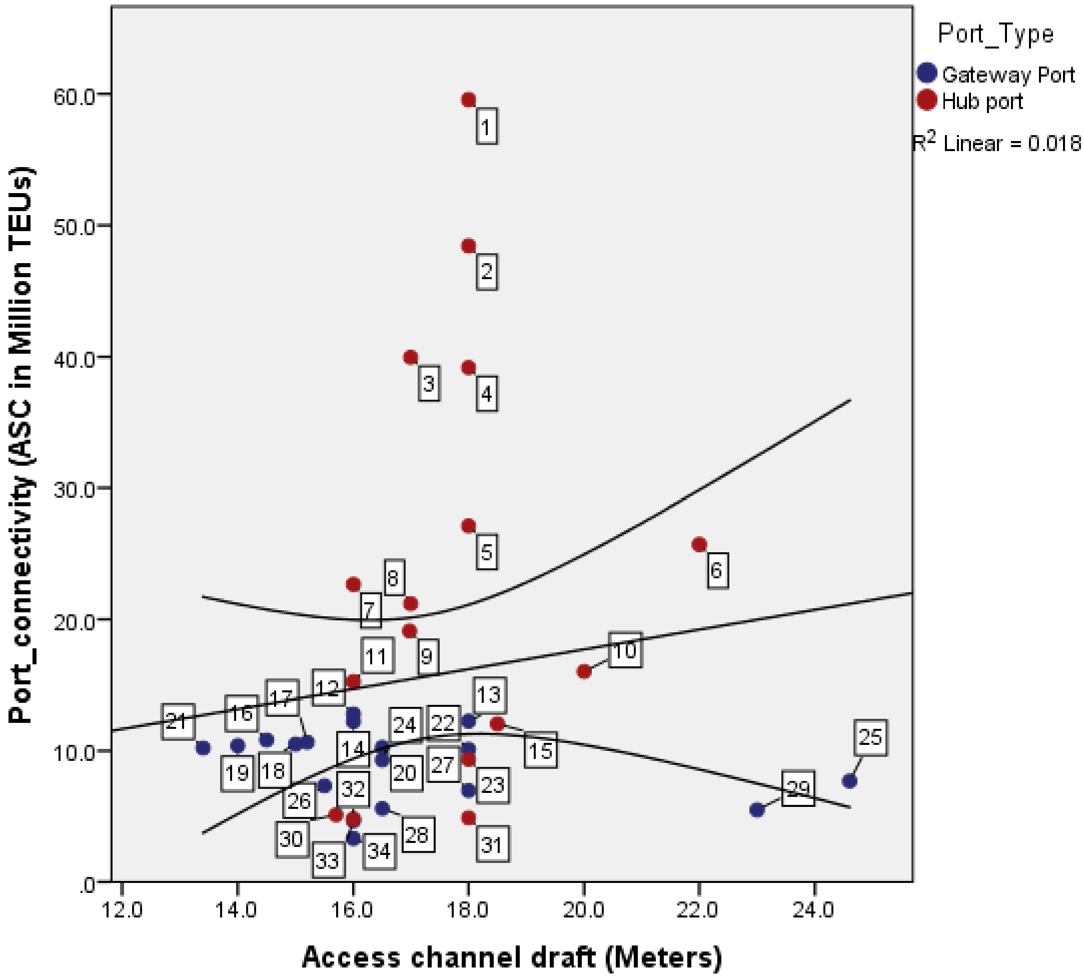

Figure 5-20 Scatter plot- Access channel draft by port type

The scatter plot diagrams illustrate how the maritime connectivity of sample ports is positioned against access channel draft. According to the Figure 5-20, the access channel drafts in most of the ports are in the range of 14m -18m. Access channel drafts of all the hub ports that have been facilitating super post panamax vessels with capacity over 18,000 TEU, are above 16m while access channel drafts of most of the gateway ports are below 17m.

However, there is no visible trend between maritime connectivity of ports and the access channel drafts. Some ports record higher connectivity for a particular access channel draft while some record lower connectivity to the same draft. For example, ports of Shanghai (1), Singapore (2) and Busan (4) record significantly higher connectivity while port of Klang (5) records moderate connectivity, and port of Tanger-Med (23), port of Piraeus (27) and port of Gioia Tauro (31) record lower connectivity though the access channel draft is 18m in all these ports.

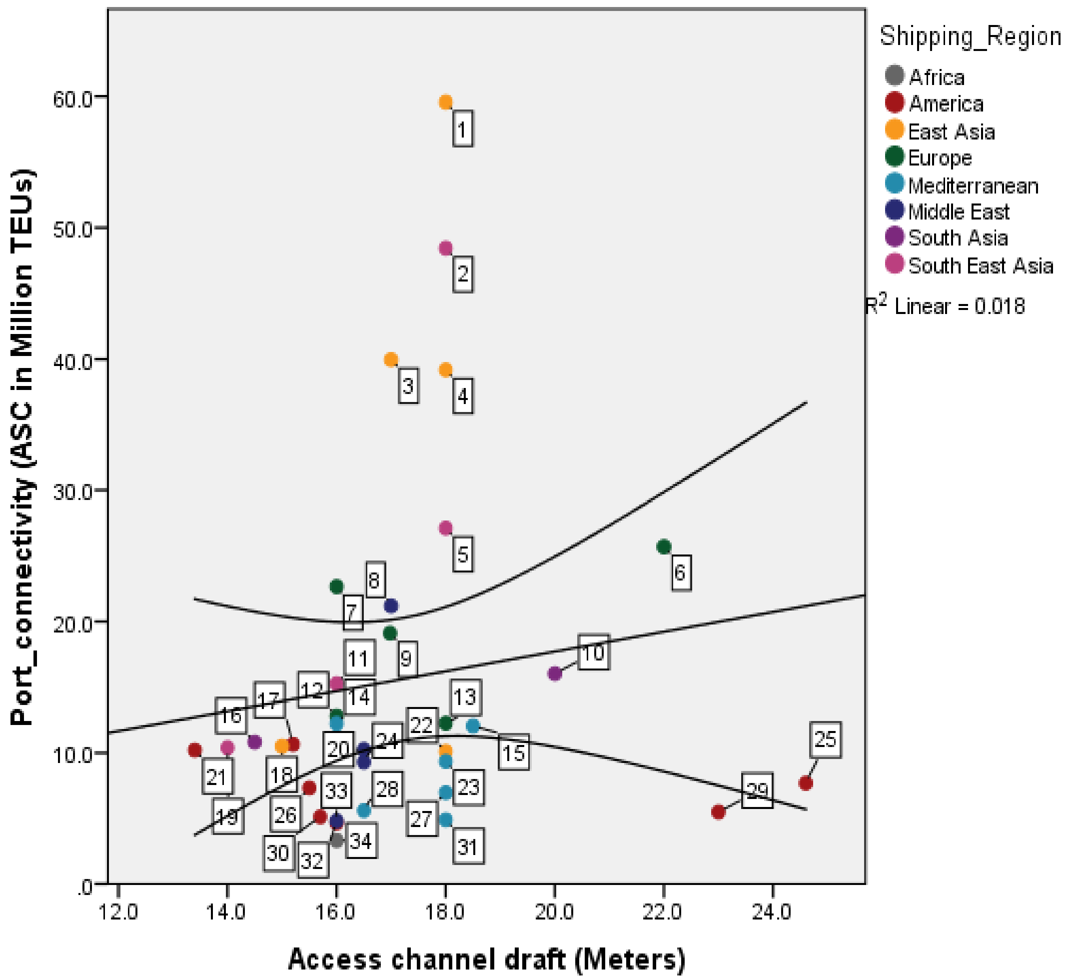

Figure 5-21 Scatter plot- Access channel draft by shipping region

As per the results obtained from the correlation analysis performed in second stage quantitative data analysis, following variables show significant correlation with maritime connectivity of a port.

