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DYNAMICS OF LINER SHIPPING NETWORKS AND TRADE VOLUME: A CASE STUDY OF WEST AFRICAN AND TURKISH PORTS

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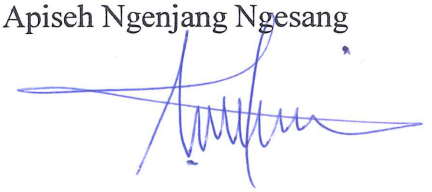
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ABSTRACT

Master's Thesis

Dynamics of Liner Shipping Networks and Trade Volume:

A Case Study of West African and Turkish Ports

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Since the discovery of containers, liner shipping has become an indispensable phenomenon in the transportation industry. It is one of the main means through which cargo is transported around the globe. The various seaports scattered along the coasts of countries in different continents are connected to each other through several services created by shipping lines, transporting cargo in containers from one country to the other. The combination of these seaports and shipping service add up to form liner shipping networks. These networks form the grounds on which international trade is carried out. Trade and liner shipping networks are therefore two highly interconnected variables. This study examines the factors that affect the relationship between liner shipping networks and trade volume in order to understand the different dynamics that exist between them. The Liner shipping network between West Africa and Turkey is used as a case study. Five ports in the West African region were selected and the analysis was based on these ports. Using a qualitative method, information was gathered by carrying out a survey that involved participants from different sectors in the area of study. The findings show five main factors that affect liner shipping networks and trade volume which include; financial factors, infrastructural factors, network structure design, competition/cooperation and trade factors. Hinging on these factors, carriers, policymakers, terminal operators and port planners could make better decisions in order to benefit their different objectives and agenda.

Keywords: Liner shipping, Trade, West Africa, Ports, trade volume, Liner Shipping Networks.

ÖZET

Yüksek Lisans Tezi

Düzenli Hat Taşımacılığı Ağları ve Ticaret Hacminin Dinamikleri: Batı Afrika ve Türkiye Limanları Üzerine bir Vaka Çalışması

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Düzenli hat taşımacılığı konteynerin icadından beri taşımacılık endüstrisinin vazgeçilmez olgularından biri olmuştur. Konteyner, yükün dünyanın dört bir yanına taşınmasını sağlayan araçlardan biridir. Farklı kıtalardaki ülkelerin kıyıları boyunca dağılmış çeşitli limanlar, yükleri konteynerlerin içinde bir ülkeden diğerlerine taşıyan taşımacılık hatları tarafından sağlanan birçok servis aracılığıyla birbirine bağlanır. Bu limanların ve taşımacılık servislerinin birleşimi düzenli hat taşımacılık ağlarını oluşturur. Bu ağlar uluslararası ticaretin yapıldığı alanlarda oluşmaktadır. Ticaret ve düzenli hat taşımacılığı ağları birbirleri ile yüksek derece bağlantılı değişkenlerdir. Bu çalışma düzenli hat taşımacılığı ve ticaret hacmi arasında meydana gelen farklı dinamikleri anlamak için düzenli hat taşımacılığı ve ticaret hacmi arasındaki ilişkiyi etkileyen faktörleri incelemektedir. Vaka çalışması olarak Batı Afrika ve Türkiye arasındaki düzenli hat taşımacılık ağları kullanılmıştır. Batı Afrika bölgesinden beş liman seçilip analizler bu limanlar temel alınarak yapılmıştır. Kalitatif metod kullanılarak, çalışma alanı kapsamında yer alan farklı sektörlerdeki katılımcılara yapılan anket vasıtasıyla bilgiler toplanmıştır. Bulgular, düzenli hat taşımacılık ağlarını ve ticaret hacmini etkileyen beş ana faktör olarak finansal faktörleri, altyapısal faktörleri, ağ yapısı dizaynı, rekabet/işbirliği ve ticaret faktörlerini göstermiştir. Bu faktörleri dikkate almak taşımacılara karar vericilere, terminal operatörlerine

ve liman planlayıcılarına farklı amaç ve gündemlerine fayda sağlamak için daha iyi karar verme konusunda yol gösterebilir.

Anahtar Kelimeler: **Düzenli Deniz Taşımacılığı, Ticaret, Batı Afrika, Limanlar, Ticaret Hacmi, Düzenli Hat Deniz Taşımacılığı Ağları.**

DYNAMICS OF LINER SHIPPING NETWORKS AND TRADE VOLUME: A CASE STUDY OF WEST AFRICAN AND TURKISH PORTS

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ABBREVIATIONS

AFDB	African Development Bank
ASC	Anualized Slot Capacity
DEA	Data Envelopment Analysis
GAL	Graph of All Linkages
GDL	Graph of Direct Linkages
GDP	Gross Domestic Product
GPHA	Ghana Ports and Harbor Authority
LSN	Liner Shipping Network
MED	Mediterranean
MLTC/CATRAM	Maritime Logistics and Trade Consulting
MPH	Moves Per Hour
MPS	Meridian Port Services
NHPA	Network-based Hub Port Assessement
NIC	Newly Industrialized Countries
O-D	Origin – Destination
OEC	The Observatory of Economic Complexity
RTG	Rubber-Tired Gantry Cranes
STS	Ship-to-Shore Gantry Crabes
TEU	Twenty Foot Equivalent Units
UNCTAD	United Nations Conference on Trade and Development
WAF	West Africa

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INTRODUCTION

Liner or Container shipping is not a new phenomenon in the transportation industry. There has been a continuous growth in this field of study since Malcolm McLean first introduced containers to the maritime world. Liner shipping is the transportation of containers on regularly serviced shipping routes by liner shipping companies which usually have specific schedules and itineraries for their services (Liu *et al*, 2013) – service calls are usually made at predetermined specified ports along a given route (Munari 2012). It is the fastest growing sector in maritime shipping and concentrates more than half of world trade value (Ducruet and Notteboom, 2012). Many researchers have carried out various studies on liner shipping. The studies carried out are on a variety of different issues pertaining to the sector including studies on liner shipping networks (Lam & Yap 2011, Tran & Haasis 2014, Lun et al 2010), inter-port connectivity and relationships between ports (Jiang et al 2015, Song 2002), port efficiency and effectiveness (Pagano et al 2013, Cullinane & Song 2005, Cullinane et al 2004), port choice and hierarchy (Tongzon 2009, Nir et al 2003, Tongzon & Sawant 2007) and port performance (Tongzon 1995, Roll & Hayuth 1993, Bichou & Gray 2004) just to name a few.

The continuous growth and changes experienced in this sector have required all stakeholders involved such as liner shipping companies, port authorities, shippers and forwarders to develop new measures, strategies and techniques of operation in order to stay competitive and remain in the business, given that the competition in this sector is becoming more fierce by the day.

The liner shipping network (LSN) plays a vital role in the running of liner shipping companies. It has great influence on the business as a whole. A network has been defined as a structure of a collection of nodes and links that represent something real (Lewis, 2008). In a network, distinct elements or actors are represented by nodes (or vertices) and the connections between the elements are represented as links (or edges). The concept of a network has also been defined as a multi-dimensional system consisting of objects, connections, relations, and units respectively called nodes, links, exchange functions and shares (Degrassi 2001). A liner shipping network can, therefore, be defined as a structure of the collection of ports (nodes) and the shipping routes between them (links) representing the real

connection of ports in different parts of the world – that is the physical liner shipping network. A route can be referred to as a sequence of visited ports with pre-determined times to call at each port (Trans and Haasis 2013). The liner shipping network has also been defined as a form of network in which firms share resources and assets among the network members and with other actors, such as intermodal service providers, container management service providers and container terminal operators, to develop mutually beneficial strategies to seek operational gains (Lun et al, 2010). Therefore, an LSN does not encompass only the physical connection involving the routes and ports but also all the stakeholders involved such as shipping companies, forwarders, terminal operators and the like are also a part of the LSN, however, this study is more concerned with the physical liner shipping network.

The choice of the liner shipping network design has to be considered carefully by liner shipping companies in order to minimize costs or maximize profits that is, have an optimal design that minimizes wastes and optimizes time usage. The network design is like a blueprint for the operation of the company. It involves selecting the rotation of ports, the number of vessels to be deployed on each route and the time that will be taken for each rotation. The costs involved such as port costs and vessel operational costs and also the cargo availability are primary considerations when designing the network (Wang & Liu, 2015). Getting a full ship is usually the main aim of carriers, therefore ports with high cargo availability will usually be primarily considered when designing the network. Lun et al (2010) identified eight factors that influence the development and operation of a liner shipping network which included vessel space management, hinterland, intermodal transport, ports, management information system, equipment supply, new agents and terminal operators. Shipping lines always aim at optimizing their shipping networks by rationalizing coverage of ports, shipping routes and transit times (Zohil & Prijon, 1999). The network design is therefore a very important part of the operation of a liner shipping company and several factors have to be taken into consideration before designing a container service. Before designing the network, operators should carry out a detailed analysis of the targeted trade route. The analysis should be carried out on the supply, demand and market profiles of the trade route (Ducruet & Notteboom, 2012). After the market analysis has been carried out and operators are certain about

the market potential of the given service, the network design process can begin and several inter-related core design variables need to be taken into consideration when designing the network including; liner service type (hub/feeder, relay, interlining, pendulum and so on), port selection, number and order of port calls, vessel speed, frequency of the service, and vessel size and fleet mix (Ducruet & Notteboom 2012).

The main business of liner shippers is the transportation of cargo in containers between different regions of the world by sea. This implies that for liner shipping companies to be able to operate there has to be cargo available for transportation by sea. The trade volume determines the availability of cargo and greatly affects the configuration of the shipping network. According to Song et al (2005), the operation of a liner shipping business consists of two key elements: trade demand and the physical shipping network. With the increase in globalization and trade liberalization amongst other factors, the volume of global trade has consistently exceeded that of world output (Park & De 2004). This can be explained by; an increase in integration of national economies across the globe, a deepening of the international division of labor, an increase in standardized business operations and a rise in the globalized production pattern (Lun et al 2010). It is estimated that about 80 percent of global trade in volume is transported by sea (UNCTAD 2015) of which about 60 percent in value is transported in containers (World Shipping Council). The quantity of goods carried by containers rose from about 100million metric tons in 1980 to about 1.7billion metric tons in 2015 (Statista), showing the importance of container transportation in international trade.

Given that liner shipping and trade volume are two highly interconnected and interdependent variables, this research paper seeks to examine the design and configuration of liner shipping networks, and the calling patterns of liner shipping services in order to understand the dynamics between liner shipping networks and trade volume. The research concentrates on the West African region and the network between this region and Turkey is used as a case study.

CHAPTER ONE

CONCEPTUAL FRAMEWORK

1.1. RESEARCH QUESTIONS AND OBJECTIVES OF THE STUDY

The main question this research seeks to answer is as follows:

What are the factors that influence the relationship between liner shipping networks and trade volume in West Africa?

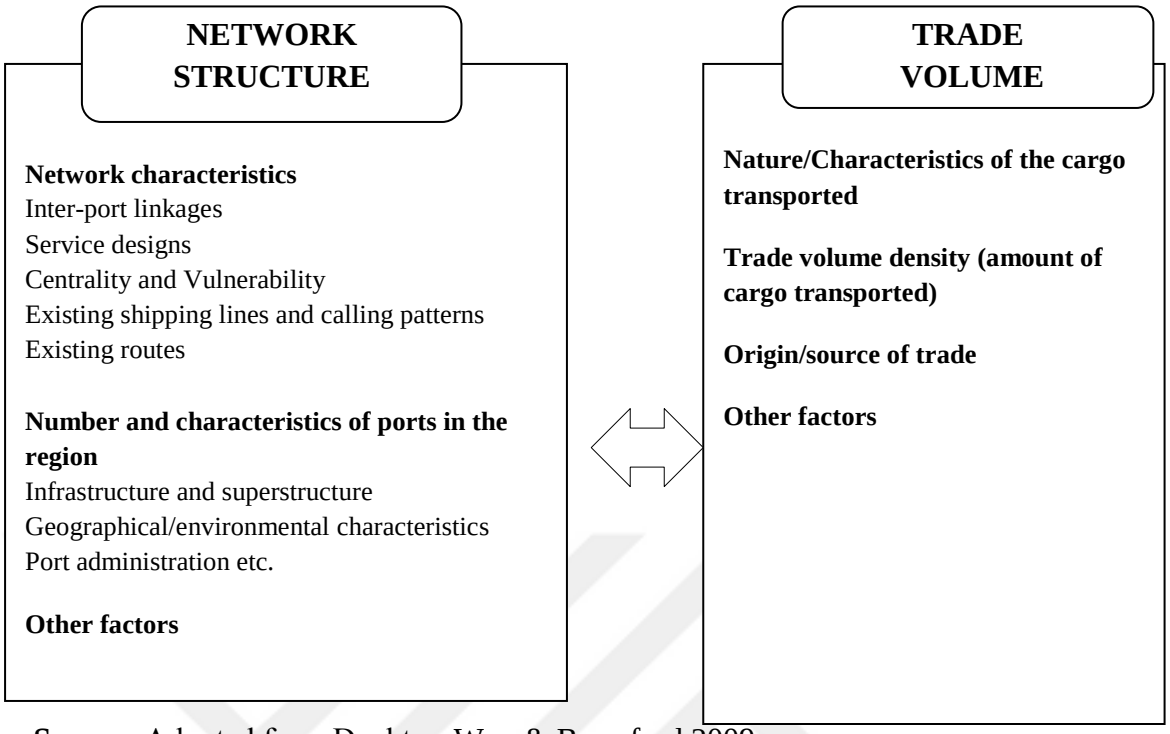
In order to answer this question, the following are the specific objectives of the research;

- To analyze the port infrastructural and superstructural facilities of the selected West African ports
- To evaluate the level of port connectivity and inter-port relationships between of these ports
- To examine the calling patterns of shipping lines in the selected area
- To analyze all linkages between the selected ports in West Africa and Turkey
- To examine the impact of trade volume on liner shipping networks
- To provide recommendations for the improvement of trade in West Africa

1.2. RESEARCH MODEL

The proposed model is going to be used in order to facilitate the investigation of the relationship and dynamics between liner shipping networks and trade volume. The model is divided into two parts; the Network Structure and Trade volume. The main factors and variables in relation to both the network structure and trade volume will be evaluated.

Figure 1: Conceptual Research Model



Source: Adopted from Denktaş, Woo & Beresford 2009

1.2.1 Network Structure

Various factors determine the configuration and design of the network. The network characteristics such as nature of the **inter-port linkages and service designs** (hub-and-spoke, relay, interlining etc,) are examined to determine to what extent these are affected by the trade volume or to determine the relationship between these network characteristics and the trade volume (see Figure 1).

Furthermore, the nature of the **existing shipping routes** and the **centrality/vulnerability** of ports in the region are examined based on vessel movements. A route is a basic component of the container shipping system. It is characterized by a predetermined sequence of visited ports, arrival schedule, frequency and deployed ships. The configuration of inter-port links determines two main measures of centrality in networks; betweenness centrality and degree centrality (Ducruet & Notteboom 2012). Betweenness centrality is a measure of accessibility or reachability as it counts the number of positions of a node on the possible shortest paths amongst all nodes in the entire network (Ducruet & Lugo 2013). Degree centrality on the other hand counts the number of ports connected to

any given port (Ducruet & Notteboom 2012). These measures are useful in determining and characterizing the position of ports in the network such as revealing ports with hub-port status and showing port hierarchy.

The characteristics of ports in the region such as **infrastructure and super structural features**, **geographical, environmental characteristics** and port degree amongst others have significant effects on the network (see Figure 1). The port infrastructure such as berth characteristics, storage facilities and handling equipment amongst others will have significant effects on the speed of traffic flow within the port and therefore will greatly affect the choice of liner shipping companies when choosing ports for their liner services. Natural characteristics such as water depth, geographical location and environmental factors also have an influence on the network configuration. The degree of a port from a network perspective is the number of links connected to or from it. It represents the total number of calls at the port per period of time. Higher degree means more centrality of the port on the network (Tran & Haasis 2014).

Other factors such as governmental regulations, international policies, economic factors and security issues also influence the configuration of the liner shipping networks.

All these factors are examined to determine the configuration and set up of the liner shipping network in order to observe the dynamics between these networks and trade volume.

1.2.2 Trade Volume

Liner shipping is dependent on trade as it is a derived demand. Therefore, the trade volume will highly affect the design of the liner shipping networks and also the organization of the networks has significant effects on the trade volume (UNCTAD 2016). According to Vanlentine et al 2013, global shipping evolves alongside the development of trade thus making it a great tool for analyzing the global economy. Over 70% of world seaborne trade in value is transported by container ships (WTO 2008) showing the significance of liner shipping to global trade. The trade volumes differ according to different regions of the world and it is mainly driven by economic growth.

Various aspects of the trade volume such as the **nature and characteristics of the cargo loaded** (mainly containerized cargo), **the amount of cargo transported** and **the origin and source of the cargo** amongst other factors will be examined in order to understand the dynamics between trade volume and the liner shipping networks (see Figure 1).

1.3. SIGNIFICANCE AND JUSTIFICATION OF THE STUDY

The findings of this study will help give a better understanding of the dynamics between liner shipping networks and trade volume. This will be helpful to liner shipping companies, freight forwarders, shippers and other stakeholders when designing or choosing service networks such as choosing transshipment ports and service type – relay, hub/feeder, interlining and the like, setting up rotation frequency and so on.

Maritime transport is the most dominant mode of transportation in international trade and more than 70% or goods are transported in containers worldwide. The configuration and design of liner shipping networks is greatly influenced by the trade volume and also has significant effects on the trade volume. The region of West Africa is an emerging region in maritime transportation with growing traffic volumes. An examination of the selected ports in the region will provide information on the ports' positions on the network and this could be helpful to governments and policy planners and port authorities to carry out actions to improve port competitiveness, international trade and development status.

Though many studies have been carried out on the liner shipping sector, very few studies examine how changes in this sector or the dynamics in this sector have impacted the global trading system. In trade literature conversely, very little attention is paid to liner shipping even though it is one of the most used modes of transportation in international trade. However the market structure and design of the liner shipping sector will have significant effects on the global economy and should thus be a matter of concern for the broader trade literature.

This paper therefore aims to fill this gap by examining the relationship and dynamics between liner shipping networks and trade volume. The West African region is a highly neglected region in the literature. Very few studies have been

carried out on this region so far (Dyck 2015, Laventhal 2009, Dyck 2015, Caschili & Medda 2015, Debrie 2012, AFDB 2010, Boermann 2015, Pálsson *et al* 2007, CATRAM 2013). Most studies always focus on the main trade lanes such as the East-West lane (Lee *et al* 2011, Macharis & Janssens 2011, Ducruet & Notteboom 2012, Ryoo & Thanopoulou 1999, Dong-Wook Song 2002, Yeo *et al* 2008, Lee and Yap 2011, Song and Yeo 2015, Degrassi 2001, Lee *et al* 2011, Wilmsmeier & Notteboom 2011, Mengqiao *et al* 2015, Hu and Zhu 2009) . However this is a growing and emerging region in the global economy therefore this paper is focused on this region.

1.4. SCOPE OF THE STUDY

In maritime transportation, there are different types of cargo with varying methods of transporting them such as bulk cargo, cargo transported in tanks (such as natural gas, oil, other liquids), Ro-Ro cargo (such as cars and other vehicles), animals, and cargo transported in containers. This study is focused on liner shipping which is the transportation of cargo in containers. The analysis is based on selected ports in the West African Region including the ports of; Dakar (Senegal), Tema (Ghana), Apapa (Nigeria) and Abidjan (Ivory Coast). These ports were chosen because they are the busiest ports in the region in terms of traffic volume and throughput measured in TEUs according to numerous policy reviews and statistical reports.

CHAPTER TWO
RESEARCH MODEL AND VARIABLES

This chapter aims at examining the research model in detail and it also examines existing literature in relation to the study in order to provide an in-depth knowledge of research that has been carried out in this area so far. The review is carried out based mainly on the following key topics; liner shipping network structure, ports and trade volume. Furthermore, certain key variables in relation to ports and liner shipping networks will also be examined in this chapter.

2.1. NETWORK STRUCTURE

The network structure and configuration of liner shipping networks is developed to meet the demands of global supply chains in terms of accessibility, frequency and transit times (Ducruet & Notteboom 2012). There are many actors, different parameters and factors that play major roles in the network configuration and structure. These are going to be examined in this section with the main aim to highlight the overall characteristics of the network structure based on topology, morphology and traffic flows. Also, following the research model, the characteristics of the ports and other factors that influence the network structure will be examined.

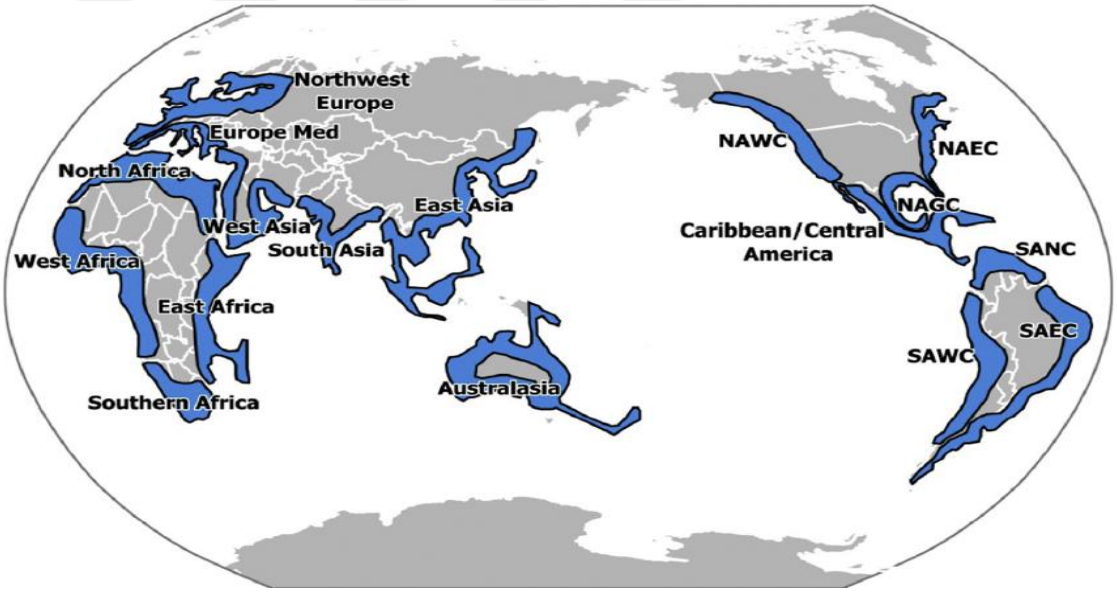
2.1.1. Inter-port Linkages

The evolution and growth of liner shipping have led to a global movement of containers between different regions of the world. Shipping lines create services that connect ports all over the world and the combination of these services which could either be line-bundling services, round-the-world services, pendulum services, hub/feeder networks and interlining or relay services altogether form the global maritime or global shipping network (Ducruet & Notteboom 2012). Within this network are local, regional and global links (trade routes) between ports which become interconnected through the establishment of hub ports, interlining and relay ports.

The global shipping network has not been clearly defined or divided into regions according to any single universally accepted criteria. On one hand, shipping lines define their service regions and design the routes they take mainly in relation to

their different market focuses (Mengqiao *et al* 2015). Different network studies on the other hand determine the regions according to their individual research interests. A maritime region has been defined as an area that includes two or more neighboring coasts (Ducruet & Zaidi 2012) or a geographical area with a group of ports together serving the area (Mengqiao *et al* 2015). Thus a region in terms of liner shipping will be a group of ports in the same geographical area, belonging to the same set of loops of inter-continental liner services and within the same coastal region. Mengqiao *et al* 2015 divide the global shipping network from a geographical perspective into seventeen regions as can be seen in Figure 2 below. Though this is not a universal standard, the division of regions in this study could be a reflection of how most studies divide the maritime regions.

Figure 2: World Regions for Global Shipping



***Source**: Mengqiao et al 2015.*
Europe Med = Europe Mediterranean, NAWC = North American West Coast, NAEC = North American East Coast, NAGC = North American Gulf Coast, SANC = South American North Coast, SAWC = South American West Coast, SAEC = South American East Coast

The flow of cargo to and from different ports between the different regions of the world form the global maritime network within which trade routes are interconnected by the establishment of hub ports, interlining and relay ports (Ducruet

& Notteboom, 2012). It is a small world network in which it is easy to move from one port to another in a small number of movements (Kaluza et al 2010). Kaluza et al 2010 also show that it is a scale-free and highly asymetric network as it was revealed that more than half of all ports are linked in only one direction, which means most liner services use different ports of call on the way back. The global liner shipping network is of an imbalanced structure in terms of weight and growth with some regions being more developed and advanced than others (Ducruet & Notteboom 2012, Mengqiao et al 2015). The most dominant regional networks and biggest trade zones in maritime shipping have been confirmed by various studies as the Europe-Asia and Asia-North America networks. That is, the East-West trade lanes (Fremont & Soppe 2005, Ducruet & Notteboom 2012, Mengqiao et al 2015, and UNCTAD 2016). This can be explained by the relatively more advanced growth and higher commodity consumption rates in these regions compared to the other regions plus the rapid economic growth that has been seen in some countries in East Asia such as China, South Korea, and the Philippines amongst others – the so-called Newly Industrialized Countries (NIC). Nine out of the top ten container ports in the world are found in East Asia (UNCTAD 2016). This greatly boosts the position of the region.

The global maritime LSN has experienced many changes, adjustments shifts and restructuring over the years mainly due to technological changes, globalization, economic, geopolitical and environmental changes. Tremendous growth has been experienced through growth in trade routes measured by the number of TEUs transported, number of ports and increased shipping capacity. There has been an evolution in liner shipping networks from the time when the network was majorly concentrated on the East-West routes mainly connecting North America, Europe and East Asia (Rimmer 2004) to the time when these networks started expanding due to growing liberalization of maritime transport and carriers started serving North-South routes (Hoffman 1998). The liner shipping network is quite dynamic and continues to face changes and restructuring over the years due to one or more of the many factors mentioned above. Shippers and carriers continuously re-assess the design of their shipping and distribution networks in order to acquire high costs efficiency, manageable risks and increased routing flexibility (Notteboom 2012). More recently,

the global financial crisis of 2008 and the global recession of 2009 have also had huge impacts on liner shipping networks. Laxe *et al* (2012) analyze the structural changes that took place in maritime shipping networks following the financial downturn of 2008-2010. Their findings show that there was an emergence of new hubs, coming together of new ports and development of new networks in maritime transport. There was a major restructuring in the maritime transportation network and despite the crisis, certain ports experienced increases in connectivity and centrality. For example, in 2008 Rotterdam in the Netherlands and Busan in South Korea were observed to be the most connected hubs, however; Hong Kong and Singapore became mega-hubs by 2010. Also, re-routing of shipping lines which normally used the Suez Canal to new routes that passed via the Cape of Good Hope (Notteboom 2012) led to the emergence in certain ports in Africa such as the ports of Dakar in Senegal, Lagos in Nigeria and Durban in South Africa. These continuous changes and new developments that occur in liner shipping networks create potentials for the emergence of new trade routes and hubs and also for new regions to strengthen their position on the global network. Interlining via the Cape route, for example, could become a competitive substitute to routing via the Suez Canal according to Notteboom (2012). The research analyses the extent to which interlining/relay operations along the Cape route could develop into a competitive alternative to existing routes and for which trade lanes. Three analyses are used to compare the two trade routes; a distance analysis, transit time analysis and cost analysis. The findings reveal the outperformance of interlining via the Cape route over the Suez route on various routes including; West Africa – Oceania, West Africa – East Asia, South America East Coast – Oceania and South America East Coast – East Asia. Though the Suez Canal was still the most dominant route used by carriers, the study revealed potentials and possibilities for the Cape route to becoming a competitive alternative in the future. The study also revealed the potential of West African ports such as the ports of Dakar in Senegal and Douala in Cameroon of becoming major interlining hubs on the South–South trade lane (Notteboom 2012).

Fremont (2007) carried out a study on global maritime networks in which he contradicts popular belief that hub and spoke networks and direct port networks are different, illustrating that they are actually complementary to each other. He

establishes that in order for shipping lines to achieve global coverage, it is required to have a complementarity or mixture between direct services and transshipment. Using a case study of Maersk line - the biggest carrier in the world, he demonstrates that a multiport model or hub-and-spoke system is not incompatible in network configurations. Ducruet and Notteboom (2012) carried out a study on the worldwide maritime network structure of container shipping in which they examine the network structure, port hierarchy and the dynamics influencing them. With the use of a graph of direct linkages (GDL) and a graph of all linkages (GAL), they show all connections between ports in the worldwide network and exhibit the characteristics of the network in terms of network structure and port hierarchy. The results show that; most traffic occurs across relatively short distances as it was shown that in the GDL, 78 to 79 percent of worldwide traffic occurred over links of up to 500 kilometers, the GAL is larger and denser than the GDL indicating a small world network – showing that distance plays an important role in determining the network structure. Also, they find out that, there was an increase in the share of the largest links due to globalization and technological progress in the maritime industry; however, intra-regional linkages (short-sea shipping and hub-and-feeder services still had more weight). Furthermore, connectivity of ports changed over the years due to economic changes in different regions and a striking absence and decline of transatlantic linkages were noticed as the Asia Pacific and Europe regions dominated the network.

Most shipping companies seek to increase their market share and have more global coverage however just a few companies such as Maersk Line, MSC and CMA CGM actually operate on a global level (Fremont 2007, Ducruet & Notteboom 2012) with a strong presence in secondary routes. Other shipping lines operate much more on a regional or local level. A smaller company such as the Turkish company ARKAS line, for example, has much more influence on the Mediterranean region compared to other regions. This was further illustrated in a study by Gadhia et al, (2011) in which they examine the port networks of container shipping companies in order to determine the level of their internationalization. The level of the companies' internationalization is important as it affects its ability to expand its customer base both at a local and international level. The data used was collected from container

shipping companies' websites in relation to the companies' standard scheduled routes. A list of world container ports was then consolidated and classified into country, region and sub-region. This generated a database that was used to evaluate, identify, compare and classify the container ports in each company's network. The examination showed that each container shipping company to an extent is international, however only a handful of companies have global coverage. They identified four levels of internationalization in the container shipping industry; Home or Legacy level in which the network is limited to the company's home region, the Core Expansion level where the company expands its network to another core zone and establishes at least one core to core route corridor and serves some major ports in the core regions, the Prospecting level in which the companies extend their network looking into additional areas near their existing networks for supplementary business and the final level is the Global level where the companies have global networks and serve a majority of the ports in every core region and many of the smaller ports. Only a few companies were seen to be operating at the global level (Gadhia et al 2011). In another research on the world maritime transportation network (WMN), Hu and Zhu (2009) carry out an empirical study of the network using two different network representations namely spaces L and P. The space L network consists of nodes which are ports and links created between consecutive stops in one route. In a space P network, two arbitrary ports are connected if there is a container line traveling between the two ports. Based on their findings, they conclude that the WMN is a small world network with power law behavior. In a small world network, it is possible to connect any two nodes - being ports in this case - through just a few links (Amaral et al, 2000), that is every single port in the network can be connected to another port through a few routes.

The geographical and economic characteristics of a region also affect the configuration of the network. Tran & Haasis (2014) carried out an empirical analysis of the container shipping network on the East-West corridor for the years 1995-2011. In their study, they examined the topological structure of the network in which they analyzed the characteristics of the network, the growth of the network, properties of links and edges, properties of inter-port links, degree of ports on the shipping system and concentration trends, scale-free attribute of the network and the relationship

between port degree and throughput. The study was carried out on nine regions in the network; East Coast North-America, Europe, Mediterranean Sea, Middle East, South Asia, South East Asia, North East Asia, West Coast North-America, Central America and the Caribbean region. The findings showed that; the network became larger in harmony with trade growth; the number of ports and the links between them increased as trade grew. Also, it was observed that links tended to connect ports with similar degrees – an attribute known as assortativity (also observed by Ducruet & Notteboom, 2012). The largest degree ports were located in East Asia where the largest manufacturing economies were located showing the great effect the economies of countries have on liner shipping - The region of Asia has increasingly taken the forefront in maritime networks due to the so-called global shift and it has become a core region in the global maritime network with many central ports with increasing connectivity and centrality (Ducruet & Notteboom, 2012) - The network was scale-free with many small degree ports and less high degree ports, high degree ports possibly gained higher throughput showing a close relationship between degree and throughput. Furthermore, regional networks experienced different developments due to the dissimilarities of their geographical location, traffic situation, and roles of regional ports as well as their competitions. North Europe, West Coast and East Coast North America, the first markets of international container shipping, saw the stability of their networks with an insignificant increase of routes, visited ports and weekly calls. In contrast, strong expansion was observed in other ranges (Tran & Haasis, 2014).

The global maritime network is seen to be highly dynamic with continues changes in the dominance of regions and changing direction of traffic flows. The emergence of new trading routes and changes in service designs and structures of liner shipping companies could also be observed. These changes are highly influenced by the availability of cargo which is driven by trade demand. Liner shipping networks are therefore denser and concentrated with heavier trade links and high traffic flows in regions with higher commodity demand and consumption rates such as North America and Europe or in regions with high manufacturing rates such as the region of East Asia. The dominance of the East-West network over North-South and South-South networks is also noticed in the global maritime network.

2.1.2. Liner Service Network Designs

The process of designing the liner service network is quite complex and many factors have to be taken into consideration when doing this. Liner shipping companies should carry out an analysis of the targeted trade route before choosing the ports of call for the network (Ducruet and Notteboom 2012). The supply, demand and market profile of the trade routes should be analyzed. Taking into consideration factors such as vessel capacity deployment and utilization, vessel size distribution, the configuration of existing liner services, the existing market structure, the port call patterns of existing operators, the characteristics of the market to be served, the geographical cargo distribution, seasonality and cargo imbalances (Ducruet and Notteboom 2012). All of these factors amongst others determine the configuration and design of the liner shipping network. Furthermore, different regional and international policies, organizational and institutional developments such as the rise of liner service alliances and hinterland specific factors such as hinterland transport costs, quality of hinterland transport and cargo dispersion in the hinterland are all determinants for liner service network configurations (Wilmsmeier & Notteboom, 2009). The design and calling pattern of the liner service is greatly influenced by trade and port specific characteristics (Wilmsmeier & Notteboom 2009).

The increase in the division of labor and specialization in international trade has led to increased manufacturing in developing countries especially countries in Asia due to the availability of cheap labor and increased industrialization amongst other factors. The so-called Newly Industrialized Countries (NICs) are mostly situated in Asia increasing the region's trade potential. China especially has had huge impacts on international trade due to her growing economy and increased manufacturing activities. All these contribute to the changes in shipping networks due to increased cargo availability and a bigger market in these regions. Due to these changes, vessel size and capacity increased rapidly over the years in a bid by shipping lines to cover the overcapacity that existed in the market before the crisis of 2009 and to benefit from economies of scale. Larger ships provide a reduction in cost as they typically have lower costs per TEU-mile (Notteboom 2004). There has been a sporadic increase in vessel sizes with vessels being able to contain as much as 20,000TEUs today compared to just a few containers that were loaded on the very

first container vessels in the 1920s. Larger vessels have characteristics such as stowage efficiency, improvement in container handling performance, ability to benefit from scale economies and reduced cost per unit (Gilman, 1999). These changes have placed limitations on ports for accommodating large vessels and traffic (Ducruet & Notteboom, 2012). As a result, hub-and-spoke networks have become the most dominant type of network operated by shipping lines. As carriers seek to minimize costs incurred through multiple voyages, the use of hub and spoke in networks helps reduce the time taken for a round trip and also increases economies of scale (Imai et al, 2009). Cargo is transported in larger vessels over long distances and exchanged at major hub ports around the world for transshipment in smaller vessels. These kinds of networks are more popular on high-volume trade routes such as the Europe-Far East trade route (Notteboom 2004).

Jiang et al (2015) carry out a study on port connectivity in which they develop an analysis framework using two models to show the impact of transshipment services on the transportation network. The first model measures the average impact of transshipment services on the transportation time of a cargo shipment and the second measures the average impact of transshipment services on the transportation capacity of one origin-destination port pair. This analysis framework and models can be used to analyze the connectivity of ports around the world. In the study, an analysis was carried out on the connectivity of major ports in the Asia Pacific region and it was revealed that Singapore was the port with the highest level of connectivity with regards to both transportation time and capacity. It is a principal hub-port in South East Asia mainly due to its efficiency and fast turnaround time (Jiang et al, 2015).

2.1.3. Centrality in Networks

A port's hub port status is dependent on several factors amongst which are; its connectivity and cooperation with other ports (Jiang et al 2015, Low et al 2009), its physical and technical infrastructure, port management infrastructure, port costs, existing feeder network and geographical location (Lirn et al, 2004) and its centrality. The centrality of a port is an estimator of the ports relative geographical importance (Laxe et al 2012). It shows how well positioned a port is in terms of

accessibility and dominance. A port's centrality could be defined in terms of betweenness centrality - the number of connections of each port on the shortest possible path within the entire network, degree centrality - the total number of connections of each port from adjacent ports, and eccentricity - the number of connections of each port on the farthest possible path within the entire network (Ducruet 2013). These are usually higher at most diversified ports indicating that such ports are relatively in better positions in the network compared to other ports in terms of accessibility and dominance (Ducruet 2013). Therefore, ports with high centralities will probably also have high hub port statuses. Fleming & Hayuth (2004) point out that large transportation hubs possess to some degree the locational attribute of centrality.

2.1.4. Port Connectivity

Port connectivity and inter-port relationships play a significant role in the configuration of liner shipping networks. Port connectivity is the level to which one port connects to others in the maritime transportation network and its ability to be reached by regular liner shipping services (Jiang et al, 2015). In a study carried out by Lam & Yap (2011), using Annualized Slot Capacity (ASC) they examined the calling patterns of container shipping services in East Asia and established that in some cases, complementary relationships amongst ports could have more positive effects for the ports instead of competition. The study was carried out on four ports in East Asia and the findings showed that most of the shipping capacity employed on the major East-West trade routes involved calls at two or more of the four ports. Therefore carriers, port planners, and terminal operators could capitalize on complementary relationships that exist between the ports such as offering packages for shipping lines to call at a portfolio of terminals owned by the same terminal operator. In designing their networks, therefore liner shipping companies could take into consideration such complementary relationships between ports. In West Africa however, very minimal cooperation exists between the ports. Ports in this area, on the contrary, are mostly in competition especially to obtain the status of hub-port for the region (Van Dyck 2015).

The potential of a port to carry hub port status is further illustrated in a research by Low et al (2009) in which they propose a model for assessing the hub port status of container ports. The novel network-based hub port assessment (NHPA) model proposed in this study is customized to the international shipping industry. This model helps to identify important quality characteristics on which carriers base their port choices through the identification of important port attributes and also it offers explicit measurements of the degree of port competition and cooperation relationships. The model requires the use of two indices; the connectivity index and the cooperation index. These indices could be used to assess the stability of hub status from a network perspective. The connectivity index can be used to directly measure port connectivity which is based on the counts of origin-destination (O-D) pairs served by individual ports in a real carriers' network. The network cooperation index is used also to evaluate the performance of hubs and the evolution of hub status within carrier networks and it is computed by the ratio of the number of O-D pairs which any two ports serve together. Ports that display high connectivity indices are classified as global hub ports whose sustainability depend on their cooperation indices. Conversely, ports with low connectivity indices but with high cooperation indices are classified as regional hub ports with a potential to be developed into global hub ports. Furthermore, it is also identified that national trade volume amongst other factors has a significant effect on port connectivity. Ducruet (2013) also identified that, the more diversified a port is (that is, the higher its connectivity index), the higher is the traffic weight of the port and the more concentrated are the links between them - implying that such ports are better positioned to acquire hub port status compared to other ports.

Ports in the West-African region are not highly connected compared to other regions of the world. According to the UNCTAD liner shipping connectivity index, these ports have relatively lower connectivity indices with values between 7 and 30 according to the data for 2016 (UNCTADSTAT). On a global scale, therefore these ports are not generally preferred by shipping lines as major global hub ports. On a regional level, however there has been a drive by West African ports to achieve hub port status in order to facilitate transshipment of containers across the region (Van Dyck 2015). These ports have the potential of becoming regional hubs; however, this

depends on the capital investments and other related activities such as policy reforms that governments are able to put in place towards port development and regeneration (African Development Bank 2010). Several factors determine the ability of a port in this region to achieve hub-port status. According to a survey carried out by Van Dyck 2015 in his study, it was established that high port efficiency and performance, stable political environment, adequate port infrastructure and handling facilities are the most influential factors that affect the potential of a port in West Africa to achieve hub-port status. The ports that are the highest contenders for hub port status in the region are the ports of Abidjan, Tema, Lagos, and Dakar. This is mainly due to the fact that these ports play a regional role and have the highest flow of cargo in the region (Van Dyck 2015, African Development Bank 2010). On the Mediterranean-West African route, the ports of Algeciras (Spain), Tangier Med (Morocco) and Las Palmas (Canary Islands) are the major transshipment hubs for services to West Africa. For traffic coming from the East via the Cape route, the port of Durban (South Africa) is the major hub port for services going to West Africa.

Hub-and-spoke networks though the most prominent or dominant form of liner shipping networks is just one of several options available to liner shipping companies when designing their networks. Other options include interlining and relay networks, also line-bundling exist within individual liner services with forms such as round-the-world services and pendulum services which could be employed in network designs (Ducruet and Nottebom, 2012). In an end-to-end pattern, a vessel sails back and forth between two markets, in round-the-world patterns, the vessel sails in only one direction; either eastbound or westbound and in pendulum network designs, the ship moves among three markets with the middle market referred to as the fulcrum from which the ship swings from either side to carry cargo among the three markets (Trans and Haasis 2013). Figure 3 below shows the different types of service designs in a liner shipping network.

Debrie 2012 put forth a two-stage process of change in the liner services in West Africa leading to a new organization of the port network. The first was the spread of point-to-point services. This was mainly because of instability and structural imbalances in the region. Political an technical instability in the region meant that operators could not invest too heavily on a particular hub or on priority

routes. The structural imbalance of West African economies results in a difficulty in managing container flows which are full in case of imports but empty in case of exports. Therefore services were mainly point-to-point in nature as operators adopted specific practices for the situation. The second stage as identified by Debrie 2012 is a move towards hub-and-spoke networks as significant increases in traffic in the region led to a higher degree of port concentration and therefore the emergence of new services (Debrie 2012).