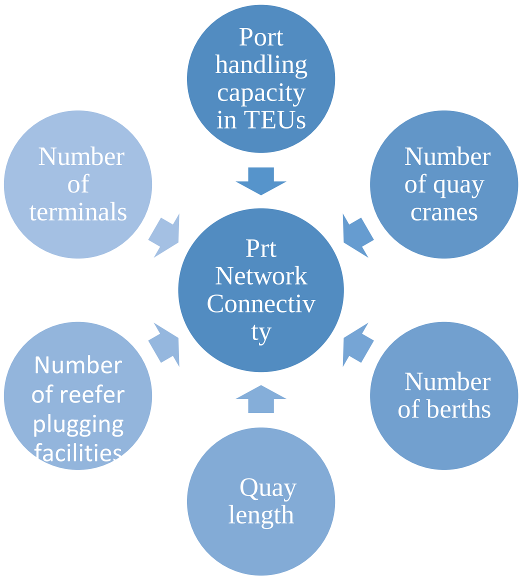

Figure 5-22 Significant Port logistics Development variables

According to scatter plot diagrams for maritime connectivity of ports, the ports positioned to left of the trend lines indicate a significantly higher connectivity compared to the port logistics developments at the particular port while ports positioned to right of the trend lines indicate lower connectivity wherein logistics developments are either excess or underutilized at port.

All the ports that record a significantly higher connectivity against the available port logistics resources have following common characteristics.

- *Belong to the countries ranked in top four positions in LSCI*
- *The port logistics resources in these ports are well developed*
- *Have higher demand for both domestic and transhipment TEUs*
- *Major ports in East-West trade lane being the regional hubs*
- *Belong to countries which originate major share of global exports*

When the ports with lower maritime connectivity are considered, most of the countries have comparatively lower demand for vessel calls though they have excess logistics facilities to accommodate ships. Further, the sizes of the vessels calling those ports are comparatively smaller compared to other ports due to the lower demand in the particular trade lane. Therefore, this results in underutilization of port resources, thus the lower connectivity.

5.4 Correlation Analysis between Independent Variables

This section will analyze correlation between each independent variable to identify whether considered variables record strong association between each other. Multicolinearity occurs when two or more independent variables are highly correlated with each other and if multicolinearity exists, it leads to issues in calculating multiple regression model as well as problems in understanding which independent variable contributes to the variance explained in the dependent variable. Hence, a Pearson correlation analysis is performed to identify the strengths of associations that exist between each independent variable.

Table 5-3 Pearson Correlation analysis between logistics factors

		Port handling capacity	**# quay cranes**	**# reefer plugging facilities**	**# terminals**	**# berths**	**Quay length**	**Access channel draft**	**Terminal draft**
Port handling capacity	Correlation	1	.899	.601	.564	.868	.793	.154	.328
	Sig.(2-tailed)		.000	.001	.001	.000	.000	.384	.058
# Quay cranes	Correlation	.899	1	.791	.712	.949	.960	.343	.392
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.047	.022
# Reefer plugging facilities	Correlation	.601	.791	1	.633	.669	.881	.421	.480
	Sig. (2-tailed)	.001	.000		.000	.000	.000	.026	.010
# Terminals	Correlation	.564	.712	.633	1	.693	.757	.349	.260
	Sig. (2-tailed)	.001	.000	.000		.000	.000	.043	.138
# Berths	Correlation	.868	.949	.669	.693	1	.905	.270	.279
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.122	.110
Quay length	Correlation	.793	.960	.881	.757	.905	1	.433	.422
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.011	.013
Access channel draft	Correlation	.154	.343	.421	.349	.270	.433	1	.571
	Sig. (2-tailed)	.384	.047	.026	.043	.122	.011		.000
Terminal draft	Correlation	.328	.392	.480	.260	.279	.422	.571	1
	Sig. (2-tailed)	.058	.022	.010	.138	.110	.013	.000	

According to the Pearson correlation analysis results in Table 5-3, the variable pairs which show Pearson correlation more than 0.6 and $P<0.05$, indicate a significantly strong association between each port logistics factor. And the pairs which show Pearson correlation less than 0.6 but more than 0.3 with $P<0.05$ indicate a moderate association between each port logistics factor while variables with Pearson correlation less than 0.3 and P>0.05 indicate no association.

Accordingly, associations between each variable pairs can be summarized as follows.

Table 5-4 Summary- Correlation between independent variables

Strongly associated variables	**Moderately associated variables**	**Variables with no association**
Port handling capacity & # Quay cranes	Port handling capacity & # Terminals	Port handling capacity & Access channel draft
Port handling capacity & # Reefer plugging facilities	# Quay cranes & Access channel draft	Port handling capacity & # Terminal draft
Port handling capacity & # Berths	# Quay cranes & Terminal draft	# Terminals & Terminal draft
Port handling capacity & Quay length	# Reefer plugging facilities & Access channel draft	# Berths & Access channel draft
# Quay cranes & # Reefer plugging facilities	# Reefer plugging facilities & Terminal draft	# Berths & Terminal draft
# Quay cranes & # Terminals	# Terminals & Access channel draft	
# Quay cranes & # Berths	Quay length & Access channel draft	
# Quay cranes & Quay length	Quay length & Terminal draft	
# Reefer plugging facilities & # Terminals	Access channel draft & Terminal draft	
# Reefer plugging facilities & # Berths		
# Reefer plugging facilities & Quay length		
# Terminals & # Berths		
# Terminals & Quay length		
# Berths & Quay length		

Accordingly, most of the independent variables have significant association between each other under 0.05 significant level where multicollinearity may exist among the variables. One of the main objectives of this study is to develop a model to identify port logistics developments which are collectively effect on maritime connectivity of a port. But the data set is not suitable for a multiple linear regression analysis as there are significant associations between independent variables. However, a simple linear regression analysis can be performed to assess how each independent variable impact on maritime connectivity of ports individually. Further, as the scatter plot diagrams between maritime connectivity and each port logistics parameter shows significant differences between hub ports and gateway ports, simple linear regression analysis are performed to both hub and gateway ports separately.

5.5 Simple Linear Regression Analysis

Simple linear regression (SLR) analysis is conducted to identify the strength of each individual port logistics development parameter on the maritime connectivity of a port and the variability of maritime connectivity of a port to the changes in port logistics development parameters (univariate correlation). Below hypothesis in Figure 5-23 is tested to assess validity of the SLR models.

Hypothesis

The hypothesis tests are conducted at 0.05 significant level.

Null hypothesis *(H_0):* There is no significant relation between maritime connectivity of a port and the individual port logistics development factor;

Hypothesis *(H_1):* There is a significant relation between maritime connectivity of a port and the individual port logistics development factor;

Figure 5-23 Hypothesis for SLR

Since α=0.05, if p value is less than or equal to significant level (0.05), considered port logistics factor is statistically significant whereas hypothesis is accepted and if the P value is greater than 0.05, considered factor is not statistically significant whereas null hypothesis is accepted.

The following general SLR model can be developed to write models for each significant port logistics factor. Based on the hypothesis, test results of each individual port logistics factor unique models can be written with their coefficients.

Port maritime connectivity $= \alpha + \beta_1 x_1$

Where,

α = constant,

x_1 = port handling capacity/ number of quay cranes/ number of reefer plugging facilities/ number of terminals/ number of berths/ quay length

ε= error

β_1 = coefficient

In selecting SLR method to analyze data, it is mandatory to first check whether the data is acceptable to run regression analysis. Otherwise it will give faults results. Thus, as the first step, basic assumptions in SLR were tested to check the validity of data to perform SLR model.

Dependent variable and independent variables are measured in continuous scale. Thus, data is acceptable to conduct SLR analysis. In running simple regression analysis, there needs to be a linear relationship between dependent variable and each independent variable. Therefore, scatter plots for each independent variable are created to check the linearity. In observing the linearity in scatter plots, observations should linearly position along the regression line while there should not be any visible pattern in observations. According to the scatter plots, it is proved that all the independent variables have linear relationship with the dependent variable except terminal draft and access channel draft. Therefore, data set is valid to run SLR analysis.

In SLR analysis, presence of significant outliers or high leverage points will reflect negative impact on the regression line. Therefore, if significant outliers exist, those should be removed from data set before running the SLR. The significant outliers were checked using box plots and the outliers identified were removed in order to minimize deviations of the results from the actual figures.

Data needs to show homoscedasticity which is where residuals should be independent from response variable, all the predictors as well as the predicted value of response variable. It is observed that there is no any visible pattern in Graphs in Annexure 2. This implies that data shows homoscedasticity and simple regression analysis can be performed.

By accepting the above assumptions, SLR analysis was performed for each significant independent variable identified through Pearson correlation analysis. As the above scatter plot diagrams show a visible deviation between hub ports and gateway ports, the analysis was performed segregating data set in to two which are hub ports and gateway ports.

In order to do a simple linear regression (SLR) analysis observations should be independent from one another and there should be no serial correlation among observations. Thus, Durbin Watson test was done to check autocorrelation in residuals of regression analysis. According to the Table 5-5, all the Durbin-Watson readings for gateway ports are below 1.5 whereas the results are relatively normal with no autocorrelation only if the test Durbin-Watson statistic is in the range of 1.5 to 2.5. Thus, when gateway ports are considered separately, all the variables record autocorrelation and no SLR model can be developed. Therefore, gateway ports are removed from the analysis.

Table 5-5 Regression analysis- Port maritime connectivity

Variable	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	F	Sig.
Port handling capacity	Hub ports	.926	.858	.848	6.3364	1.995	84.862	.000
	Gateway ports	.243	.059	.000	2.8091	.249	1.002	.332
Number of quay cranes	Hub ports	.886	.786	.770	7.7949	2.092	51.328	.000
	Gateway ports	.100	.010	-.052	2.8813	.104	.161	.694
Number of berths	Hub ports	.893	.797	.782	7.5947	2.271	54.817	.000
	Gateway ports	.064	.004	-.058	2.8898	.087	.066	.800
Quay length	Hub ports	.803	.645	.620	10.0337	1.498	25.427	.000
	Gateway ports	.101	.010	-.052	2.8810	.101	.164	.690
Number of reefer plugging facilities	Hub ports	.680	.463	.414	9.2046	1.279	9.477	.010
	Gateway ports	.370	.137	.070	2.7248	.448	2.056	.175
Number terminals	Hub ports	.772	.595	.566	10.7125	.629	20.589	.000
	Gateway ports	.138	.019	-.042	2.8681	.107	.002	.962

With respect to the hub ports, port handling capacity, number of quay cranes and number of berths show no serial correlation among observations by having Durbin-

Watson statistics greater than 1.5. Therefore, separate SLR models can be developed to identify the relationship between maritime connectivity and each of the above port logistics factor. Durbin-Watson statistics for quay length records 1.498 which is almost 1.5 with slightly higher F statistics and the $P < 0.05$. This implies that the SLR can be performed to identify the relationship between quay cranes and maritime connectivity in hub ports. However, Durbin-Watson statistics for number of reefer plugging facilities and the number of terminals are below 1.5, which implies that there is a serial correlation among observations. Therefore, no SLR can be developed for the above two variables even with respect to the hub ports.

As shown in Table 5-5, R values for port handling capacity, number of quay cranes, number of berths and quay length in hub ports are respectively 92.6%, 88.6%, 89.3% and 80.3% whereas R squared values for the same respectively record 85.8%, 78.6%, 79.7% and 64.5%. The R value more than 70% proves that there is a sound univariate correlation between the maritime connectivity of a hub port and port handling capacity, number of quay cranes, number of berths and quay length which further confirms the results given in Pearson correlation analysis. That implies data values of above four independent variables in hub ports are well close to the fitted regression line and the variability of maritime connectivity of those ports to the changes of each individual variable is high. Further it is an important finding that R squared values for the models for port handling capacity, number of quay cranes, number of berths and quay length are also more than 60%. This indicates that the percentage of variation explained by each simple linear regression line out of the total variation is fairly high and all these four SLR models are good. Thus, following SLR models can be developed for each independent variable to find how each variable impact on the port maritime connectivity.

5.5.1 Port handling capacity in TEUs

The overall model for hub ports is significant as P=0.00. Further, coefficient of port handling capacity is also significant, which accepts the alternate hypothesis. Hence, a SLR model for hub ports can be written as follows to identify how maritime connectivity of ports or hub ports is impacted from port handling capacity. Coefficients are pointed out in the Table 5-6.

Table 5-6 Coefficients- Port handling capacity

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
Hub port	(Constant)	3.765	2.634		1.429	.175
	Port handling capacity in TEUs	1.271	.138	.926	9.212	.000

Hub maritime connectivity of ports= 3.765 + 1.271port handling capacity

When only port handling capacity is considered in deciding port maritime connectivity, it can be illustrated that maritime connectivity of ports will increase by 1.271 units for the one unit increment in handling capacity. Coefficient also proves that port handling capacity has significant impact on the hub maritime connectivity of ports in hub ports.

5.5.2 Number of quay cranes

Having significant impact on hub maritime connectivity of ports to the changes in number of quay cranes, both of the overall model and the coefficient of number of quay cranes in hub ports significant as P=0.00. This accepts the alternate hypothesis. Hence if the number of quay cranes considered, below SLR model can be developed for maritime connectivity of a hub port. Coefficients are pointed out in the Table 5-7.