Figure 3: Liner Shipping Network Service types

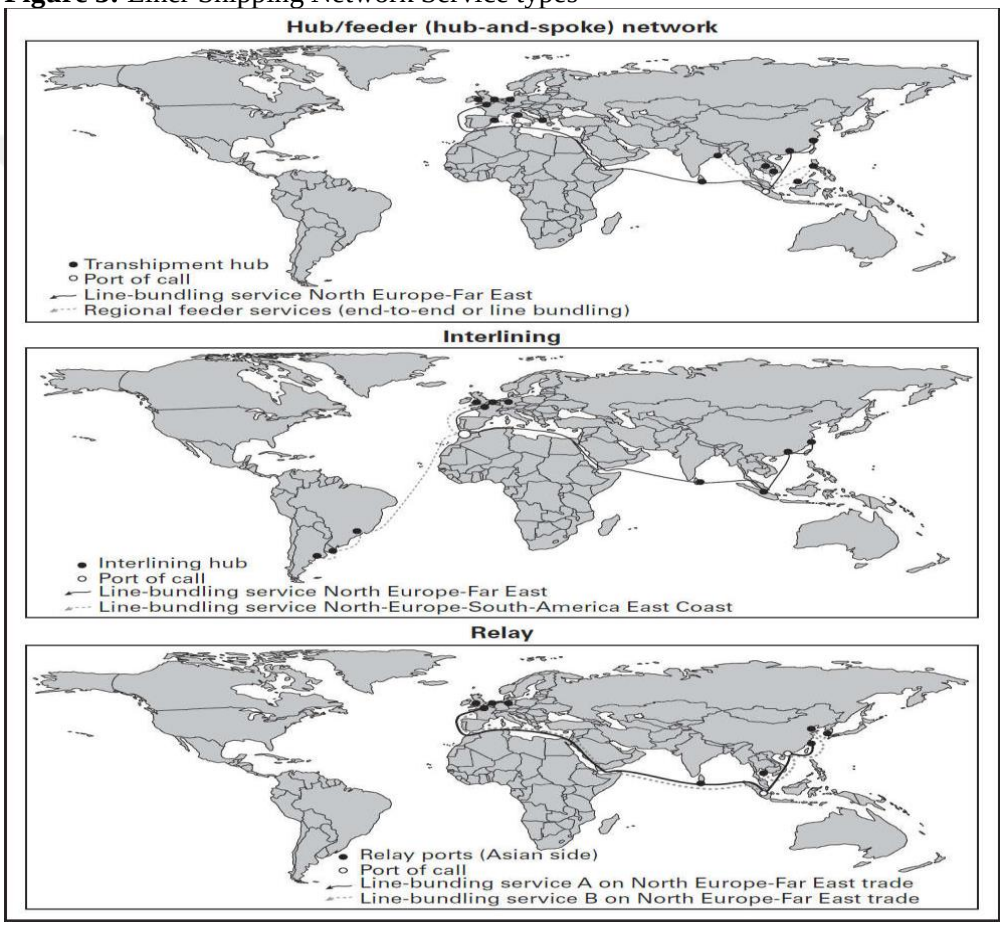
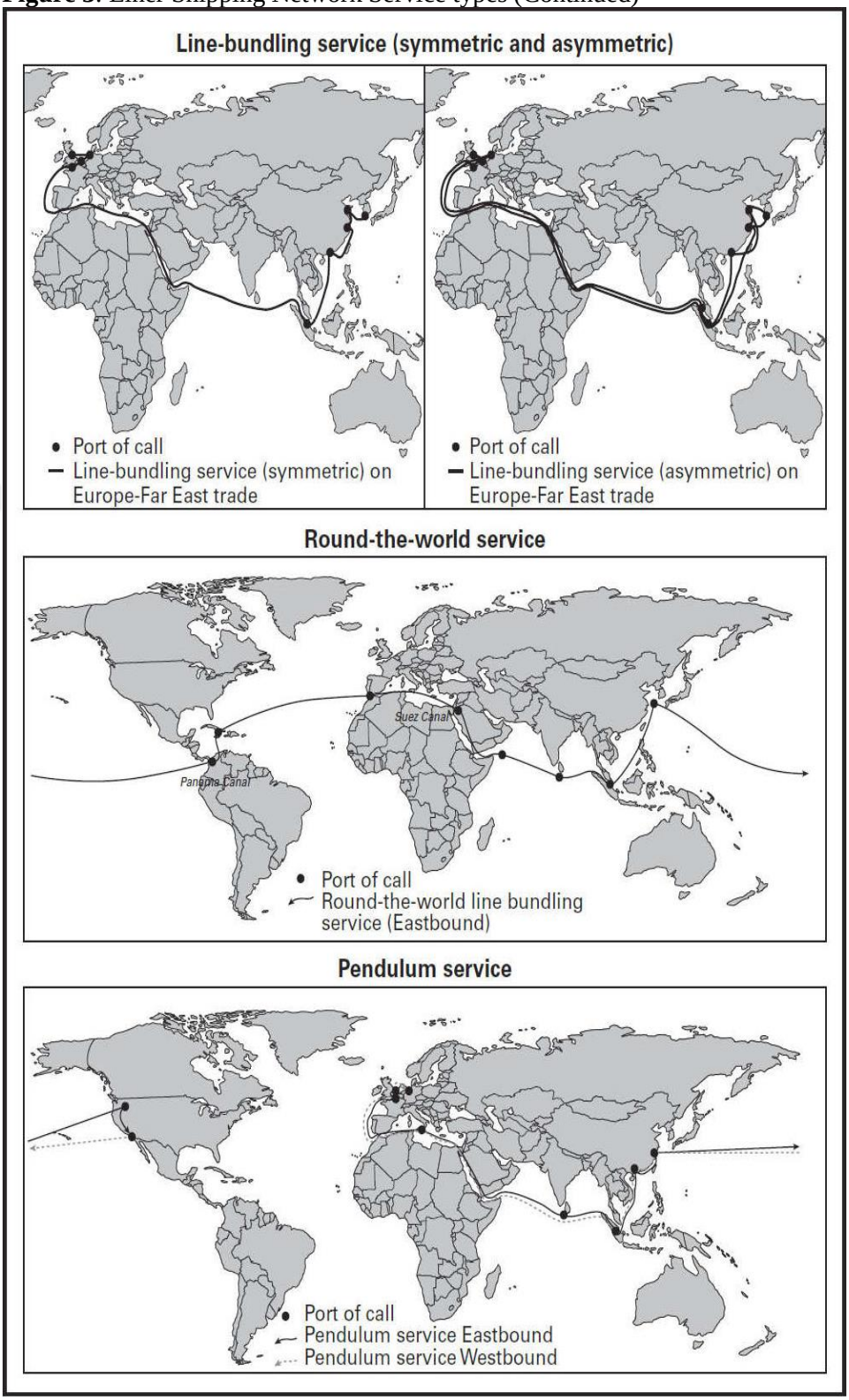


Figure 3: Liner Shipping Network Service types (Continued)



Source: Ducruet and Notteboom (2012)

2.1.5. Cooperation and Competition in Liner Shipping Networks

Due to fierce competition that exists in liner shipping, in recent years, most liner shipping companies especially the largest and leading carriers have sought cooperation with others and are in some sort of operating agreement with each other. Horizontal integration in liner shipping comes in three forms: trade agreements such as liner conferences (agreements in which shipping lines serving the same route fix and agree on schedules in order to rationalize the capacity and frequency of services offered to their customers as well as the tariffs that are publicly available (Munari 2012)), operating agreements (that is vessel sharing agreements, slot chartering agreements, consortia, and strategic alliances) and mergers and acquisitions (Notteboom 2004).

The most common form of cooperation in liner shipping is the so-called strategic alliances (Song & Panayides 2002) where members cooperate in the employment and utilization of vessels over particular routes, sailing schedules and itineraries, use of joint terminals and container co-ordination on a global scale (Panayides & Wiedmer, 2011). These strategic alliances extend their influence beyond vessel operations towards the shared use of terminals, joint equipment management, inland transport and logistics, joint purchasing and procurement (Midoro & Pitto 2000). These alliances give members increased market power and coverage, and also reduce risk levels and competition (Wilmsmeier & Notteboom, 2009, Panayides & Wiedmer, 2011). Liner shipping companies enter into such alliances with various objectives amongst which are; risks and investment sharing, cost-control, economies of scales, acquiring increased service frequencies, and achieving a wider geographical scope (Midoro & Pitto 2000). Song & Panayides (2002) classify these objectives into five main categories as such; Financial objectives (profit maximization, increase in shareholder wealth, capital investment sharing and financial risk reduction), Economic objectives (cost reduction, economies of scale), Strategic objectives (entry into new markets, wider geographical scope, increase in purchasing power), Marketing objectives (satisfy customer needs, flexibility and reliability, variety of routes and destination) and Operational objectives (increase in frequency of services, vessel planning and coordination on a global scale). The existence of these strategic alliances affects the

configuration of liner shipping networks on a global scale. Networks become more complex with existence of longer loops when shipping companies consolidate their services (Song & Panayides 2002), highly integrated and interdependent networks (Agarwal & Ergun 2010), more intensified and extensive services, the deployment of the largest vessels on alliance routes and the increase in the ports of call of individual liner services (Slack et al 2002). The current top three existing alliances include; the 2M alliance comprising MAERSK line and MSC line the two biggest container carriers in the world, Ocean Alliance comprising CMA CGM, COSCO Shipping, Evergreen line and OOCL, and The Alliance comprising Hapag Lloyd, Mitsui OSK Line, K-Line, NYK Line and Yang Ming Line. These together control more than 90% of container capacity on major routes (Wall Street Journal). These shipping lines are able to acquire a wider coverage of ports by putting together their resources. The 2M alliance, for example, covers 77 ports using 193 vessels with a total capacity of 2.4 million TEUs (Lloyd's List).

Bockrath 2016 examines the impact of liner shipping alliances on the global economy. Based on a theoretical liner shipping model, he shows that the effects of liner shipping alliances on the trading system are somewhat ambiguous as these alliances either encourage or inhibit trade. The results of the analysis show that, when entry costs to a market are low, liner shipping alliances inhibit trade conversely, when entry costs are high, such that firms do not operate on all routes, alliances can be trade enhancing. He further uses gravity models to examine the connection between liner shipping activity and trade flows. The results showed that alliances increase the volume of trade on a trade-level as there was a positive correlation between overall capacity and bilateral trade. However, on a route-level, it was revealed that alliances could have a negative effect on trade volume by abusing market power (Bockrath 2016).

Cooperation also exists between ports. Asgari *et al* introduce the idea of cooperation as a potential substitute for competition. They establish that cooperation could take place between/among ports, between ports and shipping companies or among all three (Asgari *et al*, 2012). Though ports conventionally compete against each other, working together could result in higher mutual benefits – a strategic option known as co-opetition (D.W Song, 2002). This trend is increasingly making

grounds in the maritime industry and ports, especially ports in the same geographical region such as ports in East Asia and ports in Europe are increasingly forming co-operative relationships amongst each other in order to gain more market power, utilize their combined know-how and share complementary resources (Notteboom 2009, Song and Panayides 2008). These relationships also exist amongst ports not located in the same geographical region. Ports cooperate across the globe in various ways such as information exchange, resource sharing and joint terminal infrastructural projects (McLaughlin & Fearon 2013). Low *et al* stipulated that ports with higher cooperation indices are more likely to stay connected, sustain traffic and have higher potentials of growth (Low *et al*, 2009). When designing liner shipping networks, this should be taken into consideration by liner shipping companies in order to choose appropriate hub and transshipment ports.

In the West African region however, minimal cooperation exist between ports and inter-port competition is at a very high level (Van Dyck 2015). Ports compete to achieve hub port status furthermore since they share common hinterlands, competition also exists for hinterland traffic. There has therefore been several development projects carried out by ports in the region in order to improve their position in the network. In Nigeria for example, the Lekki port project is currently being carried out and is slated to be finished in 2019. The project includes construction of all port infrastructures such as breakwaters, quays, approach channels, as well as captive utilities such as water and power. The project also includes the construction of 3 container berths that are expected to handle 2.5million TEUs when completed (African Development Bank). The Ghana Ports and Harbours Authority has also secured a 1.5billion project for the expansion of the port of Tema. The project which started in October 2016 is expected to be completed by 2019. It will triple the port of Tema's current traffic of about 1million TEUs, a dredged 19-metre deep port access channel, a new 1.4 - kilometer – long – quay for container berths, with a 16metre draft, and a 4 – kilometer – long – breakwater will enable the expanded Tema port to accommodate some of the world's largest container ships and improve cargo – handling services and capacity (AECOM). All these, are in a bid to increase the ports' competitiveness as leading maritime hubs in West Africa.

Cooperation in liner shipping will affect the overall configuration of the network and traffic flows and will therefore have an impact on the trade volume.

2.1.6. Nodes and Linkages in Liner Shipping Networks

Ports (also nodes, according to the graph theory) are an integral part of the liner shipping network. They greatly influence the configuration, design and establishment of the network (Lun et al 2009). Different port characteristics such as geographical position and features, port administration, infrastructure, port efficiency, port costs and port facilities have a significant influence on traffic flows and therefore on the entire liner shipping network. According to Wilmsmeier & Notteboom 2012, the calling patterns and service structures of shipping lines in a region will be determined based on trade and port specific characteristics.

In a study carried out by Dyck and Ismael (2015), an evaluation of the competitiveness of West African ports was carried out based on certain criteria including; cargo volume, location of the port, port efficiency and performance, port infrastructure, port costs and political stability. It was revealed according to the results of the research that port efficiency and performance were the most important criteria for evaluating port competitiveness and the port of Abidjan was revealed to be the most competitive port in West Africa as it had the best infrastructure, efficiency and performance. In another study, the port of Tema in Ghana was revealed to be the most efficient port in West Africa as it had one of the largest throughputs in West Africa (Van Dyck 2015). Port efficiency is essential for increasing the traffic of a port and therefore improving its position on the network - it greatly influences port throughput. If ports do not improve upon their efficiency, they will become increasingly marginalized and served by feeders (Harding et al 2007). Increased port efficiency leads to a reduction in transportation costs and a boost in international trade (UNCTAD 2016). Transportation costs have significant effects on trade. A reduction in costs of transport directly stimulates exports and imports whereas increased transport costs lead to a drop in trade (Sanchez et al 2003). A port's efficiency therefore plays a significant role in international trade as it is one of the important determinants of shipping costs (Clark et al 2004) and therefore volume of trade. It has been stipulated that ports play an important role in the facilitation of

trade mainly by showing that port efficiency has a significant effect on transportation costs which is a major determinant (or barrier) to trade (Veenstra 2012, Haralambides and Veenstra 1996).

The location of a port on the global liner shipping network is determined by the density of trade flows to and from the specific port (Wilmsmeier & Notteboom 2012). Higher density trade flows improve the position of the port on the network. This is mainly indicated by port throughput. Furthermore, throughput is often used to analyze the impact of a liner shipping network's operation on ports (Ducruet & Notteboom 2012). Table 1 shows the hierarchy of the selected ports in the West African region with regard to the number of containers (TEUs) or throughput handled by the ports for the period of 2008-2014.

Table 1: Container port Throughput per country (in 000 TEUs)

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nigeria	725	870	1232	1511	1723	1580	1700	1400	1437	1656
Ivory Coast	713	677	530	546	634	634	600	625	705	633
Ghana	612	557	643	813	881	900	890	900	900	921
Senegal	347	331	349	369	384	384	384	530	540	497
Benin	300	320	317	335	348	348	348	348	348	353

Source: UNCTAD Statistics

It can be seen from the table that throughput in the region has been increasing steadily over the years. Therefore improving the position of the ports on the network and also indicating an improvement in trade flows.

Haralambides & Veenstra 1995 stipulated that ports play a significant role in the facilitation of trade. This is mainly because of the role they play as a link in the transport chain for imports and exports and also other important linkages the port industry has with other industries in the global market. Ports therefore, are a

significant component of the liner shipping network and also have significant effects on trade.

2.1.7. Existing Liner Shipping Network Structure in West Africa

The area of interest in this study is the links between ports in the West African region and the Mediterranean region specifically ports along the coast of Turkey. The liner shipping network formed by these regions is the focus of this research. Though the West African region is not one of the most dominant regions in the global network, it has great potentials for growth and has shown significant and sustained growth in traffic and throughput over the years (Ducruet & Notteboom 2012, Mengqiao et al 2015). In the study of Mengqiao et al 2015 West Africa was revealed as one of the emerging regions in the global shipping network. Within the period of 2001 to 2012, a great improvement in its position on the network was noticed with a traffic growth rate of over 100% and an improvement in connectivity (Mengqiao et al 2015). This can also be seen from table 1 which shows the growing throughputs of the ports in the region over the years. Over a seven year period from 2008 to 2014, the total throughput of the selected ports increased by more than one million TEUs. This growth has led to significant changes and improvements in the network structure of the region.

Debrie 2012 stipulates that the West African port network has gone through changes and restructuring in services over the years described in a two-stage process which is leading to a new organization of ports within the network. These two stages include; a spread in point-to-point services and the beginning of port concentration and hub-and-spoke networks. The first stage is characterized by factors such as political and technical instability which makes it difficult and almost impossible for port concentration and transshipment services. As such, investors diversify their investments and keep their facilities very simple which has led to linear services (port to port) and a low level of port concentration. In the second stage however, there is a gradual increase in the degree of port concentration and a beginning of a partial hub-and-spoke system in the region. This is mainly due to the growing port concessions for terminals which result in competition between ports, huge increase in foreign direct investment in Africa, increase in Africa exports and an increase in

imports of manufactured goods. All these led to an increase in port traffic and therefore port concentration (Debrie 2012). Increased port traffic and concentration therefore gives rise to a need for ports to improve efficiency levels. High port efficiency has been ranked amongst the top factors that influence the choice of hub port for the region by major shipping lines (Van Dyck 2015). There has therefore been an interest in efficiency analysis by port operators and port users. Efficiency levels in West African ports have been noted to be relatively low, plus high levels of congestion (AFDB 2010). Van Dyck 2015 in his paper aims to measure and analyze the relative efficiency of West African ports using the DEA method. The findings show that, the port of Tema in Ghana was the most efficient West African port with the largest throughput, even though it is one of the smallest ports in terms of size in the region. The port of Cotounou in Benin on the other extreme was found to be the least efficient port in the region implying that the port is not functioning at its maximum capacity. The port of Abidjan in Ivory Coast and Lome in Togo exhibited relatively high efficiency levels while the port of Dakar in Senegal portrayed average performance in terms of efficiency. Even though the port of Lagos in Nigeria was the largest port amongst the ports analyzed, it didn't exhibit the highest level of efficiency. High efficiency levels are essential for ports in order to attract more traffic and also improve their performance and position in the entire network.

The most recent market study that has been carried out on the West African region was a detailed market research carried out on container terminals in the West African region by Maritime Logistics and Trade Consulting (MLTC/CATRAM) in 2013 which revealed much information in relation to the liner shipping network structure and configuration in West Africa. Regarding transshipment hubs in the region, the study indicates that, large transshipment hubs in the North of the region such as Algeciras, Tangier Med, Las Palmas and in the South of the region including large South African ports make it almost unnecessary for there to be any hub ports within the region itself unless they are both well located geographically (towards the center) and competitive in terms of costs. However the ports in this region really do not possess these characteristics in comparison to the other afore mentioned ports, therefore, most liners carry out transshipment activities at the ports mentioned above. Furthermore, there are few or no exchange systems in place in West African ports for

relay or interlining activities making transshipment in the region even more difficult. Transshipment to Europe and the Mediterranean region till today is therefore mostly carried out at ports such as Tangier Med and Algeciras in the North of Africa. The study also identified the various services present in the region including; local feeder/cabotage services (services departing from one port within the region to another), feeder services (departing from a transshipment port out of the region to a port within the region), and Direct line services from Europe, Mediterranean, Asia, North and South American regions. Furthermore, the study determined how container traffic evolves as a function of GDP and Population growth; they added GDP growth by country to container traffic growth by country and the results showed that, the growth rates for container traffic were consistent with the rates observed over same period implying that, as GDP increases, container traffic increases (MLTC/CATRAM 2013).

The liner shipping network in the West African region is mostly characterized by direct services to the region using the relay system or hub and spoke services with most hub ports being located out of the region itself.

2.1.8. Characteristics of Ports in the Region

In order to proceed with the research, first the ports and transportation network that will be involved in the analysis have to be determined. The area of focus in this research as already mentioned is the West African region. A selection of 5 major port pairs in the area of focus will be made based on the capacity and throughput of the ports and also based on the availability of data. The major ports in West Africa include; Dakar (Senegal), Abidjan (Ivory Coast), Tema (Ghana), Takoradi (Ghana), Lome (Togo), Cotonou (Benin), Tin Can (Lagos), and Apapa (Lagos). In order for a network analysis to be meaningful, there has to be connection to other ports. Therefore, port pairs are going to be formed with some major ports in the Mediterranean region, specifically in Turkey. Turkey has over 20 container ports. Some of the major container ports in Turkey include; Ambarli, Mersin, Haydarpasa, Izmir, Gemlik, Marport, Yilport, Evyap and Kumport amongst others. As previously mentioned, from the above ports, 5 major port pairs will be created for better analysis of the network.