Table 5-7 Coefficients- Number of quay cranes

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
Hub ports	(Constant)	3.060	3.415		.896	.385
	Number of quay cranes	.250	.035	.886	7.164	.000

Hub maritime connectivity of ports= 3.060 + 0.250Number of quay cranes

This implies that number of quay cranes has a positive impact on maritime connectivity of ports and maritime connectivity of ports increase by 0.250 units for the one unit increment in number of quay cranes. However, if the same study is performed accounting crane specifications also, this result is subject to change.

5.5.3 Number of berths

Table 5-8 implies that hub maritime connectivity of ports is highly volatile to the changes in number of berths while gateway maritime connectivity of ports does not have impact from number of berths. Further indicating significant overall model for hub ports by having P=0.00, coefficient of number of berths also significant which accept alternate hypothesis. Hence, the SLR model can be written as follows. Coefficients are pointed out in the Table 5-8.

Table 5-8 Coefficient- Number of berths

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
		B	Std. Error	Beta		
Hub ports	(Constant)	4.107	3.197		1.284	.220
	Number of berths	.878	.119	.893	7.404	.000

Hub maritime connectivity of ports= 4.107 + 0.878Number of berths

According to the above regression model, if the number of berths is increased by one unit it will increase maritime connectivity of ports by 0.878. By having considerably higher coefficient, it is further proven that hub maritime connectivity of ports is dependent on number of berths.

5.5.4 Quay length (m)

According to the Table 5-9, quay length is significant accepting alternate hypothesis as P=0.000. Thus, a SLR model can be written as follows to identify how hub maritime connectivity of ports is impacted from quay length. Coefficients are pointed out in the Table 5-9.

Table 5-9 Coefficients- Quay length

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
Hub ports	(Constant)	4.086	4.538		.900	.383
	Quay length	.002	.000	.803	5.043	.000

Hub maritime connectivity of ports= 4.086 + 0.02 Quay length

According to the regression coefficients, maritime connectivity of hub ports increase only by 0.02 to the one unit increment in quay length. This also shows that quay length has moderate impact to hub ports. Accordingly, if a hub port decided to construct more berths thus the relative quay length or extend existing quay length, it will increase maritime connectivity of ports letting more connections with the global shipping network by accommodating new generation ships with larger LOA and more number of ships.

Considering the above SLR analysis and hypothesis test results, models can be developed only for hub ports. Therefore, the following models can be written,

Hub maritime connectivity of ports= 4.231 + 1.250 port handling capacity

Hub maritime connectivity of ports= 2.399 + 0.245Number of quay cranes

Hub maritime connectivity of ports= 3.667 + 0.852Number of berths

Hub maritime connectivity of ports= 4.198 + 0.02 Quay length

According to the above models, the highest coefficient is shown in port handling capacity followed by, number of berths, number of quay cranes and quay length. It can be concluded that maritime connectivity of a port is highly sensitive to those four factors compared to all the port logistics developments considered.

CHAPTER 6- CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter summarizes the main findings of the study related to the research questions and provides an overview of how port logistics developments have affected maritime connectivity of leading ports in the world and the port of Colombo. First, the chapter briefly explains the objectives of the research study followed by the summary of the findings of the first stage and second stage data analysis with recommendations for developments. Then it continues with limitations of the study and the chapter concludes with the suggestions for future research.

6.2 Purpose of the research

The maritime connectivity is a concept, which has been introduced recently to the maritime transport literature and it has become popular among the researchers. LSCI was developed and publish since 2004 by UNCTAD as an annual magazine. Several research studies have analyzed the impact of maritime connectivity on maritime transport cost while some have measured the connectivity level of ports. Few studies have even designed connectivity indexes for ports not limiting to country level. The literature review that was done for the current study revealed the factors that have direct impact on the maritime connectivity of a port. However, only few studies have been carried out to identify how developments in maritime logistics affect maritime connectivity of a port and subsequently how it has affected maritime connectivity of Port of Colombo. Hence current research study bridges the gap in knowledge on how port logistics developments impact maritime connectivity of global ports and subsequently Port of Colombo.

Thus, the study was mainly targeted at understanding the impact of port logistics developments on the maritime connectivity of a port. Accordingly, the primary research question, which is addressed by the current research study, is;

> **PRQ - How do developments in port logistics affect maritime connectivity of a port?**

Port logistics developments were studied under five main factors such as operation and superstructure related factors, port infrastructure, location, institutional and time related factors. Two subsidiary questions were designed to answer the above primary research question,

SRQ 1 - Which port logistics developments affect maritime connectivity of a port?

SRQ 2 - How significant is each port logistics development on the maritime connectivity of a port?

The study was conducted in two stages where in the first stage, an exploratory mail survey was conducted to identify perceptions of managerial level employees attached to global container lines operating in Sri Lanka on "which port logistics developments affect maritime connectivity of a port". The questionnaire was designed based on the port logistics factors identified through the literature review. The responses were analyzed using sample mean and one sample proportion test. Accordingly, findings of the mail survey assisted to understand the industry experts' perception on which port logistics developments significantly affect maritime connectivity of a port. Then, the results obtained from online survey analysis were validated through the second stage analysis. The results obtained from first stage and second stage data analysis were compared and interpreted combining both research approaches. The limitation entailed in each method is negated through the other method and it has enhanced the validity of the results. For example, the first stage mail survey could be biased to Sri Lankan context as the sample respondents are selected only from the global container lines registered in Sri Lanka. This would be compensated by the strengths of the second stage quantitative data analysis.

The second stage data collection and analysis were conducted using a sample of thirty four hub and gateway container ports located in regions of West Coast America, East Coast America, Africa, Europe, Mediterranean, Middle East, South Asia, South-East Asia and Eastern Asia. The findings of second stage analysis addressed the second subsidiary question "How significant is each port logistics development on the maritime connectivity". The data was analysed using Pearson correlation analysis and simple linear regression analysis.

6.3 Summary of the findings

6.3.1 First stage online survey

First stage online survey was performed to identify what are significant port logistics developments for maritime connectivity of a port. This was conducted based on the perception of the industry experts attached to the global shipping lines registered in Sri Lanka. If majority of the respondents (more than fifty percent of the respondents) have perceived a particular parameter is "Highly significant (5) or "Significant (4)" on maritime connectivity of a port and with one sample proportion test P value lesser than 0.05, it was decided that there is a significant impact on the maritime connectivity of a port from the particular port logistics development parameter. Accordingly, the significant port logistics developments can be identified as follows.

Table 6-1 Summary findings- online survey

Port logistics factors	Significant port logistics developments
Operational &superstructure factors	Availability of suitable gantry cranes and yard cranes
	Availability of EDI system
	Efficiency in navigation services
	Port annual handling capacity in TEUs
	Availability of state of the art ship and yard panning systems
	Number of reefer plugging facilities
Location related factors	Adequate feeder connectivity
	Deviation distance from main shipping routes
Infrastructure related factors	Deeper terminal draft
	Access channel width and draft
	Number of berths
	Quay length
	Accessibility constraint
	Number of terminals
Institutional factors	Port tariff structure
	Port policies
	Customs policies
Time factors	Vessel turnaround time
	Availability of on time berthing windows
	Waiting time for connecting vessels

Accordingly, in total twenty port logistics developments were identified as the significant parameters while only seven were identified as the relatively not significant parameters.