The 5 major ports in Africa that will be analyzed include; Dakar, Abidjan, Tema, Cotonou and Lagos and port pairs will be made with the following ports in Turkey; the ports of Ambarli, Mersin, Izmir, Gemlik and Marport. These ports are chosen because they are some of the largest ports in the regions in terms of throughput and also the most frequently used by shipping lines. Table 2 shows the average transit times in days gotten from major shipping lines transporting cargo between the port pairs in the area of study. The figures were gotten by taking an average of the transit times of a total of 14 liner shipping companies operating in the region. Each origin-destination (o-d) pair is considered independently and the role of alliances is not considered. It is also assumed that cargoes are freely moving between all incoming and outgoing services at ports. This is however not always the case in the real world as some services are operated by different liners in the same alliance and sometimes cargo cannot be transferred to other services outside an alliance due to intra-alliance agreements. Another assumption is that there are no barriers to trade between the two regions (West Africa and Turkey) and that goods traded can be transported easily without any obstructions.

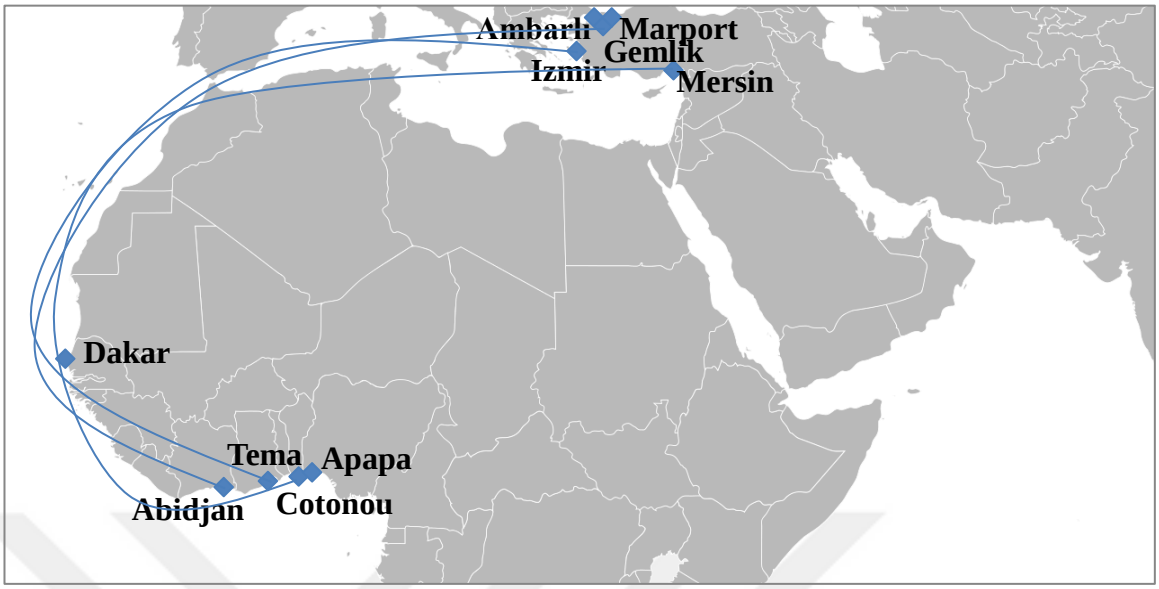
Table 2: Average Transit Time (in days) Between Port Pairs

North bound	Dakar	Abidjan	Tema	Cotonou	Apapa
Ambarli	25	24	25	26	29
Mersin	48	33	38	38	41
Izmir	53	43	44	47	46
Gemlik	41	37	39	33	44
Marport	40	36	35	38	34
South bound					
Ambarli	21	29	34	32	32
Mersin	25	36	38	45	34
Izmir	21	31	29	28	27
Gemlik	25	35	34	33	31
Marport	24	33	30	43	27

Source: Compiled from websites of major liner shipping companies in the region

These port pairs can be visualized in Figure 4 below.

Figure 4: West Africa – Turkey Port Pairs

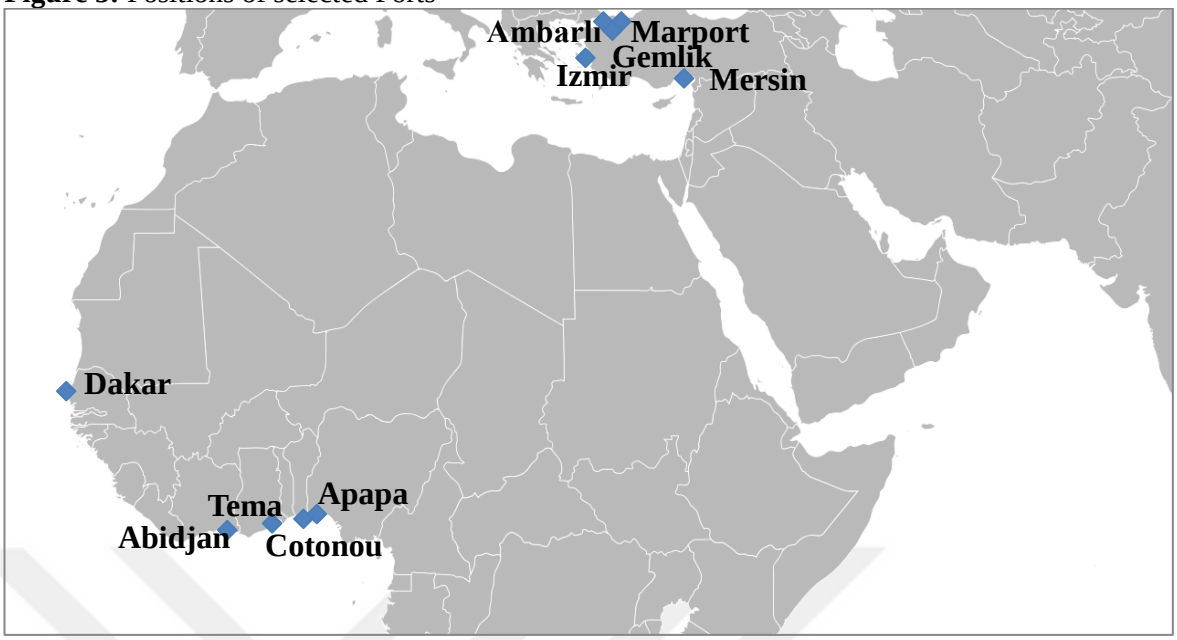


In the following sections, more details about the ports under study will be analyzed. The analysis will include information on the infrastructure and equipment, nautical conditions, container traffic and throughput amongst others. Most of the information gotten will be from the ports' websites and also a report on a market study carried out on West Africa by CATRAM (a maritime and logistics consultant) in 2013.

2.2. SELECTED WEST AFRICAN PORTS

As previously mentioned, 5 ports in the WAF region were selected for the purpose of this study. The criteria for the selection of these ports were port throughput, capacity and data availability. These are amongst the largest ports in the region with growing capacities and throughput levels. These ports will be analyzed in detail in the following sections. Figure 5 below shows the position of these ports on the World Map.

Figure 5: Positions of selected Ports



2.2.1. Port Of Dakar (Senegal)

Dakar is situated in the most western point of Africa. It is the capital of Senegal and one of the major seaports in West Africa. The port was created in 1857 by the French who colonized the city at the time. Since then, development on the port has been done in a progressive manner with the construction of beacons, roads and railways, piers, wharfs and other modernized port structures and equipment.

2.2.1.1. Infrastructure

The container terminal in the port was built from 1985 to 1987. At that time, it consisted of just 2 berths at 11.60m and 8 hectares of land exclusively for containers. It now covers 24 hectares of land and has a quay of about 700m with 3 berths between 12 to 13m. It also has 4 docks and modern handling equipment which include wheeled cranes, 10 gantry cranes, 15 reach stackers and 400 refrigerated outlets. More information about the port is found on table 3 below.

Table 3: Infrastructure - Port of Dakar

Terminal Features	**Port of Dakar**
Port Operator	DP World
Terminal size (Surface area)	28 + 7 hectares
Inland terminal	TOM, APMT, Necorans/Getma, CMA
Road access	Congestion at exit points of port Required modernization of roads
Rail access	Shareholding split between Senegal-Mali + Transrail manager
Quay length	700m
Draught	11.5m
STS	2 STS Panamax cranes + 2 post-Panamax cranes
Mobile cranes	4 Gottwald mobile cranes 100 tonnes
Reach stackers	15
RTG	10 (7 high)
Other	4 lifts for empty containers (7 high), 30 Mafi tractors 400 reefer plugs
Theoretical Capacity	600,000 to 800,000TEUs
Productivity	22 moves per/hr Service time of trucks < 30mins Berth time: average of 7hours

Source: Compiled from port's website

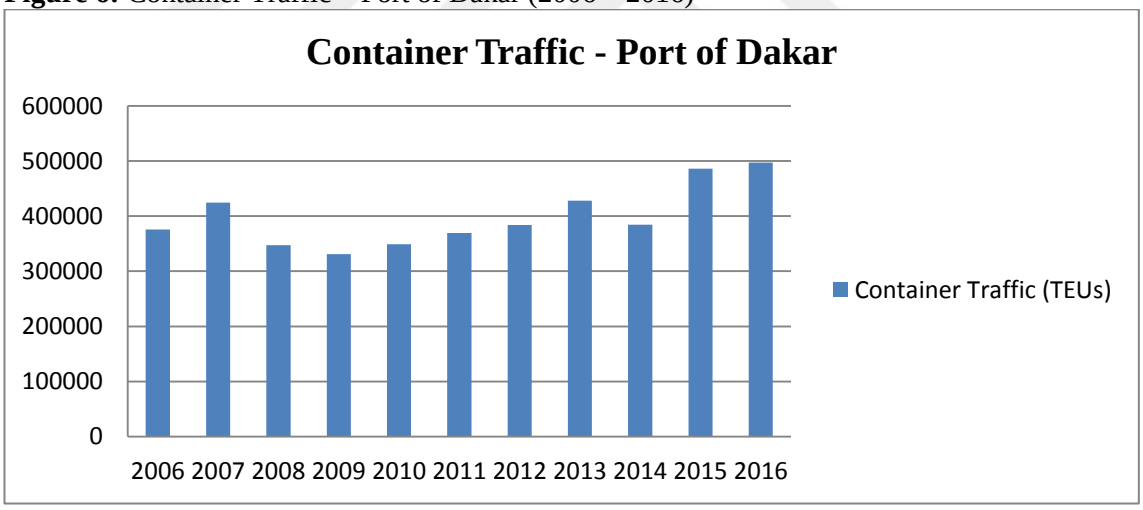
One of the largest terminal operators in the world – DP World – was awarded the concession for the port of Dakar in 2007 for a period of 25 years. The port has 4 inland terminals that are used for the processing of containers. The inland terminals have limited space and in combination with a lack of standard processing, the efficiency is relatively low. There is access to both road and rail. The road is congested at exit points of the terminal and the road infrastructure to Mali has worsened throughout the years due to an excessive use and over loading of trucks coupled with low maintainance. Rail access is present, however inefficient. The terminal has modern facilities and equipments due to heavy investment by DP

World. As a result, productivity is annually increasing. Docking times for a ship have reduced significantly over the years. Crane productivity is among the higest amongst other ports in West Africa with an average of 22 movements an hour.

2.2.1.2. Container Traffic

The annual container traffic at the port of Dakar currently stands at 300,000 TEUs per year approximately and it is constantly increasing (see Fig 6). Containerized traffic in the port declined significantly in the year 2008, most probably due to the global financial crisis. However, since the operation of the terminal was handed over to DP World in 2008, traffic has grown at an average of 6 percent per year. Traffic figures have risen steadily after 2008 to reach and even exceed pre-crisis levels. Transit traffic destined for landlocked countries especially Mali contributes significantly to this growth.

Figure 6: Container Traffic – Port of Dakar (2006 – 2016)



Source: World Bank data

The liner shipping companies that have the most share of the market in this port include; CMA CGM and Delmas, Maersk Line and Safmarine, MSC, Grimaldi and Messina.

Eventhough the efficiency of the port is relatively high, there are still major drawbacks that hinder its progress such as; high handling costs, low frequency and reliability and congestion. However, measures are being put in place to improve on

the port quality. A current project being carried out at the port by a partnership with DP World called the ‘port du futur’ project aims at attracting transhipment traffic from the lines between Asia/North – South America. It aims at enlarging the capacity of the terminal to 1.5 million TEUs.

2.2.2. Port of Abidjan (Ivory Coast)

Abidjan was one of the colonies of France in the time of the annexation. From 1934 to 1960, it was the capital of the Frenxch colony. The French built poor port facilities. In 1950, the Vridi Canal was constructed which connected the city to the open sea. After this development, the port of Abidjan soon became the most important place for maritime and financial business of West Africa. The most important productions for Abidjan are coffee, cocoa, food processions and numerous manufacturing goods such as automobiles and soap (World Port Source 2016). Table 4 below shows the major goods (general cargo), imported and exported through the port in tons.

Table 4: Major General Cargo Imports and Exorts (in tons) – Port of Abidjan

Commodity	**2011**	**2012**	**2013**
Clinker, gypsum and slags	1 265 660	1 801 769	2 014 338
Bulk and bagged rice .	1 215 282	1 773 040	1 311 756
Transhipment imports (Fishing products)	896 570	1 137 617	876 272
Transhipment exports (Fishing products)	857 440	877 309	743 461
Wheat	515 469	641 699	667 507
Fertilizer, raw materials and basics.	414 548	614 705	655 019
Sugar, glucose, salt and molasses	253 334	312 684	428 699
Cocoa beans and derivatives	824 144	739 845	765 774
Bananas and Pinaples	297 030	303 030	332 421
Wood	131 278	215 801	362 413
Ciment	11 946	53 857	358 375
Cotton fiber and seed	212 191	233 581	437 989
Raw rubber and latex	116 389	312 384	390 490
Cashew nuts	150 845	157 329	191 162
Packaging (palp, piece...)	122 172	153 021	159 461
Manganese ore	307 505	419 157	414 516
Coffee and grains	35 100	83 816	86 148
Milk produts, eggs	26 728	50 320	44 090

Source: Port's website

2.2.2.1. Infrastructure

The port is operated by SETV – a joint venture between Bollore (60%) and APMT (40%). The terminal extends over 34 hectares. SETV manages quayside container handling and then transfers responsibility to stevedoring companies. The road and rail access to the port isn't so adequate for the port as there is much congestion and difficulty to get to the terminals. The railway connects Abidjan to Burkina Faso, one of the landlocked countries served by Abidjan. A project extending the connection to Niger is envisaged. The container terminal consists of five berths. The draught is 11.5m with a maximum and the theoretical maximum capacity of the port is estimated at 1.3m TEU (with optimised facilities).

Table 5: Infrastructure - Port of Abidjan

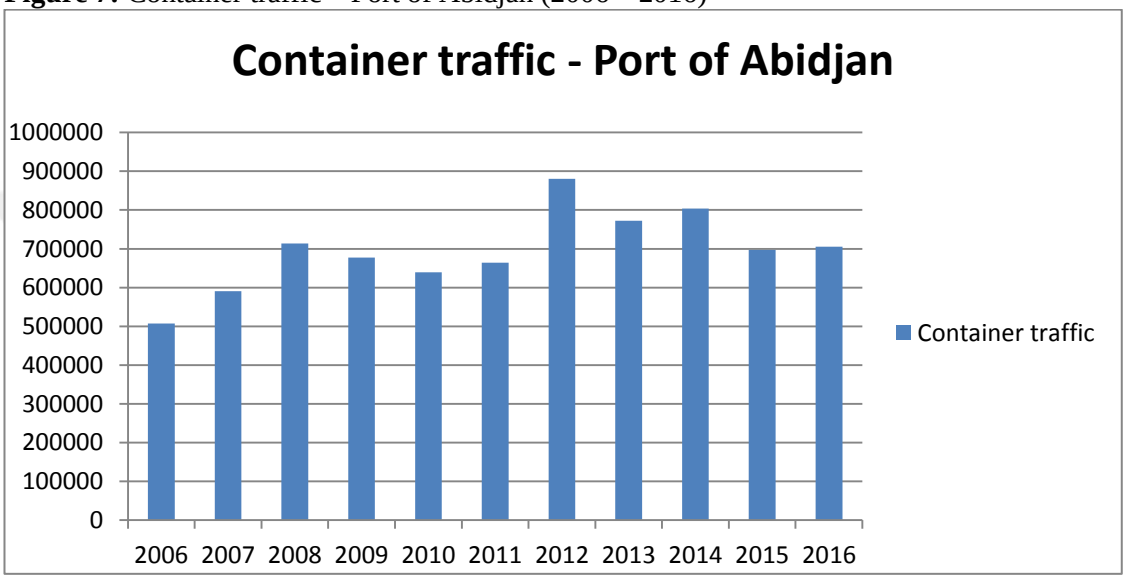
Terminal Features	**Port of Abidjan**
Port Operator	SETV (Bollore 60%, APMT 40%)
Terminal size (Surface area)	34 hectares
Road access	Congestion in port area
Rail access	SITARAIL (subsidiary of Bollorei-APM); 2 to 3 trains per week from Abidjan
Quay length	1000m (5 berths)
Draught	11.5m
STS	6 STS cranes (40 to 60 tons capacity)
Mobile cranes	3 Gottwald mobile cranes 100 tons
Reach stackers	19
RTG	16 with 40 tons capacity
Other	11 lift trucks 40 Mafi tractors 55 cornerless trailers 1 GPS oriented gantry crane
Theoretical Capacity	Up to 1.3m TEU (if equipment are optimised)
Productivity	17containers/hr

Source: compiled from website of port

2.2.2.2. Container traffic

Container traffic at the port was severely affected by the political crisis (civil war) in the country in 2011 which led to inactivity at the port for over three months. Traffic volume however started rising again in 2012 after the end of the civil war. Traffic has grown to reach over 700,000TEUs in 2016.

Figure 7: Container traffic – Port of Abidjan (2006 – 2016)



Source: World bank data

The companies with the higest share of the market at the port of Abidjan include CMA CGM and DELMAS with a share of about 33%. MAERSK Line and SAFMARINE own the second largest share of the market – 26 % (CATRAM 2013). Other shipping lines at the port with a significant share of the market include MSC, MOL and PIL.

The port of Abidjan is one of the most efficient ports in West Africa and also one of the largest providers of transit services in the area (Van Dyck 2015). Implying that the port has great potential to achieve hub port status. Projects are also put in place to improve on the port facility. The current project now aims at widening and deepening the Vridi canal in order to enable the port accomodate larger vessels. The construction of a second container terminal at the port is also beig envisaged for the nearest future.

2.2.3. Port of Tema (Ghana)

The port of Tema is the larger of two deep water ports found in Ghana. 85 percent of Ghana's trade is done through the port (GPHA 2016). Ghana was one of the first countries in West Africa to achieve its independence. The economy of the country has been improving remarkably over the years with a high GDP growth rate. The country experienced an economic boom in 2013 and is highly attractive to foreign investors mainly because of its democratic maturity and sound business climate.

2.2.3.1. Infrastructure

The Ghana Ports and Harbour Authority (GPHA) is responsible for developing, managing and operating the port of Tema facilities. The port is relatively very small and highly limited in space. It only covers about 10 hectares of land with a maximum draught of only about 11.5m. The port has 2 container berths measuring 575m in length which are managed under concession by Meridian Port Services (MPS). There's just one road connected to the port which is usually highly congested and no railway access. This highly hinders the connectivity of the port to the hinterlang. Table 6 below contains more information on the infrastructure of the port.

Table 6: Infrastructure - Port of Tema

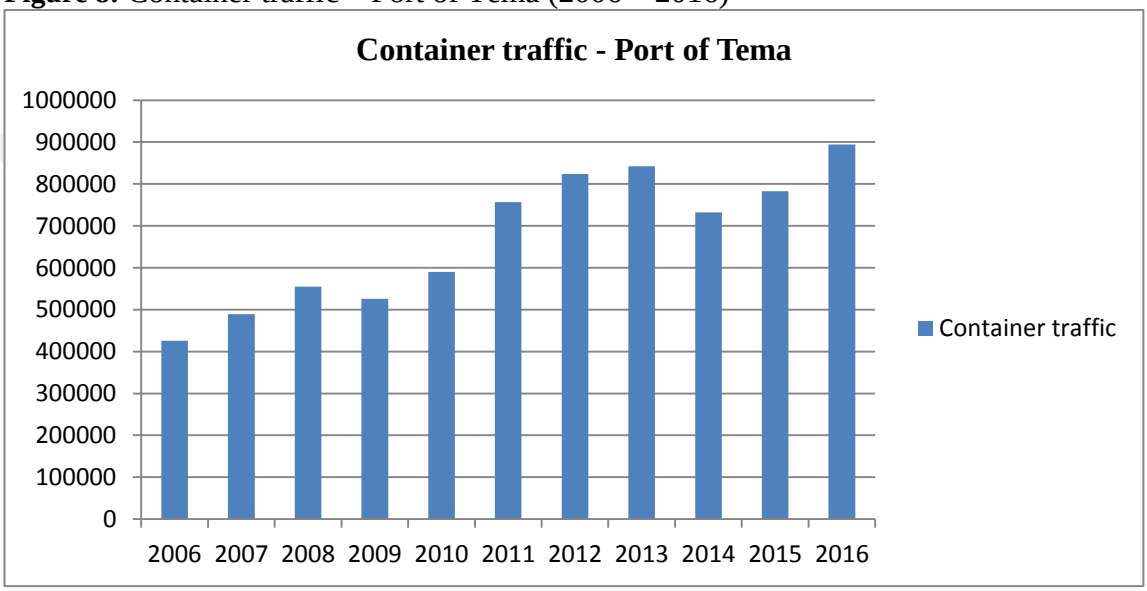
Terminal Features	**Port of Tema**
Port Operator	Meridian Port Services (Bollore 35%, APMT 35%, GPHA 30%)
Terminal size (Surface area)	10 hectars, approx
Road access	Only one road (high congestion)
Rail access	None
Quay length	575m (2 berths)
Draught	11.5m
STS	3
Mobile cranes	3
Reach stackers	>10
RTG	4
Other	
Theoretical Capacity	500,000 TEUs
Productivity	35 movements/hr

Source: GPHA 2016

2.2.3.2. Container Traffic

Container traffic in Ghana has been on a steady increase over the years experiencing a real boost in 2011 with an increase of over 30%. The traffic volume has been on a rise since then reaching over 890,000TEUs in 2016 – the highest in over ten years. Figure 8 below shows the container traffic growth rate for the port of Tema over a period of ten years from 2006 to 2016.

Figure 8: Container traffic – Port of Tema (2006 – 2016)



Source: World bank data

The most prominent shipping lines offering services to the port include; Grimaldi lines, PIL, MOL, Hapag Lloyd, UASC, MSC, CMA CGM/Delmas and Maersk/Safmarine. Projects and plans are also being put in place by the port authorities for expansion of the port. There is a plan to builf four more container terminals at the port in order to improve on transhipment services and expand the port's capacity.

2.2.4. Port of Apapa (Nigeria)

The port of Apapa is located in the Rivers Province of Nigeria. The port was established in 1913 and construction of the first four deep water berths commenced in 1921. It is the country's largest port, handling a wide range of commodities. It contains facilities specialized in handling a variety of commodities including

containers. Nigeria has the largest population in Africa. This provides a large market for the country and thus for the port.

2.2.4.1. Infrastructure

The Nigerian Ports Authority is responsible for the regulation of activities at the port. It has an important container terminal operated by APMT. The container terminal covers over 55 hectares of land for storage and can handle up to 850 thousand TEUs of containerized cargo (theoritically). It contains 4 berths alongside a depth on 10.5m with a total quay length of 1005m. It also contains 249 reefer plugs and has water, rail, and road acesss. See table 7 below.

Table 7: Infrastructure - Port of Apapa

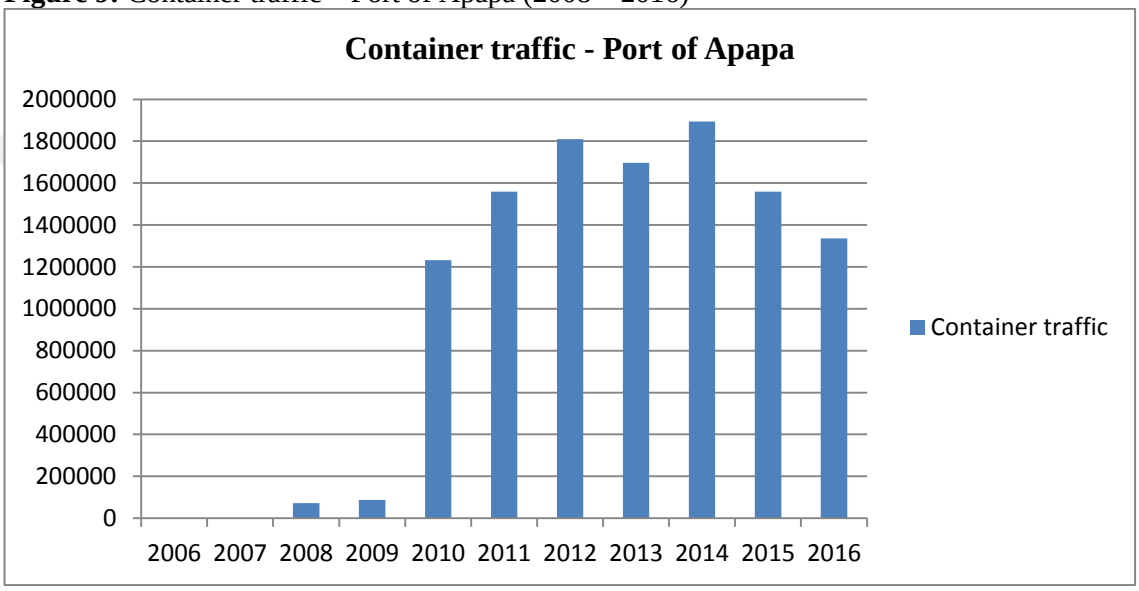
Terminal Features	**Port of Apapa**
Port Operator	APM Terminals
Storage area	55 hectares
Road access	Available
Rail access	Available
Quay length	1005m (4 berths)
Draught	10.5m
STS	1 STS crane
Mobile cranes	9
Reach stackers	31
RTG	12
Other	249 Reefer plugs 2 Warehouses
Theoretical Capacity	850,000 TEUs
Productivity	17containers/hr

Source: CATRAM 2013

2.2.4.2. Container traffic

Lagos has the largest contatiner traffic volume of all the other ports, due to the fact that Nigeria has the largest economy in West Africa. Furthermore, due to the large population of the country, majority of this traffic is meant for the huge domestic market. In 2009, there was a decline in traffic volumes due to the global financial crisis. Traffic started rising again in 2010 after the crisis (see figure 9).

Figure 9: Container traffic – Port of Apapa (2008 – 2016)



Source: World bank data

In May 2015, the construction of a new seaport in Lagos began. The new seaport at Lekki started operations in 2018 and is slated to be completed by 2020. By then, it should be the largest seaport in Nigeria with an initial depth of 14 meters with potential further dredging to 16.5 meters (Lekki Port, 2014). One of the main objectives of the project is to ease congestion in the port. The port will host a container terminal, a dry bulk container and a liquid bulk container, making it a multi-purpose port.

2.2.5. Port of Cotonou (Benin)

Cotonou is Benin's de facto capital, economic hub and biggest urban and trade center. The construction of the deep water facilities of the port of Cotonou was

completed in 1965. In 2007, the port was recognized as the third leading exporter in the region, largely due to growing re-exports to Nigeria. However, since Nigeria closed its borders to the country, this hasn't been the case.

2.2.5.1. Infrastructure

The port of Cotonou covers over 400 thousand square metres of land and its commercial quay contains 8 berths. The container berth is 220m long and it contains a container storage area of 20 hectares. The port is operated by Bollore which was given a 25 year concession starting in 2010. Table 8 below contains more detailed information on the infrastructure of the port of Cotonou

Table 8: Infrastructure - Port of Cotonou

Terminal Features	**Port of Cotonou**
Port Operator	Bollore
Storage area	20 hectares
Road access	Available
Rail access	None
Quay length	540m (3 berths)
Draught	13.5m – 15m
STS	4 STS crane
Mobile cranes	4
Reach stackers	15
RTG	10
Other	56 Reefer plugs
Theoretical Capacity	220,000 TEUs
Productivity	17containers/hr

Source: CATRAM 2013

The major commodities traded via the port include foodstuffs, consumer goods, textiles, cashew nuts, shea nuts and other agricultural products. The shipping lines with a major share of the market include CMA CGM and DELMAS, MAERSK Line, MSC, PIL and SCL.

Based on an analysis on the efficiency of ports in West Africa carried out by Van Dyck (2015) using the Data Envelopment Analysis (DEA), the efficiencies these ports were evaluated. According to the results gotten, the most efficient port was Tema eventhough it is the smallest port in terms of surface area with the port of Abidjan closely following after it as the second most efficient port. The Port of Cotonou was shown to be the least efficient port exhibiting a lot of wastage in production. The port of apapa (Lagos) achieved an average score in terms of efficiency eventhough it is the largest port in the bunch in terms of throughput and surface area. The port of Dakar also exhibited average efficiency ratings (Van Dyck 2015).

2.3. TRADE VOLUME

Maritime transportation has always been connected to trade; starting as far back as more than a thousand years ago during the period of the great explorations of the world (Veenstra 2012). As previously mentioned, liner shipping derives its demand from international trade. Goods are transported in containers to and from different regions of the world because of the existence of international trade. The liner shipping market is therefore greatly dependent on the volume of international trade. Several factors determine the volume of international trade such as transportation costs (Limao & Venables 2001, Radelet & Sachs 1998, Clarka et al 2004, Sanchez et al 2003), various national and international policies (Frink et al 2002, Clarka et al 2004), globalization (Lun et al 2010), economic factors (Warner et al 1983), political (Morrow et al 1998) and geographical factors just to name a few. This section aims at identifying various literatures in relation to liner shipping and trade volume and it also looks at the trade volume statistics of the region under study.

2.3.1. Global Trade and Liner Shipping

International trade has been on the rise in the last few decades; for many reasons but mainly due to globalization. With the increasing global nature of the world, trading between nations has become not only important, but necessary. Transportation therefore must play an important role when talking about international trade; because trading across borders will require some sort of

transportation measure to move traded commodities. Therefore, because goods are traded between nations across continents, liner shipping and international trade are two highly connected and interdependent phenomena. International trade is greatly influenced by global economic growth which in turn affects transport services and therefore global seaborne trade volumes (Yercan & Yildiz 2012). This section looks at various studies that have been carried out in relation to the global economy and global trade, together with the significance of Liner shipping on global trade and their interrelations.

The global financial crises of 2008 caused a major downward turn in the global trade cycle. From 2009, the world experienced one of the most serious recessions in several decades. Global GDP declined by 2.1 percent with an accompanying decline in total volume of global trade of approximately 13 percent (see tables 9 and 10 below). The trading patterns in both developed and developing countries were altered during these years of crisis. The output growth in sub-Saharan Africa (which includes West Africa) dropped by 2 percent in 2011 achieving the poorest growth rate in over 5 years. Furthermore, this has been accompanied by a decline in the volume of goods traded on a global scale. In 2009, the trade volume of goods imported and exported on a global scale dropped by over 13 percent. There's been a slow growth in trade volume after the crises. However, figures are still far below the pre-crisis levels. This has also been the case for the Sub-Saharan African region. Trade volume growth has also been very low in this region with growth in exports and imports dropping to as low as 0.6 and 1.6 percent respectively recorded for the region in 2015 – A fall of over 1.4 percent for exports and 7.6 percent for imports in just three years from the year 2012. These rapid declines in trade volume resulted from the contraction of import demand of some large economies such as Japan and China. In Africa, the falling trade volume was due to the decline in commodity prices and negative spill overs from countries in Asia. A country like Nigeria which is a major oil exporter has been severely affected and because of a decline in foreign demand, other African countries which depend on exporting other commodities have been severely affected. In most West African countries however, high output growth rates are expected due to increases in public investment, improving agricultural productivity and a dynamic private sector (UNCTAD 2016).

In 2010, there was a global recovery, with an expansion of 4.1 percent in GDP and a growth of 9.5 percent in total volume of trade based on World Trade Organization estimates. The annual increase in exports from developed economies was about 13 per cent in volume terms in 2010, while the annual increase in shipments from developing economies, Asian countries (14.7 per cent) and China (29.1 per cent) in particular, rose by 16 per cent as the world started to emerge from recession. This recovery played a crucial role in the expansion of the total volume of global trade and improvements in the global economy.

Table 9: Global Output Growth 2008-2016 (Annual percentage change)

Region/country	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016a*
World	**1,5**	**-2,1**	**4,1**	**2,8**	**2,2**	**2,2**	**2,5**	**2,5**	**2,3**
Developedcountries	**0,1**	**-3,6**	**2,6**	**1,5**	**1,1**	**1,1**	**1,7**	**2**	**1,6**
ofwhich:									
Japan	-1	-5,5	4,7	-0,5	1,7	1,4	0	0,5	0,7
UnitedStates	-0,3	-2,8	2,5	1,6	2,2	1,7	2,4	2,6	1,6
EuropeanUnion(EU-28)	0,4	-4,4	2,1	1,8	-0,4	0,3	1,4	2	1,8
ofwhich:									
Eurozone	0,5	-4,5	2,1	1,6	-0,9	-0,3	0,9	1,7	1,6
France	0,2	-2,9	2	2,1	0,2	0,7	0,2	1,2	1,5
Germany	1,1	-5,6	4,1	3,7	0,4	0,3	1,6	1,7	1,7
Italy	-1,1	-5,5	1,7	0,6	-2,8	-1,8	-0,3	0,8	0,8
UnitedKingdom	-0,5	-4,2	1,5	2	1,2	2,2	2,9	2,3	1,8
EUmemberStatesafter2004	3,6	-3,6	2	3,1	0,5	1,1	2,7	3,4	2,6
South-EastEuropeandCIS	**5,4**	**-6,6**	**4,7**	**4,6**	**3,3**	**2**	**0,9**	**-2,8**	**0**
South-EastEuropeb	5,8	-1,9	1,5	1,7	-0,6	2,4	0,3	2	2,8
CISincl.Georgia	5,3	-6,8	4,9	4,8	3,5	2	0,9	-3	-0,2
ofwhich:									
RussianFederation	5,2	-7,8	4,5	4,3	3,5	1,3	0,7	-3,7	-0,3

Table 9: Global Output Growth 2008-2016 (Annual percentage change) (Continued)

Developingcountries	**5,2**	**2,4**	**7,8**	**5,9**	**4,8**	**4,6**	**4,4**	**3,9**	**3,8**
Africa	5,5	3,2	5,2	1,1	5,6	2	3,7	2,9	2
NorthAfricaexcl.Sudan	6,3	2,8	4,1	-6,6	10,1	-3,7	1,5	2,9	1,7
Sub-SaharanAfrica,excl.SouthAfrica	6,1	5,8	6,7	4,7	4,6	5,2	5,8	3,5	2,8
SouthAfrica	3,2	-1,5	3	3,2	2,2	2,2	1,5	1,3	0,3
LatinAmericaandtheCaribbean	3,7	-2,1	5,9	4,5	3	2,7	1,1	0,2	-0,2
Caribbean	2,6	-0,9	3,1	2,2	2,1	2,9	2,8	3,6	2,5
CentralAmerica,excl.Mexico	3,8	-0,7	3,7	5,4	4,8	3,6	3,9	4,1	4
Mexico	1,4	-4,7	5,2	3,9	4	1,4	2,2	2,5	2,2
SouthAmerica	5	-1	6,6	4,8	2,6	3,3	0,3	-1,4	-1,8
ofwhich:									
Brazil	5,1	-0,1	7,5	3,9	1,9	3	0,1	-3,8	-3,2
Asia	5,7	3,8	8,8	7	5,2	5,5	5,5	5,1	5,1
EastAsia	6,9	5,9	9,7	7,8	6	6,3	6,2	5,4	5,5
ofwhich:									
China	9,6	9,2	10,6	9,5	7,7	7,7	7,3	6,9	6,7
South-EastAsia	4,2	1,6	8	4,8	5,8	4,9	4,4	4,4	4,3
SouthAsia	4,8	4,4	9,1	5,5	3,1	5	6,3	6,1	6,8
ofwhich:									
India	6,2	5	11	6,1	4,9	6,3	7	7,2	7,6
WestAsia	4	-2	6,2	7,7	4,1	3,4	3	2,9	2,1
Oceania	2	0,8	4,1	3,7	2,7	2,2	3,6	4,7	2,9

Source: UNCTAD 2013.

Table 10: Change in Volumes of Goods imported and exported for selected regions 2012 - 2015 (Annual percentage change)

	Volume of exports				*Volume of imports*			
Region/country	*2012*	*2013*	*2014*	*2015*	*2012*	*2013*	*2014*	*2015*
World	**3,2**	**3,3**	**2,3**	**1,4**	**3**	**2,7**	**2,4**	**1,6**
Developed countries	**1,6**	**2,2**	**1,9**	**2,2**	**1**	**0**	**2,8**	**3,3**
ofwhich:								
Japan	-4,8	-1,5	0,6	-1	2,4	0,3	0,6	-2,8
UnitedStates	3,6	2,8	4,4	-0,2	2,1	1	4,3	4,8
EuropeanUnion	-0,1	1,8	1,7	3,2	-2,3	-0,9	3,3	3,6
Transitioneconomies	**0,9**	**2,3**	**0,5**	**0,9**	**6,4**	**-0,5**	**-7,6**	**-19,4**
Developingcountries	**5,2**	**4,6**	**3,1**	**0,4**	**5,6**	**6,3**	**2,5**	**0,4**
Africa	19,5	-0,7	0	2,1	17,8	6,5	5,7	1,5
Sub-SaharanAfrica	2	2,7	1,5	0,6	9,2	8,4	4,6	1,6
LatinAmericaandtheCaribbean	4,1	1,9	3,3	2,9	2,4	3,6	0,2	-1,8
EastAsia	5	6,7	4,9	-0,5	3,2	8,9	2,8	-1,6
ofwhich:								
China	6,2	7,7	6,8	-0,9	3,6	9,9	3,9	-2,2
South-EastAsia	1,8	4,7	3,5	-0,3	5,4	4,3	1,7	2,8
SouthAsia	-6,1	4,1	5,2	-0,2	4,1	-0,4	4,6	7,2
ofwhich:								
India	-1,8	8,5	3,5	-2,1	5,7	-0,3	3,2	10,1
WestAsia	6,8	3,8	-2,3	2	11,4	7,4	1,8	2

Source: UNCTAD 2016

However, the global recovery was slower than previous post-recession recoveries, and it was particularly challenged by the uncertainties, fragile economic conditions and political problems and transformations taking place in several Middle Eastern countries at the beginning of 2011. As a result, the annual increase in exports from developed economies dropped to 0.4 per cent in volume terms in 2012, while that from developing economies was up to 3.6 per cent (UNCTAD, 2013). In Africa however, there was a significant increase in both imports and exports of 5.2 percent and 14 percent respectively in the 2012. This is because the global recession led to the search for new markets and because of the great potential for growth and under-capacity in Africa, this led to the opening of new markets in the region.

As already mentioned, trade and transport are two highly interconnected sectors in the global economy. Therefore, a positive or negative change in trade will affect transport services in the same direction. Maritime transport services - and specifically liner shipping services in this case - are directly driven by global economic growth and the need to carry goods internationally (Yercan & Yildiz 2012) so, they are therefore affected by developments in the global economy. Therefore, the contraction in global GDP and international trade volume in 2009 negatively affected maritime trade and therefore the liner shipping sector. The total volume of international seaborne trade experienced a great decline in 2009 with a reduction of about 400 million tons of goods loaded making a 4.5 percent decrease in total volume of international seaborne trade (see table 11 below). There's been a steady recovery however after the recession in 2009 with international seaborne trade volume reaching approximately 10 billion tons in 2015.