6.3.2 Second stage quantitative data analysis

6.3.2.1 Correlation between port logistics developments and maritime connectivity

One of the objectives of second stage data analysis was to validate the results obtained from the online survey. Due to the limitations in obtaining and quantification of required data, study was limited only to operational and superstructure factors and infrastructure related factors. Out of these factors, availability of ship and yard panning systems, availability of EDI system and availability of accessibility constraints were removed as they are measured in binary form wherein binary data violates main assumptions in correlation analysis and simple linear regression analysis. Accordingly, significant port logistics developments can be summarized as follows.

Table 6-2 Summary findings- Second stage data analysis

Port logistics factors	**Significant port logistics developments**
Operational and superstructure factors	Port annual handling capacity in TEUs
	Number of quay cranes
	Number of reefer plugging facilities
Infrastructure related factors	Number of berths
	Quay length
	Number of terminals
	Terminal draft

Ports with high handling capacities are provided with high ASCs by container lines, thus a significant correlation is reported between port handling capacity and the maritime connectivity of a port. Though Port of Shanghai has slightly lower capacity than Port of Singapore, Port of Shanghai recorded the highest maritime connectivity. Port of Singapore became the second due to the treat from liner shipping consolidation and growing alliances during 2016. Port of Busan recoded a moderate connectivity due to the bankruptcy of Hanjin shipping line, which was the main customer of port of Busan.

The number of quay cranes shows a significant relationship with maritime connectivity of a port. The ports with higher crane occupancy rates and transshipment hub ports located closer to major cargo exporting economies of the world (port of Shanghai, port of Hong Kong and port of Busan) and regional ports located in crossing points of the trade lanes (port of Colombo, port of Tanjung Pelepas) indicate significantly higher connectivity than mean connectivity with related to the number of quay cranes in operation.

The number of berths shows a significant relationship on maritime connectivity of a port. Port of Shanghai and port of Hong Kong do require more berths to maintain current connectivity levels as they are currently reaching the maximum output levels of available berths.

Quay length records a significant relationship with the maritime connectivity of a port. The ports which are positioned to the left of the trend line indicate the requirement for developments in the quay lengths as they struggle with existing quay lengths in facilitating current vessel traffic. Whereas the ports positioned towards the right side of the trend line show the underutilization of the existing quay length. Port of Klang and port of Colombo being pure transhipment hubs located in the South East Asian and South Asian maritime regions connecting Eastern and Western regions of the world, they are in need of expanding quay lengths to cater the increasing demand.

The number of reefer plugging facilities records a moderate relationship on the maritime connectivity of a port. Port of Klang, Port of Antwerp, Port of Hamburg and Port of Felixstowe being the regional hubs for refrigerated containers, they are highly congested for reefer containers and more developments are needed.

The number of terminals shows a moderate correlation on the port maritime connectivity. Ports operated by leading terminal operators like DP world, PSA Terminals, COSCO, Hutchison Port and Shanghai International Port Group record higher maritime connectivity as the efficiency levels of these terminal operators help to gain higher ASC by attracting more ships.

Terminal draft records a lower correlation while access channel draft shows no correlation with maritime connectivity of a port. This might be due to the limitation in dependent variable whereas ASC does not provide a clear explanation on how terminal draft affects maritime connectivity.

It is a common finding that, in general, gateway ports have positioned to the right of the trend line showing a lower maritime connectivity against all the above port logistics developments while hub ports are positioned to the left from the trend line indicating a higher maritime connectivity. Ports positioned to the left of the trend line indicate that they are securing the maximum out of the available resources even if the resources are congested and they need further port logistics developments while the ports positioned along the trend line indicate that they fairly operate with available resources. Analyzing all the ports positioned to the right of the trend line, it is proven that they have invested on more maritime logistics developments than required to cater current demand which resulted in underutilization of the resources. Further, they are mainly located in cargo importing economies, thus the number of vessel calls and the sizes of the vessels calling to these ports are comparatively lesser.

6.3.2.2 Correlation between port logistics developments

All the port logistics developments have significant or moderate associations between each other except terminal draft and the access channel draft where multicollinearity exists among the variables. Therefore, no multiple regression models could be developed to identify how port logistics developments collectively affect maritime connectivity of a port. However, a simple linear regression analysis was performed to assess how each port logistics development impacts maritime connectivity of a port individually.

6.3.2.3 Simple Linear Regression Analysis

The scatter plot diagrams between maritime connectivity and each port logistics development parameter showed significant differences between hub ports and gateway ports. Therefore, SLR analysis was performed for both hub and gateway ports separately. However, no single SLR model could be developed for gateway ports. Following models were developed for hub ports which represent forty nine percent of the sample ports considered.

M***aritime connectivity of a hub port= 4.231 + 1.250 port handling capacity***

M***aritime connectivity of a hub port = 2.399 + 0.245Number of quay cranes***

M***aritime connectivity of a hub port = 3.667 + 0.852Number of berths***

M***aritime connectivity of a hub port = 4.198 + 0.02 Quay length***

According to the above SLR models,

- Improving port annual handling capacity by one million TEUs will increase port's maritime connectivity by 1.25 times
- Investing on additional quay crane to handle ships will increase maritime connectivity of a port by 0.245 times
- Development of a new berth will enhance maritime connectivity of a port by 0.852 times
- Investing on quay length will increase maritime connectivity of a hub port wherein one meter increment will increase maritime connectivity by 0.02 time

6.3.3 Comparison between first Stage online survey analysis results and second stage quantitative data analysis

Comparing the results obtained from the online survey and the second stage quantitative data analysis, following conclusions can be made;

- Both analyses confirm that port annual handling capacity, quay cranes and reefer plugging facilities which are port logistics developments relate to operational and superstructure factors are significant to the maritime connectivity of a port
- From infrastructure related factors number of berths, quay length and number of terminals are identified as highly significant port logistics developments for the maritime connectivity of a port
- Online survey identified terminal draft as the most significant port infrastructure development on maritime connectivity of a port while second stage quantitative data analysis identified it as a moderately significant parameter.
- Access channel draft was identified as the second most significant port infrastructure development on maritime connectivity of a port through the online survey. However, second stage data analysis disconfirmed the judgement by giving it insignificant impact.

6.3.4 Port of Colombo

Findings in both online survey and second stage data analysis highlighted that port annual handling capacity, number of quay cranes, number of berths, quay length, number of reefer plugging facilities and number of terminals are highly significant on the maritime connectivity of a port while terminal draft has lower impact. Being the hub port for south Asian region, how do above port logistics developments have impacted on its maritime connectivity of port of Colombo is discussed over the period of time. Port of Colombo being the single container handling port in Sri Lanka, LSCI of Sri Lanka also can be considered as same as the LSCI of Port of Colombo. Looking at the LSCI and ASC in Figure 6-1, it is clearly indicated that maritime connectivity of port of Colombo was rapidly developing during the periods of 2004-2008 and 2013-2017 though a fair increment can be seen during 2001- 2003. Average vessel sizes calling port of Colombo also illustrated a rapid increment during 2013-2017.