Table 11: Developments in International Seaborne Trade (Millions of tons loaded)

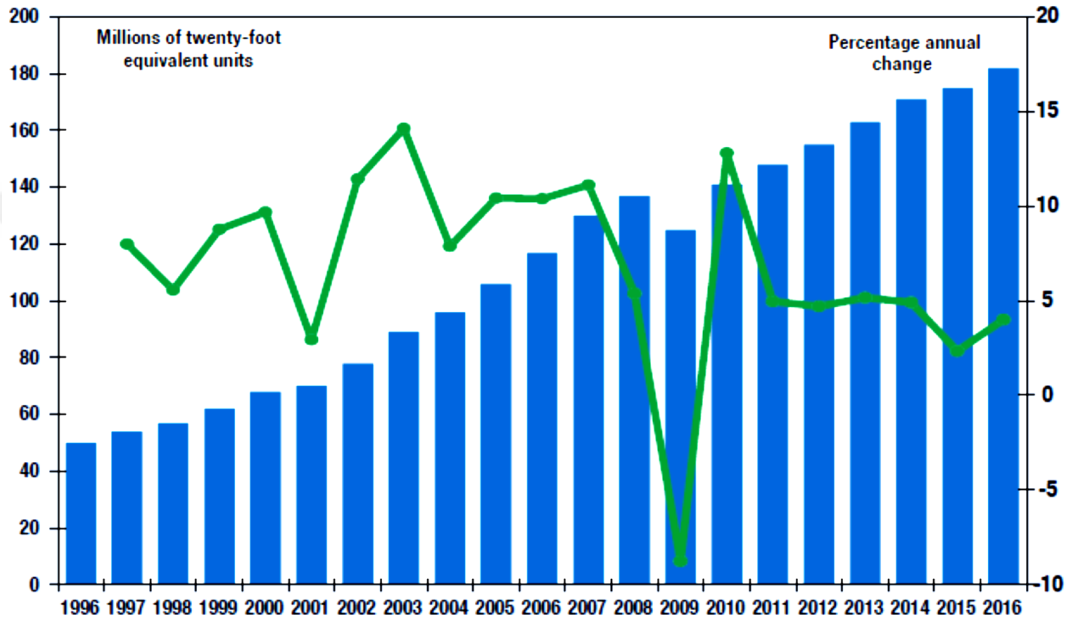
Year	Oil and Gas	Main bulks	Dry cargo other than main bulk commodities	Total (All cargo)
1970	1 440	448	717	2 605
1980	1 871	608	1 225	3 704
1990	1 755	988	1 265	4 008
2000	2 163	1 295	2 526	5 984
2005	2 422	1 709	2 978	7 109
2006	2 698	1 814	3 188	7 700
2007	2 747	1 953	3 334	8 034
2008	2 742	2 065	3 422	8 229
2009	2 642	2 085	3 131	7 858
2010	2 772	2 335	3 302	8 409
2011	2 794	2 486	3 505	8 785
2012	2 841	2 742	3 614	9 197
2013	2 829	2 923	3 762	9 514
2014	2 825	2 985	4 033	9 843
2015	2 947	2 951	4 150	10 047

Source: UNCTAD, 2016

Again, in 2009 there was an 8.5 percent decrease in the volume of dry cargo transported which is mainly made of containerized cargo. The number of tons loaded globally decreased by over 2.9 billion tons reaching an all-time low. It has also been stipulated that the year 2009 was the most challenging year for the container industry since its conception (Yercan & Yildiz 2013). This was mainly due to the global financial crisis and recession in 2009 which caused a contraction in the demand for consumer and manufactured goods and durables. After 2009, there's been a gradual recovery and increase in number of tons loaded has been recorded. However, in 2015 there was a slowdown in containerized trade across all the main trading lanes with volumes increasing by only 2.4 percent to reach 175 million TEUs (see Figure 10). The main reasons for the slowdown in containerized trade include; the decrease in

volumes on the main Eastern Asia-Europe trade route, the limited growth of the North-South trade due to the impact of low commodity prices on the terms of trade and the purchasing power of exporting countries and pressure on intra-Asian trade resulting from the economic slowdown in China. (UNCTAD, 2016).

Figure 10: Global Containerized Trade, 1996-2016 (Millions of Twenty-Foot Equivalent Units and Percentage Annual Change)



Source: UNCTAD, 2016

The above mentioned changes in global trade and global seaborne trade also had an impact on the configuration of global liner shipping networks. Due to decreased freight rates caused by the economic crisis and contraction in consumer demand, shipping lines started exploring other routes in order to find more cargo and stay in business. However, many liner companies have been facing massive loses and some such as the South Korean liner company –Hanjin have even gone bankrupt and have been pushed out of the market. Containerized trade is still struggling to get back on its feet in an ever volatile market.

2.3.2. Trade Liberalization and Liner Shipping

Trade liberalization is one of the main aims of international bodies such as the World Trade Organization. This is because, in order for trading across borders to be made easy, there has to be trade liberalization - especially in an increasingly global world where countries are becoming more and more interwoven and interdependent.

Veenstra (2013) in his study takes a look at the relationship between ocean shipping and trade by examining the extent to which shipping is a facilitator of trade. He concludes that, shipping and ports do facilitate trade however, researchers are increasingly recognizing that, transport and trade costs are important in explaining trade patterns and factors that affect trade costs negatively could be considered as barriers to trade. Some of these factors include; time delays, poor logistics services and other complexities of container shipping such as movement of containers between shipping lines/owners and shippers, customs procedures for containers and the ambiguous pricing structure of container shipping. All these act as barriers to trade. Many initiatives have been taken by various international bodies to try and ease trading between nations by reducing barriers to trade. Due to these, trade tariffs have generally decreased worldwide (World Trade Report 2013). However, restrictions to international trade in the form of non-tariff barriers still exist. A few efforts have been made to measure trade and business barriers on a global scale. These include; the Logistics Performance Index by the World Bank, the Global Doing Business Report (GDB) by the World Bank and international Finance Corporation and the Enabling Trade Report by the World Economic Forum (Veenstra 2013).

Lee et al (2011) in their research try to quantify the impact of trade liberalization on seaborne trade volumes and their findings revealed that, trade liberalization caused and increase in commodity trade which led to increased containerized cargo volumes and consequently increased the derived demand of shipping services. Markusen & Wigle (1990) in their research also show that trade liberalization leads to an increase in trade volume. The paper specifically examined the volume of North-South trade relative to North-North trade (trade amongst industrialized countries). When the resources/size of the South were magnified plus

free global trade assumed, a tremendous increase in North-South trade volumes and South-South trade volumes relative to North-North trade volumes was recorded. This was explained by the fact that protection in the North tends to be higher on primary products (imports from the South) than on manufactures. Conversely, in the South protection tended to be higher on manufactures. Therefore confirming the hypotheses that high volume of North-North trade relative to South-South trade was caused by high Northern protection against Southern exports, higher protection levels in the South and low GNP in the South relative to the North. This affects the way liner shipping networks will be designed because liner shipping companies will typically design their networks based on the availability of Cargo.

In conclusion, most of the current literature on liner shipping networks examine various parameters and factors that influence the configuration and set-up of the network such as the effects of cooperation, port connectivity and inter-port relationships on the network, the economic, financial and technological evolutions and their effects on liner shipping networks amongst other factors. Furthermore, most researches carried out on specific regions include studies on regions such as East Asia, North America, Europe and South East Asia. Very few studies are carried out on the West African region. However this region has great potentials for growth and for making a strong mark on global trade (Notteboom 2012). It is one of the emerging regions on the global shipping network with a high growth rate in terms of traffic volume and improving connectivity (Mengqiao et al 2015).

This research paper therefore by examining the calling patterns of shipping lines and by sampling the views and opinions of various experienced players in this market, aims at analyzing the dynamics of liner shipping networks and trade volume. Empirical evidence will be drawn from four major ports in the West African region namely; Dakar (Senegal), Tema (Ghana), Apapa (Nigeria) and Douala (Cameroon). The analysis will identify the shipping capacity, trade routes and geographical regions connected to the ports, shipping lines involved and the inter-port relationships between the ports. The study is based on the graph theory.

2.4. TRADE VOLUME BETWEEN WEST AFRICA AND TURKEY

A liner shipping network network as previously mentioned is a structure representing the connection between ports by different routes it therefore represents at least two parties. Trading is also done between at least two parties. Therefore, for the relationship between liner shipping network and trade volume to be properly analyzed, the analysis has to be done based on at least two regions. In this paper, it will be done between the selected ports in West Africa and Turkey. This section aims to examine the trade volume statistics between West Africa and Turkey.

Trade volumes between West Africa and Turkey have been on a steady increase over the years. In 2008 the total amount of imports to Turkey from Ghana, Senegal, Nigeria, Benin and Code D'Ivoire totaled 238.7million dollars. By 2016, this figure increased to 595.1million dollars. (see table 12 below). Also, in 2008, the total amount of exports from Turkey to these five West African countries totaled 542.4million dollars. By 2016, the total amount of exports was 888.3million dollars more than a sixty percent increase. The table below shows the trade figures between Turkey and the selected countries for the period between 2008 and 2016.

Table 12: Trade Volume Between Turkey and Selected West African Countries for the years 2008 to 2016 (Figures in millions of dollars)

Turkey	**Imports**									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Ghana	46,6	100	190	292	296	210	155	165	**180**	**1634,6**
Senegal	1,99	1,71	0	14,4	5,44	5,39	4,72	5,29	**6,14**	**45,08**
Nigeria	81,1	312	276	631	498	492	2110	180	158	**4738,1**
Benin	0	0	0	0	0	0	39	0	0	**39**
Code D'Ivoire	109	92,4	99,4	130	129	129	226	266	251	**1431,8**
Total	**238**	**506**	**565**	**1067**	**928**	**836**	**2534**	**616**	**595,14**	7888,6
	Exports									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Ghana	107	72	**107**	227	236	179	176	219	298	**1621**
Senegal	108	101	91,4	220	175	119	277	158	154	**1403,4**
Nigeria	257	371	307	951	481	511	552	314	242	**3986**
Benin	23,1	26,3	96,3	86,5	76,8	117	94,9	76	84,3	**681,2**
Code D'Ivoire	47,3	44	53,4	68,1	78,7	80,4	95,8	120	110	**697,7**
Total	**542**	**614**	**655**	**1552**	**1047**	**1006**	**1195**	**887**	**888,3**	8389,3

Source: Compiled from the Observatory of Economic Complexity (OEC)

The goods that are exported from these West African countries to Turkey mostly include raw materials suc as raw cotton, raw alluminium, cocoa beans, frozen fish, gold, raw lead and wheat amongst others. The Imports from Turkey mostly include products such as pasta, flours, electrical equipment, iron structures, cereals, paper products and cement amongst others.

CHAPTER THREE
A CASE STUDY OF WEST AFRICAN AND TURKISH PORTS

In the preceding chapters above, a great portion of the factors, variables, and topics that were up for researching in this study have been analyzed. Also, some data that will be useful in presenting the conclusions of this study have been presented in previous chapters along with an analysis of previous work that has been carried out in this line of research.

Various literature was examined and some conclusions were made by scholars at the end of their studies such as the emergence of new hub ports, coming together of ports, development of new networks and increased connectivity for certain ports which came about as a result of the financial crisis, the conclusion that distance plays a major role in the network structure and the increasing possibility of certain WAF ports in achieving hub status amongst others.

Furthermore, the five WAF ports that were selected for the purpose of this study were examined; their infrastructural features, throughput and other important characteristics. The trade volume between WAF and Turkey was also analysed and it could be seen from the figures that, trade between these two regions have increased drastically over the years with an increase in Turkish exports to the region of over 150% and imports from the region of about 64% between the years 2008 and 2016 (see table 12 above). In this chapter, the findings and conclusions of this research will be presented.

3.1. RESEARCH OBJECTIVES AND QUESTIONS OF THE CASE STUDY

As the world increasingly embraces globalization and the benefits of trading beyond national borders, liner shipping and international trade have become inevitable phenomena. This research study seeks to understand the dynamics between liner shipping networks and trade volume. In order to facilitate and organize the research work, certain research objectives and research questions were identified at the start of the research.

The main research question of this study is to get a response as to what factors influence the relationship between liner shipping networks and trade volume in the West African region. Liner shipping network and trade are two highly

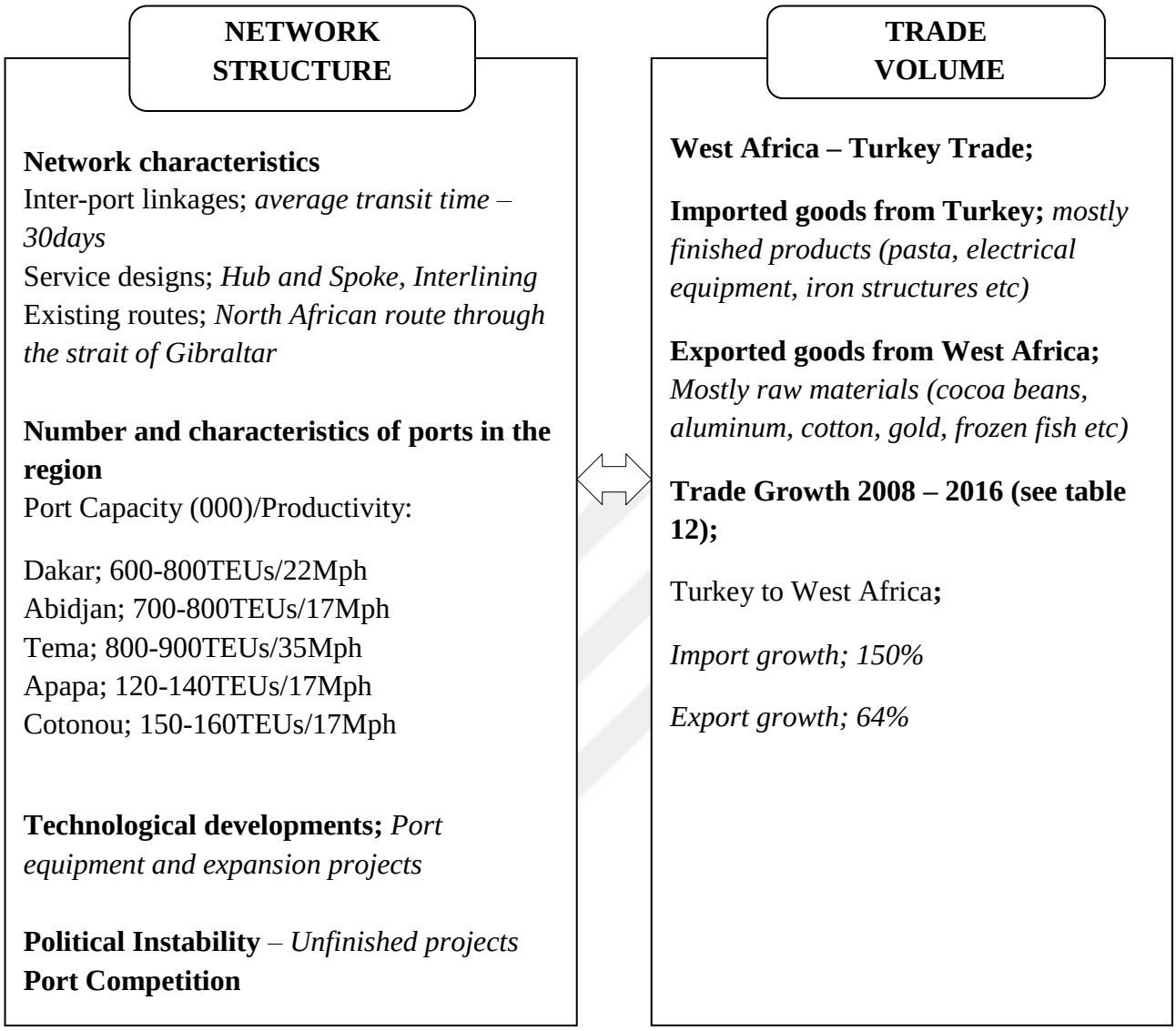
interconnected and interdependent terms therefore, this research seeks to examine the different variables, situations, conditions, states and whatever other factors that may influence the relationship between these two terms.

In order to answer this research question, the objectives of this study included analyzing the port infrastructural facilities of selected ports in the region, evaluating the port connectivity and inter-port relationships between the ports, examining the calling patterns of shipping lines in the region, analyzing the linkages between the selected ports, evaluating the impact of the network structure on trade volume, examining the impact of trade volume on liner shipping networks and to provide recommendations for the improvement of trade in West Africa.

Furthermore, a research model was also created in order to provide a framework by which the research was to be carried out therefore facilitating the research process, outline and presentation. The model was divided into two main sections – Network Structure and Trade Volume (as shown in figure 11 below). Each section was further divided into subsections under which various variables and factors were examined and analyzed in accordance with the objectives of the study. Under the Network Structure, the network characteristics such as - service designs, inter-port linkages, routes, shipping lines and calling patterns – characteristics of ports in the region – infrastructure, geographical and environmental characteristics, and other factors were examined. Under the Trade Volume section, the nature and characteristics of cargo transported, trade volume between the regions, source of trade and other factors were examined. These factors under the different sections were then examined in relation and comparison with each other in order to understand how they are influenced by each other and also to understand the various dynamics between them.

Following the analysis that have been carried out in the previous chapters on some elements of the network structure such as the different port infrastructures and on trade volume, the research model can be updated as follows;

Figure 11: Conceptual Research Model – Updated Based on Literature Review



The average transit time for the transportation of cargo from the West African region to Turkey is about 30days taking the North African route through the straits of Gibraltar. The most widely used service design used by liners in this region are the Hub and spoke and interlining network designs with transshipment hubs mostly in the North of Africa. The capacity and productivity of the ports are about 500,000TEUs and about 24mph on the average. These have been growing over the years as the ports are constantly carrying out projects to improve on productivity and capacity. However these figures are still very low when compared with some of the largest ports in the world such as the port of Hamburg in Germany with about

55.5mph and a productivity of 950,000TEUs. This shows that ports in this area still have to put in more work in order to meet up with international standards. Furthermore, other factors affecting the network structure include political instability in the regions which leads to negative conditions such as congestion and unfinished projects.

The goods traded between Turkey and the countries in West Africa mostly include raw materials such as cocoa beans, aluminum, seeds, cotton imported by Turkey and finished products such as electrical equipment, iron structures and food products amongst others. Between the years 2008 and 2016, there has been a tremendous growth in trade between these regions with an import growth rate of 150% and export growth rate of about 64%.

3.2. SELECTION OF THE METHOD OF ANALYSIS

The method of analysis used in this research is the case study methodology. While this approach is a highly controversial approach for data collection in research studies and has been criticized by many, past literature shows the application of this method in many areas of discipline and has also been praised by many as a great tool for understanding complex issues and for providing holistic and in-depth explanations of problems in question that sometimes quantitative methods are not able or are limited to provide (Tellis 1997, Yin 1984, Noor 2008, Baxter and Jack 2008).

The case study method according to Zainal (2007) enables the researcher to closely examine data within a specific context. In defining this method, he explains that in most cases a small geographical area or a very limited number of individuals are selected as subjects of the study. Yin (1989) more specifically defines the case study as an empirical inquiry that investigates a contemporary phenomenon within its real life context using multiple sources of evidence. A case study method in other words examines in detail a very small geographical area or number of subjects of interest unlike a quantitative analysis which observes patterns in data on a wider scale on the basis of the frequency of occurrence of the phenomena being observed.

There have been some criticisms or disadvantages and appraisals or advantages of the case study method that have been outlined by some studies. Some

of the advantages that have put forward for this method such as the following; the qualitative accounts produced in cased studies helps to explore or describe the data in a real life environment and also helps to explain the complexities of real life situations which may not be captured through other approaches (Zainal 2008), Case study methodology helps in expanding and generalizing theories by combining theoretical knowledge in existence with new empirical or factual insights (Yin 1989), cases studies can be used for theory building as they do not always have to rely on prior literature or empirical evidence, case studies can also be used to investigate volatile, fast changing and complex areas or processes (Vissak 2010), cases study data can also be collected from multiple levels and from different perspectives and sources. While the previously mentioned are some advantages that have been put forward in favor of the case study method, some disadvantages have also be raised in relation to this method; some of which include the fact that generalizations shouldn't be made based from the analysis of just a single case (Tellis 1997, Yin 1989). Also some have said that, in case study analysis, some descriptions may be too long as there is a lot of data that is collected with this kind of approach. Despite these disadvantages, it can be concluded that the advantages override them and that the case study method is a very useful and productive one in research as it is still being used in many studies and across different disciplines. The case study was chosen for this research for several reasons which will be clarified in the following paragraphs.

There are several types of case studies that can be carried out, each with a different aim. One of these types is the intrinsic Case Study. This term is used to describe a type of Case Study in which researchers have a genuine interest in the particular case not necessarily to use it as a representation of other cases but because the case itself in its particularity is of interest. This is one reason why the case study was used in this research. In liner shipping, there are different regions - as previously mentioned in Chapter 2 - such as the Northern European region, the Mediterranean region, South American region and West African region amongst others. Each of these regions has its own unique characteristics and peculiarities that do not necessarily apply to all the other regions such as the number of ports in the region and the different levels of infrastructural developments and they also differ by natural geographical characteristics and port positioning. All these make these

different regions peculiar in themselves and of interest. While a good amount of research has been carried out on most of the other regions, the West African region is one of the regions that haven't been very widely researched on. This study therefore aimed at shedding more light on this region and also this region was of particular interest because of its potential and its growing importance in the global maritime network system.

Another reason for the choice of this method is the intention to narrow the work down to a smaller scale in order to facilitate the collection of data and also because of the time frame. Working on a global scale would have required much more time and resources which are not at my disposal at the moment.

3.2.1. Data Collection Method

The approach used in this study was a qualitative one. A survey was carried out on the region under study by getting the views of experts operating in that region. Data was collected by the distribution of questionnaires and by carrying out interviews. This was mostly done by the filling of an online survey form developed by the author. Also, trade data consisting of the trade volume between the selected countries in West Africa and Turkey for the years 2008 to 2016 will be used in making the analyses (this has already been outlined in chapter two).

The participants used in the study included experts from, liner shipping companies, liner agencies, freight forwarders and sea ports. These participants were chosen because they have direct insight and knowledge in the liner shipping networks and also trade volume as they are directly involved in the transportation of the traded goods from one region to the order. Amongst the participants included Captains who work offshore with the main aim of designing and organizing the service routes, trade specialist who are involved in the acquisition of customers who want to transport goods and operations specialists who oversee the smooth flow of all activities and operations involved with the transported goods. While liner shipping companies create networks, liner agencies are also very involved in the creation of these networks, freight forwarders have great insight on trade, and seaports are the focal points of all these put together. It was therefore highly appropriate to use experts from these various fields. Fifteen responses were received from the survey

which was carried out in the month of May 2018. This is mainly because; the West African region is relatively a smaller region with much less activity and presence of various companies, compared to other regions in the world. Another constraint was in getting in contact with experts in the field in order to get their views. Not many people were willing to take out time to complete the survey. However, considering the size of the region, the responses gotten represent a good sample size. The distribution of these responses from the different participants can be seen from Table 13 below.

Table 13: Participants in the Survey

Institution	Positions	Number of Responses
Liner Shipping Company	Captains/Operations Manager/Export Team leader	11
Sea Port	Operations Specialist	1
Liner Agency	Trade Specialist/ Container management agent	3
Freight Forwarder	Trade specialist/marketing manager	1
Total		15

Source: Author

A total of 26 questions were included in the questionnaire that was used for the survey and these questions were asked in line with the objectives of this study. The questionnaire included questions about the network structure and financial constraints such as freight rates and costs, cooperation/competition and trade volume, infrastructure and trade volume, factors considered when designing networks and other necessary questions in line with these in order to get required details (see Appendix 1).

3.2.2. Reliability and Validity of the Data

The main objective of this research was to find out the various factors that influence and the dynamics between liner shipping networks and trade volume in West Africa. The data collected from experienced and practicing experts in the field provides great insight and information on various points of interest in this research such as infrastructure, financial constraints, ports, liner shipping services and trade amongst others. This information is clear and simple and the conclusions arrived at will hardly be different if used by someone else. Furthermore, the results gotten from the participants of the survey were not influenced in anyway but were the honest and true views of the participants.

3.3. FINDINGS

This section presents the findings from the survey. The findings will be presented based on the research model which was used for this study. The model was divided into two parts; the Network Structure and Trade volume. The main factors and variables in relation to both the network structure and trade volume were evaluated. These included factors such as service designs, transport routes, calling patterns and trade characteristics amongst others (see research model above). While some of these factors have already been evaluated and presented in previous chapters, this section sheds more light on the research model and presents further information and findings.

3.3.1. Profile of the Participants

As already mentioned above, the participants chosen for this study are experts in the region under study. These included experts from, liner shipping companies, liner agencies, freight forwarders and sea ports. These participants were chosen because they have direct insight and knowledge in the liner shipping networks and also trade volume as they are directly involved in the transportation of the traded goods from one region to the order. While liner shipping companies create networks, liner agencies are also very involved in the creation of these networks, freight forwarders have great insight on trade and seaports are the focal points of all these

put together. It was therefore highly appropriate to use experts from these various fields. Fifteen responses were received from the survey carried out. This is mainly because; the West African region is relatively a smaller region with much less activity and presence of various companies, compared to other regions in the world. Another constraint was in getting in contact with experts in the field in order to get their views. Not many people were willing to take out time to complete the survey. However, considering the size of the region, the responses gotten represent a good sample size. The distribution of these responses from the different participants can be seen from table 13 above.

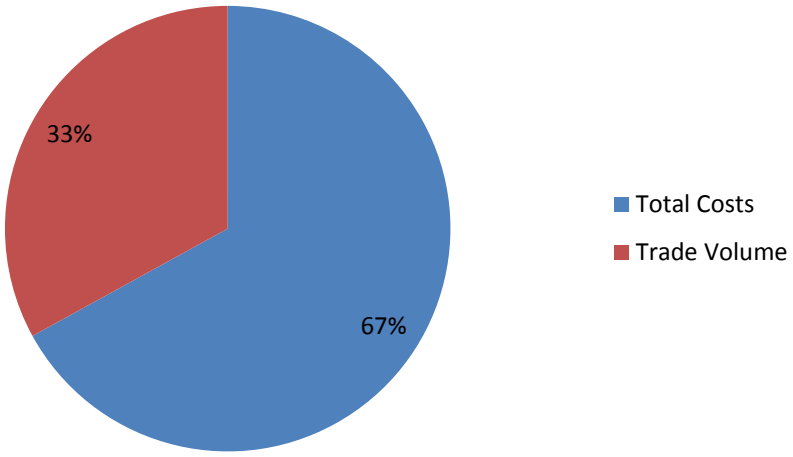
3.3.2. Network Structure

The information that was gathered in relation to the network characteristics and structure will be presented in this subsection. Information in relation to the existing liner shipping network structure in West Africa and the port infrastructure and port characteristics have already been outlined in chapter 2 above. This section presents information in relation to other factors concerning the network structure.

One central theme that was prominent during the research was the issue of Finance (cost, freight rates, financial crisis, etc.) Liner shipping companies are profit making companies therefore the issues of cost and freight rates are taken into great consideration when designing their network structures. The financial crisis of 2009 took a great toll over the industry and up till now, it is still trying to recover from that crisis. The result of this crisis was a drastic fall in freight rates and cargo availability. Competition became fiercer in the industry as companies fought for cargo. Most participants indicated that after the financial crisis of 2009, there has been an increase in the number of agreements and strategic alliances between industry players in the region of West Africa. This is in a bid to protect themselves and remain in the market. In strategic alliances, companies have the opportunity to minimise costs by sharing vessels with other companies and also maximise profits. In 2017, the box frieght rates looked more promising for the industry as they started to slightly improve. Most participants noted that this improvement in frieght rates influenced liner shipping in terms of reliability, frequency and the creation of new agreements.

It was indicated that liner shipping companies give importance to many different factors when designing their networks. However, the two factors that were indicated as the most important by most participants were first; trade volume and second; total costs. This is because the volume of trade determines the amount of revenue that will be acquired however, the cost factor has to be carefully calculated in order not to operate at a loss. Some participants said the availability of cargo (trade volume) was the most important factor because 'no cargo, no business'. Others said trade volume is more important because it gives the company an advantage, and others said trade volume because it generates revenue for the company. The other participants who said total costs is the most important factor considered by liner shipping companies when designing their networks clarified that because of dropping freight rates, companies' main focus is cutting down costs in order to make profit. Furthermore, when asked if they would design their networks targeting ports with higher trade volumes even if that could result in a loss in terms of cost, a higher percentage of participants said they would not (67%) while a handful of them said they would (33%) as can be seen on figure 10 below. Implying that most companies give more importance to total costs rather than trade volume when designing their networks. A few other participants named some other factors that also highly affected network designs such as the political climate and transit times. One participant particular said that "*trade volume and political climates are the main drivers because shipping lines need volumes to survive and daily costs are constant. It makes sense therefore to go for what will make them profitable. Political climates and policies can affect safety of vessels and cost implication to operate in a country*." While trade volume and costs still remain the main driving factors of network design that were put forth, other factors such as the previous mentioned are equally of great importance.

Figure 12: Trade Volume Against Total Cost as Factors Considered When Designing Liner Shipping Networks



3.3.3 Trade Volume

Liner Shipping derives its demand from trade; that is it is directly affected by trade. Therefore, the liner shipping network structure design will be influenced by trade. Close to 90% of the participants indicated that; a well structured and developed liner shipping network will attract more trade to a region. Several reasons where given for this conclusion including the following; a developed liner shipping network will lead to a reduction in transit times thus increase in vessel movement and eventually in trade, a well structured liner shipping network will meet efficient port operations and also good transport network on land to move cargo to landlocked countries therefore increasing the flow of cargo and increasing trade in the region. These were some reasons put forward by the participants to emphasize that a well developed and structured liner shipping network will affect trade positively. One participant gave a very elaborate response which I quote as follows; "*For North Bound, West Africa Connections to destinations like East Mediteranean and Black Sea are still not well-structured by blocking the growth of export of West African region especially for reefer cargoes like banana, mangoes etc to these destinations. If there would be some structural changes new markets can be opened for African commodities. On the other hand, some investment should be done to improve service quality for West African ports as we have been faced with many problems during*

2017 for Dakar. While the volumes are drastically increasing for Senegal and Mali unfortunately DP World Dakar terminal is unable to satisfy this growth service-wise. That is why costs of shipping lines are growing due to these infrastructural problems by forcing them to increase freight rates to absorb these extra costs. Finally, West African ports are really so expensive in terms of stevedoring, empty evacuation and Terminal Handling costs by forcing shipping lines to increase their revenues which is a great obstacle for West African Trade."

Concerning port infrastructure and trade, it was found out that, the port infrastructure in the region is not adequately developed thus leading to high levels of congestion in the region and therefore having a negative impact on trade as these lead to higher costs in terms of longer waiting times and higher logistics costs. Participants indicated that the creation of new ports and the development of existing ports in the region will affect trade volume positively as congestion in ports will greatly reduce especially during peak periods, costs will also reduce as a result of infrastructural developments leading to an increase in trade volume. Furthermore, "*the extra and normal costs of the liner industry will be decreased via the elimination of infrastructural issues which will provide cheaper freight rates for traders, shippers and consignees*" was another factor which was put forward to defend the fact that developed and more advanced port infrastructures have considerable impact on trade. One participant specified quite elaborately that '*trade will increase after infrastructural developments'*. Thus infrastructural development was emphasized very much as an important factor towards trade development and growth.

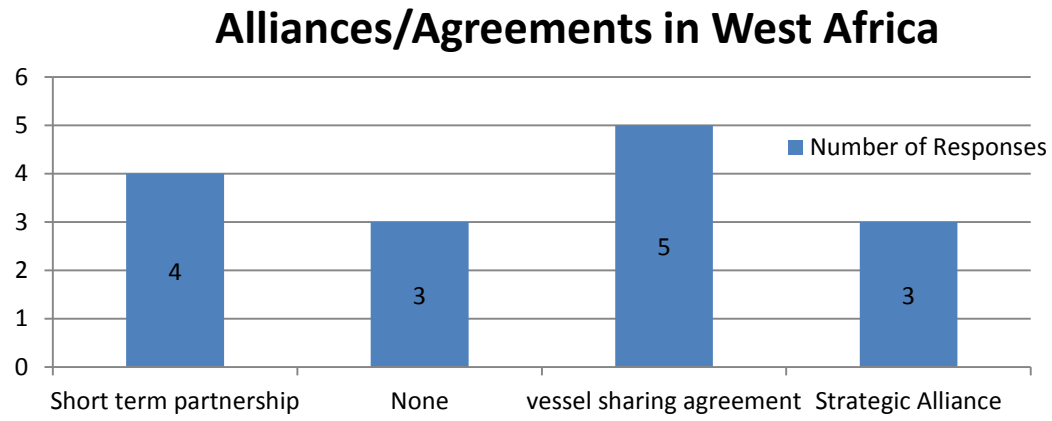
Interlining and Hub and Spoke network structures were indicated as the two most used structures in the region. The reason given as to why these network structures are the most used is that they are more appropriate and suitable in terms of cost and trade volume for the region. Transhipment is mostly done in a port out of the region however, in the North of Africa mostly as indicated by the findings. Some reasons were put forth as to why WAF ports are not used as transhipment ports. This is mainly due to availability inadequate infrastrucutral facilities. One participant particularly gave the following reason as to why WAF ports are not used as hub ports; *"I do not believe that WAF ports can be transformed to hubs and/or*

transhipment ports due to their infrastructural incapabilities and high costs. While direct services can be tried by shipping lines, MAERSK is currently evaluating the profit and loss of Turkey/East Med – Mauritania/Senegal direct service." However, the port of Dakar in Senegal was said to have the highest percentage of transhipments in the region followed by the port of Lagos in Nigeria.

About half of the participants also indicated that, there are possible shorter routes that could be used by liner shipping companies to transport cargo from West Africa to Turkey that are not in use at the moment mainly due to the low volume and high costs on these routes. These shorter routes include; using direct calls between the two regions or using West African ports for transhipment. However most participants mentioned that these routes are not feasible mainly due to poor infrastructure in these ports as mentioned above, low volume and high costs.

Cooperation and Competition as earlier mentioned is on the rise in the shipping industry. This is mainly because companies try to minimize costs and maximize gains by sharing their risks with other companies especially through slot sharing agreements, vessel sharing agreements and strategic alliances. The Figure 13 below shows the different alliances/agreements that the companies of the participants are involved in.

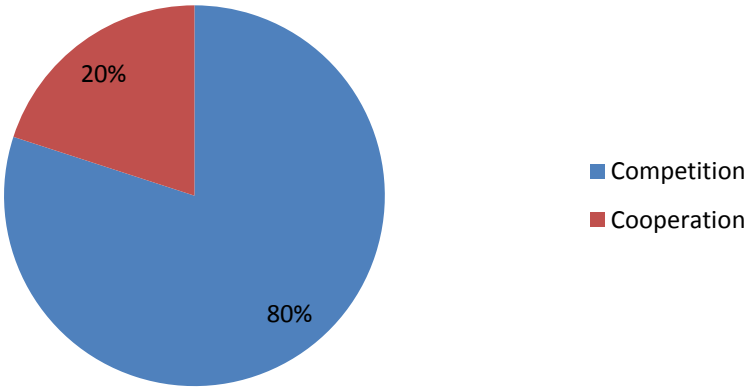
Figure 13: Strategic Alliances/Agreements



Ports also cooperate with each other through the sharing of data and intelligence amongst other resources. In West Africa however competition between ports is way higher than cooperation. There's a very minimal (if any at all) level of cooperation between ports in this regions. When asked if competition or cooperation was higher

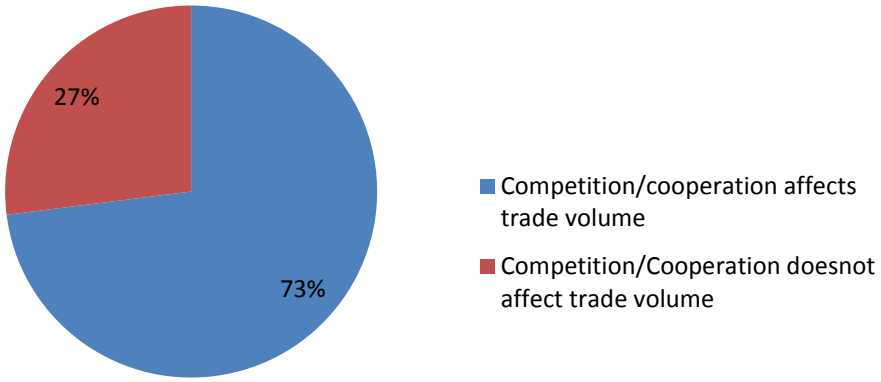
in West Africa, 80% of the participants indicated that competition is higher in the region than cooperation as can be seen in figure 14 below;

Figure 14: Competition/Cooperation in West Africa



However, about 73% of the participants also indicated that competition/cooperation doesnot affect the trade volume in the region (see figure 15 below).

Figure 15: Effect of Competition/Cooperation on Trade Volume

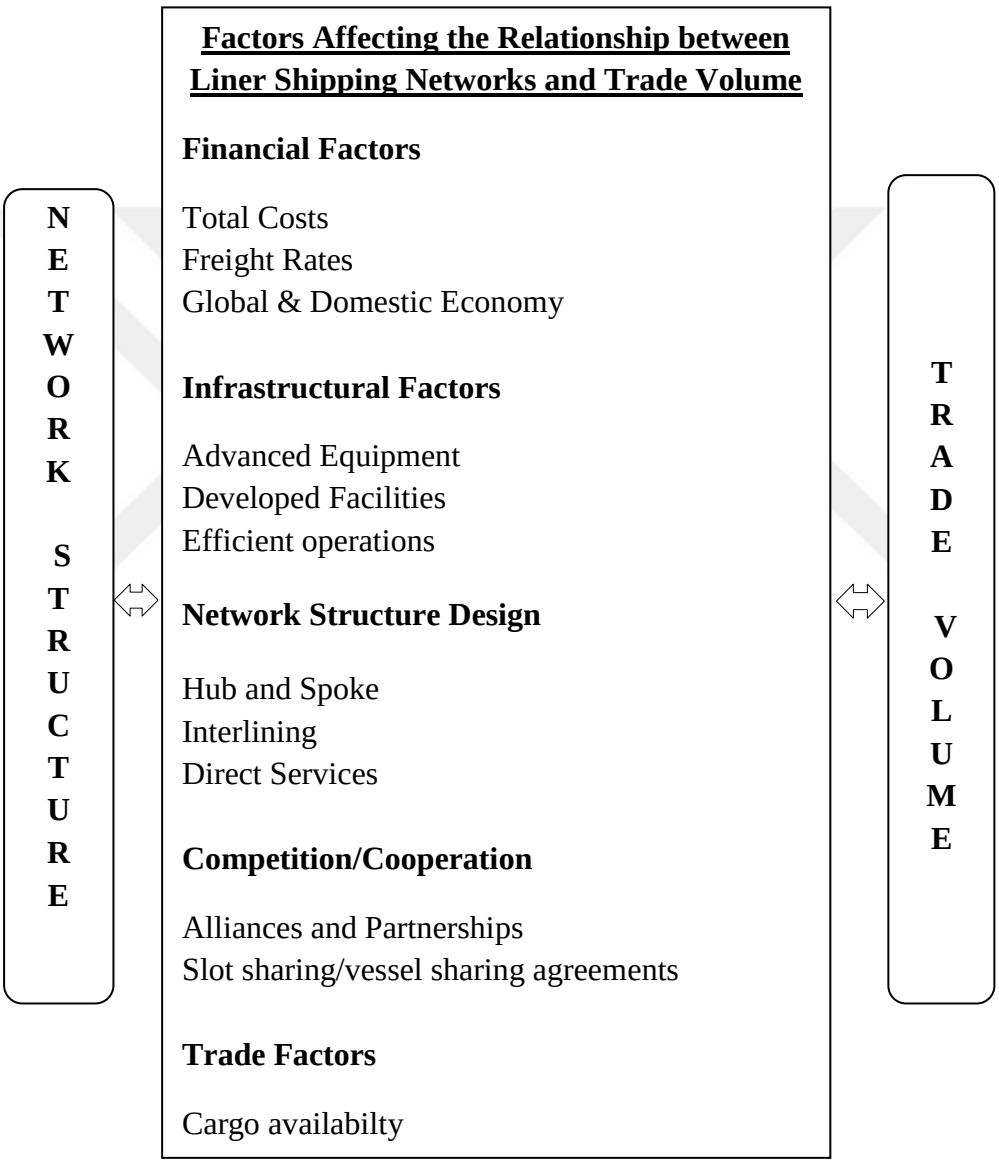


While those who said competition does affect trade volume gave reasons such as; competition forces ports to offer better services thus leading to an improvement in trade, shipping lines can choose which port of call they prefer and traffic at ports could be reduced. Most participants actually indicated that competition could lead to an increase in the number of ports of call thus affecting trade volume positively.

CONCLUSIONS

Based on the above findings and analysis of the different factors that affect the relationship between liner shipping networks and trade volume, the proposed research model that was presented at the start of this study can be modified, updated and presented below.

Figure 16: Final Research Model



Contribution to the Literature

From the above model and based on the findings of this research, it can be seen that a number of factors amongst all which have been given in earlier chapters

greatly and more substantially affect the dynamics between liner shipping networks and trade volume. These include **financial factors, infrastructural factors**, **the network service structure and design**, **Competition/Cooperation** and **trade factors**.

The financial factors mainly include total costs, freight rates, and the state of the domestic and golobal economies. According to the findings of the survey, lower freight rates which is greatly caused by changes in the global economy results in increased competition. This is because, low freight rates result from unavailability of cargo therefore, competition increases as shipping lines scramble to get whatever cargo is available to be transported for themselves. This competition leads to creation of multiple alliances, agreements and partnerships. Agreements such as slot sharing agreements, vessel sharing agreements and strategic alliances are undertaken by liner shipping companies in a bid to share costs, increase profits and gain new markets. The global financial crisis of 2009 took a bad toll on the industry and even led to the demise of some companies such as the South Korean Hianjin shipping Company. Companies therefore try to secure their position in the market by entering these agreements and alliances with each other. Freight rates also affect the service designs and line ups. Changing freight rates result in volatile service design structures as liners keep adjusting their service line ups to minimize costs and carry the most cargo they can find. Furthermore, falling freight rates shift the focus of companies to costs. Since liner shipping companies cannot do much to influence freight rates, their focus turns to total costs since it can somehow be manipulated by them as they try to bring it to the very minimum possible in order to increase profits. These financial factors therefore have great influence on the liner shipping network structure and not very much influence on trade volume. They are on the contrary influenced by trade volume.

Infrastructural factors such as developed port facilities, advanced equipment and technology and efficien port operations are one other major factor that influences the network structure and trade volume. Good infrastructure and efficient operations result in quicker transit times and therefore and increase in trade especially in the WAF region. This is because, cargo can be easily acquired from inland regions. With inadequate infrastructural facilities, even if there is growth in trade volume, these

terminals will not be able to handle and sustain this growth therefore making hard for shipping lines to acquire the available cargo. Also, poor infrastructural facilities result in increased costs such as stevedoring costs, empty evacuation costs and terminal handling cost amongst others which greatly inhibits WAF trade. Therefore, good infrastructural facilities leads to higher trade volumes and vice versa.

The choice of the network design also affects the trade volume. Different designs could be used by liner shipping companies such as the hub and spoke design, interlining, direct services and pendulum services amongst others. In the WAF region, the most used design is the hub and spoke design with ports of transhipment out of the region. This choice of network design is mainly due to the fact that ports in the WAF region are not well developed and advanced to be used as transhipment ports. Therefore, shipping lines carry out transhipment activities in other ports out of the region. It was stipulated during the survey that, direct services could enhance trade volume. This is mainly because most consignees prefer their cargo to be transported without too many transhipments. Therefore, direct services could lead to increased volumes. However, the availability of direct services do not guarantee and increased trade volumes. Contrarily, these services are created based on the volume that is available. That is one reason why direct services are not used very much in the WAF region due to the low volume levels. Therefore, the trade volume directly influences the choice of network service design.