During 2002, SAGT completed the development in first phase and commenced its operation from a single berth (quay length- 340m) with three super post panamax gantry cranes. JCT also has started operation of its 6th berth which added 350-meter quay length. ASC of Colombo port has increased from 4.99 million TEUs to 6.05 Million TEUs during 2001-2003. Thus, it can be justified that the increment in port handling capacity, quay cranes, number of berths, quay lengths have mainly impacted to the increment in ASC, thus the maritime connectivity of port of Colombo.

SAGT completed its constructions over three phases and commenced its full commercial operations in August, 2003 with 3 berths adding total quay length of 940 meters to Port of Colombo. Six super post panamax and three post panamax gantry cranes were put into operation as suitable to the largest vessels operating during this period. In addition, SAGT added 540 reefer plugs. Furthermore, feeder terminal Unity Container Terminal, which was operating with ship cranes, has commissioned three panamax gantry cranes during year 2004. Accordingly, as shown in Figure 6-1, both ASC and LSCI showed a growth during the period of 2004 to 2008. ASC has increased by 6.73 (from 6.79 to 13.52) and LSCI by 11.4 whereas LSCI was started to be calculated since 2004.

This scenario confirms that all these port logistics developments have resulted in the rapid growth in LSCI index, the ASC volumes and finally the maritime connectivity related to port of Colombo since 2004.

In July, 2013, 4thgreen container terminal at port of Colombo, CICT commenced its operations with a single berth. It is South Asia's first and only deep-water terminal, which can handle mega ULCSs. The berth inaugurated its ULCS operations by handling container vessel CMA CGM PEGASUS in 2013 with its three super post panamax gantry cranes and 400 meter quay length. The new terminal was constructed with a twenty meter deeper access channel along with an eighteen meter terminal draft. By September 2013 CICT started the operation of its second berth while in April, 2014 it completed its construction and terminal was fully operating with four berths with its deeper terminal and access channel draft to handle new generation ULCSs. The terminal commissioned 12 new state of the art super port panamax gantry cranes to operation with twin lifting capacity and with an outreach of 70 meters (23 rows across). Furthermore, CICT terminal set up 1150 reefer plugs to facilitate reefer containers. The total quay length of the port of Colombo was increased by 1200 meters. This has increased the handling capacity of port of Colombo to 7.3 Million from the previous handling capacity of 4.9 million TEUs per annum. These developments have helped Sri Lanka as a country to rise up in the LSCI index from 43 to 53 and a 2.36 million growth in ASC volumes during the period 2013 to 2017. Thus, this confirms the results obtained in both online survey and second stage analysis.

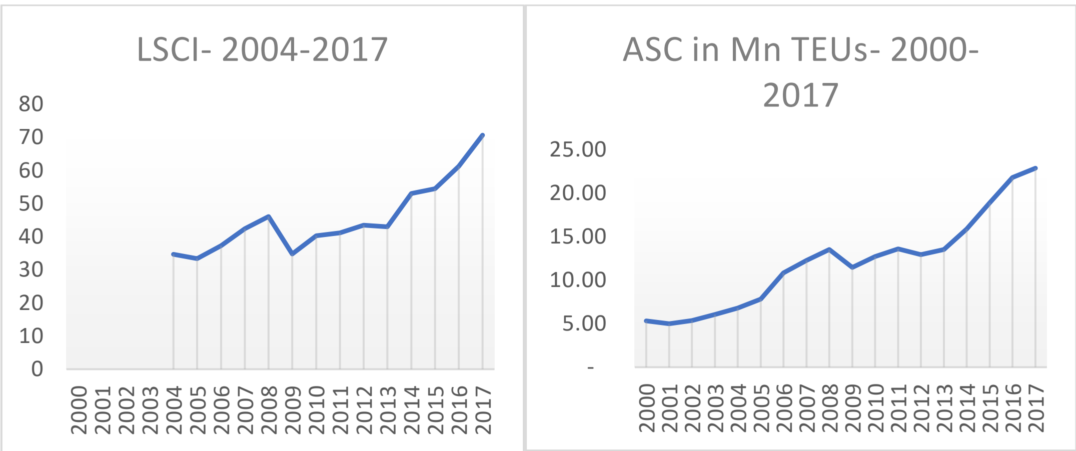

Figure 6-1 Maritime connectivity -Port of Colombo

Analysing the port of Colombo, it can be validated that the port annual handling capacity, number of quay cranes, number of reefer plugging facilities, number of berths, quay length, number of terminals and terminal draft have a significant impact on the maritime connectivity of a port.

6.3.5 Recommendation on port logistics developments

Comparing the results obtained from first stage online survey analysis and second stage quantitative data analysis, it can be recommended that a port should proactively consider in investing on following port logistics developments to enhance its maritime connectivity when they are operating to the maximum.

- Port annual handling capacity in TEUs
- Number of quay cranes
- Number of reefer plugging facilities
- Number of berths
- Quay length
- Number of terminals
- Terminal draft

6.4 Limitations of the study

The target population of the online survey is the managerial level employees attached to local offices of global container liner agencies. Therefore, the ideal sample would be the managerial employees attached to regional offices and agencies covering all the maritime regions. However due to the difficulties in contacting and collecting data from managerial level employees from different countries, a sample which represent the industry experts in container lines registered in Sri Lanka was selected as the target population. Therefore, the findings of the first stage online survey may be biased to the context of port of Colombo. If the sample contained respondents from container line headquarters, sub regional offices, agencies in hub ports, gateway ports and developed countries there might have been different answers than the current as they might assign different values to each maritime logistics factor as per the nature of the operation. Sri Lanka being mainly driven by transhipment market, naturally located in a strategic location in East West shipping route and having a single container port handling the whole volume, the importance of each logistics development factor will differ from other countries. Thus, difficulties in contacting and collecting data from managerial level employees from different countries limited the study only to Sri Lankan context.

One of the objectives of the second stage data analysis was to validate the results obtained from the online survey analysis. However, due to the unavailability of the relevant data for all the sample ports and difficulties in quantifying data, the second stage analysis was limited only to superstructure and infrastructure related factors. Data such as deviation distance from main shipping route, number of feeder connections, vessel turnaround times, berthing delays, waiting time for connecting vessels, dwell time for local containers, warehousing capacity and hinterland connectivity were not published in either port/terminal websites or annual reports or any other maritime publications like One Hundred Ports and Review of Maritime Transport. However, all these data are available on maritime databases such as CI-online, Alpha liner, Drewry logistics and Lloyd registry. But due to the funding constrains, the study had to be limited to the data which were publicly available only. Therefore, the results obtained from the first stage data analysis for all the 27 parameters could not be validated limiting the second stage analysis to the superstructure and infrastructure related variables.

The objective of the second stage data analysis was to quantify how significant is each port logistics development on the maritime connectivity of a port. As data for the whole population of container ports was not available to collect, therefore the data was gathered from a sample of 34 ports. In order to bring a better understanding on how port logistics developments affect maritime connectivity, it is advisable to measure identified factors for a fairly large number of container ports which consist of small, medium and mega ports, feeder and hub ports in covering most of the maritime regions in the world. But a lot of limitations were entailed in accessing most of the container ports such as inaccessibility of all the required data of the container ports and difficulties in collecting data. Thus, the study was limited to 34 medium and mega ports which belong to the top 50 busiest ports located in busiest routes (Asia Europe, Asian America, Asia-Mediterranean and Asia Middle east) and all these ports can accommodate at least Post Panamax size ships.

ASC was used as the dependent variable as there is no unique measure to capture maritime connectivity levels of ports. LSCI is ideal to be used as an index to illustrate maritime connectivity of a port as UNCTAD has developed it and all the maritime organizations have accepted it. However, LSCI is constructed for countries and not for a particular port. Therefore, the study was limited only to ASC which represents only average vessel size and the number of ship calls per port during an annum.

6.5 Suggestions and recommendations for future researches

The first stage online survey was conducted using a sample of industry experts in local offices of global container lines registered in Sri Lanka due to the limitation of connecting with experts working at headquarters of global container lines. Therefore, one can argue that the results obtained might differ on the global context as the respondents in the selected sample experience connectivity with respect to a Sri Lankan context where Sri Lanka is mainly driven by transhipment market and has only a single container port handling whole volume. Thus, there is a future research opening to conduct a similar study on the global perspective or in the context of other countries to validate the results.

Due to the cost and inaccessibility of required data for most of the ports, the second stage data analysis was limited to 34 medium and mega ports which belonged to the top 50 busiest ports located in busiest routes (Asia Europe, Asian America, Asia-Mediterranean and Asia Middle east) and all these ports can accommodate at least the Post Panamax ships. Therefore, the results obtained are biased to medium and mega ports. The outcome might differ once the same study is carried out adding small/feeder ports which operate with limited logistics developments. Therefore, there is a future research opportunity to conduct a similar analysis covering small, medium, mega ports and both feeder and hub ports.

Funding constrains limited the second stage analysis only to the superstructure and infrastructure related variables though the second stage analysis was to validate the results obtain for all the 27 parameters from the online survey. Thus, there is another future research opportunity to conduct a similar analysis considering other quantifiable variables like deviation distance from main shipping route, number of feeder connections, vessel turnaround times, berthing delays, waiting time for connecting vessels, dwell time for local containers, warehousing capacity and hinterland connectivity.

Due to the unavailability of detailed data on port related landside developments such as number and capacities of dry ports and logistics parks, hinterland connectivity measures like road, rail and air connectivity are exempted from the study. Therefore, there is another opportunity to study how port related landside developments affect to maritime connectivity of a port.

3.6 Summary

The chapter brought in to light all the findings of both online survey and second stage data analysis, comparison of the findings, limitations of the study and finally the recommendations. The knowledge brought into light from this study will support both container lines and terminal/port operators in developing their marketing strategies and infrastructure development strategies. Both terminal and port operators will be benefited by identifying optimal investment options which can be used to enhance the maritime connectivity. Further, port operators can use these discoveries as a benchmarking guideline to improve their services and in developing their ports as a transhipment hub port. Further terminal operators in port of Colombo will be able to identify how they can optimally use available resources. Container liner network planners also will be benefited in evaluating most connected hub ports for their liner services. For example, a container liner can use this knowledge in preparing hub port selection criteria to restructure their liner services using a hub and spoke, and relay networks.

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APPENDICES

Appendix A- Questionnaire

Contribution of port logistics development for the maritime connectivity of a port

General instructions

This questionnaire consists of two sections. Please answer all the sections considering the importance of port logistics factors contribution to the maritime connectivity of a port.

Maritime connectivity explains how well countries are connected to the global shipping networks. Port logistics is an indicator of superstructure, infrastructure, location, time and institutional factors of a port which facilitate to effective and efficient port services.

Section A: Significance of the port logistics factors affecting to maritime connectivity

The following table list port logistics factors, which contributes to the maritime connectivity of a port. To what extent do you agree that the following port logistics factors would contribute to the maritime connectivity of a port?

Scale for significance score

- 5- Highly significant
- 4- Significant
- 3- Not Sure
- 2- Not significant
- 1- Not significant at all

Please indicate your view by ticking the appropriate box shown in the scale.

	Port logistics factors	**Significance score**				
	Operational and superstructure factors	**5**	**4**	**3**	**2**	**1**
A-1.	-Port annual handling capacity in TEUs					
A-2.	-Availability of suitable gantry cranes and yard cranes to handle new generation of ships					
A-3.	-Availability of ship and yard panning systems					
A-4.	-Availability of EDI system					
A-5.	-Number of reefer plugging facilities					
A-6.	-Efficiency in navigation services					
A-7.	-Warehousing capacity (for local and MCC cargo)					
	Location related factors					
A-8.	-Distance from the main shipping routes					
A-9.	-Location of port (proximity to other ports in the region)					
A-10.	- Hinterland connectivity					
A-11.	-Adequate feeder connectivity					

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	Infrastructure related factors					
A-12.	-Number of terminals					
A-13.	-Number of berths					
A-14.	-Quay length					
A-15.	-Access channel width and draft					
A-16.	-Accessibility constraints (Tidal water)					
A-17.	-Deeper terminal draft					
	Institutional Factors					
A-18.	-Port tariff structure					
A-19.	-Customs policies					
A-20.	-Port policies (eg. Operation time)					
A-21.	-Government policies (eg. Trade agreements)					
A-22.	-Availability of skilled employees					
	Time Factors					
A-23.	-Availability of berthing windows					
A-24.	-Dwell time for local containers					
A-25.	-Vessel turnaround time					
A-26.	-Time taken for documentation					
A-27.	-Waiting time for connecting vessels					

If you have any other factors, please indicate in the below

Section B: Demographic information

B-1. What is your organization representing?

....

B-2. What is your current job title?

....

B-3. What are your general responsibilities in the organization?

....

....

....

B-4. For how many years in total have you had a senior management role? ....years

B-5. In which discipline is your professional background and qualifications?

1) Business management : ☐
2) Engineering : ☐
3) Operations : ☐
4) Marketing : ☐
5) Accounting/Finance : ☐
6) Other (please specify) : ....

B-6. Would you like to receive a copy of the summary results of the study when they become available?

Yes - ☐

No - ☐

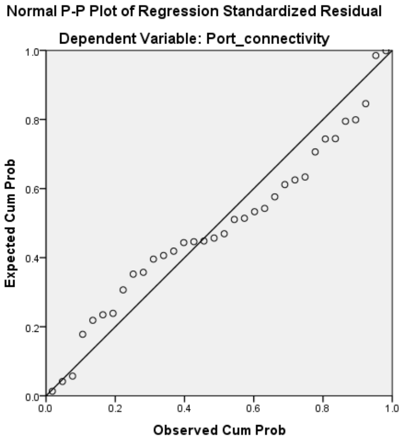
Email address: ....

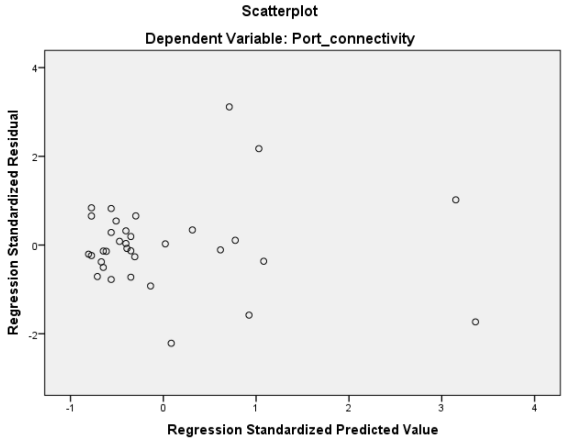
Thank you very much for your kind cooperation

End of the questionnaire

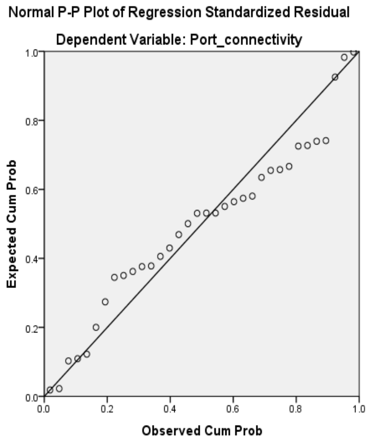
Appendix B - Homoscedasticity

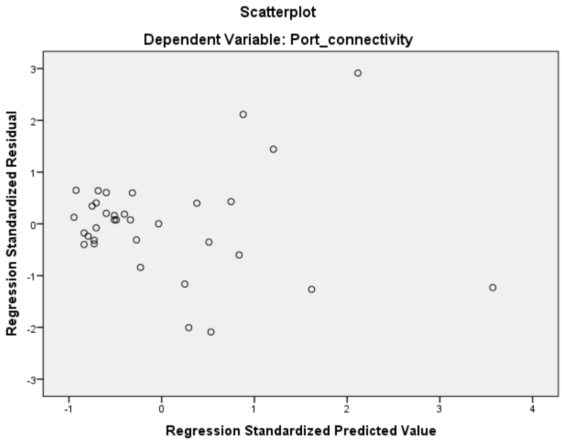
Port Handling Capacity



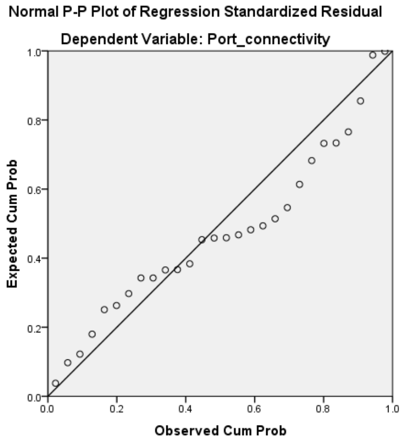


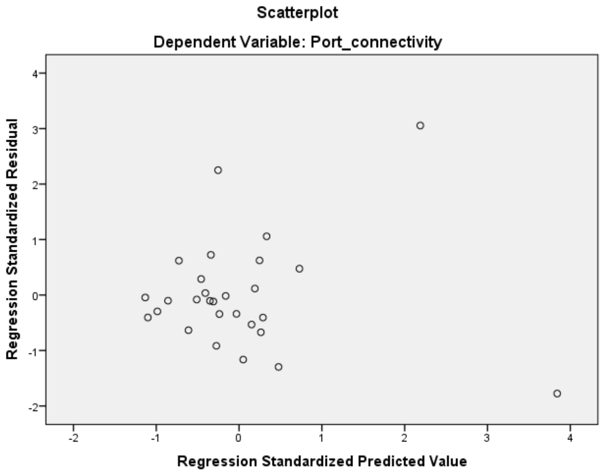
Number of Quay Cranes



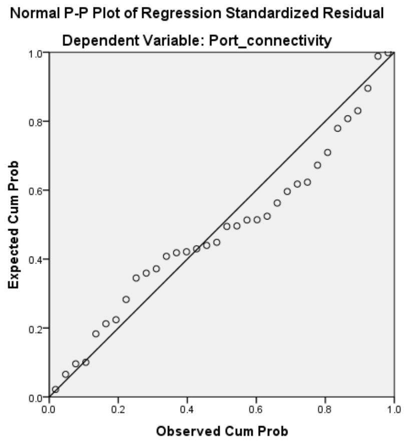


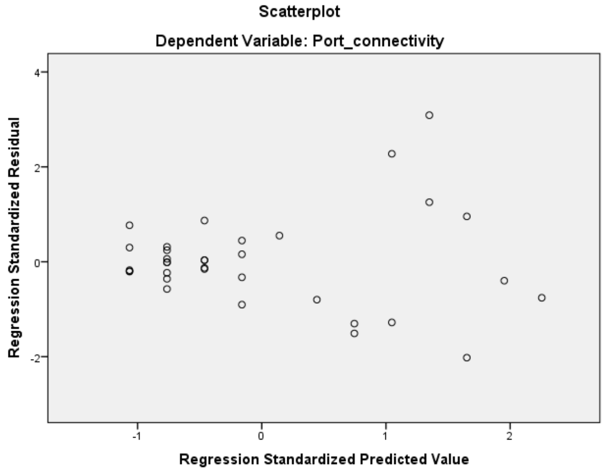
Number of Reefer Plugging Facilities



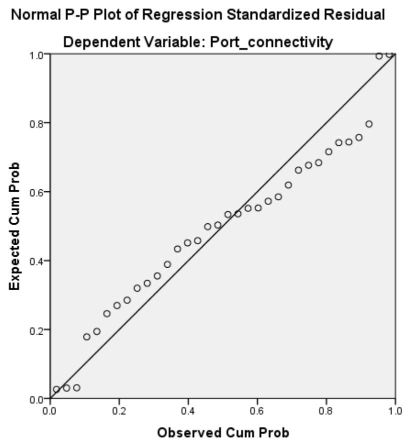


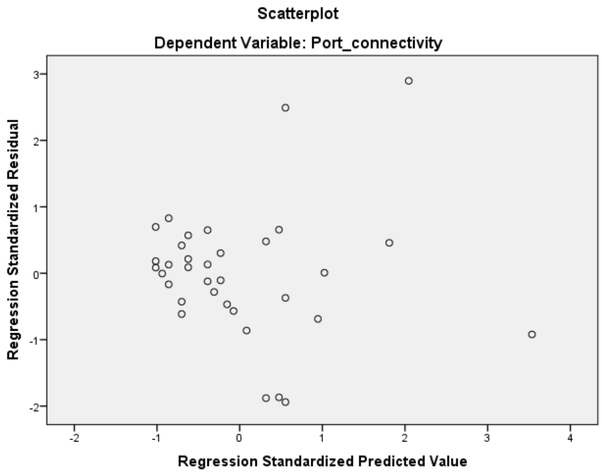
Number of Terminals





Number of Berths





Quay Length