The availability of cargo is another fundamentl factor that affects the network structure and trade volume since it is the revenue generating factor. The more cargo there is to be transported, the higher the revenue of shipping liners. Therefore, cargo availability is a huge factor that is put into consideration when designing networks as was elaborated by participants in this research. However, it was discovered that more importance is given to total costs over total volume when designing networks. This is because, a lot of cargo can be transported but at low freight rates which still leads to a loss for the company. Therefore, most companies will rather give up cargo in order to minimize costs.

This study has therefore added to the literature by outlining five pertinent factors that affect the relationship between trade volume and the liner shipping network structure and how they are interrelated.

Contribution to the Industry

The above outlined factors greatly affect the dynamics between liner shipping companies and trade volume and should be taken into consideration by policy makers, port operators, liner shipping companies and other concerned parties when carrying out operations or setting policies in order to improve trade and transportation in the region of concern.

Furthermore, the WAF region was taken into particular consideration in this research, therefore the findings and conclusions could be of special importance to all stakeholders in this region. For example, the creation of direct services from WAF to the Mediterranean region of Turkey could lead to an increase in trade volume as shown in the findings. Also, more cooperation between WAF ports in the could be beneficial for the entire region. It could lead to reduced congestion and increase traffic in the region which will eventually lead to a boost in trade volume. Also, by improving upon the infrastructural facilities of the ports in the region, the ports will become more competitive and could act as hub ports for the transshipment of cargo which will attract more trade.

Suggestions for Further Studies

This study sought to find out the dynamics of liner shipping networks and trade volume with the West African region as a Case Study. Other studies could base their research on other regions especially the under-researched regions such as South America, East Africa or South Africa. Also, this study was a qualitative study; a more quantitative research could be done by analyzing the movement of different liner services, vessel port calls, and cargo throughput.

REFERENCES

AFDB (2010). Gowing Forward: Developing Regional Hubs in Africa. http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/African%20Development%20Report%202010_CH%206.pdf (11.05.2018)

African Bank (2010). Going Forward: Developing Regional Hub Ports in Africa. *African Development Report*. pp 183 – 195

African Bank (2010). Port Development in Africa. *African Development Report* Ch 2 31 – 75

Agarwal, R., & Ergun, Ö. (2010). Network design and allocation mechanisms for carrier alliances in liner shipping. *Operations research*, *58*(6), 1726-1742.

Asgari, N., Farahani, R. Z., & Goh, M. (2013). Network design approach for hub ports-shipping companies competition and cooperation. *Transportation Research Part A: Policy and Practice*, *48*, 1-18.

Bartholdi, J. J., Jarumaneeroj, P., & Ramudhin, A. (2016). A new Connectivity Index for Container Ports. *Maritime Economics & Logistics*, *18*(3), 231-249.

Bartholdi, J. J., Jarumaneeroj, P., & Ramudhin, A. (2016). A new connectivity index for container ports. *Maritime Economics & Logistics*, *18*(3), 231-249.

Bernou B. (2011). The development of port hierarchy in West-Africa. Erasmus University Rotterdam, *Urban, Port and Transport Economics*.

Bockrath, J. (2016). *Alliances and concentration: the economic consequences of market structure in the liner shipping industry*(Doctoral dissertation, University of Delaware).

Börner, K., Sanyal, S., and Vespignani, A. (2007). Network science. *Annual review of information science and technology*, *41*(1), 537-607.

Caris, A., Macharis, C., & Janssens, G. K. (2011). Network Analysis of Container Barge Transport in the Port of Antwerp by Means Of Simulation. *Journal of Transport Geography 19: 125–133*

Clark, X., Dollar, D., & Micco, A. (2004). Port efficiency, maritime transport costs, and bilateral trade. *Journal of development economics*, *75*(2), 417-450.

Debrie, J. (2012). The West African port system: global insertion and regional particularities. *EchoGéo*, (20).

Debrie, J. (2012). The West African port system: global insertion and regional particularities. *EchoGéo*, (20).

Degrassi S. (2001). *The Seaport Network Hamburg*. Dissertation for a Doctorate Degree, University of Hamburg, Germany.

Ducruet C. (2013). Network Diversity and Maritime Flows. *Journal of Transport Geography 30: 77–88*

Ducruet, C., & Notteboom, T. (2012). The worldwide maritime network of container shipping: spatial structure and regional dynamics. *Global networks*, *12*(3), 395-423.

Ducruet, C., & Notteboom, T. (2015). Developing liner service networks in container shipping. In; *Maritime logistics* : *A Guide to Contemporary Shipping and Port Management, No. 2nd edition, pp 89-105*

Ducruet, C., and Lugo, I. (2013). Cities and transport networks in shipping and logistics research. *Asian Journal of Shipping and Logistics*, *29*(2), 149-170.

Ducruet, C., Rozenblat, C. and Zaidi, F. (2010).Ports in Multi-Level Maritime Networks: Evidence from the Atlantic (1996–2006). *Journal of Transport Geography 18, pp 508–518*

Evangelista, P., & Morvillo, A. (1999). Alliances in liner shipping: an instrument to gain operational efficiency or supply chain integration?. *International Journal of Logistics: Research and Applications*, *2*(1), 21-38.

Evangelista, P., & Morvillo, A. (1999). Alliances in liner shipping: an instrument to gain operational efficiency or supply chain integration?. *International Journal of Logistics: Research and Applications*, *2*(1), 21-38.

Fremont, A. (2007). Global maritime networks: The case of Maersk. *Journal of Transport Geography*, *15*(6), 431-442.

Gadhia, H. K., Kotzab, H., & Prockl, G. (2011). Levels of internationalization in the container shipping industry: an assessment of the port networks of the large container shipping companies. *Journal of Transport Geography*, *19*(6), 1431-1442.

Gelareh, S., Nickel, S., & Pisinger, D. (2010). Liner shipping hub network design in a competitive environment. *Transportation Research Part E: Logistics and Transportation Review*, *46*(6), 991-1004.

Haralambides, H. E., & Veenstra, A. W. (1996). *Ports as Trade Facilitators in the export-led Growth Strategies of Developing Countries*. Cacucci.

Helmick, J. S. (1994). Concentratıon And Connectıvıty In The North Atlantıc Lıner Port Network: 1970-1990. *A Dissertation Submitted İn Partial Fulfillment Of The Requirements For The Degree Of Doctor Of Philosophy*, Unıversıty Of Miami, Florida U.S.A.

Helmick, J. S. (1996). Concentration and Connectivity in the North Atlantic Line port Network: 1970-1990. *Transportation Research Part A*, *1*(30), 62.

Hu, Y., & Zhu, D. (2009). Empirical Analysis of the Worldwide Maritime Transportation Network. *Physica A: Statistical Mechanics and its Applications*, *388*(10), 2061-2071.

Imai, A., Shintani, K. and Papadimitriou, S. (2009). Multi-port vs. Hub-and-Spoke port calls by containerships. *Transportation Research Part E: Logistics and Transportation Review*, *45*(5), 740-757.

Jiang, J., Lee, L. H., Chew, E. P., & Gan, C. C. (2015). Port Connectivity study: An analysis framework from a Global Container Liner Shipping Network Perspective. *Transportation research part E: Logistics and Transportation Review*, *73*, 47-64.

Kaluza, P., Kölzsch, A., Gastner, M. T., & Blasius, B. (2010). The complex network of global cargo ship movements. *Journal of the Royal Society Interface*, *7*(48), 1093-1103.

Kaluza, P., Kölzsch, A., Gastner, M. T., & Blasius, B. (2010). The complex network of global cargo ship movements. *Journal of the Royal Society Interface*, *7*(48), 1093-1103.

Lam, J. S. L., & Yap, W. Y. (2011). Dynamics of liner shipping network and port connectivity in supply chain systems: analysis on East Asia. *Journal of Transport Geography*, *19*(6), 1272-1281.

Laventhal, W. T. (2009). Contaıner Ports In Developıng Countries: Barriers To Participation In The Global Economy. (Unpublished doctorate disertation) Graduate School-Newark Rutgers, the State University of New Jersey, Newark, New Jersey.

Laxe, F. G., Seoane, M. J. F., & Montes, C. P. (2012). Maritime Degree, Centrality and vulnerability: port Hierarchies and Emerging Areas in Containerized Transport (2008–2010). *Journal of Transport Geography*, *24*, 33-44.

Lee, T. C., Wu, C. H., & Lee, P. T. W. (2011). Impacts of the ECFA on seaborne trade volume and policy development for shipping and port industry in Taiwan. *Maritime Policy & Management*, *38*(2), 169-189.

Lee, T. C., Wu, C. H., and Lee, P. T. W. (2011). Impacts of the ECFA on seaborne trade volume and policy development for shipping and port industry in Taiwan. *Maritime Policy & Management*, *38*(2), 169-189.

Li, Z., Xu, M., & Shi, Y. (2015). Centrality in global shipping network basing on worldwide shipping areas. *GeoJournal*, *80*(1), 47-60. https://doi.org/10.1007/s10708-014-9524-3

Liu, Z., Meng, Q., Wang, S., & Sun, Z. (2014). Global intermodal liner shipping network design. *Transportation Research Part E: Logistics and Transportation Review*, *61*, 28-39.

Low, J. M., Lam, S. W., and Tang, L. C. (2009). Assessment of hub status among Asian ports from a network perspective. *Transportation Research Part A: Policy and Practice*, *43*(6), 593-606.

Lun, Y. H. V., Lai, K. H., & Cheng, T. C. E. (2010). Liner Shipping Network. *Shipping and Logistics Management*, 101-118.

Maritime, L. and Consulting T. (CATRAM Consultants). *Market study on container terminals in West and Central Africa*, 2013.

Markusen, J. R., and Wigle, R. M. (1990). Explaining the volume of north-south trade. *The Economic Journal*, *100*(403), 1206-1215.

Mclaughlin, H., & Fearon, C. (2013). Understanding the development of port and regional relationships: a new cooperation/competition matrix. *Maritime Policy & Management*, *40*(3), 278-294.

Mclaughlin, H., and Fearon, C. (2013). Understanding the development of port and regional relationships: a new cooperation/competition matrix. *Maritime Policy & Management*, *40*(3), 278-294.

Medda, F., & Caschili, S. (2015). The port attractiveness index: application on African ports. *Region et Developpement*, *41*, 47-82.

Morrow, J. D., Siverson, R. M., and Tabares, T. E. (1998). The political determinants of international trade: the major powers, 1907–1990. *American political science review*, *92*(3), 649-661.

Mulder, J., & Dekker, R. (2014). Methods for strategic liner shipping network design. *European Journal of Operational Research*, *235*(2), 367-377.

Munari F. (2012). Competition in Liner Shipping. *The Hamburg Lectures on Maritime Affairs 2009 & 2010*. Hamburg Studies on Maritime Affairs (International Max Planck Research School for Maritime Affairs at the University of Hamburg), vol 23. Springer, Berlin, Heidelberg

Notteboom T. E. (2012). Towards a New İntermediate Hub Region in Container Shipping? Relay And İnterlining Via the Cape Route vs. The Suez Route. *Journal of Transport Geography 22, pp 164–178*

Notteboom, T. (2004). Container Shipping And Ports: An Overview. *Review of Network Economics*, 3(2), pp. -. Retrieved 8 Aug. 2018, from doi:10.2202/1446-9022.1045

Notteboom, T., & Rodrigue, J. P. (2008). Containerisation, box logistics and global supply chains: The integration of ports and liner shipping networks. *Maritime economics & logistics*, *10*(1-2), 152-174.

Parola, F., & Sciomachen, A. (2005). Intermodal container flows in a port system network:: Analysis of possible growths via simulation models. *International journal of production economics*, *97*(1), 75-88.

Rauch, J. E. (1999). Networks versus markets in international trade. *Journal of international Economics*, *48*(1), 7-35.

Ridolfi, G. (1999). Containerisation in the Mediterranean: between global ocean routeways and feeder services. *GeoJournal*, *48*(1), 29-34.

Rimmer, P. J. (2004). Global Flows, Local Hubs, Platforms and Corridors: Regional and Economic Integration in Northeast Asia. *Journal of International Logistics and Trade*, *1*(2), 1-24.

Ryoo, D. K., & Thanopoulou, H. A. (1999). Liner alliances in the globalization era: a strategic tool for Asian container carriers. *Maritime Policy & Management*, *26*(4), 349-367.

Sánchez, R. J., Hoffmann, J., Micco, A., Pizzolitto, G. V., Sgut, M., & Wilmsmeier, G. (2003). Port efficiency and international trade: port efficiency as a determinant of maritime transport costs. *Maritime economics & logistics*, *5*(2), 199-218.

Slack, B., Comtois, C., & McCalla, R. (2002). Strategic Alliances İn The Container Shipping İndustry: A Global Perspective. *Maritime Policy & Management*, *29*(1), 65-76. DOI: 10.1080/03088830110063694

Song D. W. (2002). Regional Container Port Competition and Co-Operation: The Case of Hong Kong and South China. *Journal of Transport Geography 10, pp 99–110*

Song, D. W., & Panayides, P. M. (2002). A Conceptual Application of Cooperative Game Theory to Liner Shipping Strategic Alliances. *Maritime Policy & Management*, *29*(3), 285-301.

Song, D. W., & Yeo, K. T. (2004). A competitive analysis of Chinese container ports using the analytic hierarchy process. *Maritime Economics & Logistics*, *6*(1), 34-52.

Song, D., Zhang, J., Carter, J., Field, T., Marshall, J., Polak, J., and Woods, J., Schumacher, K., Sinha-Ray P. and Woods J. (2005). On Cost-Efficiency of The Global Container Shipping Network. *Maritime Policy & Management, 32:1, 15-30, DOI:10.1080/0308883042000176640*

Stake, R. E. (1995). *The art of case study research. Sage* 1995.

Talley, W. K., & Ng, M. (2013). Maritime transport chain choice by carriers, ports and shippers. *International Journal of Production Economics*, *142*(2), 311-316.

Tovar, B., Hernández, R., & Rodríguez-Déniz, H. (2015). Container port competitiveness and connectivity: The Canary Islands main ports case. *Transport Policy*, *38*, 40-51.

Tran, N. K., & Haasis, H. D. (2014). Empirical analysis of the container liner shipping network on the East-West corridor (1995–2011). *NETNOMICS: Economic Research and Electronic Networking*, *15*(3), 121-153.

Tran, N. K., & Haasis, H. D. (2015). Literature survey of network optimization in container liner shipping. *Flexible Services and Manufacturing Journal*, *27*(2-3), 139-179.

United Natıons Conference On Trade And Development (UNCTAD 2016). Revıew Of Maritıme Transport. *Unıted Natıons Publıcatıon Volume 42, pp 910-921.*

Van Dyck, G. K. (2015). Assessment of port efficiency in West Africa using data envelopment analysis. *American Journal of Industrial and Business Management*, *5*(04), 208.

van Dyck, G. K. (2015). The Drive for a Regional Hub Port for West Africa: General Requirements and Capacity Forecast. *International Journal of Business and Economics Research*, *4*, 36-44.

van Dyck, G. K., & Ismael, H. M. (2015). Multi-criteria evaluation of port competitiveness in West Africa using analytic hierarchy process (AHP). *American Journal of Industrial and Business Management*, *5*(06), 432.

Veenstra, A. W., Song, D. W., & Panayides, P. (2015). Maritime transport and logistics as a trade facilitator. *Maritime logistics: a guide to contemporary shipping and port management*, (2nd edition), 11-28.

Vissak, T. (2010). Recommendations for using the case study method in international business research. *The Qualitative Report*, *15*(2), 370-388.

Wang, C., & Wang, J. (2011). Spatial Pattern of the Global Shipping Network and its Hub-and-spoke system. *Research in Transportation Economics*, *32*(1), 54-63.

Warner, D., & Kreinin, M. E. (1983). Determinants of international Trade Flows. *The Review of Economics and Statistics*, 96-104.

Wilmsmeier, G. & Hoffmann, J. Marit Econ Logist (2008) https://doi.org/10.1057/palgrave.mel.9100195

Wilmsmeier, G., & Notteboom, T. (2011). Determinants of liner shippping network configuration: a two-region comparison. *GeoJournal*, *76*(3), 213-228.

Wilmsmeier, G., and Hoffmann, J. (2008). Liner shipping connectivity and port infrastructure as determinants of freight rates in the Caribbean. *Maritime Economics & Logistics*, *10*(1-2), 130-151.

Wilmsmeier, G., and Hoffmann, J. (2008). Liner shipping connectivity and port infrastructure as determinants of freight rates in the Caribbean. *Maritime Economics & Logistics*, *10*(1-2), 130-151.

Winston, T. (1997). Introduction to Case Study. The Qualitative Report, Volume **3**, (http://www.nova.edu/ssss/QR/QR3-2/tellis1.html).

World Trade Organization (WTO 2016). World Trade Report: Levelling the Trading field for SMEs.

Xu, M., Li, Z., Shi, Y., Zhang, X., & Jiang, S. (2015). Evolution of regional inequality in the global shipping network. *Journal of Transport Geography*, *44*, 1-12.

Yeo, G. T., Roe, M., and Dinwoodie, J. (2008). Evaluating the competitiveness of container ports in Korea and China. *Transportation Research Part A: Policy and Practice*, *42*(6), 910-921.

Yercan, F., & Yildiz, T. (2012). 03 international maritime trade and logistics. *Maritime Logistics: A complete guide to effective shipping and port management*, 23.

Yin, R.K. (1989). Case Study Research: Design and Methods. *Sage Publications*.

Zainal, Z. (2007). Case Study as a Research Method. *Jurnal Kemanusiaan*, (9), 1-6.

APPENDIX

Dynamics of Liner Shipping Networks and Trade Volume. A Case Study of West African and Turkish Ports

Survey Form for M.SC Thesis

1. The years following the financial crisis have been really challenging ones for the liner shipping industry. How would you say this affected the liner shipping network structure in West Africa

O The network has become more dense (the number of ports and connections between them has increased)

O There has been an increase in the number of agreements and strategic alliances between industry players in the region

O There has been an increase in node degree in the area (that is the number of links or connections to or from any particular port)

O Other:

2. 2017 looked more promising for the industry as box freight rates began to slightly improve. Did this affect the liner shipping network design and structure in any way?

Tick all that apply.

O Yes

O No

3. If yes to question 2 above, How?

4. Does cooperation and/or competition between ports affect the trade volume of the West African region?

Mark only one oval.

O Yes

O No

5. If yes to Question 4. How?

6. Which will you say is higher in the West African region: Competition between ports or Cooperation between ports?.

O Competition

O Cooperation

7. How does this (Competition and/or Cooperation) affect trade in the area?

O It increases the trade volume in the region

O It reduces transit times

O It increses transit times

O It leads to an increase in the number of ports of call

O Other:

8. On a scale of 0 – 7 how will you rate inter-port cooperation between ports in West Africa?

9. Which port in the West African region amongst the following is mostly used for transshipment by shipping lines?

O Port of Dakar (Senegal)

O Port of Tema (Ghana)

O Port of Abidjan (Code d'Ivoire)

O Port of Lagos (Nigeria)

O Port of Cotonou (Benin)

O None

O Other:

10. Liner Shipping derives its demand from trade as determined by several studies. However, would you say that a more developed and well-structured liner shipping network will attract more trade to a particular region?

O Yes

O No

11. Please give reasons to your choice in question 10 above

12. Which do shipping lines give more importance to when designing their networks?

O Distance

O Availability of cargo

O Time

O Trade Volume

O Total Costs

O Other:

13. Which of the above would you say is given the most importance and why is that so?

14. How does the port infrastructure in the West African region affect traffic and the trade volume?

O It attracts higher trade volumes

O It causes high levels of congestion in the region

O It eases traffic flow in the region

O Other:

15. Which type of network design is mostly used by companies in this region?

O HUB AND SPOKE (The network structure in which one port acts as the 'hub port' from which shipping lines do transhipment of cargo to other ports)

O RELAY (The network structure in which cargo is exchanged at every port of call

O INTERLINING (The network structure in which cargo transported is shared between lines without necessarily having to be in any alliance agreement

O Other:

16. What influences the use of the chosen network design the most

O Cost
O Trade volume
O Distance
O Time
O Other:

17. Will the creation of new ports and improvement of port infrastructure affect the trade volume?
O Yes
O No

18. If Yes to (17), in what ways will this change affect trade volume?

19. Are there possible shorter routes that could be used to transport cargo from West Africa to Turkey that are not in use? (For example a direct route from Istanbul to Dakar, or a route with transshipment at Cotounou, etc)
O Yes
O No

20. If yes to question 19 above, Which ones? and why aren't they in use?

21. Would you design your network targeting ports with higher trade volume even if this can result in a loss in terms of high cost?
O Yes
O No
O Other:

22. How does the existence of strategic alliances affect the configuration of the shipping network in this region?
O It leads to an increase in the numner of ports of call and connections to other ports
O It reduces transit times
O It increases trade volume

O Other:

23. Is your company currently a part of any alliance? Which one?

24. Would you say the existence of alliances facilitates trade in the region?

O Yes

O No

25. If Yes to question 24 above, how does it do so?

26. Which of the categories does the institution you work for fall under?

O Liner Shipping Company

O Sea port

O Liner Agency

O Freight Fowarder

O Other: