The Role of Technical Efficiency & Productivity Evolution in Port Development: An application to Caribbean Small Island Developing States (SIDS) ports

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ABSTRACT

Economic growth has continually remained an objective of every nation, particularly for lesser-developed countries such as the Small Island Developing States (SIDS). According to an UNCTAD (2014) report on *"Small island developing States: Challenges in transport and trade logistics,"* one way of attaining economic growth is by focusing attention on tackling the challenges faced by transport and trade logistics (UNCTAD, 2014).

Given the unique characteristics of SIDS nations, notably high import content, insularity, geographic remoteness and small economies, populations and areas, all of these factors emphasize the importance of having *"well-functioning, reliable, sustainable and resilient transportation systems, in particularly the maritime sector for SIDS development and international trade survival"* (UNCTAD, 2014).

Such policies would be consistent with what is generally referred to as 'supply led' economic development, where improvements in transport related infrastructure result in economic growth (Cowie, 2010). Such an approach assumes there is a latent demand for a country/region's produce, but this is being prevented from being exploited, because of inefficiencies in, or a lack of adequate port infrastructures and human resources.

These challenges constitute a key policy concern for the sustainable development of SIDS' ports and become not only a port concern but a national concern, as directing adequate funding to improving port efficiency, has become a top priority (UNCTAD 2014). For instance, according to the United Nations (UN), *"benchmarks need to be established to monitor and improve port performance…"*(UNCTAD, 2014), while SIDS such as the Caribbean Community (CARICOM) aim to improve their maritime sector, claims that *"…enhancing the maritime sector has the potential to fuel CARICOMs trade, increase port productivity and generate significant cost savings…"* (CARICOM, 2013).

This research aims to measure, analyse and compare port efficiency and productivity over a ten-year period (2001-2011), on 69 seaports, using non-parametric DEA based tests. The primary focus is on the Caribbean SIDS (referred as the Caribbean for abbreviation purposes), benchmarked against top ports. This is investigated from the realm of how port policy and development strategies have affected efficiency and productivity over time. This research attempts to present greater insight into SIDS ports, with reference mainly to the Caribbean, whilst the approach can become a springboard, implemented on other port types and regions of the world. Additionally, its practical contribution may become a better guide for international (UNCTAD), regional (CARICOM) and country level decision makers.

Evolutionary technical efficiency and productivity for the Caribbean's Small Island Developing States (SIDS) ports, during the period 2001-2011 are evaluated. Moreover, the region's port development initiatives are assessed over the same period. Top ports received an average efficiency of 72%, outperforming the overall 66% average for Caribbean ports as was expected. Interestingly enough, efficiencies for top ports decreased on average by 0.5% per annum over the decade, whilst increases of up to 0.7% were found for Caribbean ports. Moreover, the region's productivity grew by 3.2%, compared to their larger top counterparts, of up to 2% per annum.

This research concludes that trade volumes play an integral part in affecting efficiency and productivity. Additionally, given port development initiatives, the Caribbean's progresses in efficiency/productivity has been mainly the effects of scale and technical progress respectively. Since these ports are usually smaller scale and yield lesser throughput (compared to their larger counterparts), when they begin to grow, the focus is on enlarging their production scales, however, this is at the expense of adjusting internal practises.

Compared to TOP ports, increases in productivity is solely the consequence of technical progress. Since these are usually larger scale ports and so likely yield more throughput, will likely be operating at the size of decreasing returns to scale. This suggests, that they are not properly focusing on internal practices and sizing their production scales to accommodate the rise in technical progress.

The research findings can potentially influence decisions made by local and regional authorities in the Caribbean, when it comes to port development initiatives, as it provides an overview of efficiency/productivity, but more so that which impedes these progresses.

ACKNOWLEDGEMENTS

"5 Trust in the LORD with all your heart,
And lean not on your own understanding;
6 In all your ways acknowledge Him,
And He shall direct your paths."
Proverbs 3:5-6 (NKJV)

After three long years, I can certainly say that my thesis could not be a success without complete trust in God. It is because of Him, I had the opportunity to connect with reputable and distinguished individuals in and outside of my research. Their knowledge and advice have undoubtedly shaped my thesis, as well as my personal development. I could not have done it without their input, and for this may God bless them richly, for,"*whoever brings blessing will be enriched, and one who waters will himself be watered."* (Proverbs 11:25-26, NKJV) (Nelson, 1995).

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Becoming a Doctor of Philosophy is one of the greatest accomplishments in my life. It is an honoured title, which I have always desired attaining, and while I did not know how it would happen, God saw my end from my beginning and called it into being. So, to God be the glory, for great things He has done. I am most grateful to see this journey come to pass, and look forward to the next season of my life where God will take this accomplishment and myself.

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LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicles
AP	Average Product
ASYCUDA	Automated System for Customs Data
BCC	Banker, Charnes and Cooper Model
CAGR	Compound Annual Growth Rate
CARI	Caribbean
CARICOM	Caribbean Community
CDB	Caribbean Development Bank
CCR	Charnes, Cooper and Rhodes Model
COLS	Corrected Ordinary Least Squares
CRS	Constant Returns to Scale
CSME	Caribbean Single Market and Economy
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
DRS	Decreasing Returns to Scale
EDI	Electronic Data Interchange
EFFCH	Efficiency change
FP	Fractional Programming
GDP	Gross Domestic Product
IADB	Inter-American Development Bank
ICT	Information and Communication Technology
IRS	Increasing Returns to Scale
IT	Information Technology
LAC	Latin America and the Caribbean
LDC	Lesser Developed Countries
LP	Linear Programming
MDC	More Developed Countries
MEC	Managerial Efficiency Change
MES	Minimum Efficient Scale
MLE	Maximum Likelihood Estimation
MPI	Malmquist Productivity Index
MRTS	Marginal Rate of Technical Substitution
MP	Marginal Product
NCARI	Non-Caribbean ports
OECS	Organisation of Eastern Caribbean States.
OLS	Ordinary Least Squares
OSIDS	Other Small Island Developing States
PCS	Port Community System
PE	Port Efficiency
PECH	Pure Efficiency change

POS	Port of Spain
PPF	Production Possibility Frontier
SE	Scale Efficiency
SECH	Scale Efficiency change
SFA	Stochastic Frontier Analysis
SIDS	Small Island Developing States
SLASPA	Saint Lucia Air and Sea Ports Authority
TECHCH	TECHNICAL CHANGE
TFP	Total Factor Productivity
TFPCH	Total Factor Productivity change
TOP	Top World Ports
TOS	Terminal Operation Systems
TP	Total Product
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
VRS	Variable Returns to Scale

CHAPTER ONE

INTRODUCTION

1.1 RESEARCH BACKGROUND

Economic growth has continually remained an objective of every nation, particularly for lesser-developed countries such as the Small Island Developing States (SIDS). Economic growth is an increase in real output, resulting in higher average incomes. This means *consumers* can enjoy more goods/services and a better standard of living, *firms* can employ more workers to increase their production, which results in lower levels of unemployment, investments increase and more opportunities for more research and development, and the *government* enjoys higher tax returns (therefore reducing the country's debt), and public services can improve. According to an UNCTAD (2014) report on *"Small island developing States: Challenges in transport and trade logistics,"* one way of attaining economic growth is by focusing attention on tackling the challenges faced by transport and trade logistics (UNCTAD, 2014).

Given the unique characteristics of SIDS nations, notably high import content, insularity, geographic remoteness and the smallness of economies, populations and areas, all of these factors emphasize the importance of having *a "well-functioning, reliable, sustainable and resilient transportation systems, in particularly the maritime sector for SIDS development and international trade survival"* (UNCTAD, 2014). Such policy would be consistent with what is generally known as 'supply led' economic development, where improvements in transport related infrastructure result in economic growth (Cowie, 2010, 2017; Merkert and Cowie, 2017a). Such an approach assumes there is a latent demand for a country/region's produce, but this is prevented from being exploited due to the inefficiencies in, or a complete lack of, transport infrastructure.

Additionally, today's seaports are confronted by a fast evolving global market place which includes extensive business networks, complex logistics systems, increasing vessel sizes and global terminal operators (Notteboom, 2007).

Therefore, lack of upgrading existing port facilities and services to meet this change in the industry, insufficient port financing for capital and maintenance projects, inadequate maintenance and management, and insufficiently skilled workforce, can hinder actually port efficiencies (CARICOM, 2013).

These challenges constitute a key policy concern for the sustainable development of SIDS' ports and become not only a port concern but a national concern, as directing adequate funding to improving port efficiency, have become a top priority (UNCTAD 2014). For instance, according to the United Nations (UN), *"benchmarks need to be established to monitor and improve port performance…"*(UNCTAD, 2014), while SIDS such as the Caribbean Community (CARICOM) aim to improve their maritime sector, claims that *"…enhancing the maritime sector has the potential to fuel CARICOMs trade, increase port productivity and generate significant cost savings…"* (CARICOM, 2013).

While significant research has been conducted in the area of port efficiency and productivity over the years, none has been applied to the specific challenges faced by the SIDS ports. However, in recent times, three studies have analysed port efficiency and productivity in the Caribbean. Wilmsmeier et al.. (2013b) analysed the evolution of container terminal productivity and efficiency of 20 terminals in Latin America and the Caribbean (LAC) and Spain during the period 2005–2011. Serebrisky et al.. (2016) tested the efficiencies of 63 LAC ports representing 90% of cargo handling during 1999-2009. Suarez-Aleman et al.. (2016) investigated the regional differences in developing countries' ports, including 64 LAC ports from 2000-2010. While key lessons have been drawn from these researches, this thesis builds on these papers by analysing Caribbean island ports in their context as SIDS ports, within the global sample of SIDS ports located throughout the world.

This research therefore seeks to build on the recent work (Wilmsmeier et al.., 2013; Serebrisky et al.., 2016; Suarez-Aleman et al.., 2016), with primary focus on SIDS. It will also contribute to the existing literature on port efficiency and productivity, by looking at how and which factors influence these ports' performance. Furthermore, it also brings a practical contribution to the future development of SIDS ports, as is the agenda of local, regional (CARICOM), and international organizations (the UN).

This analysis centres on a comparison between the world's top ports, ports of Central and South America, and the Caribbean and other SIDS. Given the importance of trade to Caribbean, this research will show the changes in the region and if it has kept pace or not compared to the progress of top ports and changes in international trade. A decomposition of productivity change in the form of efficiency and technical changes will be further investigated, while exploring the contributors of port efficiency.

1.2 RESEARCH HYPOTHESES

The primary research question of this investigation will seek to answer the question: **"How has the technical efficiency and productivity of Small Island Developing States ports progressed over the last decade, due to port development opportunities?"**

The research question will be answered by first proposing the following research hypotheses derived from a reading of the literature:

Efficiency:

Hypothesis 1: *Under Constant Returns to Scale (CRS) measures, there has been no change in general port efficiency over the last decade.*

Hypothesis 2: *Given the effects of returns to scale, under Variable Returns to Scale (VRS) measures there has been a general improvement in port efficiency over the last decade.*

Hypothesis 3: *Caribbean ports are less efficient than TOP ports, but more efficient than Other Small Island Developing States (OSIDS) ports.*

***Productivity**:*

Hypothesis 4: *Total Factor Productivity (TFP) in the port sector has been positive over the last decade, and most of this have been driven by technical progress (TC) and not efficiency change (EC).*

Hypothesis 5: *Over the whole period, Caribbean ports have experienced higher TFP changes than TOP ports, and most of this is because of efficiency change (EC) rather than technical progress (TC).*
Hypothesis 6: *Over the whole period, Caribbean ports have experienced higher scale efficiencies in comparison to TOP ports.*

1.3 METHODOLOGY

Approach to Measuring Efficiency and Productivity

A formal definition of technical efficiency provided by Koopmans (1951; p.60) states that a decision making unit is fully efficient if and only if it is not possible to improve its output for a given level of inputs or decrease any of its input for a given level of output (Koopmans, 1951; Cooper et al.., 2007). Debreu (1951) and Farrell (1957) introduced two special cases of measuring technical efficiency- the input and output oriented approaches. With an input orientation, the output vector is fixed and calls a feasible input vector technically efficient if, and only if, no reduction in any input is feasible. On the other hand, an output oriented measure holds the input vector fixed and calls a feasible output vector technically efficient if, and only if, no increase in any output is feasible.

Over the past few decades, a number of methods used for measuring technical efficiency have been put forward, which are primarily centred on estimation of the production possibility frontier (discussed in the following chapters). Two main groups are those based essentially on the use of linear programming techniques, and those based on econometric measurement.

To date, however, within the literature on transport related studies there exists no academic research that justifies the best approach to measuring technical efficiency and productivity. Despite this, drawing from past research and particularly from within the maritime industry, the methods which are most commonly used. For purposes of this research, the Data Envelopment Analysis (DEA) will be employed, as it measures both efficiency and productivity changes, given panel data.

The DEA analysis is broadly defined as a non-parametric approach that uses linear programming to measure the relative efficiency of a decision-making unit (DMU). The frontier is obtained by identifying the highest potential output given different input combinations, and the degree of efficiency is measured using the distance between the observation and the frontier (Liu 2010).

The DEA efficiencies are tested under the assumptions of *constant returns to scale (CRS) and/or variable returns to scale (VRS),* applying the CCR and BCC models respectively*.* The CRS assumption is only appropriate when all firms are operating at an optimal scale. Here the DMU is operating where an increase in inputs results in a proportionate increase in the output levels. With the VRS, an increase in inputs does not only result in the possibility of a constant change in the outputs (CRS) but is also characterized by increasing returns to scale (IRS) (output increases by more than that proportional change in inputs), and decreasing returns to scale (DRS) (output increases by less than that proportional change in inputs).

Furthermore, applying the DEA- based Malmquist Productivity Index (MPI), tests for productivity change overtime. This approach comprises of temporal (here, year on year) changes in technical efficiency (the catch up effect brought about by managerial best practises (pure effect) and investments in new facilities and/or expansion of existing facilities (scale effect)) and technology (frontier shift effect resulting from technological progress) over the entire period of investigation. This approach helps in not only identifying the change in productivity overtime, but also in identifying the main and secondary causes of the effects of technical efficiency on productivity (Nishimizu and Page, 1982; Grifell and Lovell, 1993; Estache et al.., 2004; Cheon et al.., 2010).

1.4 POSSIBLE IMPACT AND RELEVANCE OF THE RESEARCH

This research aims to explore the economic theories behind container port efficiency. Trends in total factor productivity are analysed by investigating its components: technical change and efficiency change, given a decade's worth of data. This approach was undertaken, as this is one key component known to influence the port's progress and development. The research applies the foundational micro-economic theory of production, which produces a well-informed rationale leading to policy recommendations that can guide local, regional and international decision makers.

This research presents a framework that seeks to measure, analyse, and compare port efficiency and productivity over a ten-year period. This will be looked at from the perspective of how port policy and development strategies have affected efficiency and productivity over time.

The answers to the research hypotheses and emerging findings can contribute to the formulation of port policies in the SIDS region, as to the appropriate need for port investment or lack thereof. Policy recommendations can therefore provide input to the policy decisions of international (UNCTAD), regional (CARICOM) and country level decision makers.

1.5 STRUCTURE OF THE THESIS

Following on from the introduction in Chapter 1, the structure of this thesis is depicted in Table 1.1 and as follows:

Since the Caribbean region is the primary focus of this research, Chapter 2 presents an overview of the Caribbean community. This gives much insight into the region's international and regional trade, trading arrangements, port operations and traffic, and hindrances to the ports' performance. This allows greater insights into the region, before empirical analysis begin in the following chapters. Lastly, the region's development initiatives undertaken over the years concerning internal and external projects, donors, ongoing projects and future proposals, will be explored.

Chapter 3 takes an economic approach to discussing the operations, economic functions of container ports and their advancement over the centuries. Lastly, literature pertaining to port planning and development is reviewed to see how technical efficiency has come to play an integral part of the port's development.

Thereafter, chapter 4 presents a literature review on production theory, its applicability to port efficiency and previous research conducted. Moreover, the available contemporary approaches to measuring technical efficiency/productivity and their uses in the container port industry are reviewed. Among others, this includes Data Envelopment Analysis (DEA). Thereafter the chapter explores the key factors influencing the operations and so efficiencies of seaports, and delves into the use of various tests employed by previous authors in testing for technical efficiency. This chapter provides a methodological foundation which will be used for further empirical analysis and testing of the technical efficiencies of container ports in the subsequent chapters.

The methodology aspect is considered in Chapter 5. This chapter presents an efficiency measurement system, which is a powerful tool for evaluating performance. The system is used as a framework for the units of analysis and sets the way for empirical analysis in the next chapter. This chapter includes identifying the units, recognising and justifying the choice of output and input factors, data sources and collection and the approaches used in measuring technical efficiency.

In Chapter 6 the empirical results, descriptive statistics and analysis are reported and critically discussed, while lastly hypotheses are validated. Chapter 7 discusses the results in the context of recent port development initiatives undertaken and future proposed for Caribbean ports. These results then lead into chapter 8 where a summary of the overall research is presented, followed by policy recommendations derived from the research. Finally, limitations of the research are discussed and the opportunity for further research is suggested.

Table 1.1 Thesis Structure

Chapter 1 Introduction
Research background, research question and hypothesis, methodology, impact and relevance, structure of thesis

↓

Chapter 2 The Caribbean Economy
Macro/Micro Economy, International and Regional Trade Regime, Traffic Throughput and Major markets, Port composition/ structure, Hindrances to port development, Port Development Initiatives

↓

Chapter 3 Economic Approach to Container Seaports
Economic functions & administration models/ benefits of seaports, evolution and trends, port planning and

↓

Chapter 4 Production Theory and Port Efficiency/Productivity
Production technology and function, economics of technical efficiency, contemporary approaches to technical efficiency measurement, key factors of port efficiency, literature review on port efficiency

↓

Chapter 5 Methodology
Efficiency measurement system, application of system to study, model specification

↓

Chapter 6 Empirical Results and Analysis
Efficiency / Productivity Analysis and Hypotheses

↓

Chapter 7 Discussion of Results and Reflection on Port Development in Caribbean
Port development initiatives undertaken, on-going, and proposed and validation of hypotheses in line with test results and qualitative assessment

↓

Chapter 8 Conclusion, Recommendations, Limitations, and Further Research
Thesis summary and main contributions, recommendations, limitations and areas of further research

CHAPTER TWO

OVERVIEW OF THE CARIBBEAN ECONOMIES & PORTS

2.1 INTRODUCTION

The Caribbean, having derived its name from one of the main indigenous groups of inhabitants referred as the *Carib,* is known for its tropical climatic attributes of 'sun, sea and sand.' The region is geographically situated within the territories of the south east of North America, east of Central America and to the north of South America while the expanse of waters surrounding the region includes the North Atlantic Ocean, the Caribbean Sea and the Gulf of Mexico.

Given this regions' physiography, its locality has allowed it to reap the advantages of maritime transport along the major transatlantic trade routes. It is mostly covered by sea and contains approximately 700 islands which are situated roughly between the latitudes 10˚ to 27˚N and longitudes 57˚ to 87˚W spanning the furthermost nations of the Bahamas in the north, Trinidad and Tobago to the south, Barbados in the east and the Cayman islands to the west (Nkemdirim 1997) (see Figure 2.1).

Among these 700 islands, most of which are uninhabited, thirty-one nations are populated; of these, thirteen countries have assumed independent status while eighteen of the other islands remain under the sovereignty of an authority by European nations such as the United Kingdom, France or the Netherlands.

Of these, twelve Caribbean islands are members of the fifteen CARICOM countries. Internationally classified by the UN as SIDS, and stipulated under the Revised Treaty of Chaguaramas Act, the More Developed Countries (MDCs) of CARICOM are The Bahamas, Barbados, Jamaica, and Trinidad and Tobago, while the Less Developed Countries (LDCs) comprise the rest of CARICOM. These are distinguished based upon the countries' standards of living as MDCs display higher levels of growth and development than LDCs (CARICOM 2001, UN 2012) (see Table 2.1). [1]

Over the past decades there have been substantial migration of Caribbean citizens to the developed nations primarily host nation the United States of America. In anticipation of better living standards for the emigrant and remaining local household, remittances have become a major source of revenue for the region. In 2013 remittances (i.e. local emigrants living abroad sending money back home to their family) were recorded at US $9billion compared to two decades ago when it was below US$2billion (Maldonado 2013, Sampson & Branch-Vital 2013).

This alarming level has benefitted the region in areas of poverty reduction, economic growth and development and balance of payment improvements. While this is so, it has not come without adverse effects resulting in the "*brain-drain effect*" as nationals migrate in search of better living opportunities carrying with them expertise and knowledge (Connell & Conway 2000). This has been the main reason, but not the only one, that has contributed to the steady decline in the region's population over the past decade of above 30% at approximately 21 million in 2013 (World Bank, 2014a).

Every economy within the region remains unique, with respect to its culture, geographic size and economic structure. Its cultures have long been influenced by its past colony traditions which originate primarily from the British, French, Dutch and Spanish. These colonial powers governed the way in which each country's economic affairs and institutional frameworks were planned and implemented and still today has left a lingering effect on independent states. Additionally, the influxes of labourers in the nineteenth century from Africa and Asia have resulted in elements of African and Indian traditions. Overall many influences have rendered the Caribbean culture multi-ethnic and multi-diverse concerning its culinary arts, artistic styles and general way of living.

[1] For purposes of this research, CARICOM refers to solely the Caribbean.

Given each country's relatively small geographic sizes, the United Nations has classified the region within its generic classification of SIDS among other south sea islands. The Caribbean's size, together with its narrow natural resource endowments, high import content, vulnerability to natural disasters and economic shocks, remoteness, and high emigration, accounts for its lower level of economic growth than developed nations.

Furthermore, the region's economic structures are dependent upon its unique resource endowments. The Bahamas, Barbados, the Organization of Eastern Caribbean States (OECS) (see Table 2.2); obtain their main source of income from the tourism industry (service industry). Jamaica, Belize, and the Windward Islands (viz Grenada, Martinique, Saint Lucia, Saint Vincent and the Grenadines) pride themselves in the agriculture sector (banana, sugar, spices, cocoa, alcohol: rum). On the other hand, Trinidad and Tobago receives most of its revenues from the energy industry (petroleum, oil). Furthermore, the strategic locality of Jamaica and the Bahamas affords the benefits of being global hub ports, while Trinidad and Tobago functions as the Caribbean's regional hub port.

Achieving full regional integration via the Caribbean Single Market and Economy (CSME) has become a milestone for the region since the 1990's and become fully established in 2015. The organization consists of twelve member states with nine countries from CARICOM (see Table 2.1). CSME and its objectives will be elaborated on in section 2.3.2.

Given the countries' distinctive characteristics and similar setbacks, regional integration is expected to improve the development of the region by enlarging markets, diversifying production and trade which will bring the region economies of scale since independent small markets limit opportunities for this (UNECLAC 2014). The current challenges include the effects of brain- drain and lack of technological advancements resulting in lower factor inputs and productivity, substandard competitiveness, poor institutional quality, weak private sector, macroeconomic instability, and heavy reliance on donor nations.

In light of globalization and trade liberalization, these concerns present a major problem for the improvement of the region's economic activities, in particular those relating to international trade due to its heavy contribution to economic output. In light of this, CARICOMs seaport industry, which is predominantly the lifeblood through which goods and services flow, must be at the competitive edge where superior value is offered over its near neighbours, or be forced out of the market.

This chapter will present an overview of the Caribbean community. This gives much insight into the region macro and micro economies. Particularly, it's substantial dependence upon international trade, various trading arrangements, and so port operations/ traffic. Moreover, several hindrances to port performance. These all present further insight into the Caribbean port industry, which will aid in adequate policy recommendations later on.

Figure 2.1 Geographical Location of the Caribbean Region

Source: (Worldatlas, 2015)

Table 2.1 Island Caribbean Economies

COUNTRY	STATUS	ADMINISTERING AUTHORITY	CARICOM	MDC	LDC	OECS	CSME
ANGUILLA		United Kingdom				√	
ANTIGUA & BARBUDA	Independent		√		√	√	√
ARUBA		The Netherlands					
BAHAMAS	Independent		√	√			
BARBADOS	Independent		√	√			√
BERMUDA		United Kingdom					
BONAIRE		The Netherlands					
BRITISH VIRGIN ISLANDS		United Kingdom				√	
CAYMAN ISLANDS		United Kingdom					
CUBA	Independent						
CURACAO		The Netherlands					
DOMINICA	Independent		√		√	√	√
DOMINICAN REPUBLIC	Independent						
GRENADA	Independent		√		√	√	√
GUADELOUPE		France					
HAITI	Independent		√		√		
JAMAICA	Independent		√	√			√
MARTINIQUE		France					
MONTSERRAT		United Kingdom	√		√	√	
PUERTO RICO		United States					
SABA		The Netherlands					
SAINT BARTHELEMY		France					
SAINT KITTS AND NEVIS	Independent		√		√	√	√
SAINT LUCIA	Independent		√		√	√	√
SAINT MARTIN		France					
SAINT VINCENT & THE GRENADINES	Independent		√		√	√	√
SINT EUSTATIUS		The Netherlands					
SINT MAARTEN		The Netherlands					
TRINIDAD & TOBAGO	Independent		√	√			√
TURKS & CAICOS ISLANDS		United Kingdom					
UNITED STATES VIRGIN ISLANDS		United States					

Source: (CARICOM, 2015; United Nations, 2012)

2.2 THE CARIBBEAN ECONOMY

2.2.1 Macro Economy

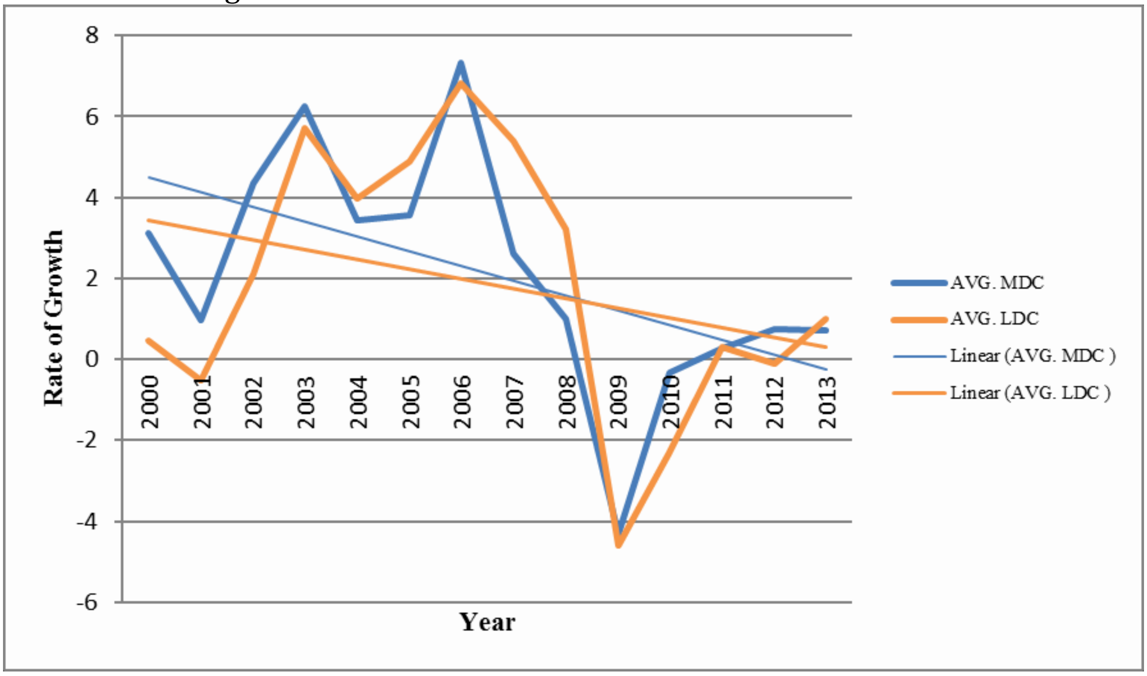
In a comparative investigation of the Caribbean, the countries' geographic and population sizes and natural resources, primarily account for their levels of economic development. Though they have similar characteristics which are likened to the "plantation economy" (Fay 1936), the subtle differences have grave impacts upon their economies.

Over the past decade, the annual rates of growth of Gross Domestic Product (GDP), for both MDCs and LDCs, have shown an overall downward trend ending 2013, as illustrated in Figure 2.2. The slightly steeper slope of the trend line for MDCs shows a greater change than LDCs. Overall, the region has grown as high as 7% in 2006 prior to the economic crisis in 2008 which the resultant economic recession resulted in a fall of 11% to -4% in 2009.

In the most recent years (2009- 2013), the region has managed to regain its momentum, given the world's sluggish growth, growing by almost 1.5% for MDCs and less than 1% for LDCs. Furthermore, a comparison of the Caribbean's growth to the world's richest Organization for Economic Cooperation and Development (OECD) countries show a high susceptibility with respect to its trade openness and dependence toward the world's power giants (Briguglio 1995; Easterly & Kraay 2000; Read 2004; Streeten 1993).

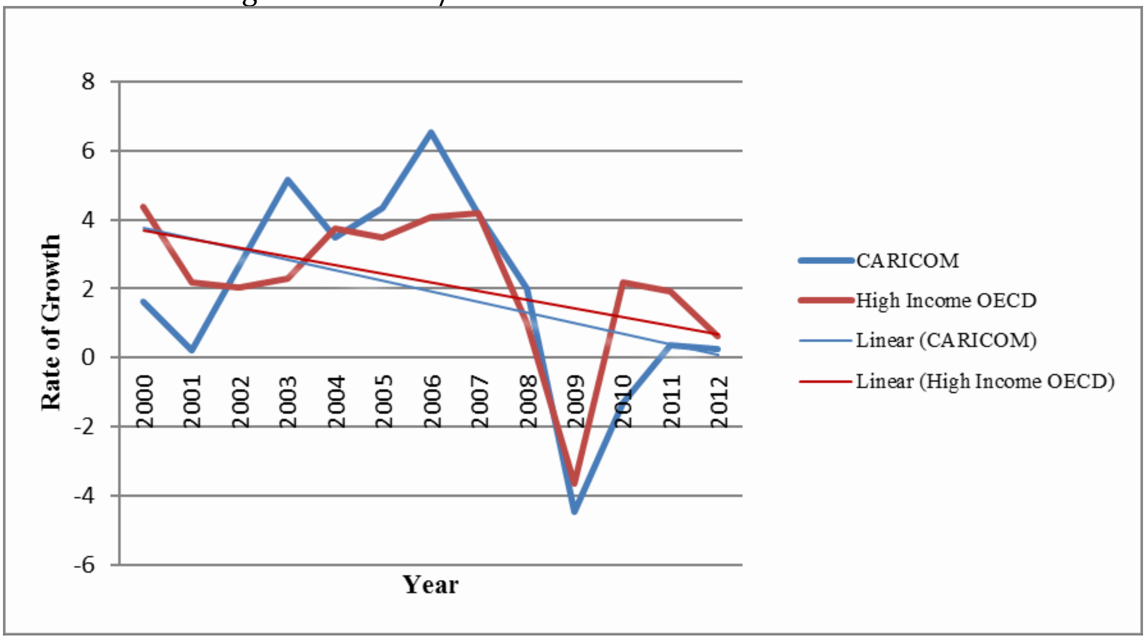
Despite fluctuations, over the period 2000 to 2012 both groups show similar trends, reflecting an overall downward trend in economic growth with a very close growth average of 2.28% and 2.19% for the Caribbean and OECD respectively (see Figure 2.3) (World Bank, 2014b).

Figure 2.2 CARICOM Rate of Growth of GDP: MDC & LDC



Source: (World Bank, 2014b)

Figure 2.3 OECD/CARICOM Rate of Growth of GDP



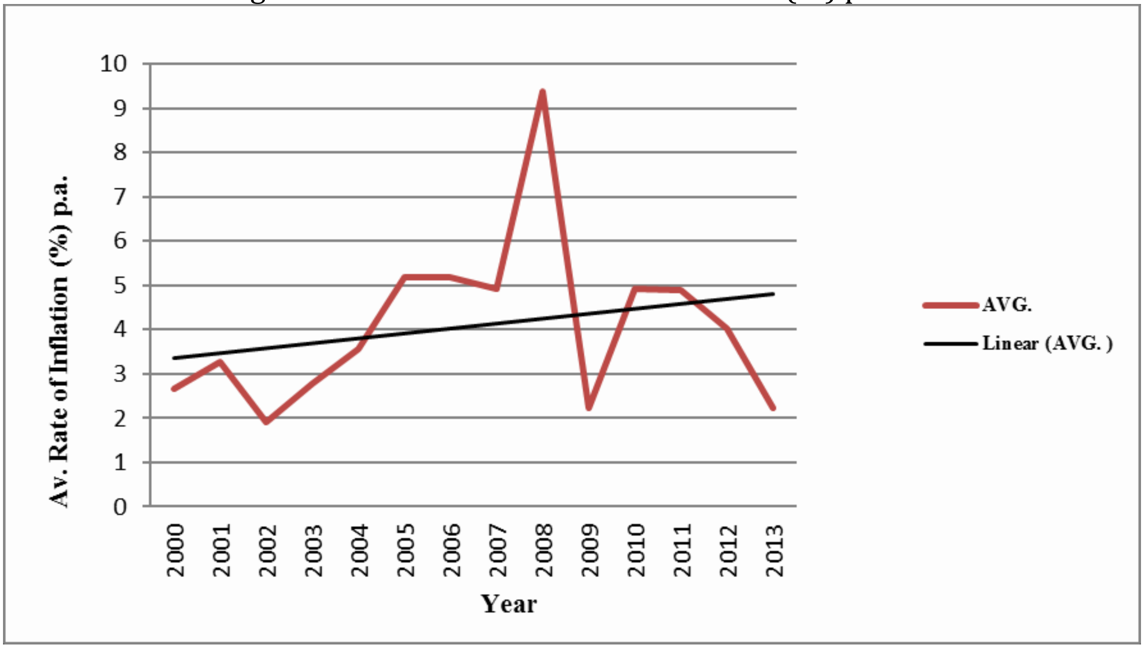
Source: (World Bank, 2014b)

Over the ten-year period (2001-2011), the region's annual rate of inflation depicted an upward trend. Its largest rise to 9% occurred in 2008 amidst the economic and financial crisis. Thereafter, the contraction and soon recovery of the world economy, resulted in a drop to 2% in 2013 (see Figure 2.4). The majority of countries did not incur double digit inflation rates with the exception of Jamaica in 2008 which recorded its highest rate of 22% as result of the high cost commodities market and high unemployment rate (Dacosta and Greenidge 2008; The World Bank 2014c). This is bad to a country, as continual rising inflation rates, is likened to a tax on money holders, being consumers and firms, which means a diminishing of purchasing power. This also leads to unemployment as firms' cost of production increases.

On the other hand, the richer countries (MDC) are reported to have higher inflation rates than their poorer counterparts (LDC). In the earlier year of 2003 and more recently 2013, all LDCs have still managed an average inflation rate of approximately 2%. They have managed to maintain lower rates of inflation due to the establishment of its single currency board arrangement, as members of the Organisation for Eastern Caribbean States (OECS) group (Mccarthy & Zanalda 1995). With the exception of Barbados which recorded low rates similar to the LDCs, Jamaica and Trinidad and Tobago rates have been above 4% and as high as 10% for the Jamaican economy (see Figure 2.5).

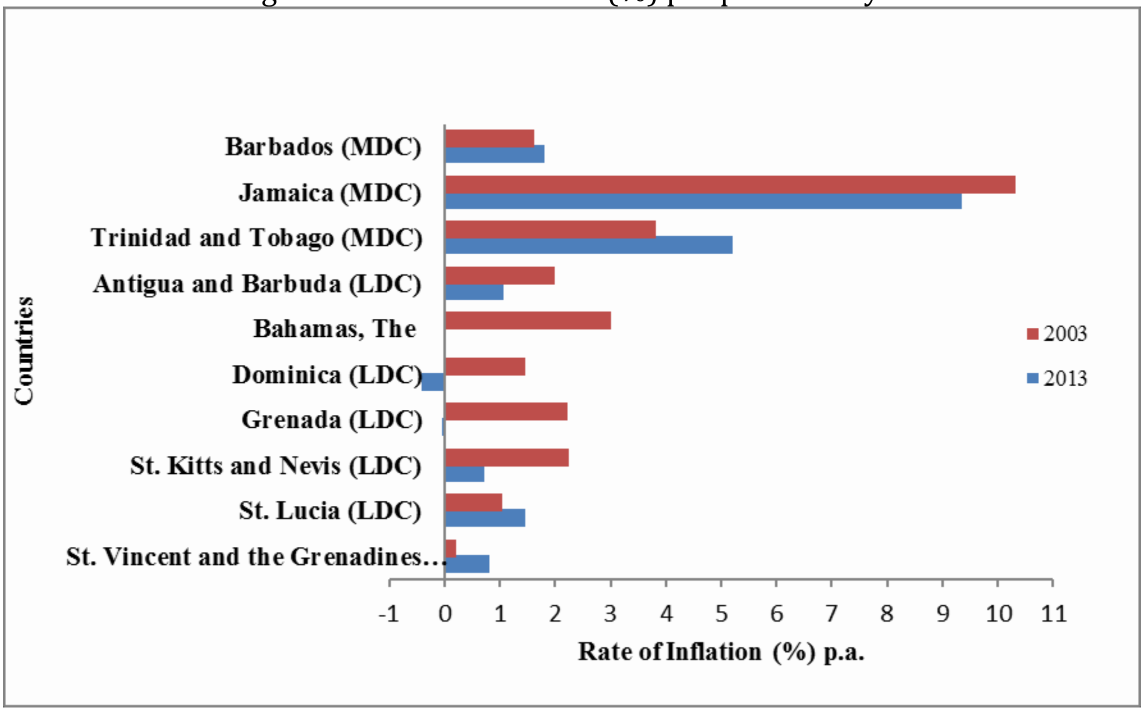
Generally, the primary factors known to impact the region's rate of inflation have been a combination of demand-pull, cost-push and imported inflation. These have continued to manifest itself as compounded with expansionary fiscal and monetary policies, unstable exchange rates (particularly Jamaica's floating exchange rate regime), high unemployment, money supply and interest rate fluctuations and imported inflation (Nicholis et al.., 1995; Rajapatirana and Seerattan 2000; Dacosta and Greenidge 2008).

Figure 2.4 CARICOM Av. Rate of Inflation (%) p.a.



Source: (World Bank, 2014c)

Figure 2.5 Rate of Inflation (%) p.a. per country



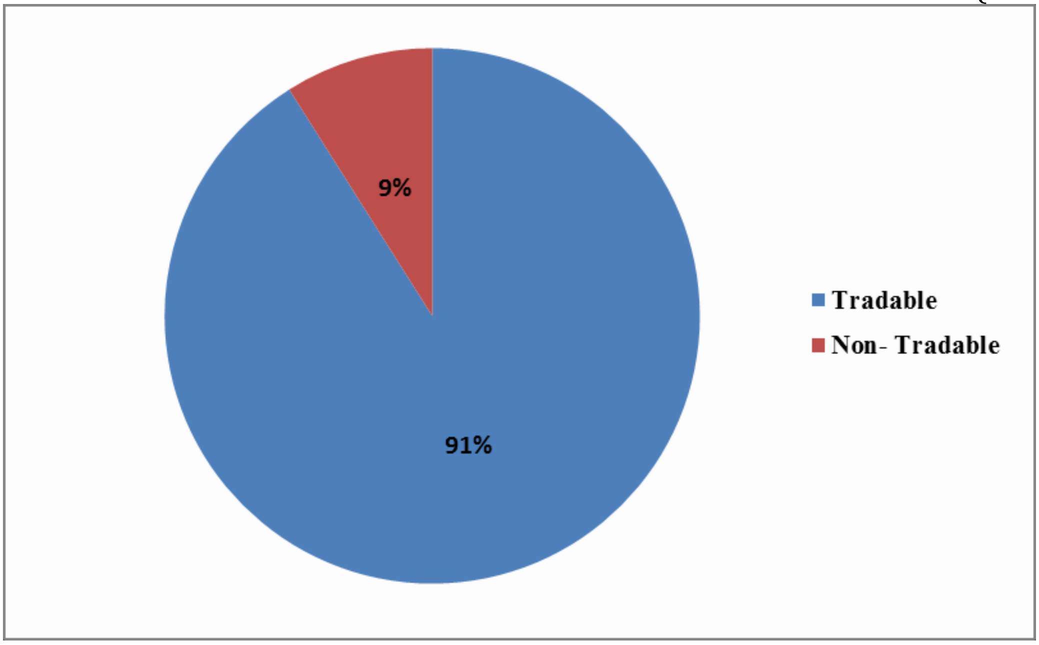
Source: (World Bank, 2014c)

The Caribbean is distinguished for its "openness" synonymous to its large dependence upon international trade. The countries' small geographical size and limited range of natural resources endowments which are primarily agricultural, results in relatively high import content, in relation to its GDP (Briguglio 1995).

For instance in 2012, the majority of countries which include MDCs among others, recorded trade deficits and have been so over the past years, with exception of periods prior to the financial economic crisis (see Appendix 1).

The region's trade sector continues to contribute a vast percentage to its GDP; according to the World Bank, its Trade-to-GDP-ratio in 2012 was approximately 91% (World Bank, 2014d). Compared to the United Kingdom for instance with a trade- to- GDP ratio of around 60%, this shows CARICOM's vast openness to trade. Domestic producers remain heavily reliant on foreign demand while domestic consumers are geared towards the foreign supply for goods and services (see Figure 2.6).

Figure 2.6 CARICOM Trade Sector Contribution to Gross Domestic Product (2012)

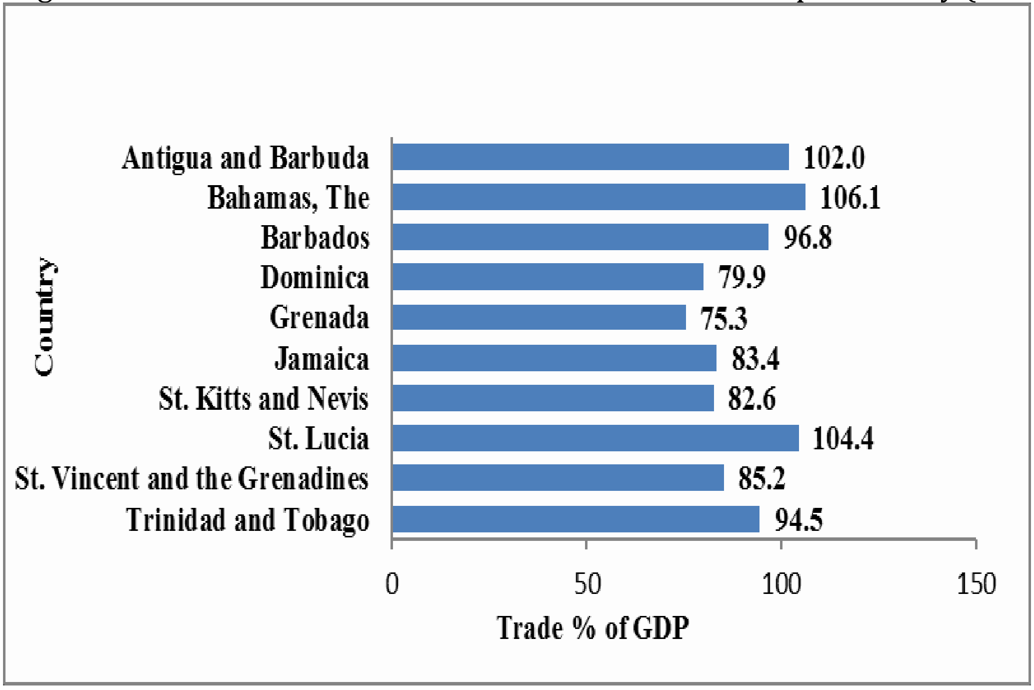


Source: (World Bank, 2014d)

Calculated at current prices, a high degree of trade openness is attributable to the individual countries in which all have shown ratios which are above three quarters of their Gross Domestic Product. According to the World Bank national accounts data, trade openness is calculated as Trade (% of GDP) being the sum of exports and imports of goods and services measured as a share of gross domestic product i.e. (value of import + value of exports/ GDP) (World Bank, 2018).

In the year 2012, Antigua and Barbuda (102%), the Bahamas (106%), Barbados (96.8%), St. Lucia (104%) and Trinidad and Tobago (95%) had ratios of approximately 100%, with The Bahamas having the largest Trade-to-GDP-ratio (see Figure 2.7).

Figure 2.7 Trade Contribution to Gross Domestic Product per country (2012)

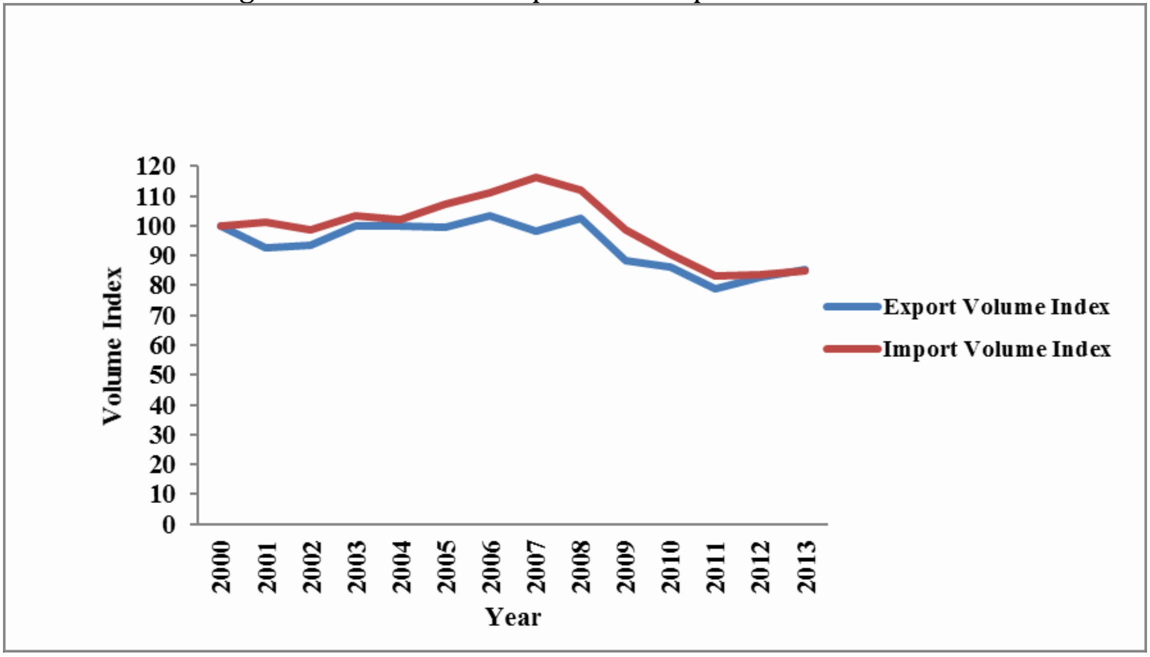


Source: (World Bank, 2014d)

This has shown the region's large openness and dependence on international markets and trade. Though the region imports goods and services to satisfy home demand and for use as intermediate inputs for production, the added value created from the various sectors as will be further investigated in section 2.2.2 are usually greater than total economic output (Hilaire & Dhoray-Baig 2013).

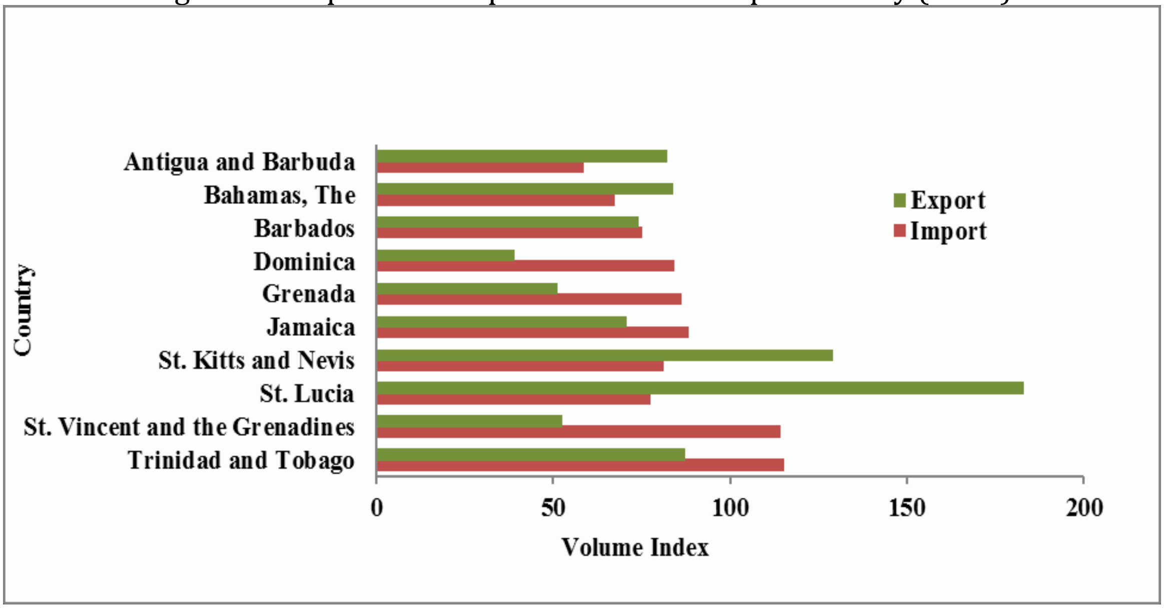
Furthermore, introducing the volume index measures the region's level of imports versus its exports. Prior to the crisis both imports and exports showed upward trends in growth reaching a high of index 116 for imports and 103 for exports, given a base year of 100 in 2000. After 2008, the volume of both imports and exports declined averaging around index 80 in 2011 (see Figure 2.8). More recently, as world demand has been recovering, signs of growth are evident but at a very slow pace averaging around 90. The majority of countries which also include MDCs show larger import volume indices in relation to its corresponding exports in 2013 (see Figure 2.9, and Appendix 2).

Figure 2.8 CARICOM Export and Import Volume Index



Source: (World Bank, 2014e)

Figure 2.9 Export and Import Volume Index per country (2013)



Source: (World Bank, 2014e)

2.2.2 Micro Economy

The Caribbean's micro economic environment, with respect to its production and export structures, has long been influenced by its colonial past. Given its export market which comprised of primarily agricultural goods, under the authority of a colonial government, the Caribbean was labelled a "plantation economy." Fay's article on the Plantation Economy relates the plantation system to:

> *"The acquisition of a limited but fairly extensive area for the cultivation of a particular crops ..."* (Fay 1936)

The region provided a settlement for labourers to exploit the agricultural sector given its natural resources. Because of the land being cultivated and fertile, the economies gained long-term preferential trade access, in particular with their mother colony such as the European market and the United States. The main agricultural export commodities included bananas, sugar, rice, tobacco, rum, spices and other vegetables were exported on a large scale from the Organization of Eastern Caribbean States (OECS), Dominican Republic, Trinidad and Tobago and Jamaica.

While these main commodities remained the major source of production and therefore export revenue but drastically began declining over the years. The effects of trade liberalization resulted in increased agriculture import substitutes, while competition from Latin American and African suppliers due to lower labour costs, led to a fall in its exports (Griffith 2010).

Today, many of the countries have shifted their dependence away from agricultural based exports; in most cases, the sector contributes less than 10% toward Gross Domestic Product. Factor endowments are now allocated toward more profitable sectors such as manufacturing and services. The manufacturing sector, according to the World Bank, comprises areas of commerce such as construction, electricity, water, gas and agro-processing. Its value added is the sum of net output after adding up all outputs and subtracting intermediate inputs (inputs used in the production of other goods).

On the other hand, services largely include tourism related business and added value in the areas of hotels, restaurants and transport, but also includes education, health care, communications and financial services, particularly offshore banking services.

The energy industry of Trinidad and Tobago continues to contribute the most to national income in relation of other countries. Its main source of income is derived from this sector and together with the agro-processing, industry (such as fertilizers, flour milling, rice, fish canning etc.) accounted for 57% of Gross Domestic Product (GDP) in 2013. Of significance also, St. Kitts and Nevis' electronics (producer of transmission apparatus for radios, telephones and televisions) and sugar processing industries accounted for 26% while Jamaica's bauxite and aluminium industry contributed 21% to national income which the most of these are exported (see Table 2.2).

With respect to the region's services sector which accounts for the majority of national income, its top seven travel and tourism economies in 2013 were Aruba (84.1%), the United Kingdom Virgin Islands (76.9%), Antigua and Barbuda (62.8%), Anguilla (57.1%), the Bahamas (46%), St. Lucia (38.7%) and Barbados (36.2%). These islands have also remained the top seven during the period 2009-2013 (see Appendix 3).

With the exception of Trinidad and Tobago (43%), the services sector has contributed almost three quarters to GDP in all countries, with Barbados (83%), St. Lucia (83%), Antigua and Barbuda (80%) and the Bahamas (80%) accounting for the most (see Table 2.2). In addition to the tourism related area of commerce, offshore banking services for instance in the Bahamas resulted in its contribution to national income.

Having investigated the overall structure of the Caribbean economy, and where most of its economic activities are established for domestic and international consumption, the following section will investigate the structures and patterns of international trade within which these economies engage.

Table 2.2 Structure of CARICOM Economies

Country	*Year*	*Agriculture Value Added (% of GDP)*	*Industry Value Added (% of GDP)*	*Manufacturing Value Added (% of GDP)*	*Services (% of GDP)*
Antigua and Barbuda	2013	2	18	3	80
Bahamas	2013	2	18	4	80
Barbados	2012	1	16	7	83
Dominica	2013	17	14	3	69
Grenada	2013	6	15	4	79
Jamaica	2012	7	21	9	72
Saint Kitts and Nevis	2013	2	26	11	73
Saint Lucia	2013	3	14	3	83
Saint Vincent and the Grenadines	2013	7	18	5	75
Trinidad and Tobago	2013	1	57	6	43

Source: (World Bank, 2014f)

2.3 INTERNATIONAL AND REGIONAL TRADE REGIME

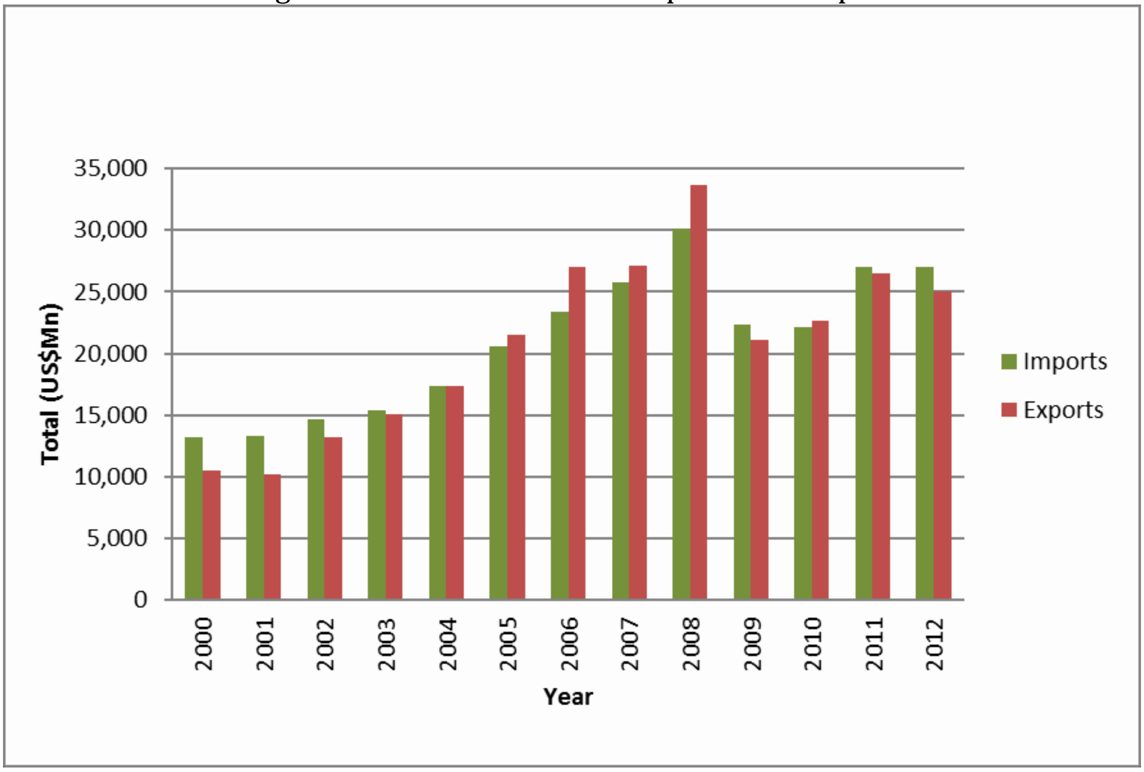
2.3.1 Patterns and Partners of Trade

The Caribbean's attributes that render the states "*small and open*," limits their productive capacities while being highly dependent upon its trade partners for factors of production and finished goods. The region's pattern of trade as discussed in section 2.2.2 includes top imports such as automobiles, telecommunications and industrialized machinery and equipment while exports comprise primarily industrialized commodities such as iron ore, aluminium, petroleum, natural gas and agro- processing.

Over the past twelve years ending in the year 2012, CARICOMs total imports and exports for goods and services have shown an overall upward trend in growth despite the global economic crisis in 2007/2008 which thereafter resulted in a decline. The region's imports increased by 105 % to US$27,068Mn in 2012 while exports by 138 % to US$25,031Mn for the duration of the period (see Figure 2.10)[2].

[2] Refer to Appendix 1 for CARICOMs Total Imports and Exports for the period 2000 to 2012.

Figure 2.10 CARICOM Total Imports and Exports



Source: (World Bank, 2014e)

The More Developed Countries (MDCs) in the region contributed to the bulk of CARICOMs trade, collectively accounting for just over two thirds of the total CARICOM trade for exports and imports. For this group, Trinidad and Tobago held the bulk of this share as its exports and imports were approximately half of the CARICOM region's total international trade. On the other hand, Lesser Developed Countries (LDCs) reflected only 24% of the region's exports and 30% imports with the Bahamas representing the majority of the share with 16% exports and 18% imports (see Appendix 1).

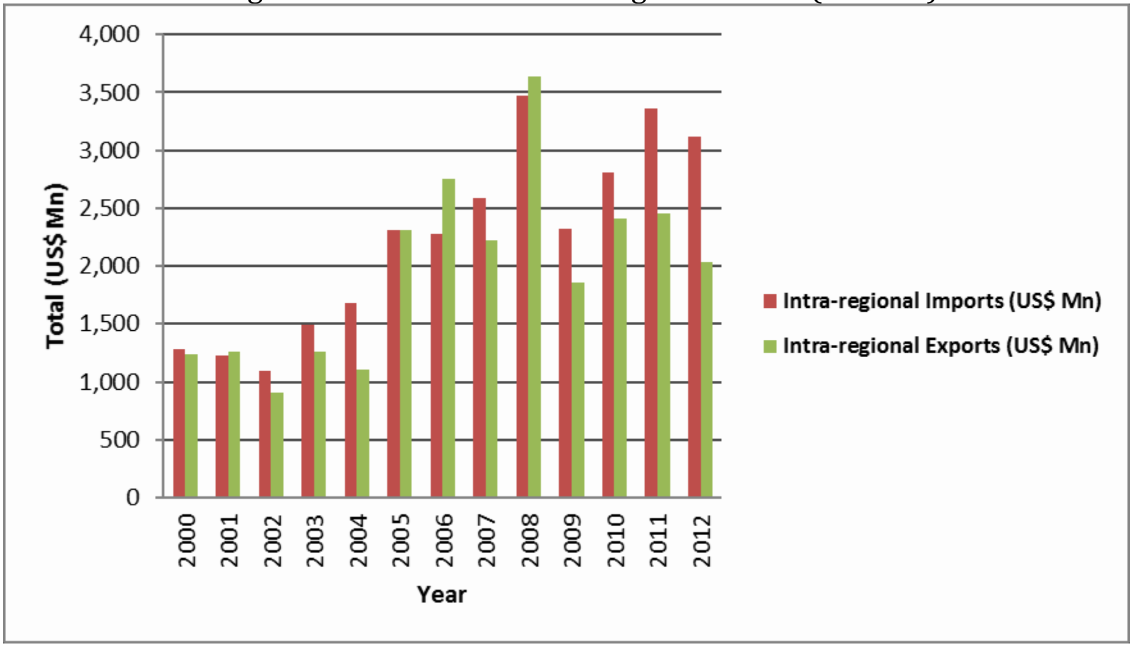
A closer analysis of the region's trading patterns, show that CARICOMs extra-regional trade has continued to dominate its intra- regional market for goods and services. For instance in 2012, extra regional imports represented 73% of total imports with intra-regional imports accounting for 8%; on the other hand, in the aforementioned year extra regional exports marked 51% of total exports with 8% belonging to intra-regional exports (see Appendix 4).

Intra- regional trade is the economic exchange of goods and services primarily between countries of the same trading bloc based on agreed trading arrangements. This trade flow is mainly engaged by MDCs. In the year 2012, Trinidad and Tobago was the region's leading exporter (82%), while Jamaica (38%) and Barbados (28%) were the major importers; OECS countries followed shortly behind with 25% of the region's total imports (see Appendix 5).

Prior to the world's economic crisis, exports grew higher than imports. Exports increased by 195% while imports by 162% during the period 2000 to 2008. Exports and imports were recorded at their highest in 2008 with US$3640Mn and US$2768Mn respectively; this was partly attributed to the region's growing demand fuelled by a growing population and consumption for imports while reliance on inelastic demand energy associated commodities from Trinidad and Tobago and tourism related industries in the other islands contributed to export revenues.

On the other hand, the post economic crisis period showed an overall decline in intra-regional trade. Owing to the region's high susceptibility to the international market, its imports fell by 39% while exports fell by almost 50% during the period 2008/2009 alone. This however was shortly changed as demand gradually recovered; subsequent to the great drop in 2009, imports grew by 33% from 2009 to 2012 to US$2,240Mn in 2012 while exports slowly recouped growing by only 10% to US$2,032 in 2012 (see Figure 2.11, Appendix 5).

Figure 2.11 CARICOM Intra-regional Trade (US$ Mn)



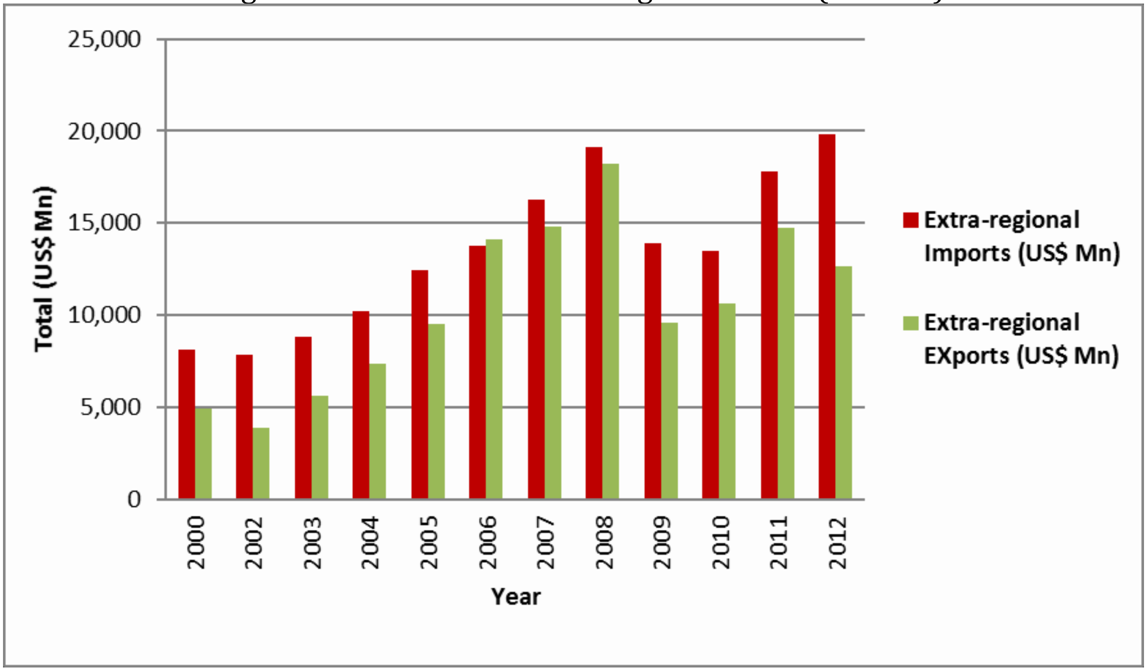
Source: (CARICOM, 2014)

Extra- regional trade as examined previously accounts for the bulk of CARICOM'S international trade. Extra- regional trade is the economic exchange of goods and services primarily between a country/ countries of the same trading bloc and the rest of the world. The top international partners with which this trade takes place includes the United States of America (they accounted for approximately 30% of all imports in 2012), Latin America (15%) and Asia (8%) while export markets for 2012 include the United States (30%), Europe (4.5%), the Caribbean (3.6%) and Latin America (3.4%) (CARICOM 2014). These countries engage in trade with chiefly the MDCs of which Trinidad and Tobago remains the dominant importer and exporter accounting for 48% and 81% respectively in CARICOM (see Appendix 5).

Prior to the financial economic crisis, just as intra- regional trade, imports and exports grew by 54% and 91% respectively during the period 2005 to 2008 to US$19096Mn and US$18228Mn. The collapse of the world economy became evident throughout the region as both imports and exports decreased in 2009, exports falling (47%) at the faster rate than its imports (27%). Thereafter, the region has slowly been regaining its momentum as world demand increased, imports rising by 42% and exports by 32% for the period 2009-2012 to

US$19775Mn and US$12663Mn in 2012 (see Figure 2.12, Appendix 6, get from other doc.).

Figure 2.12 CARICOM Extra- regional Trade (US$ Mn)



Source: (CARICOM TradSys Online, 2014)

2.3.2 Trading Arrangements

The Caribbean community (CARICOM) engages in organized trading arrangements at the multilateral, bilateral and regional platforms. Trading arrangements are negotiated among member countries, which afford the region access to international markets, deepen its regional integration ties and foster agreements between individual nations. Among other objectives, CARICOM is geared toward improving standards of living and work, enhancing levels of international competitiveness, and achieving a sustainable level of economic development within the Caribbean region.

Multilateral Level

At the multilateral level, all CARICOM members (with an exception of the Bahamas and Montserrat, which yet lie within the accession process to becoming members) hold membership with the World Trade Organisation (WTO). Governed by legal trade rules with an aim of relaxing trade barriers among member countries, CARICOM can access increased exports opportunities, protect its home markets and satisfy its growing home demand.

The region has committed to agreements in relation to its trade in goods, services and intellectual property rights. These are set out within the General Agreement on Tariff and Trade (GATT), the General Agreement on Trade in Services (GATS) and the Trade- Related Aspects of Intellectual Property Rights (TRIPS). Furthermore, the latest round of trade negotiations as established in *"The Doha Round,"* launched in 2001 has been fully supported by the region over the years as all members anticipate increased trading benefits. Other organizations CARICOM continue to be a part of include the CARICOM WTO Small Vulnerable Economies (SVE) and the Africa, Caribbean and Pacific Group (ACP) created in 1975 aimed towards eradicating poverty and promoting sustainable development.

Bilateral Level

The majority of bilateral trade arrangements are made with first world trading economies such as the United States of America, the European Union and Canada. Maintaining good trade relations with the United States is crucial to CARICOM, since the nation holds a large percentage of CARICOMs extra- regional imports and exports. Relations with the United States were first established under the Caribbean Basin Economic Recovery Act (CBERA) also referred to as the Caribbean Basin Initiative was enacted in 1983.

The program aimed to provide a non-reciprocal (one- way) duty free access for a range of CARICOM goods to the United States' market. It was later amended into the Caribbean Basin Trade Partnership Act (CBTPA) effective over a twenty-year period, which began in 2000, and has since then afforded the region a broader range of traded goods. Three hundred and eighty seven additional goods, with eight digit level standard industry traded characters where given duty free treatment.

Furthermore, both parties continue to maintain collaborations as the most recent Trade and Investment Framework Agreement of 2013 was implemented, this is expected to promote future trade, investment and economic co-operative relations thereby stimulating regional growth and development.

In 2012, the European Union (EU) market imported 4.5% of CARICOMs exports (these markets usually include: the United Kingdom (2.1%), and the Netherlands (2.4%) (CARICOM 2014). The platform through which trade the EU has been accommodated is mainly the Caribbean Forum of African, Caribbean and Pacific States (ACP) (CARIFORUM) and represents members of CARICOM, the Dominican Republic and Cuba. ACP- CARIFORUM manages and coordinates primarily the Caribbean region's relations with the European Union as specified in the European Union Economic Partnership Agreement (EPA) of 2008, which is the signing of the agreement.

This agreement offers primarily, a region-to-region trade relation, compared to its ACP- European Community Conventions' predecessors (Lomé 1975 and Cotonou 2000 agreements). Other new aspects include reciprocal trade preferences, trade facilitation, and the regional integrating of CARIFORUM into the global economy. In order to achieve these objectives, the parties committed to an agreement of primarily improving trade policy and trade related issues (relating to customs legislation and procedures), investment and trade services and establishing development cooperation by providing assistance for capacity and institution building, private sector and enterprises development, and diversification opportunities (European Union 2008).

Extra- regional trade with Canada accounts for almost 3% of CARICOMs exports in 2012 (CARICOM 2014). Though relatively small, in comparison to the United States, trade relations with the Canadian market persist. The Caribbean- Canada Trade and Economic Co-operation Agreement was implemented in 1979 to promote trade, technical, financial and industrial co-operation. Originating out of this agreement was the CARICOM- Canada Rum Protocol of 1998 implemented to achieve the greatest possible facilities for the expansion of the sales of CARICOM rum.

Furthermore, the Caribbean- Canada Trade Agreement (CARIBCAN) negotiation of 1986 was introduced with the objective of enhancing CARICOMs trade and export earnings while maintaining trade and economic co-operation. This granted the Commonwealth Caribbean countries (which includes all of the CARICOM countries) unilateral duty free access, for most of its commodities into the Canadian market.

More recently, this agreement was allowed to expire in December of 2013 since it did not comply with the governing rules of WTO (given both parties are members of) and since the Canadian government showed little interest of requesting a further renewal of the WTO waiver for CARIBCAN. A new set of rules conforming then to the WTO needed to be instituted in order for preferential trade to persist; yet, up to date both parties have still not formed a resolution for a replacement.

Furthermore, other current bilateral trade relations with the region include Latin American arrangements which consists of the CARICOM- Colombia Free Trade Agreement of 1994, CARICOM- Cuba partial scope Agreement of 2000 and the CARICOM- Venezuela Free Trade Agreement of 1992 (each year represents the signing of agreements).

Regional Integration

Over the years, numerous reports and empirical research have been conducted on regional integration and its effects. While no concrete definition has been given to the term, its primary objective is to improve trade by reducing and/or eliminating trade barriers among member countries of a trading bloc, while non-member countries are excluded from this preferential treatment (Cheng & Tsai 2008; Schiff & Winters. 2003).

Given the region's uniqueness in relation to the country's similarities with respect to its small size, openness to international trade, factor endowments, and development stage, RTAs are expected to create a greater benefit than countries remaining independent of each other (Asafu-Adjaye J. & Mahadevan R. 2009; Francis K. 2006; Griffith W.H. 2010; Moreira M. M. & Mendoza E. 2007). While this is so, the region has yet to achieve full regional integration status; intergovernmentalism is a primary key in this process, as heads of states are required to co-operate with one another on matters of common interest that will benefit the entire region.

Today political unity is yet to be achieved since it is hindered as a result of racial diversity, economic disparities, and differing colonial past powers (O' Brien 2011). Furthermore, the region has yet to settle differences related to a lack of financial and technical assistance, discretionary macroeconomic policy decisions, and increased economic divergence (Girvan 2005).

In the face of these challenges, three attempts to Caribbean regional integration are recognized in the organizations of CARICOM Single Market and Economy (CSME), which is its highest order of integration, the Organisation of Eastern Caribbean States (OECS), and the Caribbean Forum (CARIFORUM), which will be discussed in the subsequent section.

CARICOM Single Market and Economy

The CARICOM Single Market and Economy (CSME) consists of two phases: the CARICOM Single Market, which is the first phase, was formed in 2006 and secondly the CARICOM Single Economy projected to take effect in 2015. The primary goals of the CSME are to achieve regional and economic integration as the region endeavours to sustain greater bargaining power in light of globalization.

Presently there are fifteen CARICOM countries, of which twelve belong to the SIDS category, together with Guyana, Suriname and Belize. Of these CARICOM nations, twelve countries are actively involved member countries, which comprise the CSME. Nine of these CARICOM/CSME countries are SIDS (i.e. minus Bahamas, Haiti and Montserrat), together with Guyana, Suriname and Belize. Haiti is also a member, but has been provisionally relieved of its duties, because of the calamitous earthquake and its effect upon the nation in 2010 (see Table 2.1 and Figure 2.13)

Figure 2.13 Geographical Location of CARICOM Countries [3]

Source: (Roberts and Olson, 2012)

Under this initiative, fully utilizing the region's factors of production and fostering a competitive environment for its goods and services is a means to achieving the goals of the organization as it rewards are reflected in the region's improved standard of living, economic growth, development, and positioning in the international markets.

Furthermore, as a trading bloc, the region can collectively foster greater bargaining powers with the rest of the world through the WTO than individually. Of the thirteen member countries, eleven have on average population of approximately one million each, Jamaica being the only nation with over two million inhabitants, while Haiti is the largest of all with a population of over ten

[3] Of which 12 countries are island economies for focus of this research, while Guyana, Suriname and Belize are non-island economies.

million, but is currently inactive in the CSME (World Bank, 2014a).

The Single Market seeks to synchronize institutions, whereby there markets are easier to access. This is done by fostering a free movement of the region's labour, capital, goods, and services markets. The various mechanisms utilized include removing all barriers to intra-regional trade by allowing businesses to operate in another member country without restrictions (The Right of Establishment), eliminating foreign exchange controls, introducing a single currency, and allowing free movement of labour.

The Single Economy phase (just as its name suggests), works towards further bringing the countries together as one economic "*powerhouse,*" where all decision- making processes relating to the economies are transparent and comparable for all countries. Execution of monetary, fiscal and other economic policies will therefore be sub-servant to achieving such an outcome. Work towards establishing a Single Economy has been slowly progressing to date. For example, the pre-requisite of establishing regional institutions, to assist member countries in local execution, is still not complete.

In light of the challenge of getting all government bodies to agree on decisions for moving forward to the next step of achieving a single economy, efforts are still being advanced, but at a slower pace than expected. A survey was conducted by CARICOMs secretariat in 2012 in an attempt to determine the region's compliance to the relevant initiatives, with the resultant statistics revealing that the region's overall level of compliance is only at sixty- four percent (64%),indicating it falls considerably short of fully implementation. While considerable progress has been made, further improvements need to be made, particularly in areas of the Free movement of Services (37% compliance), the Right of Establishment (64% compliance) and the free movement of skills (66% compliance) (CARICOM Secretariat 2012) (see Table 2.3).

Table 2.3 Free Movement Initiative and Level of Compliance

The Free Movement of Skills	*66%*
The Free Movement of Goods	*80%*
The Free Movement of Services	*37%*
The Movement of Capital	*72%*
The Right of Establishment	*64%*

Source: (CARICOM, 2013)

Organisation of Eastern Caribbean States

The Organisation of Eastern Caribbean States (OECS) has been in existence since 1981. After years of revising its agreements, which further facilitated the group's growth and development, the OECS Economic Union was then established in 2010. Its main objectives are to promote a common market whereby there is a free movement of its factors of production and a common market for goods. It furthermore acts to assist the member countries in fulfilling their international obligations.

The group realizes a deeper level of economic integration since it is already a subset of CARICOM. The group comprises nine members which consist of the smaller and lesser developed Eastern Caribbean states (see Table 2.1), together with two associate members Anguilla and the British Virgin Islands. Though associate members participate in all of the OECS' committees, they remain dormant in other committees such as Foreign Affairs, Defence and Security.

To date its thrust toward integration has resulted in member countries sharing a common currency called the Eastern Caribbean Dollar (ECD), which is monitored by a single central bank called the Eastern Caribbean Central Bank (ECCB); they furthermore share a common Supreme Court. Furthermore, the free movement of persons came into effect in 2011, while its target for gaining free circulation of goods in 2013 has not yet been fulfilled.

The Caribbean Forum of African, Caribbean and Pacific States

The Caribbean Forum of African, Caribbean and Pacific States (CARIFORIUM), was established in 1992. It originated as a subgroup of the Group of African, Caribbean and Pacific States (ACP), which was formed in 1975, under the Lomé Convention. The convention afforded aid (under the European Development Fund (EDF)) and trade relations between ACP and the European Community (EC) in which delegated responsibilities in co-ordinating and monitoring the Caribbean's regional projects were performed by CARICOM member states.

In 1992, under the Lomé IV convention, two Caribbean ACP countries (Dominican Republic and Haiti) which were not CARICOM members at the time became signatories of the convention, this then necessitated the need for a new forum including new member countries and further facilitating consultation on regional integration and co-operation within the framework of the ACP/ EC. In 1992, CARIFORUM was then established which Cuba subsequently joined the in 2001.

Altogether, there are sixteen signatories of CARIFORUM. This includes Antigua and Barbuda, The Bahamas, Barbados, Belize, Cuba, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago. Today, co-operation within CARIFORUM includes CARICOM and the Dominican Republic Free Trade Agreement (1998) and CARICOM- Cuba Trade and Economic Cooperation Agreement (2000).

The Association of Caribbean States

The Association of Caribbean States (ACS) was established in 1994 under the initiative of fostering consultation, cooperation and action among those countries particularly sharing the borders of the Caribbean Sea. Termed the "Greater Caribbean Region," these countries include CARICOM, Central America and the northern countries of South America. The association's focal areas are geared toward disaster risk reduction, sustainable tourism, trade (strengthening intra and extra regional trade and investment flows), transport and the reservation and conservation of the Caribbean Sea being the countries' main link.

As of 2012 which ends the period understudy, there are twenty-five member countries and eleven associate members. Of this twenty-five, fifteen belong to

CARICOM- Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Suriname. Central American countries include members of the Central American Common Market (CACM) - Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama, and other countries such as the Dominican Republic, Cuba, Colombia, Mexico and Venezuela. France and the Kingdom of the Netherlands act as associate members operating on behalf of their respective colonies: Guadeloupe, Martinique, French Guiana, St. Barthelemy and St. Martin, and the Kingdom of the Netherlands represents Aruba, Bonaire, Curacao, Eustatius, Saba and St. Maarten.

Actions proposed by ACS have strengthened ties with CARICOM, Central America and parts of South America. Though minimal compared to previously mention regional organizations, the group has primarily focused on collaborative efforts and dialogue providing assistance in certain areas. This entails small enterprise development, mutual support and training in tourism, continued dialogue and research for direct and regular cross border movement of goods, services and people, trade and investment opportunities, agriculture diversification and development programmes, scientific and technological cooperation and human resource development such as training, planning.

In addition, ACS remains a platform through which the smallest of islands (being the Dutch and French) can participate in efforts to strengthen trade and investment opportunities increasing their competitiveness and competitive advantage within the international market.

2.4 INTERNATIONAL TRADE RELATED PRIORITIES FOR ACTION

In a fast evolving and competitive world economy, heads of CARICOM are compelled to engage in a greater strategic focus in order to achieve its regional development agenda, of which one particular avenue given priority is its positioning in regional and international trade (CARICOM 2013; CARICOM 2015). Trade development is being hampered by the growing effects of supply side constraints. Its evidence is seen in poor infrastructure, weak institutions, low levels of private sector innovation and partnership with public entities, lack of technological advancements, financial resource deficiencies, and undiversified export markets.

Having acknowledged these, CARICOM has tailored three integral goals proposed to eliminate these barriers and efficiently allocate already limited finances so as to improve the region's stance in the international market. Goal one focuses on upgrading the key economic infrastructure in the areas of maritime transport, Information and Communication Technology (ICT), and energy which acts as a feeder in accomplishing Goal two. Goal two aims to enhance competitiveness and facilitate trade expansion and diversification by addressing the areas of trade facilitation, sanitary and phytosanitary measures, quality infrastructure, services and private sector development. Furthermore, both goals result in the success (or lack thereof) of Goal three, which is for the region achieving full CSME status and maximizing its gains from external trade arrangements (see Table 2.4).

The next three sections will discuss these goals in further detail, and its relevant areas for achieving them. For purposes of this study, precedence will be given to the *areas of maritime transport and quality infrastructure*.

Table 2.4 Goals for CARICOM Trade Strategy

Goal	***Goal 1: Upgrading Key Economic Infrastructure***	***Goal 2: Enhancing Competitiveness and Facilitate Trade Expansion and Diversion***	***Goal 3: Deepening Regional Integration and Maximizing Gains from External Trade Agreements***
Areas of Priority	**Maritime Transport**	**Trade Facilitation**	**Regional Integration**
	Information & Communication Technology	Sanitary and Phytosanitary Measures	External Trade Agreements
		Quality Infrastructure	
	Energy	Services	
		Private Sector Development	

Source: (CARICOM, 2013)

2.4.1 Goal 1: Upgrading Key Economic Infrastructure

Partially attributed to the success or demise of a community, is the service it seeks from the relevant associated infrastructures. Dedicated resources are necessary for constant upgrading of key economic infrastructures. The rippling effects of this are recognized throughout the economy and manifested in its positive economic growth and development (Snieska & Simkunaite 2009). In order for CARICOM to realize full gains from international trade and regional integration, it has indicated the need for improvement in the areas of maritime transport, Information and Communication Technology (ICT) and energy.

Areas of Priority

Levels of maritime transport are proportionately reported to be 30% higher in the Caribbean than what is typically found elsewhere in the world (CARICOM, 2013). This is partly attributed to the region's deficiencies in port infrastructure, reflected in its lack of equipment, technological advancement, port security and safety procedures and storage capacity.

The ranking of the region's quality of port infrastructure, as commissioned by the World Economic Forum in its latest competitiveness report, has shown this paucity to some extent. Seaport facilities were judged on a scale of one (extremely underdeveloped) to seven (very extensive and efficient) with a world's average (the mean) of 4.2. Out of 142 worldwide countries, Barbados's port facilities were ranked in 18th place and 1st in CARICOM, this was followed by Jamaica (75th/ 2nd in CARICOM); both countries had an index above average (5.6, 5.1 respectively) for its port infrastructure quality. On the other hand, Trinidad and Tobago (4.1) and Haiti (2.4) scored below world average (see Table 2.5) (Schwab and Sala-i-Martin 2013)[4].

[4] Lack of data availability for the remaining CARICOM countries

Table 2.5 Quality of Port Infrastructure Global Competitiveness Index *(2013-2014)*

Country	***Quality of Port Infrastructure***	***Rank***
Barbados	5.6	18th
Haiti	2.4	144th
Jamaica	5.1	39th
Trinidad & Tobago	4.1	75th
Mean World Average	4.2	

Source: (Schwab and Sala-i-Martin, 2013)

Proposals to upgrade its maritime transport system include tackling areas such as modernizing port infrastructures, storage and capacity of ports, shipping technology, and establishing regional co-operation in maritime infrastructure development. In today's ever evolving technological world, information exchange and rapid communication are vital in order to stay abreast. CARICOM has seen this as another driver for achieving regional competitiveness in the international market. Currently, the global digital divide necessitates the need to upgrade its existing technologies.

2.4.2 Goal 2: Enhancing Competitiveness and Trade

The movement of goods/services and its related documentation, coupled with minimum impediments to cross- border trade, are primary criteria for enhancing trade competitiveness. These measures are referred as trade facilitation which comprises reform actions of getting to, at and behind the border (Notteboom 2007; Sánchez & Wilmsmeier 2009; Yeo et al.., 2011; Cruz et al.., 2013).

General areas trade facilitation policies are geared toward impacting, include customs procedures, finance, infrastructure, regulations, information and telecommunications technology (ICT) and corruption (Clark et al.., 2004; Wilson et al.., 2005; Iwanow & Kirkpatrick 2008; Wilson et al.., 2003; Moise and Sorescu, 2013). This is implemented with the objective of reducing trade barriers and costs thereby impacting favourably the macro- economic variables such as International Trade, National Income, Growth, Development whilst promoting regional integration (Wilson et. al, 2005; Kirkpatrick and Iwanow, 2007; Persson, 2010; Hoekman and Shepherd, 2013).

Following the principle of trade facilitation and its impact upon trade, it is imperative that the region address its trading procedures. Most recently, the Global Competitiveness Report 2014 which measures the ease (or lack thereof) of trading across borders, ranked one hundred and eighty- nine countries on the basis of cost, time and official procedure necessary to export/import a standardized cargo by maritime transport. Overall, though the region remains principally within the 50^{th} percentile, eight out of the ten Caribbean countries ranks' either fell or remained the same in 2012 to 2013 (Schwab and Sala-i-Martin, 2014).

Lengthy times taken to clear goods at the port, excessive documentation and unnecessary costs all act as impediments to facilitating an effective trade. The region therefore seeks to improve its technology in the area of customs: where a more efficient flow of information exchange can be accommodated within and amongst the Caribbean (CARICOM, 2013).

2.4.3 Goal 3: Deepening Regional Integration and Maximizing External Trade Agreements

It is with expectation that goals one and two will contribute to deepening regional integration and thereby facilitate goal three, which is to capitalise on external trade agreements. Furthermore, more effort is needed to achieve CSME status. This means mechanisms through which Lesser Developed Countries (LDC) can fully integrate into CSME and establish a body that has the institutional capacity to monitor CSME implementation at the national level. Effectively tackling these areas, coupled with goals one and two, are priorities for action, which is expected to achieve the eventual aim, which is goal three.

2.5 TRAFFIC THROUGHPUT AND MAJOR MARKETS OF THE CARIBBEAN

In the midst of long term economic and trade growths with trade growth almost doubling world's production, the world has witnessed bouts of economic instability. The most recent global financial crisis in 2008 resulted in a downturn of economic activity, which led to an economic recession affecting every possible inhabited nation. International trade growth in both volume and value (merchandise trade) sharply declined by 12.2% and 23% respectively in 2009 (World Trade Organization, 2010).

The lethargic pace in countries' confidences, coupled with high unemployment, little import demand, and export growth partly resulted in sluggish growth of global trade and output of around 2% in 2012 and 2013. However, according to the World Trade Organization, projections of output and trade growth are expected to improve at a faster rate. Amidst growing regional trade agreements and expansionary monetary and fiscal policies, global trade growth is forecasted at 4.7% in 2014 with a faintly modest rate of 5.3% in 2015 while output is expected to grow at a faster rate of 3% in 2014 and 3.3% in 2015 (World Trade Organization, 2014).

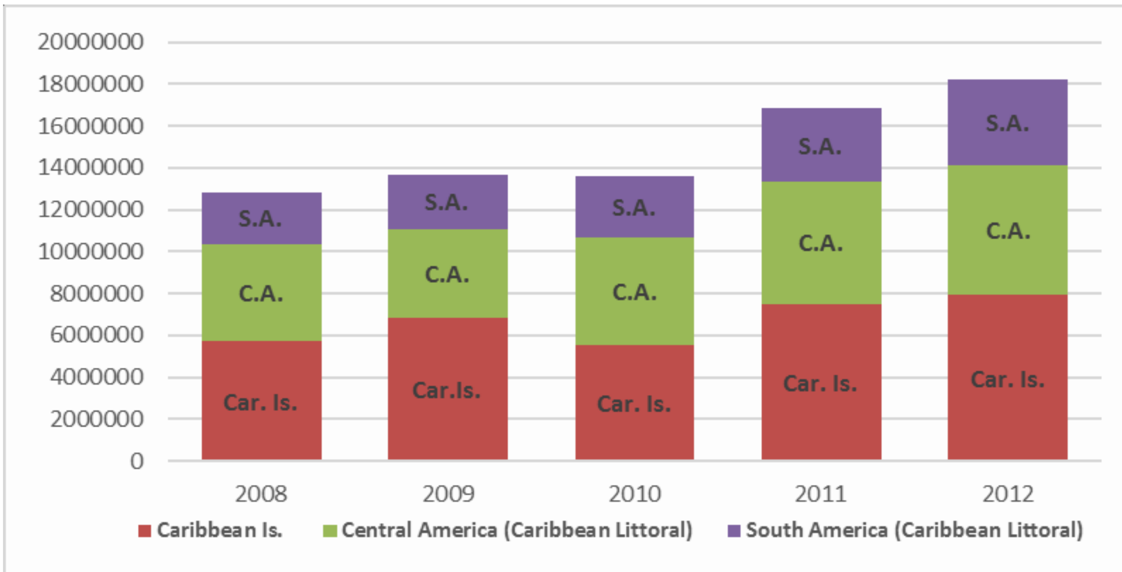
With expectations of economic and trade growth (though dawdling), and increased international trade related negotiations potentially fostering freer international trade, the impact upon seaborne trade is imminent. Maritime transport continues to be the dominant mode of transport for goods and services accounting for almost 90% of the volume of worldwide trade (IMO 2014). Over the last decade ending 2012, seaborne trade rose by 53%; containerised trade recorded as the main traded commodity grew by 147%, followed by bulk trade (106%), liquid bulk trade (31%) and lastly other non-containerised general cargo (13%) (UNCTAD 2013; p.7).

Given these worldwide growths, developing economies such as the Caribbean region have benefited. Their growth in merchandise trade has actually outpaced that of the developed nations for both exports and imports in the most recent years (UNCTAD 2013; p.5).

Maritime traffic growth has mirrored global trade patterns over the years. Given the region's susceptibility to world economic trends; similar to all port regions of the world, Caribbean have witnessed an increase in port throughput by 40% over the past five years. North Coast South America (NCSA) i.e. South America littoral which comprises Colombia, Venezuela, Suriname and Guyana recorded the most growth with 66% while Central America littoral (i.e. Panama, Costa Rica, Guatemala, Honduras, Nicaragua and Belize) of 32% (Figure 2.14).

Furthermore, as more ports are built, the degree of competition have increased. This is derived from the Herfindahl- Hirschman Index (HHI), which is an indicator of the amount of competition among firms in an industry. An HHI ranges from zero (perfect competition depicting a high level of competition) to one (pure monopoly) (Krivka, 2016). According to Table 2.6, the HHI declined from 0.209 in 2005 to 0.154 in 2012, reflecting a movement toward increased competition in the industry. The implications of this, is that the benefits will outweigh its costs, as increased competition can contribute to increased productivity. This is so, as it puts pressure on ports to lower and controls their costs; encourages innovation, which is a strong driver of lowering costs and improving efficiency, and which thereby encourages further investments. Furthermore, it also has potential to improve the growth prospects of an economy (Buccirossi et al., 2013).

Figure 2.14 Caribbean Region Containerized Traffic



Source: (Nathan Associates, 2014)

Table 2.6 Caribbean Maritime Concentration Ratio

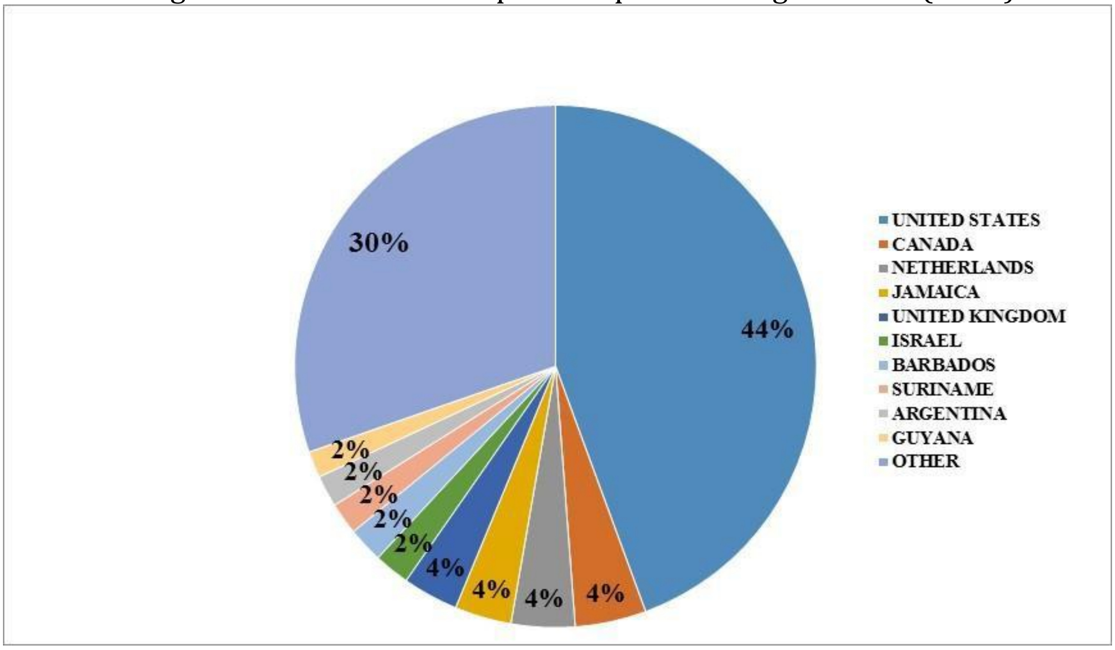
Caribbean Maritime Data	***2005***	***2012***
No. of ports > 100,000 TEU	9	12
HHI (ports > 100,000 TEU)	0.209	0.154
HHI minimum	0.111 (0.098)	0.083 (0.071)
Top 5 Transhipment Ports		0.171

Source: (Wilmsmeier et al.., 2014)

According to the CARICOM TradSys online, the region's major markets for both exports and imports have remained the United States of America for several years. Almost half of its exports (supported by 48%, which includes Canada also) supply the United States, while other countries account for 30% collectively. Other regions including Europe and the Caribbean for intra- regional trade in exports account for 8% and 6% respectively (see Figure 2.15). Merchandise trade includes primarily energy-based items such as natural gas, petroleum, iron ore, aluminium and inorganic chemical items.

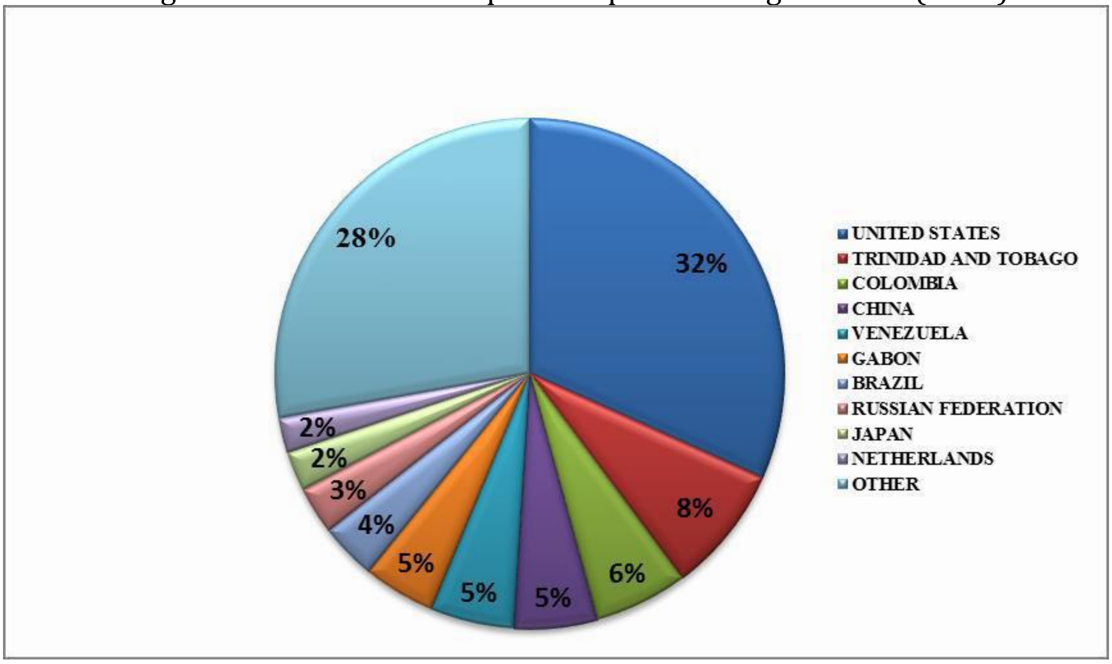
On the other hand, imports from the United States account for 32%, followed by other countries which total 28%, Latin America 15% and intra-regional imports 8%; Asia (8%), Africa (5%) and Europe (5%) hold lesser market shares (see Figure 2.16). The Caribbean countries import mainly industrial items such as machinery, equipment, medicaments, energy based commodities, and transportation vehicles.

Figure 2.15 CARICOMs Top Ten Export Trading Partners (2012)



Source: (CARICOM TradSys Online, 2012)

Figure 2.16 CARICOMs Top Ten Import Trading Partners (2012)



Source: (CARICOM TradSys Online, 2012)

2.6 THE CARIBBEAN'S PORT COMPOSITION

2.6.1 Categorization of Caribbean Ports

The main ports of the Caribbean consist of varying port types based on a number of reasons, such as their strategic location, port capacity, and facility, quality of service and government intervention. According to Huang et al.. (2008) the main validation for a hub port is the not necessarily the number of throughput cargo the port serves, but its transhipment cargo. While hub ports of the Caribbean may not accommodate large throughput numbers compared to major hubs of the world, its strategic locality positions it to accommodate transhipmentcargoes.

The World Bank (2007) further specifies that ports differ based on their orientation in the market, which can take the form of a local, regional or global characteristic. Or, on the other hand, port system can be categorized as pure transhipment hub (having a minimum of 70 per cent transhipment cargo), hybrid port (between 30 and 70 % transhipment cargo), gateway port (less than 30 % transhipment cargo), and local and inter-islands transhipment port (Wilmsmeier et al.., 2014). While the region has a number of global and regional hub ports, it is found primarily among the MDC countries. These ports have high transhipment incidences, some acting as pure transhipment ports or hybrid ports; LDCs on the other hand serve specific island ports, resulting in lower transhipment incidences.

Global hub ports serve as a central connection for large international scale redistribution of cargo using smaller scale shipments to its final destination port. Within CARICOM, The Kingston Container Terminal (KCT) of Jamaica and Freeport Container Port, Bahamas function as global transhipment hub ports. The Kingston Container Terminal serves shipping lines such as Zim Integrated Shipping Services and CMA CGM in which the majority of cargoes are transhipped to the Eastern parts of the United States, Gulf of Mexico ports and parts of the Caribbean.

Likewise, due to higher costs and cabotage restrictions as enforced by the Jones Act, nearby Freeport assumes the role of accommodating transhipment cargo into the United States. Primarily along the East Coast, in addition to this market, Freeport facilitates the Caribbean, Central and South America. Out with CARICOM, transhipment traffic is competed for by Panamanian ports (see Table 2.7).

Regional hub ports facilitate intra- regional trade throughout Caribbean countries. These include Kingston Wharves Limited (KWL) of Jamaica, the ports of Port of Spain (PPOS) and Point Lisas, Trinidad and Tobago. All three ports serve mainly shipping lines that connect to the south-eastern parts of the United States (such as Florida) and provide feeder services to smaller Caribbean islands (along the eastern corridor) and South American countries such as Guyana and Suriname (see Table 2.7).

Other ports within the region are smaller due to their demand, smaller capacity and limited infrastructures in accommodating connections with larger ports, they therefore serve specific islands. These include Bridgetown of Barbados (but specialises in cruise vessels due to its large dependence on tourism), St. John's (Antigua), St. Georges (Grenada), Basseterre of St. Kitts and Nevis, Kingstown (Saint Vincent and the Grenadines), Roseau (Dominica) and Vieux Fort, St. Lucia (see Table 2.7).

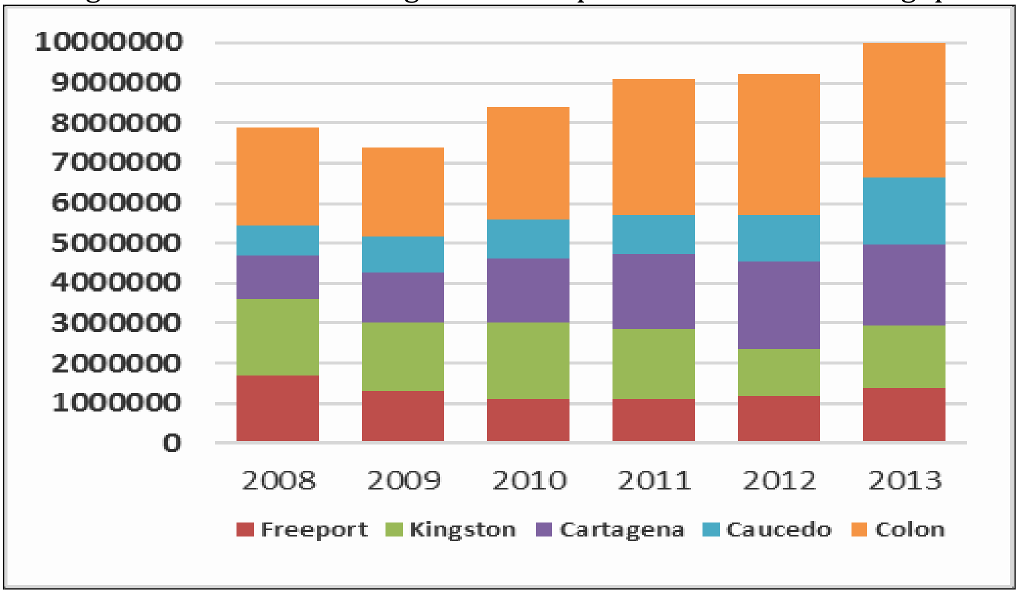
Table 2.7 Global, Regional and Local Orientation Hub Ports of the Caribbean, Central and South America Littoral

Port	Country	Area	Transhipment Port	Global Hub	Regional Hub	Service
Freeport Container Port	Bahamas	Caribbean	x	x		
Cartagena	Colombia	S.A		x		
Caucedo	Dominican Republic	Caribbean		x		
Kingston Container Terminal	Jamaica	Caribbean	x	x		
Balboa	Panama	C.A	x	x		
Cristobal	Panama	C.A		x		
Colon	Panama	C.A	x	x		
Manzanillo	Panama	C.A	x	x		
San Juan	Puerto Rico	Caribbean		x		
Oranjestad	Aruba	Caribbean			x	
Barranquilla	Colombia	S.A			x	
Santa Marta	Colombia	S.A			x	
Limon-Moin	Costa Rica	C.A			x	
La Havana	Cuba	Caribbean			x	
Puerto Plata	Dominican Republic	Caribbean			x	
Rio Haina	Dominican Republic	Caribbean			x	
Puerto Cortes	Honduras	C.A			x	
Puerto Castilla	Honduras	C.A				x
Kingston Wharves Limited	Jamaica	Caribbean			x	
Corinto	Nicaragua	C.A			x	
Ponce	Puerto Rico	Caribbean			x	
Port of Spain	Trinidad	Caribbean			x	
Point Lisas	Trinidad	Caribbean			x	
La Guaira	Venezuela	S.A			x	
Puerto Cabello	Venezuela	S.A			x	
St. John	Antigua	Caribbean				x
Bridgetown	Barbados	Caribbean				x
Belize City	Belize	C.A				x
Roseau	Dominica	Caribbean				x
St. Georges	Grenada	Caribbean				x
Georgetown	Guyana	S.A				x
Port au Prince	Haiti	Caribbean				x
Basseterre	St. Kitts	Caribbean				x
Castries	St. Lucia	Caribbean				x
Vieux Fort	St. Lucia	Caribbean				x
Kingstown	St. Vincent	Caribbean				x
Nieuwe Haven (Paramaribo)	Suriname	S.A				x
Guanta	Venezuela	S.A				x
Maracaibo	Venezuela	S.A				x

Source: (CARICOM, 2015)

Transhipment hub ports continue to account for the bulk of throughput flowing into and out of the region. Over the period 2008 to 2013, transhipment traffic increased by 27% (Figure 2.17). The majority of transhipment cargo that are competed for occurs primarily in Colon accounting for 26% of the Caribbean's transhipment, followed by Freeport (21%) and Kingston Container Terminal (KCT) (19%).

Figure 2.17 Caribbean Region Transhipment Hub Ports Throughput

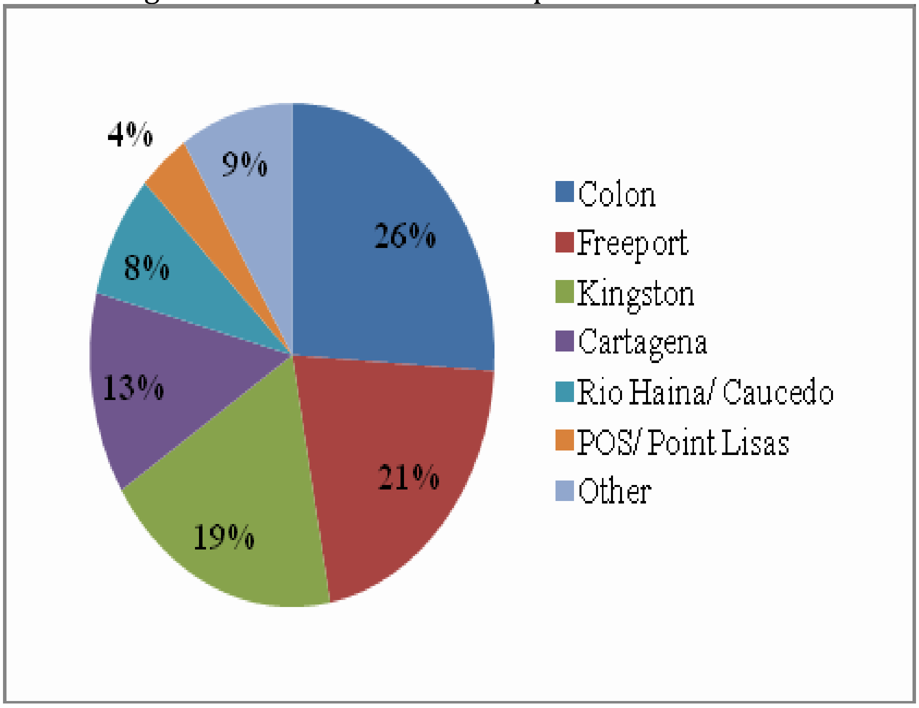


Source: (Nathan Associates, 2014)

Together these ports handle approximately two thirds of transhipment traffic in the Caribbean (Figure 2.18). Altogether, the level of competition in the market has yielded a concentration value of 0.171 in 2012, which proves the existence of competition among the top five transhipment ports (Table 2.6). Furthermore, Freeport's strategically close proximity to the United States hinterland and situated along a major shipping route, accommodates primarily transhipment cargo into and from the United States. The port has the highest transhipment incidence of 98%, followed by KCT of 90% making them purely transhipment hubs. Colon on the other hand has a lower incidence of 80% as a large share of its traffic also serves the hinterland (Rodrigue, 2013) (Figure 2.18 and Figure 2.19).

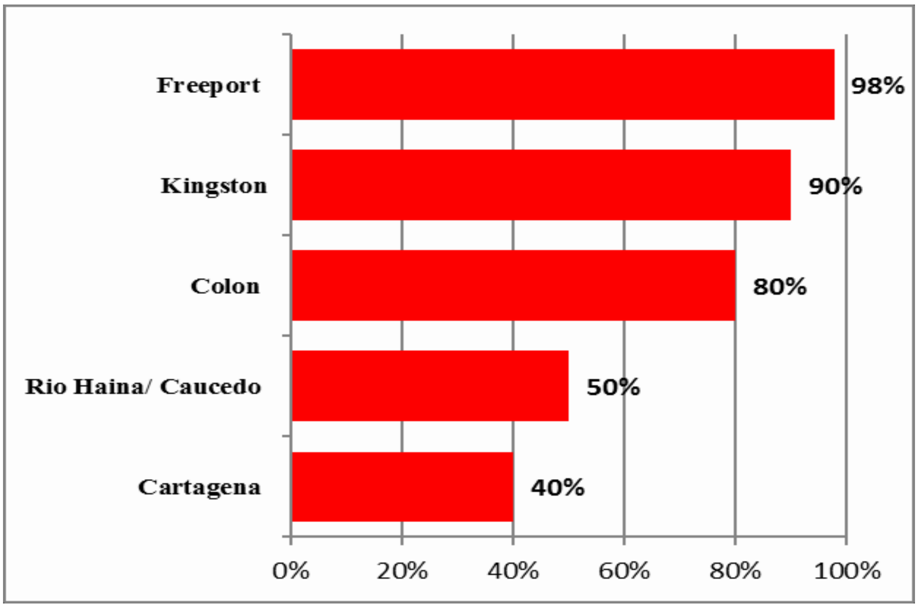
In light of this, CARICOM ports are hurriedly improving operations in the face of potential competition from South American and Central American neighbouring ports. Furthermore, Mariel, Cuba and San Juan, Puerto Rico ports pose as potential rivals to CARICOM ports; yet, given the United States of America trade embargo and Jones Act of the 1920s era, it places them at an uncompetitive advantage over others.

Figure 2.18 Caribbean Transhipment: Market Share



Source: (Nathan Associates, 2014)

Figure 2.19 Caribbean Transhipment: Transhipment Incidence



Source: (Nathan Associates, 2014)

2.6.2 Port Management Models

According to the World Bank, a number of factors are understood to determine the motivation for a particular port management arrangement over another. These factors include the countries' historical progress, socioeconomic structure, location and primary types of cargoes handled (World Bank, 2007).

In the Caribbean, the ports' management have long been influenced by its colonial past, as the ports were previously designed in support of more general cargoes: basic and agricultural items governed by a colonial master, its high international trade dependence and strategic locality accommodating west to east (vice versa) trade (Pinnock & Ajagunna 2012). Today these unique features have resulted in most of Caribbean ports administered more so under the public interests of either service or landlord port models rather than commercial enterprises.

Freeport Container port in Bahamas remains the sole fully privatized port in CARICOM. Hutchison Port Holdings (HPH) opened it in 1997 after investors of the company saw the nation's competitive advantage in its strategic locality allowing it to accommodate north/ south and east/west trade. The port is a joint venture between HPH and the Grand Bahama Development Company (Devco) (Devco is also jointly owned and managed by HPH and the Port Group Limited (PGL) (Freeport Container Port Company, 2014). Similarly, the port of Caucedo, is a privately owned container terminal operated by Dubai Port World (DPW) which began operations in 2003; KWL is another privately owned terminal.

In landlord ports, the administration of landlord ports encompasses a mixture of both public and private sector involvements. The port authority which is referred as the landlord regulates the port's operations. For instance, the Port Authority of Jamaica is a statutory board appointed by the government which gives oversight to the Kingston Container Terminal (KCT) of Jamaica, similarly the Barbados Port Incorporated of Bridgetown, Barbados, the Port Authority of the Dominican Republic for Rio Haina and Puerto Plata ports, and the Port Authority of Trinidad and Tobago for the Port of Spain. On the other hand, the Point Lisas Industrial Port Development Corporation Limited (PLIPDECO) is a public company which owns fifty one % of the port of Point Lisas, Trinidad and Tobago while forty-nine

% is owned by private companies.

Various activities of the port are then delegated to private operators, such as cargo handling activities, but utilizing assets such as the port's infrastructures which are leased by the port authority. Superstructures are however privately provided while dock labour is sometimes privately or publicly arranged. In 2009, the APM Terminal Limited Group after eight years concluded their operations management contract with KCT. Currently, the Kingston Container Terminal Services Limited (KCTS), a subsidiary of the Port Authority of Jamaica, manages the terminal. On the other hand, forty nine % of the Point Lisas port is privately owned while the landlord unit: Port of Spain Infrastructure Company (POSINCO) which is publicly owned maintains a strategic role in managing the port (Pinnock and Ajagunna 2012) (see Figure 2.20).

Service ports are generally governed by the port authority which belongs to a particular governmental ministry, for instance Vieux Fort ports, St. Lucia are administered by St. Lucia Air and Sea Ports Authority (SLASPA) of the Ministry of Communications and Works and St. Georges port, governed by the Port Authority Grenada (GPA) of the Ministry of Finance, port of Roseau by the Dominica Air and Seaports Authority (DASPA) of the Ministry of Public Works, Energy and Ports, Basseterre Cargo port by the state-owned St. Christopher Air and Seaports Authority, St. John's by the Antigua and Barbuda Port Authority (ABPA), and Port Kingstown answerable to the St. Vincent and the Grenadines Port Authority (SVGPA).

Furthermore, Ponce and San Juan ports are currently owned and managed by the Port of the Americas Authority (a joint venture between the municipality of Ponce and the Government of the Commonwealth of Puerto Rico) and the Port Authority of the Port of San Juan respectively, furthermore, Aruba Ports Authority for the Port of Oranjestad and the port of Havana is 100% Government owned.

The port authority offers services necessary for the effective functioning of the seaport and therefore owns, manages, and operates the port's assets (superstructure, infrastructure and labour). Cargo handling activities though administered by the port authority as well are sometimes executed by a separate public entity called a cargo handling company. For instance, at the port of Vieux St. Lucia, subsidiary company, St. Lucia Marine Terminals Limited manages the operations of the port's cargo (see Figure 2.20). (Grenada Ports Authority, 2013; St. Lucia Air and Seaport Authority (SLASPA), 2010; The World Bank, 2007). This port management model has become more evident amongst the LDCs of the region.

Figure 2.20 Port Management Models of Caribbean Ports[5]

Public

Public Service Port

- St. John, Antigua
- Oranjestad, Aruba
- La Havana, Cuba
- Roseau, Dominica
- St. Georges, Grenada
- Georgetown, Guyana
- Port au Prince, Haiti
- Ponce, Puerto Rico
- San Juan, Puerto Rico
- Basseterre, St. Kitts
- Castries, St. Lucia
- Vieux Fort, St. Lucia
- Kingstown, St. Vincent
- Paramaribo, Suriname
- Guanta, Venezuela
- La Guaira, Venezuela
- Maracaibo, Venezuela
- Puerto Cabello, Venezuela
- POS, Trinidad & Tobago

Public ***INFRASTRUCTURE*** Private

Landlord Port

- Bridgetown Port, Barbados
- Belize City, Belize
- Barranquilla, Colombia
- Cartagena, Colombia
- Santa Marta, Colombia
- Limon-Moin, Costa Rica
- Puerto Plata, DR
- Rio Haina, DR
- Puerto Cortes, Honduras
- Puerto Castilla, Honduras
- KCT, Jamaica
- Corinto, Nicaragua
- Balboa, Panama
- Cristobal, Panama
- Colon, Panama
- Manzanillo, Panama
- PL, Trinidad & Tobago

SUPERSTRUCTURE

Privatized Port

- FCP, Bahamas
- Caucedo, DR
- KWL, Jamaica

Private

Source: (Adapted from the World Bank, 2007)[5]

(adaptations include the grouping of Caribbean/ Central America/ Littoral South American ports into their respective port management models).

Overall, for the majority of Caribbean ports, the government still plays a key role in governing the ports' infrastructures and superstructures. This arrangement however may come with a number of challenges, which will be discussed in the subsequent section. Today due to the changing dynamism of the port infrastructure, best practise is focused on increased service levels, increased operational efficiency and improved allocation of public funds to private operators. Ports have therefore become more specialised and integrated into the global logistics chains, taking on regional and global attributes and approaches (Pinnock and Ajagunna, 2012; World Bank, 2007). This has led to a gradual decline in the role of the government in recent years, towards more privatizing operations. For instance privatizing partly such as cargo handling activities, superstructures, and labour, as is the instance of Rio Haina DR, KCT, Jamaica and PL, Trinidad, or becoming fully privatized such as Freeport, Bahamas, Caucedo, DR, and KWL, Jamaica.

2.7 REPORTED HINDRANCES TO CARIBBEAN PORT DEVELOPMENT

Seaports are confronted by a fast evolving global market place which includes extensive business networks, complex logistics systems, increasing vessel sizes and global terminal operators (Notteboom, 2007). The upgrading of its ports' facilities and services are crucial and if ignored will result in increased competition pressures at the expense of declining market shares. Among these hindrances, include insufficient port financing for capital and maintenance projects, inadequate maintenance, management, and IT systems, insufficiently skilled workforce, and little or no environmental protection practises.

The derived demand nature of seaport operations are perceived a natural or simply something that performs in facilitation of international trade, which policy makers primarily focus on. Hence, policies are not highly pursued at the national and regional level resulting in inadequate port financing for capital and maintenance projects. Among the other hindrances to port efficiency, include a slow progression in adopting new technological advancements. The technological divide between the Caribbean and developed countries is currently greater than the development gap which slows the progression in adopting new Information and Communications Technologies (ICT).

For instance, paper streaming of customs documentations continues at particularly LDC ports. The deficient legislative and regulatory frameworks for immediate and proper implementation of ICTs by government officials, unavailability of data adequate data for research and innovation, and lack of incentives for public- private partnerships, have resulted in a slow progression or even stagnant ICTs in the maritime industry. Furthermore, with respect to the region's thrust toward regional integration creating an environment which performs business electronically nationally and regionally takes great prominence (CARICOM 2013).

Additionally the maritime sector is plagued with unsatisfactorily unskilled workforce. The current and potentially future workforce lacks the adequate training and education not only in practical operations but also theoretical, hence these inadequacies are particularly acute at management level. This is because of a number of factors which include the lack of planning and investment for training activities by government officials, disorganized training events, and undersupplied training instructors and university programmes (Sánchez & Wilmsmeier 2009).

Moreover, the quality of CARICOM's economic infrastructure with reference to its ports' has been reported of high standards according to international criteria, particularly for MDCs. However issues surrounding its maintenance and inadequate management have come under scrutiny (Sánchez & Wilmsmeier 2009). Given that the majority of main ports in the region are highly government influenced, political interference is likely to impede performance at the expense of unscrupulous gain or simply a not for profit objective.

Policy makers lack the foresight to adequately pursue national infrastructure development plans and export facilitation policies, primarily because they do not see the significance of the port's operations and its rippling effect throughout the region. For instance, appropriate regulatory frameworks governing the independent selection of boards of directors and private sector involvements in infrastructural development projects require sufficient national and regional legislation that are transparent and work in cohesion.

On the other hand, sustainable development practises in relation to environmental management have grown rapidly over the years (Couper 1992; Dinwoodie et al.., 2012). Complying with environmental protection practises and research projects as commissioned by the World Bank, Marine Pollution (MARPOL) Convention of the International Maritime Organization (IMO), and achieving international certifications such as from the International Organization for Standardization (ISO 14000) are key essentials in gaining a competitive advantage.

Furthermore, concerns are growing since the region's ecosystem remains one of its main sources for tourist attraction. However, ports are plagued with insufficient waste disposal facilities and sewage treatments which meet the terms of international standards, lacks effective legislative mechanisms, skilled personnel, knowledge and finances to fully achieve the benefits of sustainable port management (Sánchez and Wilmsmeier, 2009).

Additionally, the government's strong involvement in the operations of the ports has hindered competition and opportunities for privatization. The concept of port privatization has been empirically investigated in numerous literatures over the years; it has proven to be an integral factor for a nation's international competitive advantage via improvements in port efficiency (Baird, 2000; Cullinane et al.., 2002; Tongzon & Heng, 2005).

Despite the ports' incapability in supporting multiple and or larger ports, they still possess the potential to foster healthy competition among services within the port (Pinnock & Ajagunna 2012). This may however become a situation, where privatisation is unlikely to occur/be of real benefit in terms of investment etc. until port flows increase; however, this is constrained by inefficient public management of the ports.

Though the list may not be exhaustive, we can take a further look into the proposed port hindrances for individual countries (see Figure 2.21). These main bottlenecks reveal- weaknesses in the ports institutional framework. In the instance of St. Lucia and Trinidad and Tobago excessive government interference in order to make decisions, can actually hinder efficient investment decisions, or the government may lack funds for investment decisions. In addition, excessive charges by the port authority to the government can too delay port development.

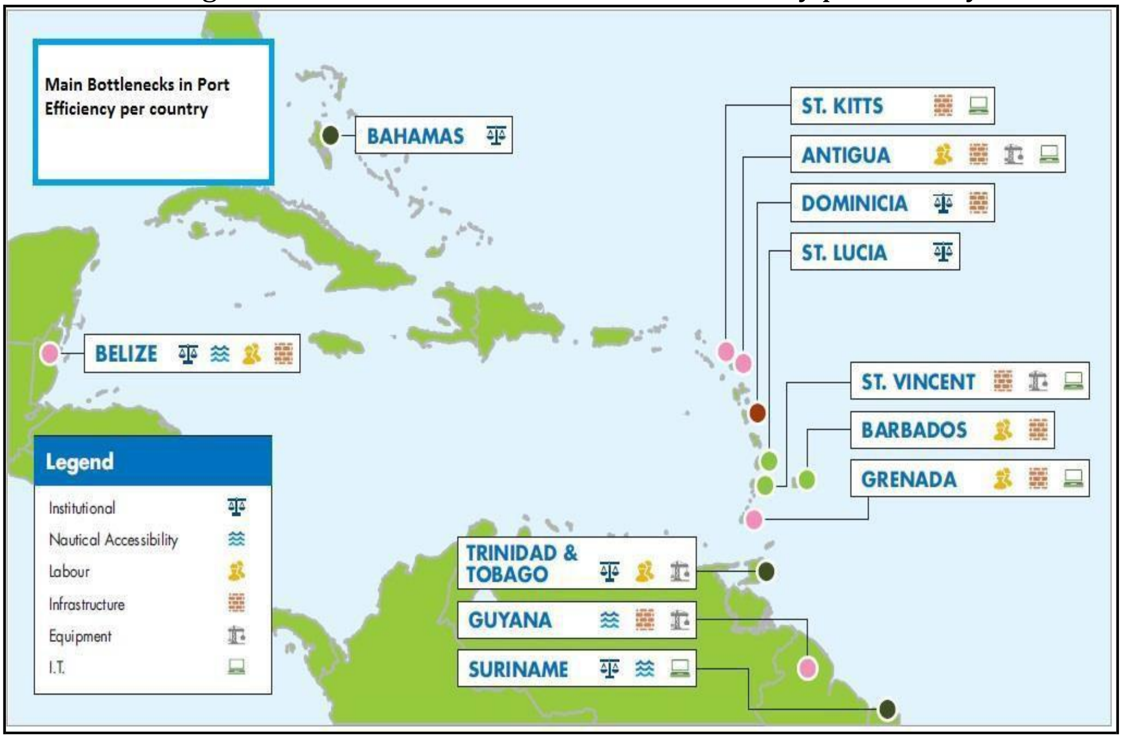
In the case of Guyana, though not in the Caribbean but worth mentioning, there are no clear stipulations and structure as to who assumes control over port development issues, due to a number of operators. Moreover, where there exists more private sector involvement, such as in Belize and the Bahamas ports, the public authorities may not have the capacity and sufficient funds for improving port efficiencies (such as dredging) at the request of private operators.

Lack of adequate port infrastructure and equipment is another hindrance to the port's progress. For instance, ports of Guyana, Grenada, St. Vincent, Dominica, St. Kitts, Trinidad and Tobago, and Antigua, lack some or all of the basic port infrastructures (such as paved quays, suitable depths and nautical accessibility), efficient terminal designs and pier structures, and equipment. Port equipment is generally broken-down and takes time to replace, outdated and/or in insufficient numbers. All of these bottlenecks, present delays and leads to operational inefficiencies.

Labour issues act as a bottleneck especially when port operators and the port authority, take lightly the role of human capital in the operations of the port. Outdated labour practises, dangerous working conditions, lack of shift systems and strong labour unions resulting in work stoppage, can hinder port efficiency. Mainly ports of Belize, Grenada, Antigua, Trinidad and Tobago, St. Lucia, and Barbados are plagued with this situation.

Lastly the lack of information technology (IT) systems amongst Caribbean ports, continue to be addressed given the technological century we live in. Presently, smaller ports of Antigua and St. Kitts have no IT systems installed and so still engage in paperwork for cargo tracking and clearing. On the other hand, Belize and Grenada ports have standard IT systems for cargo and customs, while Guyana, Dominica, St. Vincent, and Suriname ports utilize systems that are more advanced. While this is so, the issue lies about the lack of integration between systems. These results in delays and increased dwell times of cargo (see Figure 2.21).

Figure 2.21 Main Bottlenecks in Port Efficiency per country



Source: (CDB, 2016)

2.8 CONCLUSION

This chapter has explored the Caribbean, and extensively its macro and micro economies. It has given an indication of their progresses or lack thereof over the past decade, and primarily the region's large dependence/openness to international trade. This shows the port industry as predominantly the region's lifeblood, through which goods and services flow. It therefore stresses the relevance of local and regional authorities in making pertinent decisions when it comes to the performance of each port, and achieving their objectives. Furthermore, it takes the reader deeper into their trade patterns, partners and levels of trading arrangements at the local, regional and international level.

Ongoing port related hindrances, which is one of the key investment priorities for tackling in CARICOM, present a direct impact upon port performance that cannot be ignored, and will be examined later on in Chapter 7. Overall, in light of increased globalization and trade liberalization, the region's large dependence upon international trade become a problem, when policy makers hinder the port's efficiency / productivity due to poor policy and investment decisions. In order to better understand Caribbean ports, the following chapter delves into academic literatures centred on the economic functions/ administrative models of the port itself, and a number of port development models.

CHAPTER THREE

THE ECONOMIC APPROACH TO CONTAINER PORTS

3.1 INTRODUCTION

A seaport is a point of convergence between the maritime and inland domain for some types/s of cargo/passenger circulation. The most basic function of a seaport is for the transference of goods and passengers between ships and shore and/or between ships (Goss, 1990).

Today ports are seen in an entire different spectrum. Their progress is influenced by world changes driven by globalization, trade growth, increases in vessels sizes, logistics networks, technology and private sector involvement in port management. This has changed the way in which port development is now approached (Notteboom and Winkelmans, 2001; Notteboom, et al. 2013; Peters, 2001). In order to be successful, port managers must incorporate these changes or face the possibilities of losing existing and potential market shares to competitors. Port authorities must address the current challenges such as congestion and limited handling capacity in order to allow better access to the hinterland and seaway (Pettit and Beresford, 2009).

This chapter looks at the academic literature on the general composition of the port, and its various management models. The evolutionary trends in containerization and the progresses in port development to accommodate these changes are examined.

3.2 THE PORT SYSTEM, ADMINISTRATION MODELS & BENEFITS OF CONTAINER PORTS

3.2.1 The Port System (Facilities, Services, Activities)

According to the Port Reform Toolkit, by the World Bank (2007), the general functions of a port are usually performed by one or more organizations. Though these functions are self-explanatory, they are further elaborated in this section and summarized in Figure 3.1. These include:

1) *Landlord for private entities offering a variety of services*
2) *Regulator of economic activity and operations*
3) *Regulator of marine safety, security, and environmental control:*

    The port authority acts as a policing power that enforces regulations and monitors shipping and port operations carried out by private entities, to ensure that they are being abided by. Some of these include regulations regarding the upkeep of port infrastructure, public safety and security, and environmental practices.

4) *Planning for future operations and capital investments*
5) *Operator of nautical services and facilities*
6) *Marketer and promoter of port services and economic development:*

    Aimed at promoting the successes of the port industry, for attracting new clients and for business promotion.

7) *Cargo handler and storer*
8) *Provider of ancillary activities*

In order to fulfil its functions, the port must provide basic facilities and services, in the form of infrastructure, superstructure, and service to its clients, acting as the interface between maritime and land access (see Figure 3.1) (World Bank, 2000). Furthermore, the port has an internal infrastructure, which includes docks, berths, storage area, and internal connections such as roads. They also have a superstructure, which are fixed assets, assembled on the infrastructure. These include terminals, cranes and pipes and so on.

Furthermore, on the maritime access side, the port is responsible for providing facilities such as proper channel points, approximation zones, breakwaters and locks and, signalling equipment. All of these are relevant in order to best accommodate the port's most significant client, which in most cases are the shipping lines.

On the other hand, land access infrastructure includes roads, railways and proper navigation channels. The port itself cannot influence the establishment of this infrastructure, but must be given hefty relevance, as poor land access can affect port development. They are necessary in accommodating clients who enter from the maritime and/or land access.

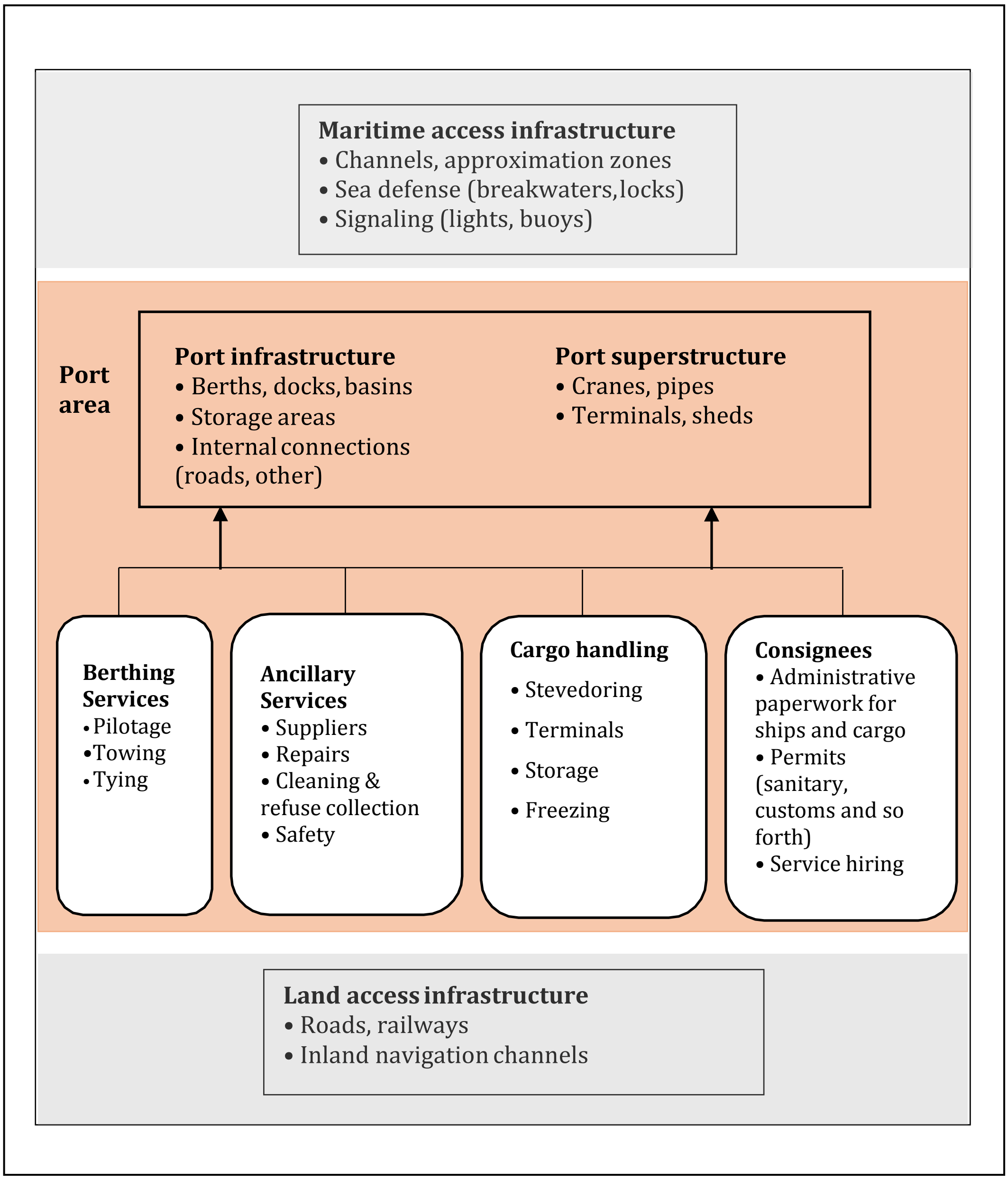
Different operators provide many port services. These include berthing, ancillary, cargo handling and consignees' services. Berthing services include pilotage which relates to activities such as the operations required for the ship to enter/exit the port safely, towage actions which encompasses operations of manoeuvring the ship using tugs, tying, and vessel traffic services, and so on. These amenities are provided by the port authority themselves and/or private firms.

Moreover, ancillary services to ships and crew include supplies to ships such as repairs, cleaning and refuse collection, safety such as fire protection services, fuel and water, and port information. Private firms in the case of large ports usually provide ancillary services, but, in instances of smaller ports, the port authority affords these activities, which is the state.

Statistics reveal that cargo-handling charges account for between 70% and 90% of the cost of moving goods through a port (World Bank, 2000). Port operators must pay close attention to these services, since it is a reflection of the port's operations and efficiencies. These services include all activities related to the movement of cargo to and from the ship and across the port's facilities, such as stevedoring, terminals, storage and freezing. Today, due to containerization, ports increasingly have to adapt to newer technologies and equipment to better accommodate these cargoes, which requires additional capital investments.

Furthermore, background work is required in order for the ship to dock and offload/on-load at a particular port. A shipping agent (consignee) handles those activities such as administrative works relating to customs, the access to certain permits for instance health clearance, import and export requirements and so.

Figure 3.1: Port Facilities, Services, and Activities



Source: (World Bank, 2000)

While the facilities, services and activities of Figure 3.1 may still be relevant post 2000 and today that other functions over the past decade have been made to port operations. This includes incorporating logistical and distributional activities that function as intermodal hubs in the supply chains, offering door-to-door service to the customers. This means the port coordinates activities or services for one or several supply chains from the point of origin to the point of destination, adding new value to the goods in this process. The logistical and distributional function can be generated in seaports with adequate organization and management. In addition, there are other elements instrumental for the seaport to develop the

logistical and distributional function, these include:
-the organization providing for all the documents and the reception of goods,
-storage,
-conservation,
-quality and quantity control,
-packing,
-palletization,
-labelling,
-commissioning,
-personalization of goods or products,
-customs clearing (brokerage),
-inspection by inspectors,
-automatic invoicing,
-consolidation of consignments for delivery to the consignee,
-the organization providing for all the documents and the reception of goods, and -commercial agency for third parties, to name a few (Jakomin, 2003; Montwill, 2014).

3.2.2 Port Administration Models

The government plays a key role in the port's operations, particularly through the governing aspect. On the other hand, private operators and investors perceive the port to be a business through which they can achieve optimal returns from its capital. While both parties reveal differing interests, their private versus public involvement, determine the port's administration style.

The World Bank (2007) outlines four key port administration models. They include public service ports, tool ports, landlord ports and fully privatized ports. Each model differs with regard to the management of its most valued assets: infrastructure, superstructure, labour and other functions, as summarized in Table 3.1. Other functions include a mix of private/public ownership for mainly cargo handling, pilotage, towage, mooring services and dredging.

Public service ports usually controlled and run by the Government or public sector. This includes, the port governed by some form of arm under the government such as the Ministry of Transport or Trade. Here the port authority offers all the services required- infrastructure, superstructure, port labour and other functions, for the port's operations.

Furthermore, under a tool port model, the port authority controls the port's infrastructure and superstructure themselves. However, private staff contracted by shipping agents or other principals licensed by the port authority, perform cargo handling activities and port labour.

Within the landlord port model, infrastructures are owned by the Port Authority, and leases it to private operators. These private operators provide and maintain their own superstructure such as buildings, and quay cranes etc. Private operators also provide the specific labour, for the handling of cargo.

For private sector ports, all assets and activities of the port are taken over by the private sector. Port land, other port infrastructure, superstructure, labour and even regulatory functions are carried out by private companies.

Table 3.1: Port Administration Models

Type	***Infrastructure***	***Superstructure***	***Port Labour***	***Other functions***
Public service port	Public	Public	Public	Majority public
Tool port	Public	Public	Private	Public/private
Landlord port	Public	Private	Private	Public/private
Private sector port	Private	Private	Private	Majority private

Source: (World Bank, 2007)

Regardless of the administration model a port chooses to adopt, all ports accommodate a combination of public and private goods/services. They are therefore important to every economy and without a fully functioning port, providing the basic functions will result in unfavourable effects to that nation's economic growth. Put another way, ports act as *funnels to economic development* since they incite three major effects, direct benefits to the port, indirect benefits to port users and induced benefit to the economy (Rodrigue et. al., 2017).

Direct benefits to the port include revenues accrued from the use of port facilities. These include pilotage, berthing and towing fees, cargo-handling charges, rental fees, and terminal concessions, as in the case of landlord models. Additionally, ports are increasingly engaged in value added services such as warehousing, storage, distribution and value added services such as labelling, assembling, repairing, and arranging of inland transportation modes (rail and/or road). All of these services generate additional revenue to the port and transport companies.

Indirect benefits to port users go toward firms that use the port for import and export of its goods/services. These benefits are gained when the port's operations improve, for instance through enhanced terminal productivity, and reduced ship turnaround time and lower processing time for cargo. The outcome of this is lower shipping costs to shipping lines, lesser inland transport costs to truckers, and savings in insurance.

Induced benefits to the economy include those that pass through to the suppliers of input factors. This includes income to port staff, and income to industries supplying the port with good and services, which create indirect employment. These incomes furthermore generate spending throughout the economy, which results in more employment and income through the multiplier effect.

3.3 EVOLUTION AND TREND OF CONTAINER PORTS

Traditionally seaports were a gateway to the desired hinterland ships wanted to dock. Primarily seen as a single node, positioned along specific international supply and transport chains, under the governance of the local Government authority. Being publicly owned, its role as a "merit good," was to make an economic impact whereby among others, employment and tax revenues can be generated (Pettit and Beresford, 2009; La Saponara, 1986; Suykens and Van De Voorde, 1998; Yochum and Agarwa, 1988).

Little thought or consideration was given to the issue of efficiency; this was considered dependent upon primarily internal weaknesses and strengths encompassing just a local port level mind set (Notteboom, 2007). As noted within the World Bank's Port Reform Toolkit, (2007), *"The port sector has radically changed over the past two centuries. During the 19th century and first half of the 20th century, ports tended to be instruments of state or colonial powers. Competition between ports was minimal and port-related costs were relatively insignificant in comparison to the high cost of ocean transport and inland transport. As a result, there was little incentive to improve port efficiency."*

World Bank, (Pg. 21, 2007)

Today given world changes driven by globalization, trade growth, increases in vessels sizes, logistics networks, technology and private sector involvement in port management, ports are seen in an entirely different spectrum thereby altering the way in which port performance is now approached (Notteboom and Winkelmans, 2001; Peters, 2001; World Bank, 2005; Notteboom, et al.., 2013). Furthermore, given that over 90% of cargo is transported by sea compared to decades ago, it confirms a huge significance for continuous development of seaports in addition to the development of very efficient and sophisticated land based logistical supply chains (IMO, 2005, 2012; Monios and Wilmsmeier, 2011). In order to be successful a port's role must incorporate these changes or face the possibilities of losing existing and potential market shares to neighbouring ports.

Furthermore, the growing part of information technology (IT) is increasingly used throughout the industry. IT system electronically connects port administration, with shipping lines, terminal operators, inland operators, and other members of the port community, using real time data. With IT systems, port information such as cargo status, availability of port facilities, and inland logistics can be determined and planned beforehand so that delays and uncertainties on part of all users, are minimized.

Containerisation has become a rising trend within the maritime industry and has necessitated the need for adequate port facilities, that position the port for success in this newly logistics orientated environment (Notteboom, 2007). On the terminal side, private sector port involvement has become largely recognizable by ports owing to economic efficiency rewards resulting in financial and operational progress, geographical expansion, and/or to support their core business (such as shipping operations) (Baird, 2000; Hoffmann, 2001; Peters, 2001).

For these key reasons, leading global terminal operators (in terms of volume and hectares they control) such as Hutchison Port Holdings Limited (HPH), A.P. Moller Terminals (APMT), Port of Singapore Authority (PSA), and Dubai Ports (DP) World attempt to increase a port's scale of operations by engaging in new terminal developments and/or existing facility expansions (Notteboom and Rodrigue, 2012). This implies proper planning and policing on part of investors and local government officials, acquisitions in cargo handling facilities and equipment, modern information and communications systems- all that seek to ensure operational excellence.

Given this evidence, De Neufville and Tsunokawa (1981), and Heaver (1995), further point toward the fact that an employment of more capital investments in physical assets and IT systems is largely associated with an expansion of terminal/port facilities. This is because as international trade increases, larger ship sizes are built to accommodate more throughput in hope of reaping economies of scale. With this rise in throughput, ports are purchasing more equipment, likely to employ more port staff, and expanding their terminal area.

Today, ports have dramatically improved their operations taking on board these trends within the industry. This has resulted in large capital investments and port expansions, which have affected productivity and efficiency. Given all of these influencing factors throughout time, the concept of port development and so its impact on efficiency and productivity in order to meet changing demands, has received the attention of academics and the industry, which is explored next.

3.4 PORT PLANNING AND DEVELOPMENT

"Moreover, port development is very often dependent upon and determined by the degree to which a specific port in question is embedded within local and regional institutional considerations and, therefore, beyond the direct sphere of influence of the port system itself. This is critically important not only to the port but also to the economy it serves…"

(Wilmsmeier et al.., 2014, pg. 20-21)

In exploring the literatures on port development, the evolution of ports stems from one of the most traditional port development models called the 'Anyport' model. First introduced by J.H. Bird in 1963, he proposed five stages through which ports develop over time. These include:

Step 1: Setting- Here the port remained basic in its operations and facilities and was the furthest point of inland navigation by ships.

Step 2: Expansion- Due to the industrial revolution in the 18th and 19th centuries, quays and docks were expanded to handle larger ships with more cargoes and passengers,

Step 3: Expansion- also railways were integrated into the logistics system, as it was constructed to take cargo further inland.

Step 4: Specialization- This engaged in specialized freight, which required expanding warehousing and increasing terminal equipment to accommodate containers, ores, grain, petroleum and coals. In addition, larger vessel access required deeper dredging; longer berth lengths and increased handling capacities.

Step 5: Specialization- Furthermore due to larger vessels, port sites located adjacent to downtown areas were too small to accommodate this change, and so these ports became obsolete and abandoned, overtaken by other uses such as commercial and housing centres (Bird, 1963; 1971).

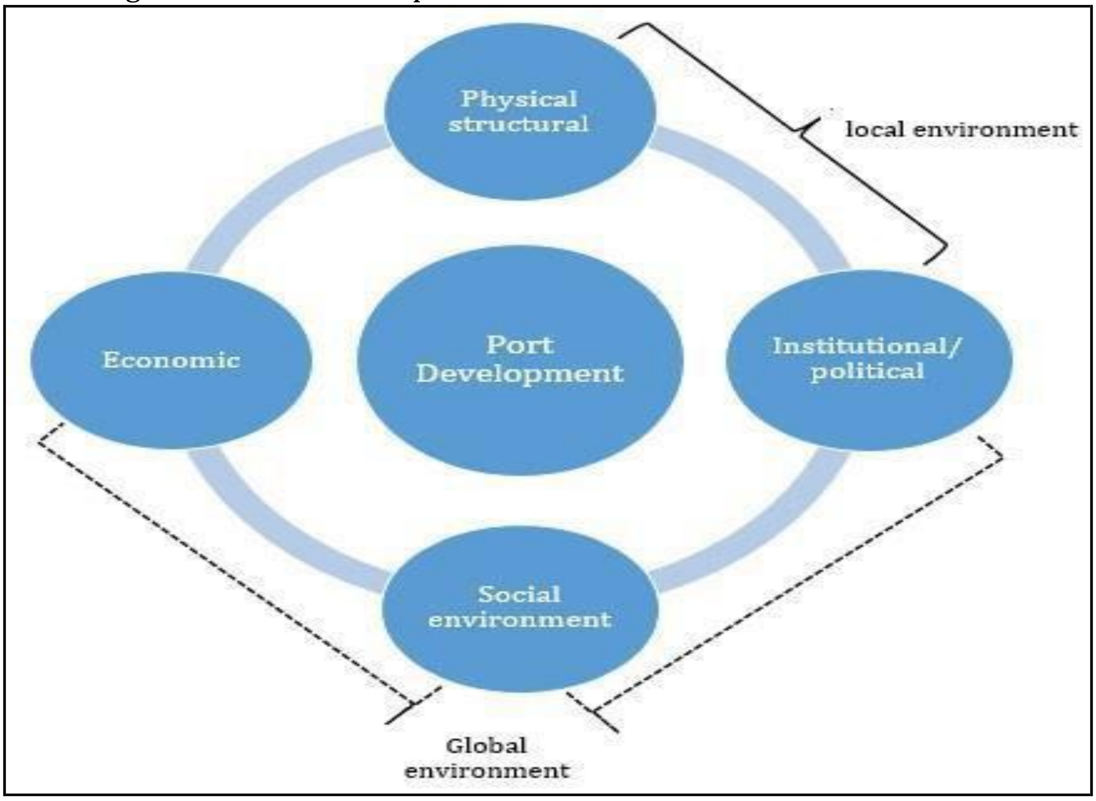
Continuing from the '*Anyport*' model, Taaffe et al.. (1963), Bird (1963), and Hoyle (1983), attempted to explain port development beyond the context of land/ maritime interface. This resulted in the inclusion of a wider context of economic, political and technological factors. Furthermore, in an attempt to capture port operations into a port development framework, the UNCTAD Three Generational Port Model was introduced in 1992. The model generally showed first, second and third generation ports and their phases of development as it existed during the pre-1960s, post 1960s and post 1980s eras respectively.

First generation ports acted as an interface between land and sea transport, isolated from transport and trade activities. Due to rising industrial activities, second generation ports developed better relations with transport and trade links. Lastly, third generation ports though maintained traditional activities of the first and second generation, integrated transport centres and logistics platforms, together with advanced equipment and information technologies for international trade (UNCTAD, 1992). Likely, Robinson (2002) and Notteboom and Rodrigue (2005, 2008) among others, have expanded on the integration of logistical integration in port development. While adequate attempts have been made to improve the concept of port development, the UNCTAD, 1992 model was criticised for its inabilities to capture the complexity of port infrastructure, operations/services, geographical location, and the extent of public/private sector involvement (Beresford et al.., 2004, Bichou and Gray, 2005; Wilmsmeier et al.., 2014).

In response to criticisms like these, Beresford et al.. (2004), introduced the WORKPORT model, which investigated the transition processes in European ports for over four decades. In addition to the main categories identified by the UNCTAD model, WORKPORT, included operational and development port issues such as working cultures, health and safety, cargo handling processes, and environment issues (Beresford et al.., 2004; Pettit and Beresford, 2009).

On the other hand, Sanchez and Tuchel (2005) approached port development from a systems approach, which involves identifying those variables that are likely to affect the port's progress. These include the port's physical structure (location, infrastructure, superstructure), the institutional/ political environment (political, institutional, organizational), economic and the social environment. Each is interrelated and having different impacts upon port development, in any given time period (see Figure 3.2).

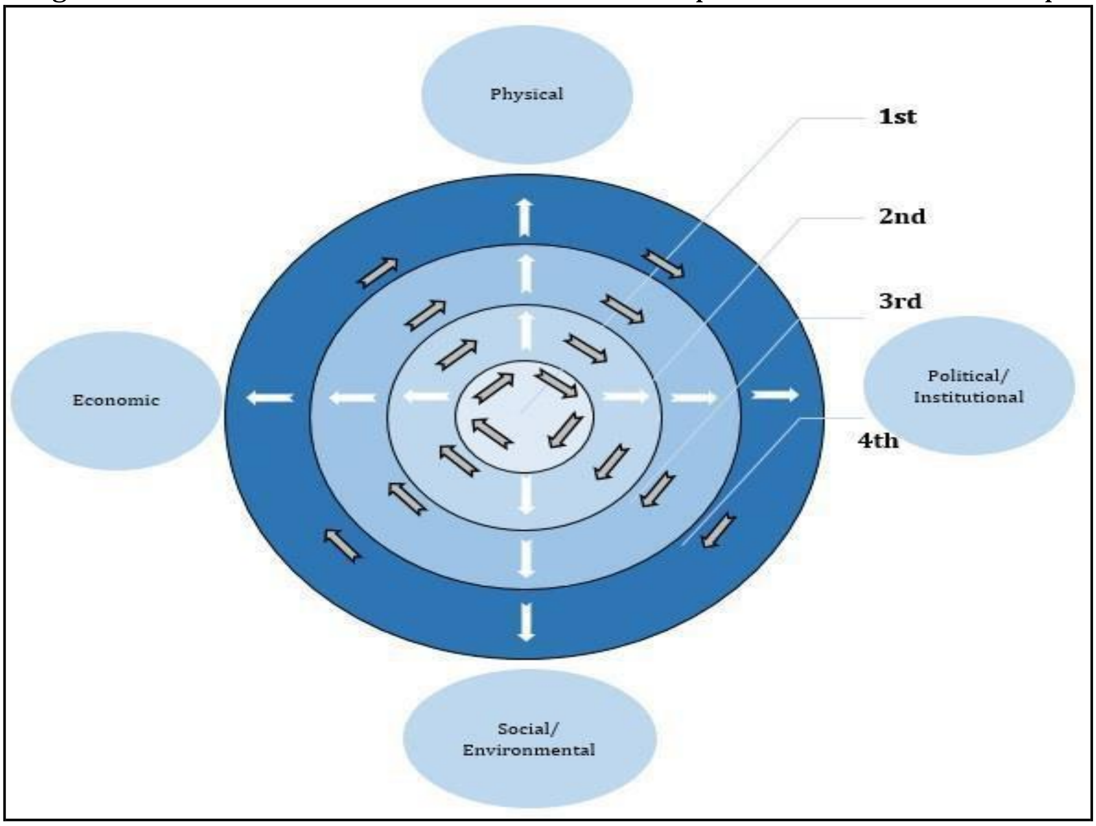
Figure 3.2: Port Development, its main determinants and environment



Source: (Sanchez and Tuchel, 2005)

The local and global environment was also introduced into the system, since different levels of the environment influenced each component. Sanchez and Tuchel (2005) afterward developed a conceptual vertical and horizontal process. This looks at the different levels of port development (1st, 2nd, 3rd and 4th generation ports) through a horizontal and vertical process in which the development of a port to a different level (vertical) requires the determinants as mentioned in Figure 3.2 to move in the same direction and reach similar levels of development (horizontal) (see Figure 3.3).

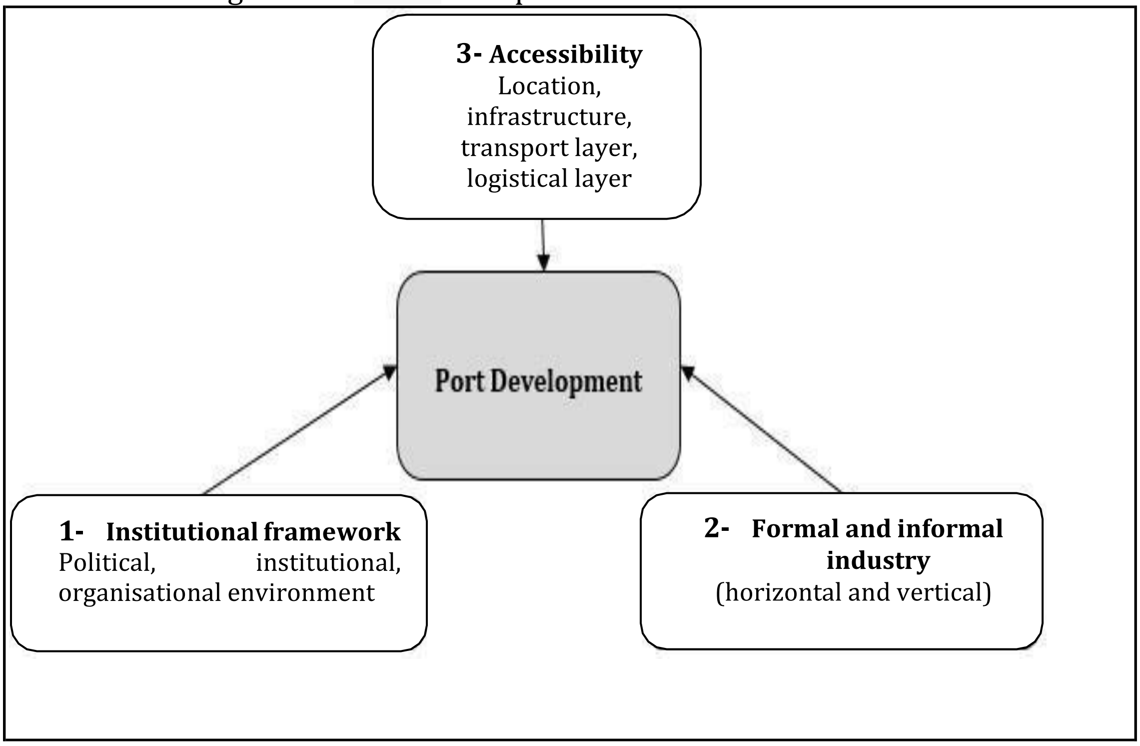
Figure 3.3: Horizontal and Vertical accumulation processes for Port Development



Source: (Sanchez and Tuchel, 2005)

Most recently, Sanchez and Wilmsmeier, (2010), identify with port development as the straightforward interaction of three groups: accessibility (location, infrastructure, transport layer and logistical layer), formal and informal industry relationships (horizontal and vertical relationships and the transfer of expertise), and institutional framework (political, institutional, organizational and environmental). Interaction and relationship between these variables are what impacts port development. The strength of each determinant is important since port development is likely to be hindered if any is taken lightly or ignored (see Figure 3.4).

Figure 3.4: Port Development and its main determinants



Source: (Adapted from Sanchez and Wilmsmeier, 2010)

Today, port development is seen in a wider context, which stretches beyond strategies relating to the port itself toward boarder strategies, which connect the port to increasingly inland, logistical facilities and activities termed *Port Regionalization* (Notteboom and Rodrigue, 2005, Pettit and Beresford, 2009, Monios and Wilmsmeier, 2012, 2013). Within this context, Sanchez and Wilmsmeier, 2010 describes port development as the *"process of creation and adaptation to satisfy changing demands of clients, with shifting requirements from basic port facilities to logistics facilities…"*

Establishing the key contributors of port development and its modifications over the years, we can agree that the common denominator in port development is the efficient use of the port's physical structure and accessibility. Successful port development exists when port authorities address the current challenges that stem primarily from congestion and limited handling capacity as traffic rises. Furthermore, a more efficient port allows better access to the hinterland and seaway, and if this is not addressed, the problems limit port development with regards to capacity and efficiency (Pettit and Beresford, 2009).

The *accessibility/ physical* component that this research stems from via port efficiency and productivity is of crucial importance, which must be continually investigated, given the evolving port environment and its dynamics. According to the United Nations (UN), *"benchmarks need to be established to monitor and improve port performance…"* (UNCTAD, 2014). While Small Island Developing States (SIDS) such as the Caribbean Community (CARICOM) aim to improve their maritime sector, they agree that *"…enhancing the maritime sector has the potential to fuel CARICOMs trade, increase port productivity and generate significant cost savings…"* (CARICOM, 2013).

3.5 CONCLUSION

This chapter has investigated the academic literature on the general composition of the port itself, its various management models, and the evolutionary trends in containerization and so progresses in port development to accommodate these changes. As ports continue to develop, the changes in efficiency and productivity over time reveal the need for adequate research in this area. This is so particularly among regions where there is reason to believe that this role may be significantly different to elsewhere in the world.

Furthermore, emerging findings can contribute to the formulation of port policies in the Caribbean, as to the appropriate need for port investment or lack thereof. It is likely that massive port investments in port expansion may possibly not be the most viable option for improving efficiency. This suggests that maximizing the most efficient use of existing capacities for particularly the Caribbean and considering thereafter port expansion can possibly be the most feasible option for improving port efficiency and productivity.

In the following chapter, critical examination is done of the literatures on the production theory of the firm, with particular reference to efficiency and productivity. Moreover, this theory is applied, to the container port industry, and results derived.

CHAPTER FOUR

PRODUCTION THEORY AND PORT EFFICIENCY: LITERATURE REVIEW

4.1 INTRODUCTION

Embedded within microeconomics, is the theory of the production and the firm. This is the ratio of converting inputs (factors of production) into output/s, and referred to as *productivity*. It is an absolute measure of performance, applied to all inputs and output/s- individually or simultaneously. Although total productivity (total factor productivity) is helpful in giving an overall sense of how a firm may be performing, it is very useful to measure the productivity of each input individually, termed partial productivity or single factor productivity.

Another key component of the theory of production is *efficiency.* Though productivity and efficiency are often used interchangeably, this should not be, since they both hold different meanings and uses. The efficiency of a firm on the other hand, compares between observed and optimal values of its output and input. This means comparing observed output to maximum potential output obtainable from the input, or comparing observed input to minimum potential input required to produce the output, or a combination of the two. For the two comparisons, if the optimum is defined in terms of production possibilities, then it is associated with technical efficiency, while if defined in terms of optimum cost, revenue or profit, then it is associated with allocative efficiency.

A thorough understanding of this economic theory and concepts, can aid decision makers with the necessary information that supports them with more informed policymaking or actions geared toward improving the performance of the firm.

In this chapter, the literatures on the production theory of the firm are examined, with particular reference to technical efficiency and productivity. Moreover, the methods employed to measure these are then looked at. Thereafter the container port industry is explored, conducting an exhaustive literature review on the key factors influencing port efficiency/ productivity, the various tests employed by credible authors. This literature review is then used to derive research hypotheses that will be empirically tested. This chapter provides a methodological foundation, which will be used for further empirical analysis and testing of the technical efficiencies of container ports in the subsequent chapter.

4.2 PRODUCTION TECHNOLOGY & FUNCTION

Not only does economic theory involve consumption, but the production of goods/ services. Production is the process of transforming inputs i.e. land, labour, and capital into outputs such as finished or intermediate products.

In order to determine what the best possible combinations of inputs are for producing an output, or what outputs from the various combinations of inputs are, this is encapsulated in the production possibilities of a firm. This looks at the various combinations of inputs and outputs that are technologically feasible i.e. the firm's production possibilities set and, is denoted by *Y.* The state of technology determines and restricts what is possible in combining inputs to produce outputs.

This is depicted within a production function. A production function stipulates the maximum amount of output that can be achieved from a given set of inputs, and is expressed as:

$$Q=f(x_1, x_2,\ldots,x_n) \quad \textit{(Equation 4.1)}$$

Simply put, output (Q) is a function of the factors of production, (x_1, x_2,..., x_n) such as labour, capital, and land (see Equation 4.1).

From a graphical perspective, (see Figure 4.1) the production function maps the total, average and marginal product curves. The total product (TP) curve represents the firm's total production in relation to the quantity of its variable input (for e.g. labour) that is assumed to be variable in the short run while capital is held constant.

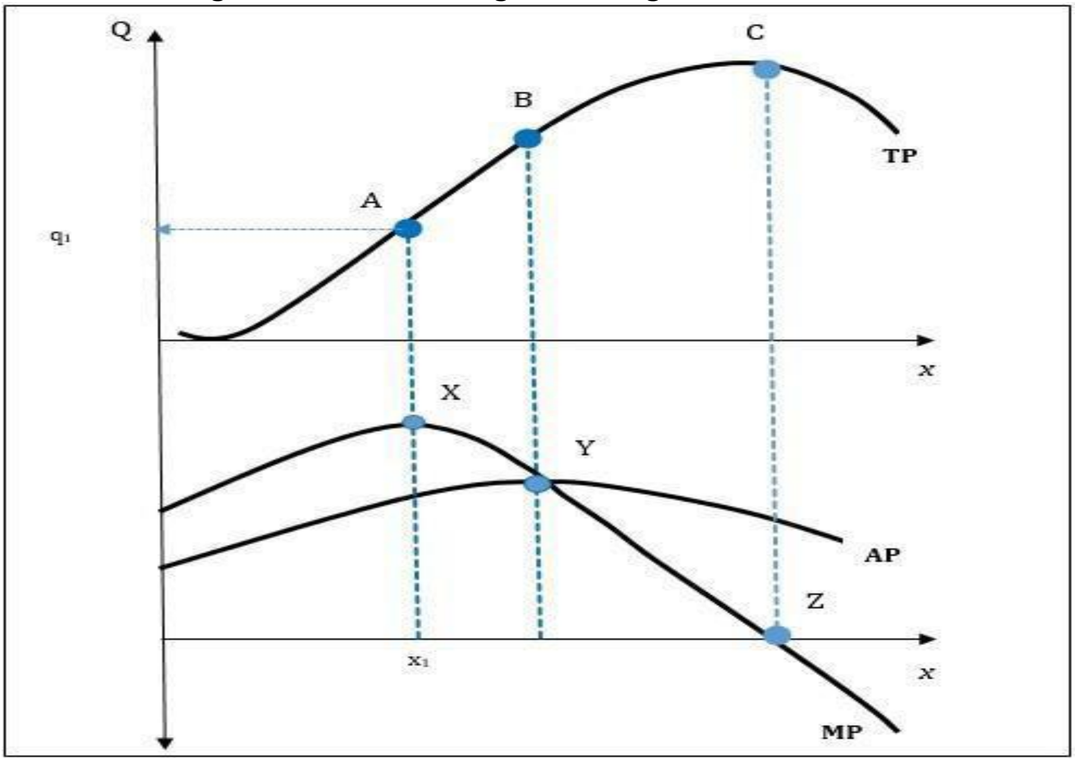
On the other hand, the average product (AP) curve calculates the quantity produced per unit of variable input, ceterus paribus. It is calculated by the formula (TP/Quantity of labour). Moreover, the marginal product (MP) curve represents the slope of the TP curve. It is the change in the quantity of TP resulting from a unit change in the variable input, while all other inputs are unchanged.

Leading up to point A on the TP curve, the firm experiences positive and increasing average and marginal returns, as additional units of labour are employed which increases output per unit. At point A, marginal returns is maximized at q_1 units of output and x_1 units of input (point X).

Between points A and B, TP is still positive but MP has started to fall (X to Y) due to decreasing marginal returns to the variable input- labour. Here, as labour increases, the extra units of output increases but at a decreasing rate. Average product however is still positive and reaches its maximum at point Y since output per unit of labour is still improving (seen by point B).

From points B to C, TP is also positive, but AP begins to fall as there is diminishing average returns (point Y and beyond). Here TP is rising but at a slower rate as the employment of additional labour decreases the output per unit given a fixed amount of capital.

Figure 4.1 Total, Average and Marginal Product Curves



Source: (Cooper, Seiford, and Tone, 2000)

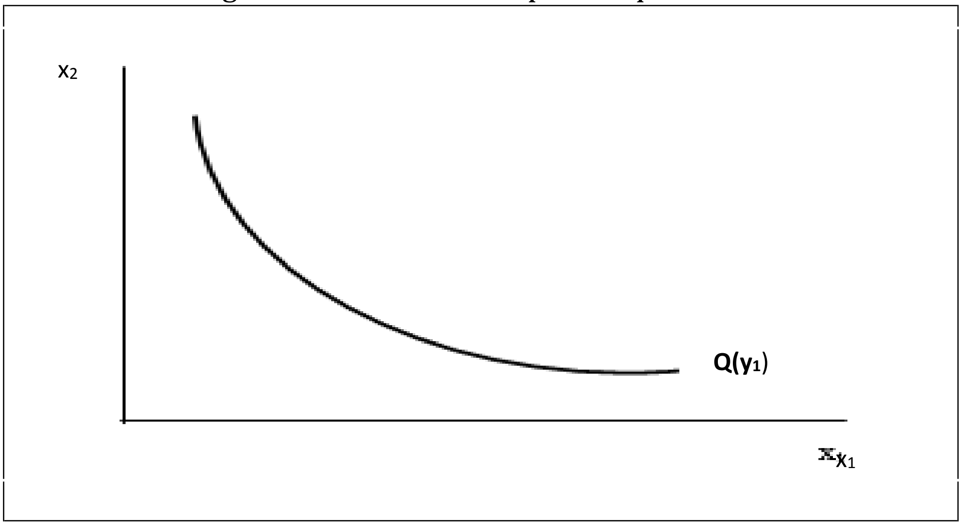
Now suppose all inputs are varied- labour and capital, which is the usual case in the long run period, then, the Cobb Douglas production function for a single output using two factors of production- labour (L) and capital (K) becomes:

$$Y=AL^{\beta} K^{\alpha} \qquad \text{(Equation 4.2)}$$

The total factor productivity is represented by *A*, and accounts for effects in total output growth with relation to growths in its inputs. α and β are output elasticities and range between values 0 and 1 which are determined by the available technology of the firm.

Graphically, the production function is illustrated on an Isoquant curve. The Isoquant curve shows all the combinations of inputs that yield the same level of output (see Figure 4.2).

Figure 4.2 A General shaped Isoquant Curve



Source: (Cooper, Seiford, and Tone, 2000)

Common Properties of the Isoquant include:

Many technology sets share similar properties even though they may have different processes and structures. Generally, the main properties of the isoquant include:

- *Possibility of Inaction*: no action on production is a possible production plan, $0 \in Y$.
- *Intersection of isoquants:* any two or any amount of isoquants cannot intersect each other. This is because they represent two different levels of output.
- *Isoquants do not touch either axis:* this implies that no input goes unused to produce the given level of output.
- *Higher isoquants represent higher levels of output:* a higher level of output is depicted by an outward shift of the isoquant curve.
- *Isoquants do not need to be parallel to each other:* this is because of the rate of substitution that may vary with the production technology of the firm.
- *Convexity*: the downward slope of the isoquant curve is due to the effects of diminishing Marginal Rate of Technical Substitution (MRTS), which implies that, an increase the use of labour for instance, fewer units of capital will be required, so that the same level of output is produced.

4.3 THE ECONOMIC CONCEPT OF TECHNICAL EFFICIENCY

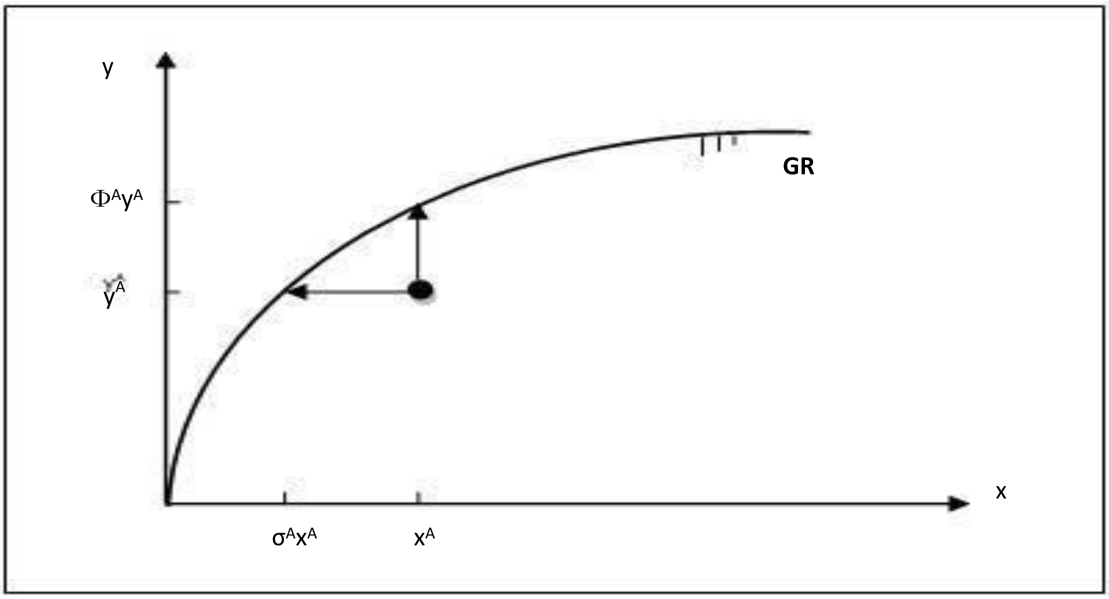
Embedded within the concept of economic efficiency, is technical efficiency. A DMU is technically efficient if it can produce the maximum amount of output from a given set of inputs or, if it can minimize waste given a level of output. A formal definition of technical efficiency provided by Koopmans (1951; p.60) states that a decision making unit is fully efficient if and only if it is not possible to improve its output or decrease any of its input (Koopmans, 1951, Cooper et al..; 2007). Put another way, a technically inefficient firm has capacity to produce the same amount of output with lesser input/s, or, can use the same inputs to produce at least one extra unit of output or more.

Debreu (1951) and Farrell (1957) introduced two special cases of measuring technical efficiency- the first being an input oriented approach and secondly, output oriented. An input approach holds the output fixed and calls a feasible input vector technically efficiency if and only no reduction in any input is feasible. On the other hand, an output oriented measure holds the input vector fixed and calls a feasible output vector technically efficient if, and only if, no increase in any output is feasible.

A system that schedules the production process aiming to minimize waste and costs while producing maximum output (production technology), is represented using a production possibility frontier (PPF). The PPF is a graphical depiction of the maximum output possibilities given its inputs. A firm is considered to be technically efficient if it is operating on the frontier, while, technically inefficient if it is operating below the frontier. Furthermore, the firm's PPF may change over time due to changes in the underlying technology deployed.

Now if a firm uses multiple inputs to produce a single output (applied later on in this research), Figure 4.3 uses the production frontier f(x) to demonstrate both measures of technical efficiency. A firm using *xA* to produce *yA* is technically inefficient since it operates beneath *f(x)* (the PPF).

Figure 4.3 Input- Oriented and Output- Oriented Measures of Technical Efficiency (M=1, N=1)



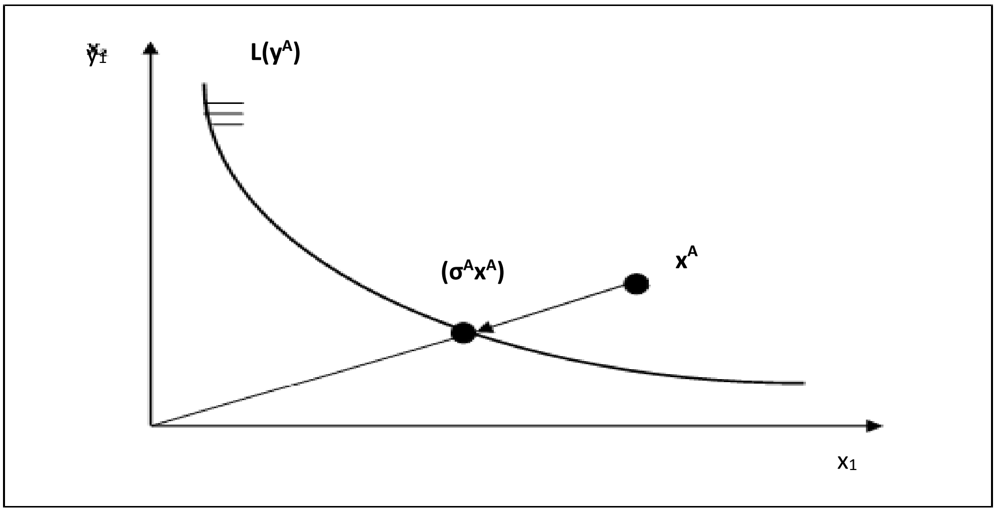
Source: (Cooper, Seiford, and Tone, 2000)

An individual representation of the input oriented measure of technical efficiency, can be shown on an isoquant. As discussed previously, an isoquant is a line drawn through the set of points at which the same quantity of output is produced, while changing the quantities of its inputs. Figure 4.4 uses the input set L(y) and its isoquant Isoq *L(y)* to demonstrate this measure.

This measure holds output constant while inputs are allowed to vary so that it returns to the most technical efficient point i.e. $\Theta^A x^A$. In this case, there is wastage of resources from the point of operation x^A since lesser amounts of both resources $x1$ and $x2$ should be used in order to produce at a technical efficient point, i.e. along the isoquant curve y^A.

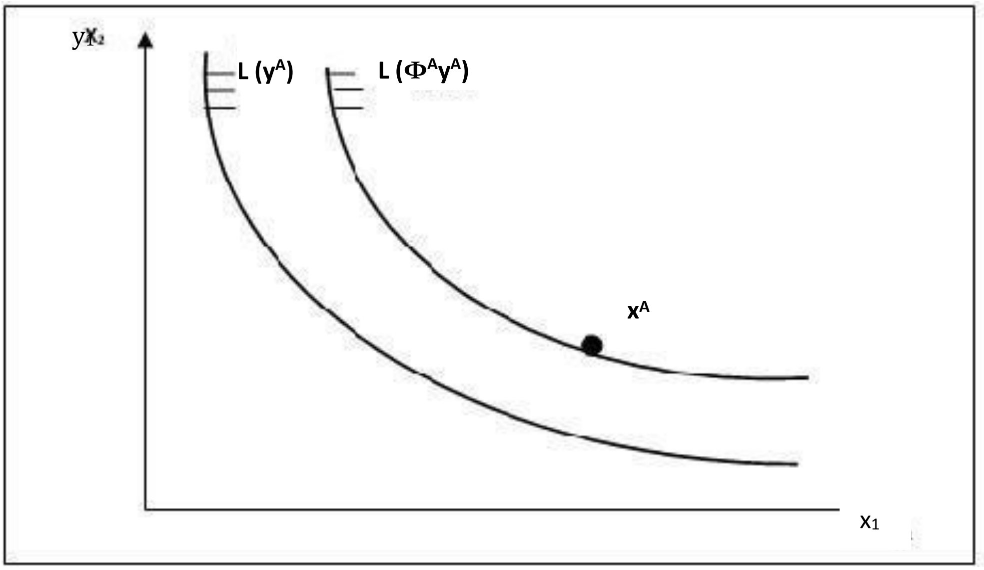
On the other hand, Figure 4.5 uses the input set *L(y)* and its isoquant Isoq *L(y)* to illustrate the output-oriented measure of technical efficiency. Simply put, by applying this measure the firm's input set x^A can increase its level of output that is beyond y^A, by an amount ϕ^A while still being technical efficient but on a new and higher isoquant curve Isoq $L(\phi^A y^A)$.

Figure 4.4 Input- Oriented Measure of Technical Efficiency (N=2)



Source: (Cooper, Seiford, and Tone, 2000)

Figure 4.5 Output - Oriented Measure of Technical Efficiency (N=2)



Source: (Cooper, Seiford, and Tone, 2000)

4.4 CONTEMPORARY METHODS OF TECHNICAL EFFICIENCY MEASUREMENT

Over the past few decades, a number of methods used for measuring technical efficiency, have been put forward which are centred on the production possibility frontier. These methods essentially use techniques to assess the productive performances of DMUs, and have become popular according to Bauer (1990), because they are:

- Consistent with the underlying economic theory of optimising behaviour and returns;
- Deviations away from the frontier are considered to be a measure of relative efficiency with which business units pursue their objectives and;
- Results of the frontier and relative efficiency of business units have many policy implications.

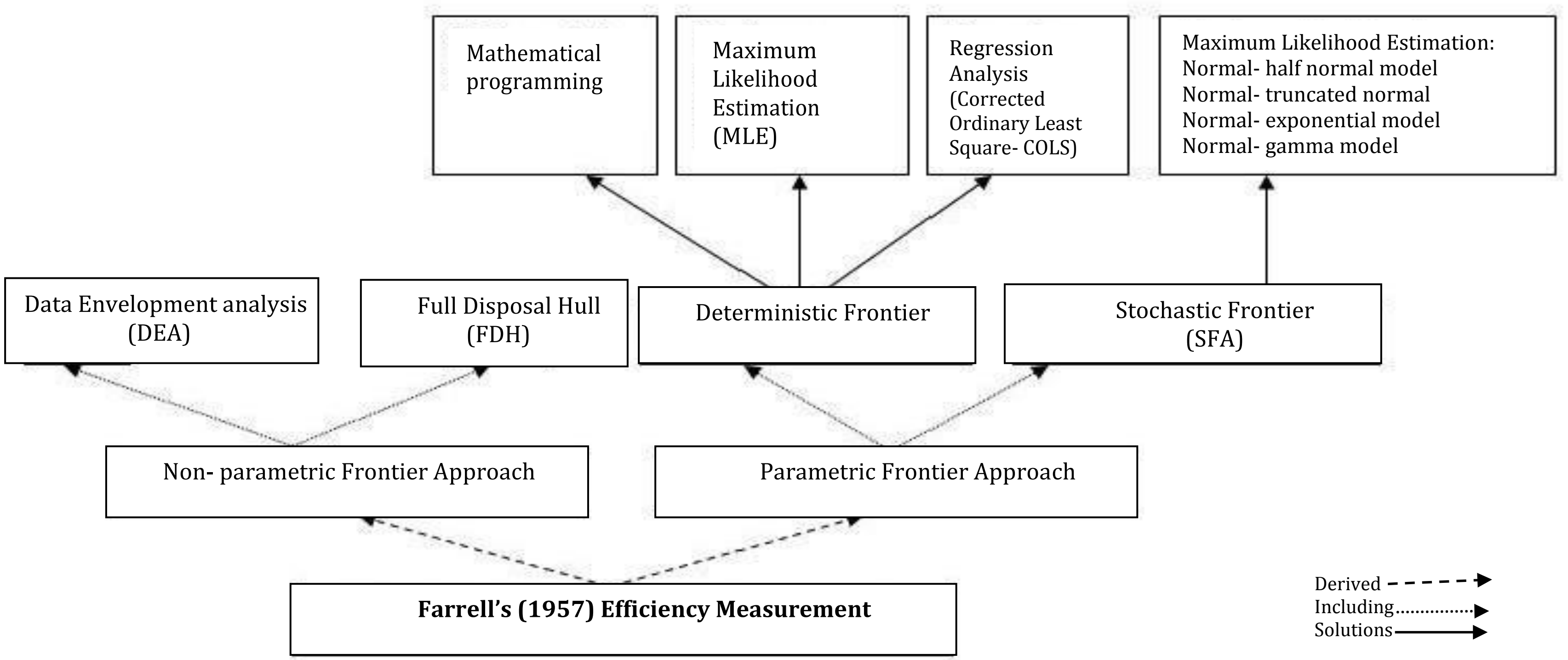
Within the transport related literatures, two prominent approaches stand out concerning the specification of the frontier model; these include a parametric versus non-parametric approach. Another important concept to note is, whether the model is stochastic versus deterministic.

- Stochastic (a random probability distribution or pattern that may be analysed statistically) methods allow for explicit assumptions with regards to the stochastic nature of the data, while deterministic methods take all its observations as given and implicitly assume that these observations are exactly measured.
- A parametric method is classified based on what is known about the population under study. It usually assumes that sample data comes from a population that follows a probability distribution based on a fixed set of parameters, while non-parametric methods are not dependent upon assumptions made about the population. The non-parametric frontier approach is centred on mathematical programming techniques, which is generally referred to as Data Envelopment Analysis (DEA) and Full Disposal Hull (FDH), while a parametric approach, employs more econometric techniques such as Corrected Ordinary Least Squares (COLS), and Stochastic Frontier Analysis (SFA) that are statistically

estimated based on an assumed distribution (see Figure 4.6).

While there are a great number of methods to test for technical efficiency, to date there exists no academic research that justifies the best approach to measuring this. Despite this, nonetheless drawing from past research and particularly from within the port industry, as to the methods that are most widely employed, and why.

Figure 4.6 Alternative Approaches to Efficiency Measurement



Source: (Wang et al.., 2005)

There currently exists no “best practise” test as to the most appropriate method to use in testing for the technical efficiency and productivity of seaports. While a number of alternative approaches have been utilized in the container seaport industry over the years, the author will, for this research apply the DEA-MPI approach due to its relevance in responding to the research hypotheses. The advantages of using the DEA is that it is a frequent approach used in scholarly port productivity related journal articles. In fact, could be described as the mainstay of research in this port productivity, hence the results produced from this research will be directly comparable with other studies on the subject. Also, it is relatively more workable with regards to data requirements (e.g. it only requires basic units, and these can be specified in different units of measurement). Moreover, the DEA can incorporate multiple inputs and outputs, it does not require the specification of an underlying functional form of the relationship between the output and the inputs, and finally DMU’s are directly compared against those ‘most like’ rather than a sample wide ‘best’, which may be operating at a completely different level/scale.

The DEA and other contemporary methods, are be explored next.

Non-Parametric Methods

4.4.1 Data Envelopment Analysis

Data Envelopment Analysis is a non-parametric approach that uses linear programming to measure the relative efficiency of a DMU. The frontier is obtained by identifying the highest potential output given different input combinations, and the degree of efficiency is measured using the distance between the observation and the frontier. Both input/output oriented approaches as well as the assumption of the relevant returns to scale, can also be examined using this approach.

The CCR Model

A key characterization of the shape of the frontier relates to the assumption with regard to returns to scale (RTS); the DEA can be conducted under the assumption of *constant returns to scale (CRS) or variable returns to scale (VRS)*. Based on the seminal work of Charnes, Cooper and Rhodes (CCR) in 1978, the CRS assumption is appropriate when all firms are operating at an optimal scale. Here the DMU is operating where an increase in inputs result in a proportionate increase in the output levels. For each DMU, the virtual input and output by weights (V_i) and (U_r) are:

$$\text{Virtual input} = V_1X_{1o} + \ldots + V_mX_{mo}$$
$$\text{Virtual output} = U_1Y_{1o} + \ldots + U_sY_{so}.$$

Here,

The weights assigned to each input, range from V_1 (weight of input 1) to V_m (weight of input m, being the final input in the data set).

$V_i = V_1 \ldots\ldots V_m$

X_1 represents input 1, to X_m being input m, depicting the last input in the data set.

The weights assigned to each output, range from U_1 (weight of output 1) to U_s (weight of output s, being the final output in the data set).

$U_r = U_1 \ldots\ldots U_s$

Y_1 represents output 1, to Y_s being output m, depicting the final output in the data set.

Over the entire data set for DMU_o which ranges for firms 1…, n.

The weights usually vary from one DMU to another DMU and are determined from the data using linear programming that maximizes the ratio:

$$\frac{\text{virtual output}}{\text{virtual input}}$$

Given the data, measuring the efficiency of each DMU and obtaining *n* optimizations, which means one for each DMU_j. DMU_j is designated as DMU_o where o ranges over the data set firm 1…, n which is then evaluated. We then proceed to solving the following fractional programming (FP) problem, which obtains values for the input weights (V_i) (i = 1,…,m) and the output weights (U_r) (r= 1,…,s) as variables.

(FP$_o$) max	$\theta = \frac{U_1Y_{1o} + U_2Y_{2o} + \ldots + U_sY_{so}}{V_1X_{10} + V_2X_{20} + \ldots + V_mX_{m0}}$	*(Equation 4.3)*
subject to	$\frac{U_1Y_{1o} + \ldots + U_sY_{so}}{V_1X_{1o} + \ldots + V_mX_{mo}} \leq 1;$	*(Equation 4.4)*
	$V_1, V2, \ldots, Vm \geq 0$	*(Equation 4.5)*
	$U_1, U_2, \ldots, U_S \geq 0.$	*(Equation 4.6)*

Source: (Cooper, Seiford, and Tone, 2000)

Maximizing the fractional programming problem (FP$_o$) Θ (see Equation 4.3), yields the maximum value of 1 which means a relatively efficient DMU whereas a number less than 1 shows inefficiency. Subject to the constraints (see Equations 4.4- 4.6), the ratio of virtual output vs. virtual input should not exceed 1 for any DMU, therefore the objective is to obtain weights (V_i) and (U_r) that maximize the ratio of DMU$_o$, the efficiency of the DMU being evaluated.

Thereafter, convert the fractional program (FP$_o$) into a linear program (LP$_o$) which is supported by two theorems- 1) FP$_o$ is equivalent to LP$_o$, and 2) the optimal values of Θ are independent of the units in which inputs and outputs are measured, provided that these units are the same for every DMU. The LP$_o$ is denoted by Equation 4.7 subject to constraints Equations 4.8-4.11.

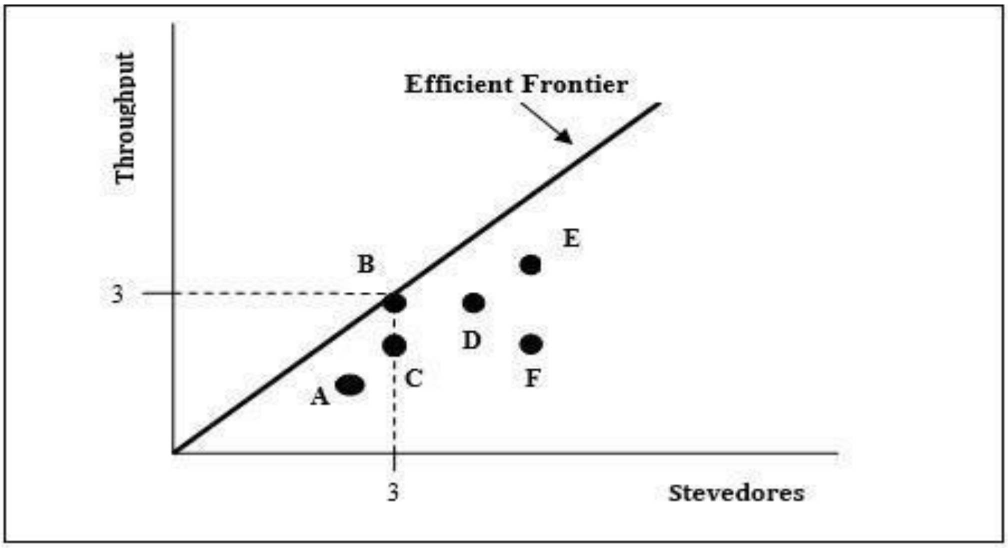
(LP$_o$) max	$\theta = U_1Y_{1o} + U_2Y_{2o} + \ldots + U_sY_{so}$	*(Equation 4.7)*
subject to	$V_1X_{1o} + V_2X_{2o} + \ldots + V_mX_{mo} =$	*(Equation 4.8)*
	$(U_1Y_{1o} + \ldots + U_sY_{so}) - (V_1X_{1o} + \ldots + V_mX_{mo}) \leq 0;$	*(Equation 4.9)*
	$V_1, V2, \ldots, Vm \geq 0$	*(Equation 4.10)*
	$U_1, U_2, \ldots, U_S \geq 0.$	*(Equation 4.11)*

Source: (Cooper, Seiford, and Tone, 2000)

As a result, *DMU$_o$* is CCR-efficient if Θ* = 1 and *there exists at least one optimal* (v*, u*), with v* > 0 and u* > 0. Otherwise, *DMU$_o$* is CCR-inefficient. A graphical depiction of the CCR production frontier is shown in Figure 4.7. Here, DMU B is the most efficient DMU within the sample, given its input (stevedores) and output

(TEU throughput). For its level of input (3), it has been able to maximize output (3) unlike the other DMUs in the sample, which is not operating at full capacity, but below the efficient frontier. For instance, DMU A is not fully utilizing its input. If it increases the use of its existing stevedores, it can possibly accommodate more TEUs, pushing its production toward the efficient frontier.

Figure 4.7 CCR- Efficiency Production Frontier



Source: (Cooper, Seiford, and Tone, 2000)

The BCC Model

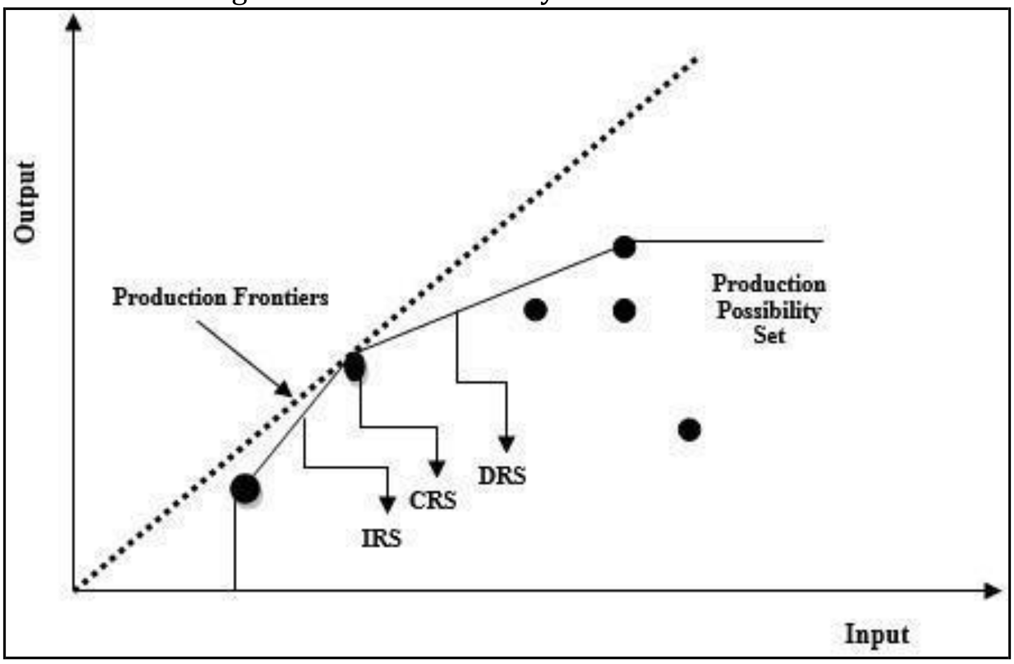
An extension of the CCR model have been proposed and developed over the years, of which the most well-known and applied is the Banker, Charnes and Cooper (1984) (BCC) model. It allows scale effects to be incorporated into the estimation , in which modifications to the LP_o are denoted in Equation 4.12, subject to the constraints Equations 4.13-4.16. Consequently under the DEA approach, VRS efficiency must always be greater than or equal to efficiencies estimated under the CRS assumption.

(LP_o) max	$\theta = (U_1Y_{1o} + U_2Y_{2o} + \ldots + U_sY_{so}) -$	*(Equation 4.12)*
subject to	$V_1X_{1o} + V_2X_{2o} + \ldots + V_mX_{mo} = 1$	*(Equation 4.13)*
	$(U_1Y_{10} + \ldots + U_sY_{so}) - (V_1X_{1o} + \ldots + V_mX_{mo}) - \quad \leq 0;$	*(Equation 4.14)*
	$V_1, V2, \ldots, Vm \geq 0$	*(Equation 4.15)*
	$U_1, U_2, \ldots, U_S \geq 0.$	*(Equation 4.16)*

Source: (Cooper, Seiford, and Tone, 2000)

With VRS, an increase in inputs does not result in only a constant change in output but also by increasing returns to scale (IRS) (output increases by more than that proportional change in inputs), decreasing returns to scale (DRS) (output increases by less than that proportional change in inputs) (see Figure 4.8).

Figure 4.8 BCC- Efficiency Production Frontier



Source: Cooper, W., Seiford, L.M., Tone, K., (2000)

Malmquist Productivity Index

The Malmquist productivity Index (MPI) has become a standard approach in productivity measurement over time. First introduced by Malmquist (1953) and further developed by some, note mentioning Caves et al.. (1982) and Fare et al.. (1994).

The MPI is an index, which measures growth and declines in productivity, which is a representation of the changes in efficiency levels over the period, under investigation. Temporal changes in efficiency can be credited to two key sources of the management and business environment, namely i) *catch up effects* and ii) *frontier shift effects* (Nishimizu and Page, 1982; Grifell and Lovell, 1993; Estache et al.., 2004; Cheon et al.., 2010).

Under the *catch up effect*, which is referred to as the change in technical efficiency ($EFFCH_k$), depicts the port's movement toward and thereby along the production frontier over a period. As the term implies, it shows the DMUs potential to employ the necessary managerial best practises so that it can operate on the frontier at any point in time. Here, the DMU either a) maximizes outputs given its level of inputs or varies inputs where there is minimum wastage in order to accommodate a given amount of outputs (pure technical efficiency change (PECH)), and/or b) responds to port demand by flexibly changing production scales (scale efficiency change (SECH)). Scale efficiency changes are usually acquired from investment in new facilities and/or expansion of existing facilities.

Incorporating size within the analysis, then the concept of scale efficiency comes into play. The efficiency value calculated under VRS is generally technical efficiency (which ignores scale effects), whereas under the CRS assumption, technical efficiency is decomposed into pure technical efficiency and scale efficiency. A DMU is scale efficient when it is operating at an optimal scale. Any changes in its size however will render the DMU scale inefficient because it is either too small or too large. A scale efficiency score of 1 indicates that the firm is operating at its most productive size, while, a score smaller than 1, expresses otherwise. Pure technical efficiency on the other hand ignores the impact of scale size by comparing DMUs of similar scale.

Under the CRS and VRS assumptions, efficiency scores of the latter are usually equal to or higher than CRS evaluations. This is because the frontier more closely wraps around the data points as opposed to the CRS assumption.

Moreover, the *frontier shift effect* is, just as its name implies, a shift of the production frontier due to technological progress. Here the DMU is able to keep abreast and adapt innovative technologies in its production processes. This means employing longer term strategic planning, engaging in huge capital investments that eventually accesses larger markets.

The usefulness of learning about the decomposition of technical efficiency is that it can more adequately reveal the main source of inefficiency of a DMU, in comparison under the CRS assumption. It can reveal issues related to the quantity and combination of inputs and outputs, or, scale effects concerning the stage of increasing or decreasing returns to scale in order to ascertain the increase/decrease of the scale.

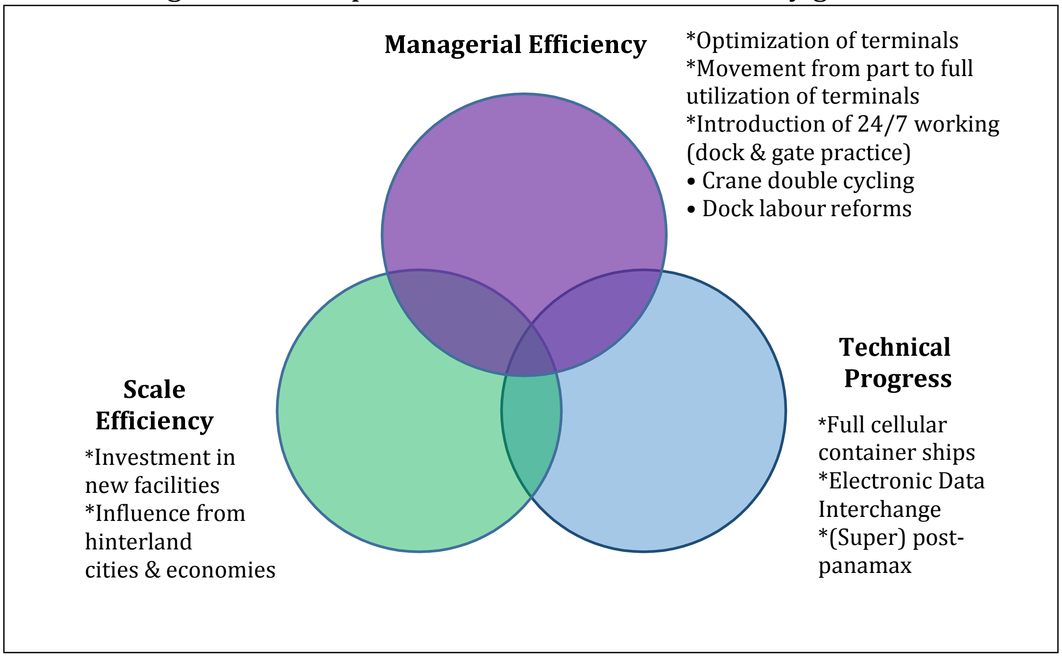
When applied to the port sector, Cheon et al.. (2010) nicely depicts the various port practises world ports have implemented to achieve each source of efficiency (see Figure 4.9). For instance, gaining technical efficiency or *the catch up effect*, focuses more on the internal operations of the port such as its managerial and operational practises. These can consist of terminal optimization, movement from part to full utilization of terminals, introduction of 24/7 working (dock & gate practice), crane double cycling, dock labour reforms and so on.

Furthermore, scale efficiency improvements can be achieved from investments in new facilities, primarily for small and medium sized ports who may be operating at increasing returns to scale and have not optimized its operations. Additionally the influence from hinterland cities and economies due to a change in demand fuelled by rising economic growths can also improve scale efficiency. While this is so, port authorities however may not be in a position to influence this. This is because these factors are external to the port itself (Estache et al.., 2004).

Moreover, technological progress or that which shifts the frontier outward (*frontier shift effect*) has to do with the implementation of new technologies in the port's operation process. These may include fully cellular container ships, electronic data Interchange, and being able to accommodate (Super) post-panamax container ships to name a few.

Each of these three practises and sources of efficiency gains when applied together or individually, can improve a port's MPI. These practises however can be interdependent and so an improvement in port efficiency may depend on the dependence between two or more practises. For instance, scale efficiency can support frontier shifts, mainly when the issue of congestion and capacity constraints arise.

Figure 4.9 Port practices for sources of efficiency gains



Source: (Cheon et al., 2010)

Therefore, the Malmquist TFPCH for a decision making unit *k,* is decomposed into two components, the:

- change in technical efficiency ($EFFCH_k$)
- change in the frontier technology ($TECHCH_k$)

Therefore, ***$TFPCH_k = EFFCH_k \times TECHCH_k$***

EFFCH is furthermore the product of pure efficiency change (PECH) and scale efficiency change (SECH):

- PECH measures the changes in pure technical efficiency of a DMU; pure technical efficiency ignores the impact of scale-size
- SECH measures the changes in the scale efficiency of a DMU, measured by dividing total efficiency change by pure efficiency change in a particular point in time.

A mathematical composition of the TFPCH is constructed through a simple one input/output case in two periods, *t* and *t*+1. For this reason, the level of productivity is the ratio of output to input (Equation 4.17) and subsequently, its productivity change becomes (Equation 4.18):

$$\frac{y^t}{x^t} \text{ and } \frac{y^{t+1}}{x^{t+1}} \qquad \textit{(Equation 4.17)}$$

$$\frac{y^{t+1}/x^{t+1}}{y^t/x^t} \qquad \textit{(Equation 4.18)}$$

Source: (Caves et al.., 1982)

In most cases however, calculating the productivity changes of multiple inputs and outputs, in this circumstance, the above equation is rewritten in terms of distance functions (D_o), as follows:

$$\frac{y^{t+1}/x^{t+1}}{y^t/x^t} = \frac{y^{t+1}/x^{t+1} D_o\,(1{,}1)}{y^t/x^t D_o\,(1{,}1)} = \frac{D_o\left(x^{t+1}/y^{t+1}\right)}{D_o\left(x^t/y^t\right)} \qquad \textit{(Equation 4.19)}$$

Source: (Caves et al.., 1982)

Consequently, the Malmquist productivity change index in terms of the distance function becomes (Caves et al. (1982)),

$$M_o^t = D_o^t\,(x^{t+1}, y^{t+1}) \,/\, D_o^t\,(x, y)$$ *(for time period t)* *(Equation 4.20)*

and

$$M_o^{t+1} = D_o^{t+1}\,(x^{t+1}, y^{t+1}) \,/\, D_o^{t+1}(x^t, y^t)$$ *(for time period t+1)* *(Equation 4.21)*

Source: (Caves et al.., 1982)

As a result, the productivity change for a particular DMU in time *t* and *t*+1 is given as,

$$M_o\,(x^t, y^t, x^{t+1}, y^{t+1}) = (M_o^t \,.\, M_o^{t+1})^{1/2}$$

$$= \left(\frac{D_o^t\,(x^{t+1}, y^{t+1})}{D_o^t\,(x, y)}\,\frac{D_o^{t+1}\,(x^{t+1}, y^{t+1})}{D_o^{t+1}\,(x, y)}\right)^{\frac{1}{2}}$$

(Equation 4.22)

Source: (Caves et al.., 1982)

Finally, the MPI, which decomposes multiplicatively into the efficiency change (EFFCH) component, and technical change (TECH) component becomes:

$$EFFCH = D_o^{t+1}\,(x^{t+1}, y^{t+1}) \,/\, D_o^t(x^t, y^t)$$

(Equation 4.23)

$$TECH = \left(\frac{D_o^t\,(x^{t+1}, y^{t+1})}{D_o^{t+1}\,(x^{t+1}, y^{t+1})}\,\frac{D_o^t\,(x^t, y^t)}{D_o^{t+1}\,(x^t, y^t)}\right)^{\frac{1}{2}}$$

(Equation 4.24)

$$M_o\,(x^t, y^t, x^{t+1}, y^{t+1}) = EFFCH \times TECH$$ *(Equation 4.25)*

Source: (Caves et al.., 1982)

When the $TFPCH_k > 1$, it is indicative of a gain productivity while $TFPCH_k < 1$ is a decline in productivity, and $TFPCH_k = 1$ means no change in productivity from time *t* to *t*+1.

4.4.2 Free Disposal Hull

Another non-parametric frontier approach that has received research attention over the years is the Free Disposal Hull (FDH). Introduced by Deprins, Simar and Tulkens (1984), the two primary motivations of this model, are to ensure that efficiency evaluations are effected from only actual observations, and there is free disposability.

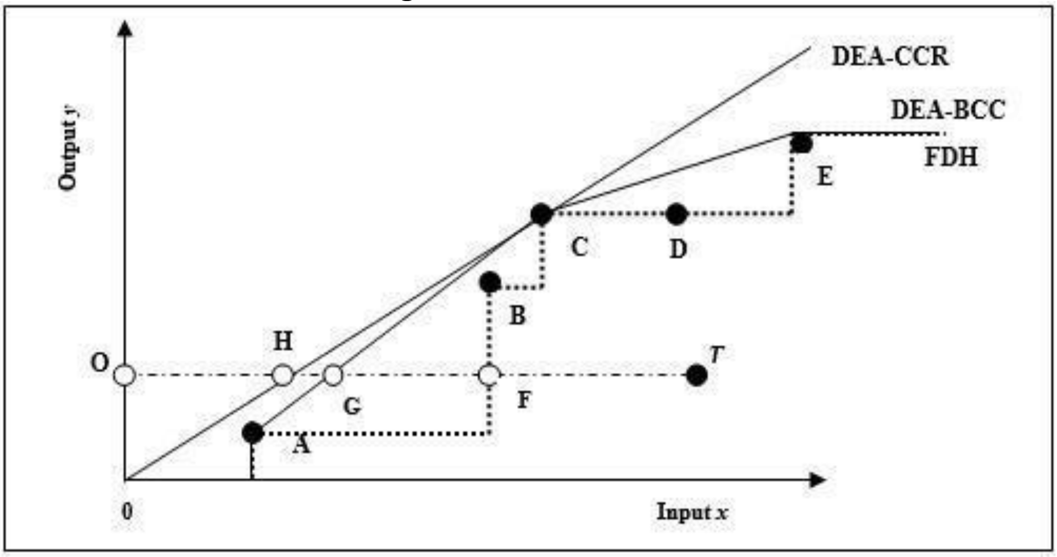
As both the DEA and FDH are deterministic and non-parametric methods, they assume no particular functional form for the boundary (non-convexity nature). The best practice technology therefore is the boundary of a reconstructed production possibility subset based upon directly enveloping a set of observations. This is accomplished through mathematical programming techniques.

Secondly, FDH assumes free disposability which makes it possible that, given inputs x, a DMU can decrease the production of any output by any desired amount (output disposability) or on the other hand, it is possible to produce any given output y with more input resources than is absolutely necessary (input disposability).

Figure 4.10 presents an example of FDH for five DMUs, having one input x to produce one output y (also included, the DEA-CCR and BCC graphs for comparison purposes). The boundary of the set represented by DMUs A-E forms the production possibility sets for DEA-CCR, DEA-BCC and FDH, it can be seen that observations A and C are feasible under every approach. Since each approach defines its production possibility set differently and therefore efficiency results, for instance the input oriented efficiency of DMU T is given by OF/OT (FDH), OH/OT (DEA-CCR) and OG/OT (DEA-BCC).

According to Lovell and Van den Beckaut (1993), the FDH is becoming more popular today, although it is less utilised than the DEA.

Figure 4.10 FDH- Illustration



Source: (De Borger et al.., 2002)

Parametric Methods

4.4.3 Corrected Ordinary Least Squares (COLS)

One of the parametric methods as highlighted in Figure 4.6 is the Corrected Ordinary Least Squares (COLS) approach, and first discussed. COLS implies that all deviations from the estimated frontier is due to inefficiency and this is derived from a two-step approach.

In step one; OLS is used to specify the relationship between the output and inputs having derived consistent and unbiased estimates for the slope of the parameters but biased estimate for the intercept parameter.

In step two, the biased intercept is then shifted or 'corrected' for by taking the exponential, of the difference of the maximum value, of the largest estimated error, from the residuals to every DMU under investigation. Having taken the exponent, the most and least efficient DMUs retain a score of and between 1 and 0 respectively. Furthermore, with regards to the average, when the DMU is more efficient than the average, its residual is greater than zero, on the other hand, when it is less efficient than the average score, the residual is less than zero.

Similar to Ordinary Least Squares (OLS), a large data set is required in order to obtain reliable estimates and results. Moreover, the scores are highly sensitive to outliers, which these serve as a type of benchmark for comparison with other DMUs in the analysis. Another shortfall of COLS is that the error term only identifies the technical inefficiency component of the error term. Therefore, most studies that utilize parametric frontier approaches apply the COLS method in conjunction with SFA analysis, which decomposes the error term into two elements- the noise component and the nonnegative technical inefficiency component.

4.4.4 Stochastic Frontier Approach

Aigner et al. (1977), and Meeusen and van den Broeck (1997) introduced the SFA model is estimated using econometric modelling. It has its starting point in frontier analysis with MLE regression tests and so its production function is evaluated to express the ideal industry structure from which the (in) efficiency of individual firms can be assessed. A key characteristic of the SFA is that it allows for technical inefficiency, as this is not all attributed to the residual, and allows for the provision for random shocks outside the control of the DMU, which can affect output. These may include strikes, adverse weather conditions, equipment failure and so on. This is embedded in the error term, which is decomposed into two elements- the noise component and the nonnegative technical inefficiency component.

Since the SFA takes a parametric functional form then the production frontier is shown in Equation 4.26:

$$y_k = f(x_{1k}, x_{2k}, \ldots, x_{Mk}, U_k, V_k) \qquad \textit{(Equation 4.26)}$$

Where y_k is the observed scalar output of the DMUs, k=1, 2, … , K,
x_k is the observed scalar input of the DMUs, k=1, 2, … , K
U_k is the non- negative technical inefficiency component
V_k is the noise component

Therefore, the output is a function of the inputs, technical efficiency and a noise component. The next step in solving a stochastic frontier is to specify its functional form. Justification for a particular choice is largely based upon *a priori* information about the underlying technology, however, most production practises appear to be much more complicated than just studying the underlying technology and so it is usually difficult to determine the best functional form to be used. Instead, a decision is usually based on its flexibility and statistical properties concerning the underlying assumptions relating to returns to scale (Gong and Sickels, 1992).

As shown in Equation 4.27, if we assume a simple log- linear Cobb-Douglas form using cross sectional data, the model becomes:

$$In\, y_k = \beta_0 + \sum_{m=1}^{M} \beta_m\, In\, x_{mk} - \mu_k + v_k, \qquad \textit{(Equation 4.27)}$$

$$\mu_k \geq 0,\ k = 1,2,\dots,K$$

Where maximum likelihood estimation method is used to estimate the values of both β (a vector of technology parameters to be estimated) and μ. The advantage of Ordinary Least Squares (OLS), based results is that they are easy to obtain, but it is based on asymptotic theory (or large sample theory) and many times sample sizes may be relatively small. For reasons as this, the Maximum Likelihood Estimation (MLE) based tests, using cross sectional data is considered.

All maximum likelihood estimations require assumptions made about the variables, the inefficiency component and the statistical errors, so that technical efficiency of each DMU is estimated. The four models primarily used entail: the normal-half normal model, the normal-exponential model, the normal-truncated normal model, and the normal-gamma model. These are the assumptions regarding the distribution of the efficiency components. Since it is not the author's intention to delve into each estimation procedure, their respective efficiency components referred to in the works of Aigner (1977), Meeusen and van den Broeck (1997), Stevenson (1980), Greene (1990), and Jondrow et al.. (1982).

Panel data strongly contains more observation points than does cross sectional data for each DMU. Use of panel data enables some of the strong distributional assumptions used with cross sectional data to be relaxed or result in estimates of technical efficiency with more desirable statistical properties. While cross sectional data may be used for reasons such as lack of data availability, Schmidt and Sickels (1984) noted three issues concerning cross sectional stochastic production frontier models:

- Separation of technical inefficiency from statistical noise both requires strong distributional assumptions on each error component. The robustness of inferences to these assumptions is not well documented.
- MLE requires an assumption that the technical inefficiencies error component be independent of the regressors, even though it is easy to imagine that the technical inefficiency may be correlated with the input vectors that DMUs select.
- While the technical efficiency of DMUs can be estimated using the Jondrow et al. (1982) technique, it cannot be estimated consistently since the variance of the conditional mean of the conditional mode of (μ_k | ε_k) for each individual DMU does not go to zero as the size of the cross section increases. Repeated observations on a sample of DMUs resolve the inconsistency problem.

Each of these limitations can be avoided if panel data is used since it enables us to:

- Adapt conventional panel data estimation techniques to the technical efficiency measurement problem; and not all of these techniques rest on strong distributional assumptions. Repeated observations on a sample of DMUs can serve as a substitute for strong distributional assumptions.
- Not all panel data estimation techniques require the assumptions of independence of the technical inefficiency error component from the regressors. Repeated observations on a sample of procedures can also serve as a substitute for the independence assumption.
- Adding more observations on each DMU generates information not provided by adding more procedures to a cross section.

4.4.5 Summary

This section has established the main parametric and non-parametric efficiency measurement approaches. While each has its benefits and so the appropriate reasoning of its use, the DEA is chosen in this research for various reasons. Firstly, it does not require assumption of a functional form relating inputs to outputs, as is the case of parametric approaches such as the SFA. In addition, DMUs can be directly compared against a peer or combination of peers, which is the focus of this research given the four sub-groups. Thirdly, inputs and outputs can have very different units. For instance berth length is measured in centimetres, whereas terminal area in hectares, without requiring an a priori trade-off between the two. Furthermore, the DEA can calculate for efficiency and productivities, unlike the FDH and SFA, which may be very difficult, or if not impossible to do as to date, the author has not seen it done.

4.5 PORT TECHNICAL EFFICIENCY ANALYSIS WITHIN THE CONTAINER PORT INDUSTRY

Containerisation has become a rising trend within the maritime industry and has necessitated the need for adequate port facilities which position the port for success in this newly logistics orientated environment (Notteboom, 2007). Directing port resources toward the improvement of terminal operations are necessary in improving the efficiencies and productivities of seaports.

On the terminal side, private sector port involvement has become largely recognizable by ports owing to economic efficiency rewards resulting in financial and operational progress, geographical expansion, and/or to support the ports' core business (such as shipping operations) (Baird, 2000; Hoffmann, 2001; Peters, 2001). For these key reasons, leading global terminal operators (in terms of volume and hectares they control) such as Hutchison Port Holdings Limited (HPH), A.P. Moller Terminals (APMT), Port of Singapore Authority (PSA), and Dubai Ports (DP) World dedicate to increasing a port's scale of operations by engaging in new terminal developments and/or existing facility expansions (Notteboom and Rodrigue, 2012). This implies that proper planning and policing on part of investors and local government officials, acquisitions in cargo handling facilities and equipment, modern information and communications systems and skilled labour in port operations - are all expected to ensure an improvement and move toward the port's operational excellence.

The efficiency/ productivity of a port's operations as depicted from the use of its factors of production- land, labour, and capital, required to perform a given task in a given time frame, is a measure of how efficient the port is. These include but are not limited to, the berth's length, terminal area, storage capacity, the number of dockworkers, and cranes & equipment (see Table 4.1).

Overall, the literature shows a rising trend in the use of DEA with emphasis on constant and variables returns to scale (CCR, BCC) assumptions. For instance, authors who used the DEA method where keen to employ both constant and variable returns to scale assumptions when conducting their analysis rather than just one (see Table 4.1).

Itoh (2002) set out to analyse the efficiencies of 8 major international Japanese ports during the period 1990 to 1999. Itoh applied inputs- number of container berths, number of cranes, area of container terminal and labour to determine the impact upon TEU throughput, using the DEA window analysis method. This method uses the concept of moving averages, which is useful in detecting performance trends of a DMU over time. Each DMU in every segmented period is treated differently. In so doing, the performance of it in a particular period can be compared with its own performance another period, while furthermore comparing it the performance of other DMU.

Using DEA window analysis, those ports such as Tokyo and Shimizu recorded higher efficiency scores in relation to the other ports. These ports had a timelier development and sound demand growth as it was more responsive to receiving larger shipping vessels and with that increased traffic, than those with deferred re-planning and slow demand recovery. Furthermore, the incorporation of labour in the analysis improved the efficiencies of the other ports that performed relatively poorly. While, applying BCC, which assumes variable returns to scale, improved the efficiency scores of smaller scale operations compared to tests under the CCR assumption. This analysis has revealed the significance of port response and reactiveness to an evolving industry. Implementing panel data furthermore was appropriate as it helped reveal changes over time in the environment, which is connected to the impact of the ports' efficiency.

On the other hand, Cullinane et al. (2005) analysed the world's top 30 ports/terminals in the 1999 to determine their level of efficiencies applying different model forms. He incorporated both DEA and FDH, which are two non-parametric approaches and had never been comparatively applied to the port industry before. The article provides a validation of the inputs used which include, the number of gantry cranes, and straddle carriers, quay length and terminal area since they are considered the most important facilities for handling containers within a terminal; output chosen is TEU throughput. The results of DEA- CCR and BCC revealed technical efficiency scores with an average 58% and 76% respectively, while the FDH showed a 90% mean. The relevance of this paper shows that while the effects of these tests yield different results, Cullinane et al. (2005) proposes the relevance of expectations about the presence of economies of scale, which renders the DEA-BCC model more appropriate. In addition, if it is desirable to identify scale (in) efficiency, in addition to technical (in) efficiency, then there is justification for the application of both DEA-CCR and BCC model forms.

Moreover, Cullinane and Wang, (2006) analysed the efficiencies of 57 of the world's top ports/terminals, using cross sectional data for 2001 and panel data for the period 1992- 1999. This research was conducted so that substantial waste, if any, could be identified in the ports' production process. Using quay length, terminal area, quayside gantry cranes, yard cranes, and straddle carriers as inputs, the authors assess the efficiencies of the ports by looking at the inputs impact upon its TEU throughput. Under the assumption of DEA-CCR, and using cross sectional data the average efficiency score was 58% while the DEA- BCC model form yielded 74%. While this is so, Cullinane and Wang emphasise the importance of using panel data, since the efficiency of different container ports can fluctuate over time to different extents and, from time to time even drastically.

A further issue is that capital inputs are only acquired over the long run, as opposed to labour, which can be varied to match more immediate needs, hence where labour is not included in the assessment, its omission can lead to considerable fluctuations over time of estimates of a port's efficiency. Use of panel data tends to cancel out these effects over time, and hence gives a far better estimate of the port's underlying efficiency level. One final issue is that production is a flow process; it is not a static concept at a single point in time, although for practically purposes data observations relating to specific periods are used to estimate the production process. Panel data gives a far better dynamic to this type of analysis as it far better reflects the reality of production.

Due to limited research conducted within these countries' grouping, as well as it's increasing economic growths, Wu and Goh (2010) applied DEA-CCR and BCC model forms to determine the efficiency scores of twenty-one of the top emerging and advanced countries in the year 2005. Using quayside and yard cranes, straddle carriers and quay length as inputs with TEU throughput as their output, the ports average efficiency scores for both DEA- CCR and BCC were 65% and 74% respectively. Another key finding of the article is that no advanced country had a port ranked highly compared to the ports of the emerging countries.

Furthermore, Wilmsmeier et al.. (2013), analyses the evolution of container terminal productivity and efficiency of twenty terminals in Latin America and the Caribbean, and Spain for the period 2005–2011. Spain was used as a benchmark to the LAC ports. The analysis applied a DEA based Malmquist productivity index to determine the impact of inputs terminal area, ship to shore crane capacity, and the number of workers upon output TEU throughput. Overall results show the productivity of the sampled ports for the period increased by 3%. While this presents a final answer, the article allows for specifically identifying the effect of dynamic economic environments (such as pre-crisis effects) on productivity and efficiency on the terminals. Furthermore, this paper is also the first that analyses and compares port productivity and efficiency evolution for the main container terminals in Latin America and the Caribbean, and presents contribution to existing literature, which this dissertation will furthermore expand on.

Lastly, Serebrisky et al. (2016) tested the efficiencies of 63 Latin American and Caribbean ports (LAC) whose ports represented 90% of cargo handling in the region. Collecting cross sectional (2009) and panel data (1999-2009), They employed quayside and mobile cranes, berth length, terminal area, ownership structure and port size as inputs, with TEU throughput as output. Exogenous variables were also introduced to determine their impact upon the ports' efficiencies such as GDP, liner shipping connectivity index (LSCI), merchandise trade, and a corruption index. SFA and DEA tests were incorporated for comparative analysis sake. Under the SFA, tests revealed an improvement in the average efficiency of ports in the LAC region from 52% to 64% during the 10-year period, with an average of 59% over the same timeframe. Additionally, one key finding of this research has revealed that the ports' efficiency has been more closely related to port management such as port ownership, than to institutional and countrywide variables.

Table 4.1: Literature Review of Container Port Technical Efficiency: DEA

Author	***Data Set***	***Year Examined***	***Input***	***Output***	***Model***
Tongzon (2001)	Australian and other international	1996	No. cranes, berths, tugs, labour, delay time, terminal area	TEU throughput, Ship working rate	DEA-CCR,
Valentine and Gray (2001)	31 top	1998	Total berth length, av. berth length	TEU throughput, Total tons	DEA-CCR,
Itoh (2002)	8 Japanese	1990-1999	Terminal area No. of berths No. Gantry cranes No. of workers	TEU throughput	DEA-CCR DEA-BCC
Barros (2004)	6 Portuguese and Greek	1998-2000	Labour, capital	TEU throughput, Total cargo handled, movement of freight, no. of ships	DEA-CCR DEA-BCC
Turner et al. (2004)	26 North American	1984–1997	Quay length, terminal area, No. cranes	TEU throughput	DEA
Cullinane et al. (2005)	Top 30	1999	No. Gantry cranes No. Yard cranes No. Straddle carriers Quay length Terminal area	TEU throughput	DEA-CCR DEA-BCC
Cullinane and Wang (2006)	Top 30	2001, 1992-1999	No. Gantry cranes No. of Yard	TEU throughput	DEA-CCR DEA-BCC

			cranes No. of Straddle carriers Quay length Terminal area		
Wang and Cullinane (2006)	European	2003	Terminal length, area, equipment costs	TEU throughput	DEA-CCR DEA-BCC
Hung, Lu and Wang (2010)	31 top Asian-Pacific	2007	Terminal length, area, No. berths, No. gantry cranes	TEU throughput	DEA-CCR DEA-BCC
Wu & Goh (2010)	Top 21 BRIC	2005	No. of Quayside cranes No. of Yard cranes No. of Straddle carriers Quay Length	TEU throughput	DEA-CCR DEA-BCC
Niavis and Tsekeris (2012)	30 South-Eastern European ports	2008	No. of berths, berth length, No. of cranes	TEU throughput	DEA-CCR DEA-BCC
Li, Luan, and Pian (2013)	42 coastal Chinese	2010	Terminal length, handling equipment, labour quantity	TEU throughput	DEA-CCR, DEA-BCC,
Lu and Wang (2013)	31 Major Chinese and Korean	2010	Yard area per berth, No. quay cranes, No. yard cranes, No. yard tractor per berth, Berth depth and length	TEU throughput	DEA-CCR, DEA-BCC
Schoyen and Odeck (2013)	24 Norwegian/UK	2002-2008	Berth length Terminal area, No. yard cranes, straddle carriers	TEU throughput, container handling trucks	DEA-CCR, DEA-BCC
Suárez-Alemán et al. (2014)	African	2010	Terminal area, No. cranes, No. berths, total length of berths,	TEU throughput, TEU throughput movement/hour	DEA-CCR
Cullinane et al. (2006)	Top 30	2001	Terminal length, area, No. quay cranes, yard cranes, straddle carriers	TEU throughput	DEA-CCR, DEA-BCC SFA
Wanke et al.. (2011)	25 Brazilian	2009	No. of berths, Terminal Area, Parking lot (no. of trucks)	Throughput tons, Loaded shipments	DEA-CCR, BCC SFA
Serebrisky et al. (2016)	63 LAC ports	1999-2009, 2009	Berth length Terminal area Ownership structure Port size	TEU throughput	DEA-CRS DEA- VRS SFA

Source: (Compiled by Author, 2016)

Furthermore, port related studies applying the DEA based MPI are outlined in Table 4.2. For over the last decade, these studies have adopted a multi country and/or multi-port approach using panel data. They span from a variety of ports/terminals dispersed throughout the world such as top ports Cheon et al.. (2010), or on the contrary ports of developing countries ports Suarez-Aleman et al. (2016).

On the other hand, Wilmsmeier et al. (2013) undertook a regional perspective by investigating Latin American and Caribbean ports/terminals, and Al-Eraqi et al.. (2009) investigated Middle East and East African terminals. Díaz-Hernández et al.. (2008), Lozano (2009), and Chang and Tovar (2014), explored Spanish ports. Additionally, Barros (2003), Estache et al.. (2004), Bo-xin et al.. (2009), Guerrero & Rivera (2009), Choi (2011), Barros et al.. (2012), Halkos and Tzeremes (2012), Mokhtar and Shah (2013), carried out a multi-port, single-country analysis by looking at Portuguese, Mexican, Chinese, Brazilian, Greek, and Malaysian ports respectively.

In recent port efficiency studies pertaining particularly to the Caribbean region, Wilmsmeier et al.. (2013), analysed the evolution of container terminal productivity and efficiency of 20 terminals in Latin America/ the Caribbean, and Spain during the period 2005–2011. Spain was used as a benchmark to the LAC ports. The analysis applied a DEA based Malmquist productivity index for which productivity increased by 3%, mainly due to the effects of scale adjustments. Furthermore, this paper was the first to analyse and compare port productivity and efficiency evolution for the main container terminals in Latin America and the Caribbean (LAC).

Moreover, Serebrisky et al. (2016) tested the efficiencies of 63 LAC ports, which represented 90% of cargo handling in the region. Using panel data (1999-2009), they employed DEA based tests on inputs, which also included exogenous variables. Results revealed an improvement in the average efficiency of ports in the LAC region from 52% to 64% during the 10-year period, with an average of 59% over the same timeframe. Additionally, one key finding of this research has revealed that the ports' efficiency was closely related to port management such as port ownership, than to institutional and countrywide variables.

On the other hand, Suarez-Aleman et al.., (2016), investigated the regional differences in developing countries' ports. Included in their analysis, 64 ports in LAC were investigated during the period 2000-2010. The region's average technical efficiency stood at 58%, with results of the DEA based Malmquist productivity index revealing an average of 2.4% growth in productivity. This change was primarily the cause of changes in pure efficiency and scale adjustments.

This research seeks to contribute to existing literature on port efficiency and productivity, by building upon these three most recent papers on the Caribbean region, by focusing particularly upon SIDS, and the factors that influence their performance. It also brings a practical contribution to the future development of these ports, as is the agenda of local, regional, and international organizations, as the United Nations.

Table 4.2: Examples of Reviews on Malmquist Productivity Index in Port Technical Efficiency

Author	***Region/Country***	***Time period***
Barros (2004)	Portuguese ports	1990-2000
Estache et al.. (2004)	Mexican ports	1996–1999
Díaz-Hernández et al.. (2008)	Spanish ports	1994–1998
Bo-xin et al.. (2009)	Chinese ports	2001–2006
Guerrero & Rivera (2009)	Mexican ports	2000–2007
Al-Eraqi et al.. (2009)	Middle East and East African terminals	2000–2005
Lozano (2009)	Spanish ports	2002–2006
Cheon et al.. (2010)	Worldwide ports	1991-1994
Haralambides et al.. (2010)	Middle East and East African ports	2005–2007
Choi (2011)	Chinese ports	2003–2008
Barros et al.. (2012)	Brazilian ports	2004–2010
Halkos and Tzeremes (2012)	Greek ports	2006–2010
Mokhtar and Shah (2013)	Peninsular Malaysia ports	2003–2010
Wilmsmeier et al. (2013b)	Latin America & the Caribbean and Spain ports	2005-2011

Chang and Tovar (2014)	Peruvian and Chilean ports	2004-2010
Serebrisky et al.., (2016)	Latin America & the Caribbean ports	1999-2009
Suarez-Aleman et al. (2016)	Developing Countries	2000-2010

Source: (Compiled by Author, 2016)

4.6 DERIVING THE RESEARCH HYPOTHESES

The overall research question for the thesis is: **"As a result of port development opportunities over the past decade, how has the technical efficiency and productivity of Caribbean Ports progressed in the last decade?"** In order to answer this question, it must be broken down into separate hypotheses. These are derived from the literature analysed in this chapter, based on previous work on port efficiency and productivity in general and also with specific regard to the Caribbean:

Efficiency:

Hypothesis 1: *Under Constant Returns to Scale (CRS) measures, there has been no change in general port efficiency over the last decade.*

Hypothesis 2: *Given the effects of returns to scale, under Variable Returns to Scale (VRS) measures there has been a general improvement in port efficiency over the last decade.*

Hypothesis 3: *Caribbean ports are less efficient than TOP ports, but more efficient than Other Small Island Developing States (OSIDS) ports.*

Productivity*:*

Hypothesis 4: *Total Factor Productivity (TFP) in the port sector has been positive over the last decade, and most of this have been driven by technical progress (TC) and not technical efficiency change (EC).*

Hypothesis 5: *Over the whole period, Caribbean ports have experienced higher TFP changes than TOP ports, and most of this is because of efficiency change (EC) rather than technical progress (TC).*

Hypothesis 6: *Over the whole period, Caribbean ports have experienced higher scale efficiencies in comparison to TOP ports.*

4.7 CONCLUSION

This chapter reviews theoretical literature on the production theory of the firm, concerning utilization of its factors of production. In regards to this, investigation is conducted with reference particularly to the concepts of efficiency and productivity. Furthermore, contemporary methods of measuring technical efficiency and productivity with particular distinction between parametric versus non-parametric methods, are examined. Furthermore, reasons for their application, using panel data over cross sectional data, is justified.

Background research is undertaken to understand the former approach, with reference to deterministic- COLS versus stochastic-SFA analyses. The differences, yet similarities, between both, reveal the shortfall of the COLS, as the error term only identifies the technical inefficiency component.

Therefore, the COLS method can be used in conjunction with the SFA analysis, which decomposes the error, term into two elements- the noise component and the technical inefficiency component. It also caters for exogenous variables within the model unlike non-parametric approaches. Yet, the complexities of both approaches show *a prior* assumptions that would be made about the population, based on a fixed set of parameters. Furthermore, decomposing the inefficiencies rely on even stronger assumptions concerning the statistical distribution of each element.

This chapter also discusses non-parametric methods such as the DEA and FDH methods. Non-parametric methods are not dependent upon assumptions made about the population. Moreover, the DEA-MPI measures changes in efficiency and productivity over time, and decomposes these giving their relative components. The correlation between the models' DEA and FDH average efficiency scores is usually very high, making the overall results very similar. Therefore, there is no generally accepted model for assessing industry efficiency/productivity behaviour as it all depends on the objective of the research under investigation. As a mere commercial user of the software for purposes of this research, the DEA approach has become more relevant. Reasons being, the FDH is a multidimensional step function, its reference technology is less useful in answering other questions such as the determination and decomposition of factor productivity unlike the DEA.

Furthermore, for managerial relevance and decision making purposes, the results generated by these alternative methods are considered for predictive- decisions concerning the future, thus requiring forecasts, versus evaluative uses- relating to decisions that somehow involve the past, which we can learn from. However, as for predictive purposes, FDH frontiers are of almost no use because of their extremely conservative character. Indeed, whether the needed predictions require extrapolation or interpolations of the productive activity in areas of the input-output space, for interpolations, frontiers of the DEA type are somewhat more informative, mainly because it suggests convex combinations of observed realizations, unlike the FDH. Additionally, a further justification refers to the number of port related academic literatures presented in Table 4.1, on pages 106-107. While no justifications have been given in these literatures as to the lack of FDH use over the DEA , still this observation cannot be ignored (De Borger et al., 1994; Wohlrabe and Friedrich, 2017; Tulken, 1993).

Discussing the various methods to measuring efficiency and productivity changes over time, this chapter also critically reviews their uses in the container port industry. While each approach has its strengths and weaknesses, the method that most stands out, with regards to measuring efficiency and productivity changes over time, while informing decision making thereafter, is the DEA-MPI approach. Their remains no empirical research in relation to measuring efficiency and productivity changes using this model on the SIDS region. Therefore specific research hypotheses were derived in order to structure the research process. This chapter concludes that such a study will yield important results about the applicability of the model, and also results and conclusions concerning the region.

CHAPTER FIVE
METHODOLOGY

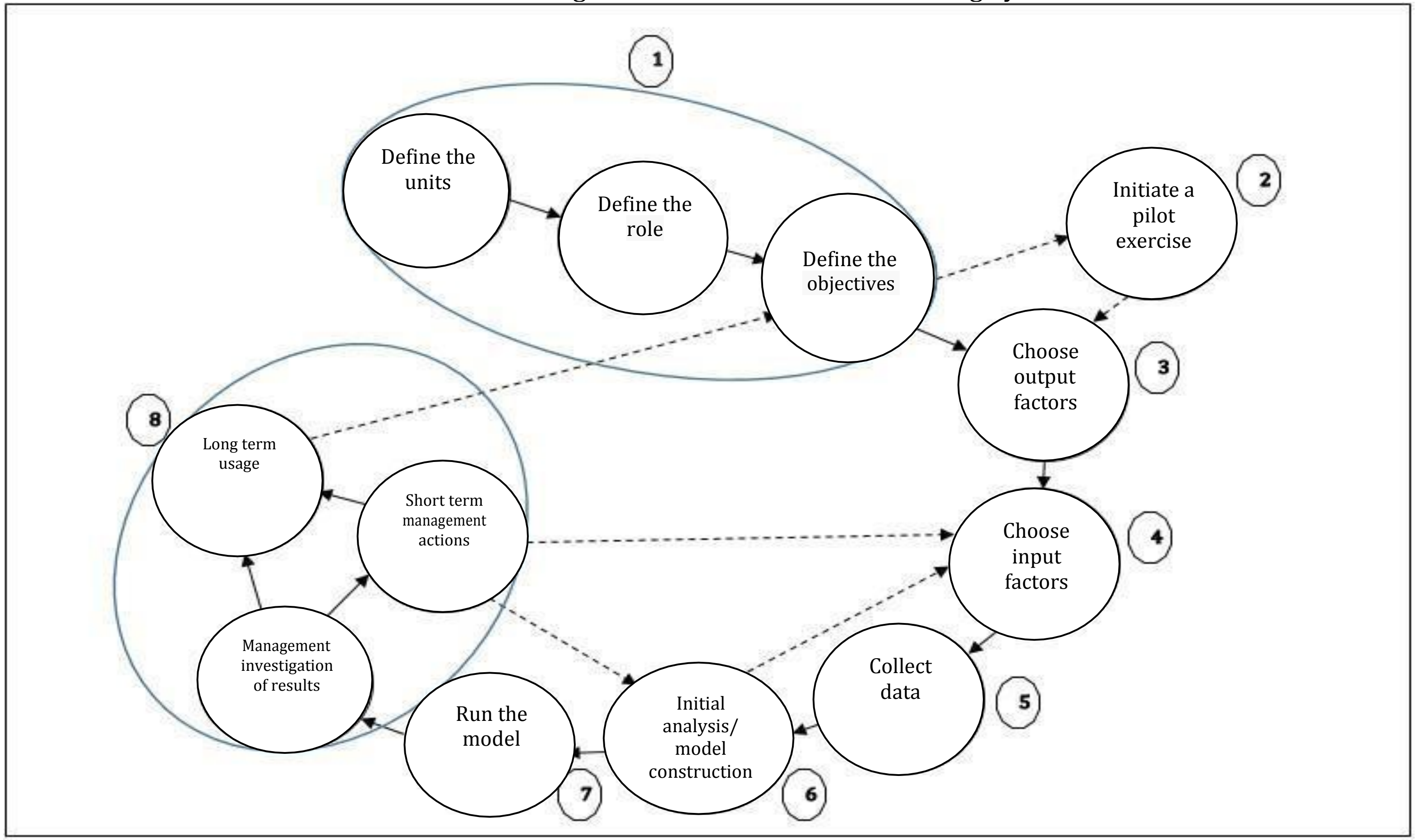
5.1 INTRODUCTION

This chapter presents the DEA/MPI model's specification, by firstly applying an efficiency measurement system introduced by Norman and Stoker (1991) shown in section 5.2. This system outlines the relevant steps for choosing inputs/ output, as well as data collection. This is then applied to the container port industry, which is the focus of this research, and justifications are given for the choice of relevant inputs/output and the DMUs sample, based on the existing literature review. This is conducted in section 5.3. Thereafter, section 5.4 presents the DEA based model specification applied to the issue to be examined, before concluding in section 5.5.

5.2 EFFICIENCY MEASUREMENT SYSTEM

Norman and Stoker (1991) introduced a performance measuring system, which outlines the relevant steps for implementation of efficiency measurement in this study. The system provides a very helpful guide that genuinely structures the methodology section as depicted within the various steps outlined in Figure 5.1.

Figure 5.1: Performance Measuring System



Source: (Adapted from Norman and Stoker, 1991)[5]

5 (Adaptations include the grouping of units, role and objectives into Step 1, and the grouping of investigation of results and short and long term recommendations into Step 8).

Step 1) Define the units/role/objectives

This involves identifying where authority/responsibility (together with their limits), and resources, which are involved, lie. The DMU's role is usually embedded within the context of the firm's Mission Statement and answers questions such as why the DMU was set up, what it does and who/what, it serves. From this the mission statement then sets out to specify and give (company) policy guidance with regard to the DMU's objectives.

Step 2) Initiate a pilot exercise

This step is primarily concerned with the number of DMUs that should be used in the analysis. Since there exists no hard and fast rule as to the optimum number of DMUs to be used in conducting efficiency tests, Norman and Stoker (1991) indicate that a minimum of 20 DMUs can be considered. On the other hand, Cooper et al. (2000), (as cited by Cullinane and Wang, 2007) presents another guideline as to this minimum number,

$$N \geq max\ \{m \times s, 3(m+s)\} \qquad \textit{(Equation 5.1)}$$

Where N is the minimum sample size of DMUs, m the number of inputs and s the number of outputs. Furthermore, Golany and Roll (1989) state that the number of DMUs should be at least twice the number of inputs and outputs. Why this is an important issue is that failure to include sufficient DMUs can lead to over-specification of the (DEA) efficiency problem, where if the number of inputs and outputs are too large in relation to the sample size, this does not provide enough discriminatory power in order to produce a reliable efficiency assessment. To give a simple example, a sample size of 6 DMUs with 3 inputs and 2 outputs gives 6 different combinations under which a DMU can be found to be 100% efficient. In other words, all 6 DMUs can end up 100% efficient, not because they are, but because the problem has been over-specified. While different authors may have varying standards by which to guard their decisions on the number of DMUs to include, it is of the author's view that the more data one can access on the DMUs under study the more reliable and robust results will become. In this study, over-specification is not deemed an issue.

Step 3) Choose output factors

According to Norman and Stoker (1991), choosing the relevant output/s involves defining the outcomes that reflect and support the firm's objectives. These are measurable quantities that point toward the firm's achievement such as throughput and/or revenue.

They furthermore state that, in choosing output/s, the 'golden rule' is to choose factors that cover the whole gamut of work that the firm undertakes. Since the firm is serving someone, this means identifying firstly the customers of the firm. Two key questions that therefore need to be answered are, a) who receives the product/service of the firm, and b) how can these products/services be measured. In answering these questions, the main customer benefits as the firm seeks to satisfy their demand, which results in success to the firm.

An economist on the other hand would argue that the output to be specified is one that should match the main aim of the firm. As all firms are assumed to profit maximise, the output should match an objective that meets that aim. Other aims may be pursued in the short to medium terms, such as sales maximisation (to eventually dominate the market) or revenue maximisation, but the long run aim of the firm would be to maximise profits.

4) Choose input factors

The fourth step involves identifying and choosing the firm's input factors. Inputs are internal to the firm which come in the form of factors of production (land, labour, and capital), they can also be external (Gross Domestic Product) and environmental (socio-economic background of customers). The aim is to identify factors that will aid/hinder the production of the firm's output. Norman and Stoker (1991) recommend that including an exhaustive list of inputs usually results in a list that is impractically too long. This is however preferable in the early stages which, thereafter, through the administering of statistical tests would results in the removal of inputs. Alternatively, choice of the inputs can be primarily driven by economic theory, consequently all inputs should represent part or all of the factors of production. In this study for example, all of the specified inputs represents the capital input.

5) Collect data

Step 5 is dependent upon steps five and six. In many cases, there is usually the issue of little/no data existing for the inputs at hand and this can therefore become an iterative process between the two steps. In cases like these, Norman and Stoker (1991) suggest a) informatively removing these input factors, b) initiate data gathering exercises, and c) combining the two alternatives a and b.

6) Initial Analysis/ Model Construction

In Step 6, the model is specified, and justification of the most appropriate method in conducting the analysis. This is done in this Chapter, section 5.4.

7) Run the Model

Next, in Step 7, tests are conducted, and results retrieved for analysis in accordance with the research hypotheses, presented in Chapter 6.

8) Results Analysis and Policy Recommendations

Thereafter, results are analysed. Referring to Figure 5.1, this specifies the practical/business operational outcomes, while validating the research hypotheses, shown in Chapter 7. Subsequently, the research findings are deliberated in accordance with existing literature, and future proposals are made, of practical contributions via policy recommendations of Caribbean ports. This is presented in Chapter 8.

5.3 APPLICATION OF THE EFFICIENCY MEASUREMENT SYSTEM

This section implements Norman and Stoker's efficiency measurement procedure to the container seaport industry, and discusses the author's justification through each step.

Recapping for purposes of this research, step 1 *define the units/role/objectives*; this becomes step 1 for purposes of this research. Thereafter proceed to step 2 through to 7 where a *pilot exercise is initiated*, *choose output and input factors, collect data, and construct and run the model respectively*. Steps 2 through to 6 will be elaborated in this current chapter. Section 5.4 will specify the models to be estimated, and method to be used in deriving the results. Step 7, the results, will be emphasized in chapter 6. Thereafter, step 8, which is the *discussion of results leading to policy recommendations,* will take much priority in Chapter 8.

Step 1: Identify the units/roles and objectives

Though similar, ports are generally different in their role, assets, functions and institutional organizations (Bichou and Gray, 2005). This is primarily due to the port's objectives, usually used to guide its operations. According to Yap (2009), the main objectives of container seaports include:

- Throughput maximization
- Profit maximization
- Revenue maximization
- Customer costs minimization
- Optimization of resource usage
- Welfare maximization (employment)
- Maximization of economic benefits for local and hinterland community

Put more succinctly, this would represent consumer sovereignty in the container port market. Nevertheless, amidst all these objectives, container seaports continue to associate with container throughput handled, which suggests a strong significance in the maximization of their respective objective functions. High total factor productivity in the production of container throughput has a major influence on all of the factors highlighted above.

Within the analysis of this research, the author will adopt an approach that assumes input minimization with a view to output maximization. The reasons for this choice point toward today's world changes. Driven by globalization, trade growth, increases in vessel sizes, logistics networks, technology and private sector involvement in port management, ports are seen in an entire different spectrum thereby altering the way in which determining port success is now approached (Notteboom and Winkelmans, 2001; Notteboom et al.., 2013; Peters, 2001). Another justification for this assumption points toward the number of studies that also conform to this approach (see Table 4.2).

Step 2: Initiate a Pilot exercise

According to Norman and Stoker (1991), the best practise is to begin investigations and tests gathering the maximum number of data available, and then proceed to removing those that are not statistically viable in order to move forward.

Initially, data was collected for 120 ports situated across the world. Among these, 89 were top ports according to the 2011 Containerisation International Yearbook and situated across the world. There were 24 SIDS ports, with 15 located in the Caribbean and 9 situated within the Pacific and Indian Ocean. Lastly, 7 were Near Caribbean ports and non-island ports situated in Central and South America. These ports' have a coastal border with the Caribbean Sea.

The Data Envelopment Analysis[6] is used to calculate efficiency and productivity changes. The underlying (DEA) method however does not cater for negative and zero value input/output factors. In this context, such values would also be inconsistent with economic theory. This is more generally referred to as the 'positivity' requirement of DEA since it can only take strictly positive values (no zero values).

According to Bowlin, 1998, in some cases it is advised to make the zero values factor a significantly larger number in magnitude compared to what other DMUs hold for that factor input, in the data set. As such, this will ensure that the specific input is not included in the efficiency calculation. This however may overcome the zero value limitation, but is a far from ideal solution. In some cases, results can change depending on the scale (adjusting value) used by the model and this can furthermore alter efficiency results for the ports, which can be misleading. To some extent, this is dependent upon researcher diligence, as a large enough value should be chosen to ensure the relevant DMU input is excluded from the efficiency calculation, but as stated, that is not an ideal situation.

[6] (DEAP) 2.1 version

In this research, datasets for some of the ports in the earlier years recorded zero quayside and landside cranes, while also smaller ports usually utilize crane vessels or ships with cranes and therefore having quayside/landside cranes is not an essential requirement to port operations. Due to this, for all ports that had instances of zero quayside cranes (which was usually the case for those that were non- top ports), instead of separating the dataset and having separate crane inputs such as quayside versus landside cranes (which was the initial plan), both were aggregated into one aggregate input called *total equipment*. This still left several ports that had zero total equipment i.e. zero quayside and landside cranes, which then at this point, rather than employ the Bowlin (1998) solution, were removed from the analysis.

Proceeding with further tests, the DEA tests results yielded average efficiency scores that were considerably below expected averages, which suggested that there might be data reporting issues. For instance, the first run produced an average efficiency value of around 13%, which could have been a result of just one misreported port (as it sets the efficiency frontier). As such, data cleaning began using past credible journal papers who investigated similar data sets and period. Partial productivity analysis was then conducted, which reflects the ratio of output to individual inputs. The averages were then derived for each input, which aided in identifying those ports that were way outside of these averages (outliers), of up to two standard deviations, which seemed appropriate, less than that appeared too restrictive, and more than +/-2 standard deviations, might not eradicate data reporting issues.

There exists no conventional standards as to the maximum standard deviation one can employ, concerning eliminating data points when using the DEA tests.

Data cleaning is appropriate, as maintaining good quality representative data is pertinent for getting reliable results. Which means, having incorrect data can lead to misleading results and incorrect policy decision making in the short, medium and long term? The author's decision to choose two standard deviations, came from the fact that, using one standard deviation would restrict the sample size further reducing the number of ports in the study, whereas using three standard deviations though increasing the sample size and so having more ports for analysis, this standard deviation created to large a dispersion from the sample's average, significantly lowering overall average efficiencies.

For instance, every port that had partial productivities in excess of each input's respective average +/-3 standard deviations was removed. Those ports for which their partial productivities still stood outside this range, and occurring for the majority of their years and for inputs, were removed from the analysis and DEA tests were conducted on this new data set. The average DEA efficiency scores were then compared to past academic related research as shown in Table 4.1 and 4.2, particularly Serebrisky et al.., (2016), Suarez-Aleman et al. (2016) and Wilmsmeier et al. (2013b) which investigated the Caribbean region. If average efficiencies scores were very low, they were removed from the analysis and retested at +/-3 standard deviations. If further DEA tests still showed lower average efficiency scores incomparable to past academic research, then a new standard deviation was introduced. As it is predicted +/-3 standard deviations created to wide a dispersion, significantly lowering average efficiency scores.

Therefore, attempts were then made at +/-2 standard deviations. The same procedure continued, where every port that had partial productivities in excess of the input's respective average +/-2 standard deviations was removed. Those ports for which their partial productivities still stood outside this range, and occurring for the majority of their years and for inputs, were removed from the analysis and DEA tests were further conducted on this new data set.

Satisfactory results were retrieved at +/-2 standard deviations, which were also convincing and comparable to average efficiency scores of past research and journal publications. The dataset most convincing to move forward with were those ports, which had partial productivities for each input closest to the overall respective means. Those ports that had individual averages of about +/-2 standard deviations or lesser were proceeded with, as these ports average efficiency scores were also comparable to past academic articles as just previously mentioned.

Step 3: Choose Output Factors

As stated, for this research the output factor- total annual TEU throughput per port, is utilized. Concerning testing for technical port efficiency, Table 4.1 presents a number of evidence for justification of using this factor as a measure of output. Container throughput has become the most widely and accepted indicator of port output and about measuring technical port efficiency. It is also entirely consistent with the aim of profit maximisation.

This is justified because container throughput closely relates to the need for cargo- related facilities and services (inputs, such as quay length, terminal area, quayside cranes, yard equipment etc.) to best accommodate it. Furthermore, container throughput is primarily the chief ground on which container ports are compared to each other, particularly in assessing their relative size, investment magnitude, activity levels and port production (Cullinane and Wang, 2007).

While this is so, having a single output is not always the instance as some past research have incorporated multiple outputs. These include and are not limited to the number of ship-calls and total cargo (Barros, 2005), containers, ro/ro cargo and general break bulk (Rodriguez-Alvarez et al.., 2007), and containers, liquid bulk, and passengers (Gonzalez and Trujillo (2008). While these studies introduce multiple outputs, TEU throughput yet remains a prevalent measure of output performance.

Step 4: Choose Input Factors

The choice of inputs in the literature as presented in Table 4.1, does not include a standard set of factors which is applied to every container port seeking to measure technical efficiency. What is observed however is that in measuring efficiency, the factors of production-land, labour and capital, are the key input factors. These include the number of berths or berth length and terminal area, the number of dockworkers and the number of gantry cranes, yard cranes and equipment.

Berth usage has been included in different ways when testing for efficiency; Serebrisky et al. (2016) applied berth length in their analysis, while Itoh (2002) used the number of berths. For purposes of avoiding biased estimates later on, it is academically advised, that the total length of berths is a wiser choice of input than the number of berths. This is so since the latter bears no underlying relationship to capacity. A port with one berth does not necessarily indicate its efficiency over another port that has five berths.

As for labour, it can take the approach of accessing data on the number of dockworkers and other employees who work on the terminals (Tongzon, 2001; Cullinane and Song, 2003). While this is highly desirable, there is the issue of difficulties in accessing data on staff levels. On the other hand, there have been cases of labour estimated based the type of relationship that exists between the number of gantry cranes and the number of dockworkers in the terminal. As such, the labour factor is determined as a mathematical function of the facilities of the port (Notteboom et al., 2000; Wang et al., 2005; Liu, 2010).

While this approach appears very sophisticated, the mathematical function may not always be accurate given that different equipment requires different numbers of workers and different skill sets. Furthermore, it is a 'false' input, as ultimately the estimated labour levels will be dependent in one form or another on the facilities, which are already included in the efficiency assessment. Also Cullinane et al.. (2004) claims that a predetermined relationship between port labour and container cranes does not necessarily have to remain as expected. This is further complicated by the port's rapid deployment of new and more advanced equipment such as automated guided vehicles and automatic stacking cranes (Cheon et al.., 2010).

Terminal equipment such as quayside and the various types of yard cranes/equipment is highly likely to be included in port efficiency studies, since they are considered the most important items of equipment for container handling (Wang, et al.., 2005). The number of cranes/equipment can be incorporated into one aggregate (Tongzon, 2001; Cheon et al.., 2010), or if there is a need for equipment comparability among ports, or, simply put, data is available so the equipment can be analysed separately, then this is feasible also (Serebrisky et al.., 2016; Cullinane and Wang, 2006). In this study, quayside and landside cranes have been aggregated on a 1:1 weighting, as specified in Cheon et al., 2010. For the justifications stated above, this research will investigate inputs- terminal area (h), berth length (m), and total terminal equipment (being an aggregate of Ship to Shore, quay side, yard gantry and mobile cranes). Due to lack of data availability, a labour variable was not introduced.

Step 5: Collect data

Given the initial pilot exercise in step 2, and the iterative processes involved, for this research, the author has proceeded with 69 container seaports to be analysed over an 11-year time span (i.e. 759 observations) (see Appendix 7, page 223-241). Among this, 49 are top ports, chosen according to the 2011 Containerization International Yearbook, which is based on those ports with the highest levels of TEU throughput. These are located across the world. Furthermore, 17 of the 69 are ports located in SIDS (as defined by the UN), with 13 of these located in the Caribbean, and 4 located in the Pacific/African region. Moreover, a further 4 are Central/South American ports which border the Caribbean Sea. (see Appendix 8). Whilst port efficiency will be considered in the general context, the main focus of this research is the performance of Caribbean ports, hence division of the sample into TOP, Caribbean, Other SIDS and Near Caribbean allows the performance of the Caribbean ports to be 'benchmarked' against those other groups. Overall, this gives an abundant rich supply of 3,036 data points. As will be seen, when it came to formal 'testing' of these groups, the Near Caribbean comparator group had to be dropped due to the small sample size in this group.

5.3.1 Summary

The efficiency measurement system has provided a helpful guide for structuring the methodology section. It has incorporated the key objective of the port, which guides the choosing of input and output variables. The combination of inputs- terminal area, berth length and equipment determined to impact output- container throughput will provide essential information about the port's operations and its progress. One concern however, is that labour being a key input, is not included because of lack of data availability. A container terminal depends crucially on the efficient use of labour, land and capital, which means it affects efficiency/productivity significantly. If labour is excluded regardless of how capital intensive the industry may be, its results are not fully reflective of performance. As engaging in new terminal developments and/or existing facility expansions implies that proper planning and policing of cargo handling facilities and equipment, modern information and communications systems and skilled **labour** in port operations - are all expected to ensure an improvement and move toward the port's operational excellence (Notteboom and Rodrigue, 2012). This is also supported by Itoh (2002) who having investigated international Japanese ports using panel data, concluded that among others, the incorporation of labour in their analysis improved the efficiencies of the other ports that performed relatively poorly. On the other hand, capital inputs are only acquired over the long run, as opposed to labour, which can be varied to match more immediate needs, hence where labour is not included in the assessment, its omission can lead to considerable fluctuations over time of estimates of a port's efficiency. Therefore, using panel data tends to cancel out these effects over time, which gives a far better estimate of the port's underlying efficiency level (Cullinane and Wang, 2006).

5.4 MODEL SPECIFICATION

5.4.1 Efficiency Estimation

There currently exists no "best practise" test as to the most appropriate method to use in testing for the technical efficiencies of container seaports. While a number of alternative approaches have been utilized in the container seaport industry over the years, the author will, for this research apply the DEA-MPI approach due to its relevance in responding to the research hypotheses. The advantages of using the DEA approach in this research is that it is a frequent approach used in scholarly port productivity related journal articles, in fact, could be describe as the mainstay of research in this area, hence the results produced from this research will be directly comparable with other studies on the subject. Other advantages are that it is relatively light with regards to data requirements (e.g. it only requires basic units, and these can be specified in different units of measurement), DEA can incorporate multiple inputs and outputs, it does not require the specification of an underlying functional form of the relationship between the output and the inputs, and finally DMU's are directly compared against those 'most like' rather than a sample wide 'best', which may be operating at a completely different level/scale.

While for the purposes of this research, the use of DEA is justified, it is not without its limitations, as any other measuring method, yet this should not be ignored. Firstly, unlike the stochastic approach, the DEA method does not account for measurement errors (noise) due to its nature as a deterministic approach (Ray, 2002). Subsequently, forward-looking techniques have been developed in literature to overcome this issue, such as sensitivity analysis and statistical testing. These are however applied to very limited DEA studies in the port industry. Furthermore, the DEA method does not cater for exogenous variables, which may influence productivity such as the state of the economy embedded within variables such as economic growth, national income and so on. One the other hand, DEA estimates "relative" efficiency, such that it can tell how well a DMU is doing compared to another, but is not compared to a "theoretical maximum."

Embedded within the sixth step of Norman and Stoker's efficiency measurement procedure, is *construction of the model*; here, the model is specified. Within the DEA model, the input and output oriented approaches have their usefulness, but are applied under different objectives. The input approach is closely related to operational and managerial issues whilst the output approach is associated with more port planning and strategies.

Once a port is built, together with its capital investments, the port is usually tied in to the maximum capacity it can accommodate. This constraint hugely determines its customer base, which both the port and shipping lines enter into contracts over a considerable length of time. This action, ceteris paribus, guarantees some form of stability concerning throughput, since this is roughly known. In cases like these, an input-oriented approach is better suitable for the analysis of container production, since it entails a more stable market.

On the other hand, given the rapid technological and innovation changes within the port industry, container ports frequently have to adapt to newer and more efficient operations. This may suggest the purchasing of automated guided vehicles (AGVs), or building a new terminal, or a combination of the two. Whatever the case may be, before ports can engage in massive capital investments, it must review its existing capacity.

Ports must be in a position to answer questions such as whether it is fully and efficiently utilizing its existing facilities, and, if output is being maximized given its existing inputs. This stems from knowing that ports are likely to be more throughput maximizers rather than input minimizers (Cheon et al.., 2010; Cullinane et al.., 2004; Tongzon, 1995).

Given this discussion, the output-oriented approach presents itself a more useful method for measuring port efficiency within this context. Moreover, since in-depth analysis is primarily conducted on the Caribbean concerning its port development progress and productivity changes, this approach will better aid in informing policy decisions at the local and regional level.

Furthermore, both CRS and VRS assumptions will be applied, since the envelopment surface differs depending on the scale assumptions of the model. CRS involves constant returns to scale, which reflects that output will change by the same proportion as inputs change, whereas variable returns to scale (VRS) shows that the DMUs production technology may exhibit increasing, constant or decreasing returns to scale. For this analysis, both scale assumptions are used as it can show the DMUs' capacity utilization level given both returns to scale, under the output-oriented assumption.

So far the methods to efficiency assessment in outline have been discussed, but this section will apply these to the problem to be researched, that of port efficiency, and in terms of the variables to be used. Next, the CCR and BCC models respectively are applied using the primal multiplier problem in standard form[7], which is the most intuitive form of describing a linear programming problem. These are shown in equations 5.2 and 5.3 as examples.

Let PE_i = the efficiency of Port I,

Hence the CRS specification of the problem to be solved is:

Max: $PE_{iCRS} = \mu(TEU_i)$

Subject to: $v^B BL_i + v^A TA_i + v^E TE_i = 1$

$$\mu(TEU_j) - \left(v^B BL_j + v^A TA_j + v^E TE_j\right) \leq 0, \quad j = 1,2,\dots,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad \textit{(Equation 5.2)}$$

Therefore the efficiency of port i (PE_i) is given by the virtual weight (μ, which with just one output is a virtual scalar) attached to the output (TEU), and a weighting of the three inputs by virtual weights v^{BL}, v^{TA}, v^{TE}, consequently the virtual output is maximised when the inputs are scaled to one by the virtual input weights, such that when the weights are applied to all other ports in the study, no port efficiency value exceeds 100%.

In a similar fashion, the VRS specification of the problem to be solved is given by:

Max: $PE_{iVRS} = \mu(TEU_i) - z_i$

Subject to: $v^B BL_i + v^A TA_i + v^E TE_i = 1$

$$\mu(TEU_j) - \left(v^B BL_j + v^A TA_j + v^E TE_j\right) - z_i \leq 0, \quad j = 1,2,\dots,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad \textit{(Equation 5.3)}$$

[7] For computational purposes however, the dual form of the problem is specified, but conceptually this is very difficult/almost impossible to outline.

Where z_i is a second scalar that allows for scale effects to be incorporated into the estimation, and consequently under the DEA approach, VRS efficiency must always be greater than or equal to efficiencies estimated under the CRS assumption.

One final aspect to consider is scale efficiency, and this is simply derived from the previous two calculations, hence:

$$SE_i = \frac{PE_{iCRS}}{PE_{iVRS}} \qquad \textit{(Equation 5.4)}$$

5.4.2 Malmquist Productivity Index Parametric Estimation

As a reminder, the Malmquist productivity index is given by:

$$TFP(x^t, x^s, q^t, q^s) = \left[\frac{d^s(q^t, x^t)d^t(q^t, x^t)}{d^s(q^s, x^s)d^t(q^s, x^s)}\right]^{\frac{1}{2}} \qquad \textit{(Equation 5.5)}$$

which for calculation purposes is expressed as:

$$TFP(x^t, x^s, q^t, q^s) = \frac{d^t(q_t x_t)}{d^s(q_s x_s)}\left[\frac{d^t(q_t, x_t)}{d^s(q_t, x_t)} x \frac{d^t(q_s, x_s)}{d^s(q_s, x_s)}\right]^{\frac{1}{2}} \qquad \textit{(Equation 5.6)}$$

It is thus expressed as the ratio of the outputs q to the inputs x over two time periods t (current year) and s (preceding year) and is measured in terms of the relative distances (d) to a theoretical maximum. The first part of equation 5.6 represents efficiency change (EC) and the second (the part in square brackets) is technical change, hence under the Malmquist approach TFP consists of these two parts such that:

$$TFP_{ts} = EC_{ts} \times TC_{ts} \qquad \textit{(Equation 5.7)}$$

Key to the MPI is the efficiency assessment that underpins the index, and as highlighted in equation [5.6], the four efficiency measurements are calculated:

- the current year production position to the current efficiency frontier
- the previous year production position to the previous efficiency frontier
- the current year production position to the previous efficiency frontier

the previous year production position to the current efficiency frontier

(see Appendix 8 for the mathematical programming of efficiency measures).

In order to test for significant differences in the results found from the efficiency estimations for each of the peer groups to be examined in the results section, a Mann Whitney test has been used, as this test requires no prior assumption with regard to the underlining distribution of the values to be estimated, unlike for example is the case with Student's T distribution.

One final issue to consider before examining the results is the issue of the CRS and VRS assumptions with regard to efficiency assessment and which one is 'more appropriate' as the measure of efficiency. One reason to favour the VRS specification is that it divides efficiency into managerial (pure) and scale efficiency components, it better reflects management effort and isolates the components of efficiency under which management has control. One reason to favour the CRS specification however, which is important in this context, is that CRS has been defined as long run efficiency, and VRS as short run. Hence, in the long run all firms should aspire to eradicate all inefficiencies by moving to the minimum efficiency scale point (MES), and this can only be done in the long run, hence the reason CRS equates with long run efficiency.

5.4.3 Testing for Statistical Difference in DEA Estimated Efficiencies

As stated above, the purpose of this analysis is to benchmark the performance of the Caribbean ports against comparator group- namely TOP ports. What is therefore required is an objective measure of statistical inference to test for found differences. Efficiencies estimated from the DEA method however are difficult if not near impossible to define in statistical distributional terms. Consequently, in order to test for significant differences in the results found from the efficiency estimations for the peer groups to be examined in the results section thereafter, Mann Whitney tests have been used. This test requires no prior assumption with regard to the underlining distribution of the efficiency values.

The M-WU test, is a test of *stochastic equality.* It tests a randomly determined sequence of observations or in this case- efficiency scores, that may be analysed statistically but not necessarily predicted precisely (Mann and Whitney, 1947). It is generally used in a two-sample case, and its general form is given by:

$$U = n^1 n^2 + x = \frac{n^2(n^2+1)}{2} - \sum_{i=n_1+1}^{n_2} R_i \qquad \text{(Equation 5.8)}$$

Where n_1= sample size one, n_2= sample size two, and, R_i = sum of the ranks in sample each sample.

The smaller M-W U score and its respective probability value is always chosen, and then tested against the conventional critical value, to determine whether the samples are significantly different or not.

Within this context of the port industry, tests are conducted to determine if there may be any difference in the efficiency scores of the two groups- Caribbean v the comparator group.

5.4.4 Constant Returns to Scale or Variable Returns to Scale Efficiencies?

One final practical consideration before examining the results is the issue of the CRS and VRS assumptions with regard to efficiency assessment and which one is 'more appropriate' as the measure of efficiency. According to Fare et al. (1994), one reason to favour the VRS specification is that because it divides efficiency into managerial and scale efficiency components, it better reflects management effort and isolates the components of efficiency under which management has control.

One reason to favour the CRS specification however, which is important in this context, is that CRS has been defined as long run efficiency, and VRS as short run. Hence, in the long run all firms should aspire to eradicate all inefficiencies by moving to the minimum efficiency scale point (MES), and this can only be done in the long run, hence the reason CRS equates with long run efficiency. These ideas will be developed and discussed further in the next chapter.

5.5 CONCLUSION

This chapter discusses the theoretical framework and methodology employed in the research. Using a combination of economic theory and an efficiency measurement system introduced by Norman and Stoker (1991), the relevant steps for choosing inputs/ output, as well as the data collection and cleaning processes, have been outlined. Justifications, both theoretical and in line with literature reviews, have been made.

The specifications of the DEA based model for conducting efficiency and productivity tests are derived, in line with the research hypotheses. The Data Envelopment Analysis Program (Coelli, 1996) will then estimate these measures. The next chapter presents the results, beginning with an overview of the main inputs and outputs to be used in the form of summary statistics, a formal specification of the hypothesis to be tested, the results and lastly analysis.

CHAPTER SIX

SUMMARY STATISTICS, EMPIRICAL RESULTS AND ANALYSIS

6.1 INTRODUCTION

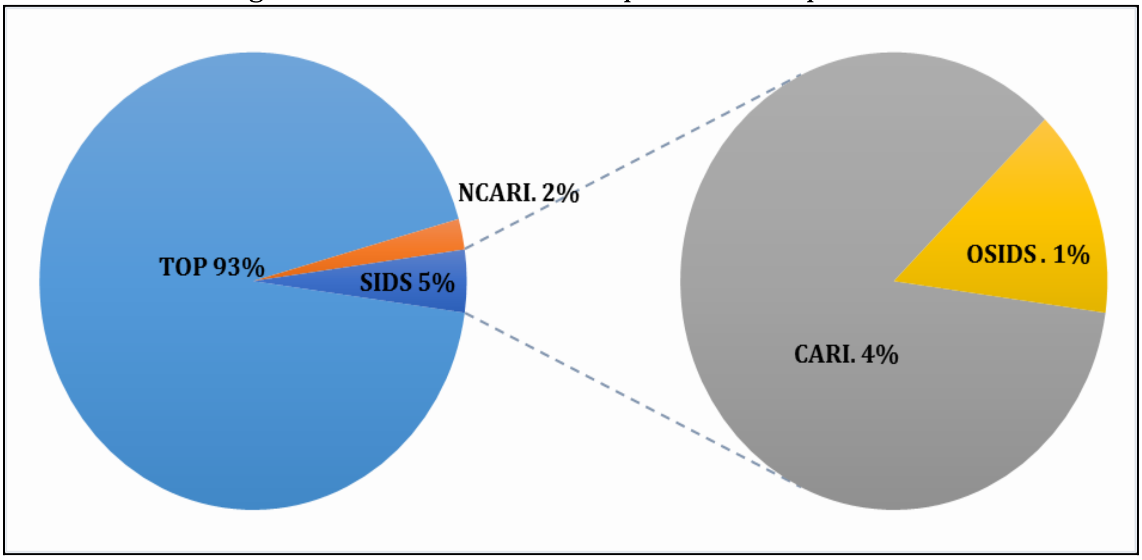
This chapter presents the empirical results and analysis derived from applying a DEA-MPI approach, as discussed in the previous chapters. In this chapter, background statistics are firstly presented on container port traffic mainly for Caribbean SIDS, in addition to the other sub-groups in terms of their evolutionary trends, and market shares. Summary statistics are reported, on a per sub-group basis, which also allows for identification of differences/similarities. Thereafter, analysis and reporting of results as per technical efficiency are given for both CCR and BCC assumptions. Moreover, results on port productivity are derived. Lastly, in order to ensure the relevance of these results, preliminary tests are conducted.

6.2 EVOLUTION OF PORT TRAFFIC & SUMMARY STATISTICS

This section presents the groups' port traffic, growth, market shares and summary statistics using cross sectional and panel data. This summary is firstly conducted which allows for a better overview of port traffic in the region, and so a better understanding of the test results thereafter.

For the overall sample, see Appendix 7 and Appendix 8, on pages 223-242. Comparing total traffic per sub- group, for this analysis, TOP ports inevitably dominate the market in 2011. They account for 93% of total TEUs, followed by Caribbean SIDS (CARI) (4%), Near Caribbean ports (2%), and then Other SIDS (1%). Altogether, SIDS ports, account for 5% of the market (see Figure 6.1).

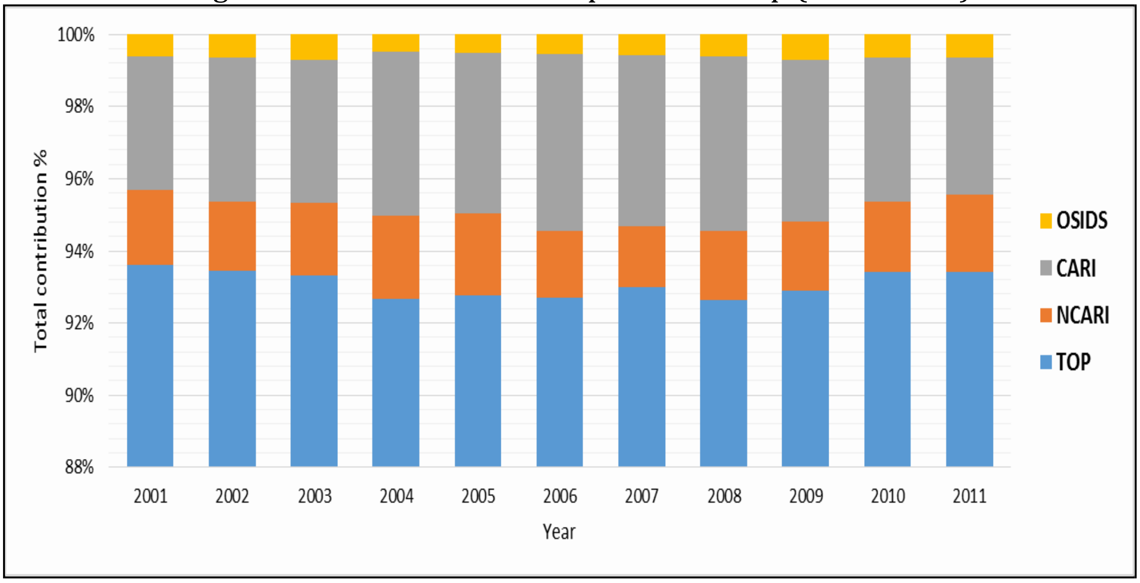
Figure 6.1 Port Market Share per Sub-Group in 2011



Source: (Derived and drawn from Containerisation International Yearbook, 2012)

Taking a look into TEU throughput and its progress or lack thereof over time, the contribution of each group to total throughput shows TOP ports accounting for the majority of the market, well over 90% and remaining fairly stable over the 11-year period, despite the miniscule dip during the crisis period. The same can be said for the remaining groups as they've fairly remained stable, with CARI handling approximately 5 % of throughput, followed by NCARI (<5%) and then OSIDS (<1%) (see Figure 6.2).

Figure 6.2 Port Market Share per Sub-Group (2001-2011)



Source: (Derived and drawn from Containerisation International Yearbook, 2001-2012)

Furthermore, a closer look at the groups' traffic growths, as derived from their compound annual growth rates (CAGR) in TEU traffic (see Table 6.1) shows OSIDS having the highest rate of 6% from 2001- 2011. This is followed closely by the NCARI with 5.9% growth, CARI experiencing a 5.6% progress and lastly TOP ports with 5.4%. Despite this, note mentioning are their trends pre and post the financial crisis.

During the pre- economic crisis period, 2001-2007, each group-sustained growths, with CARI ports actually incurring the highest growth with an average of 7.3%, as port development and expansions have been CARICOMs moving agenda to accommodate increasing traffic over the years. The TOP group (5%), OSIDS (4.4%), and NCARI expiring the least progress (3%), follows this. The aftermath of this crisis (2008-2011) however, resulted in negative to diminutive growths as CARI ports suffered the largest loss, of 1.9% decline. NCARI ports on the other hand, was the least adversely affected, with a 1.4% progress. Furthermore, the effects of the crisis on throughput show that during the period 2008-2009, the groups mainly affected were CARI who actually incurred a 19% dip in port traffic. The largest decline in throughout during this period.

Generally, the financial and economic crisis has played a key part in affecting port traffic. During the post crisis period, CARI ports have been impacted the most with 1.9% fall in traffic, while NCARI has managed to outperform, with growths of up to 1.4% per annum.

Overall, despite the dip in traffic during this period, each group has managed to maintain average growths over the entire period (2001-2011). SIDS ports (CARI and OSIDS) progressing just as much (5.6% and 6%) as TOP ports (5.4%) concerning the average annual growths in port traffic (see Table 6.1).

Table 6.1: Port Traffic Growth per Sub-Group

	CAGR % 2001-2007	*CAGR % 2007-2011*	*CAGR% 2001-2011*	*Growth Rate % (2008-2009)*
TOP	4.8	0.4	5.4	-13
NCARI	3.0	1.4	5.9	-12.7
CARI	7.3	-1.9	5.6	-19
OSIDS	4.4	1	6	0.3

Source: (Data derived from Containerisation International Yearbooks, 2001-2012; Author's calculations) (See Appendix 7)

Additionally, CARIs total container traffic has shown evidence of growth over the past decade, despite the adverse effects of the financial crisis beginning 2007/2008. However, leading up toward 2008, TEU throughput increased to approximately 5.5 million, resulting in 7.3% growth. This however was gradually diminished, as the effects of the economic and financial crisis resulted in a decline in the region's throughput by up to -19%, over just a one-year period, 2008-2009 (see Table 6.1).

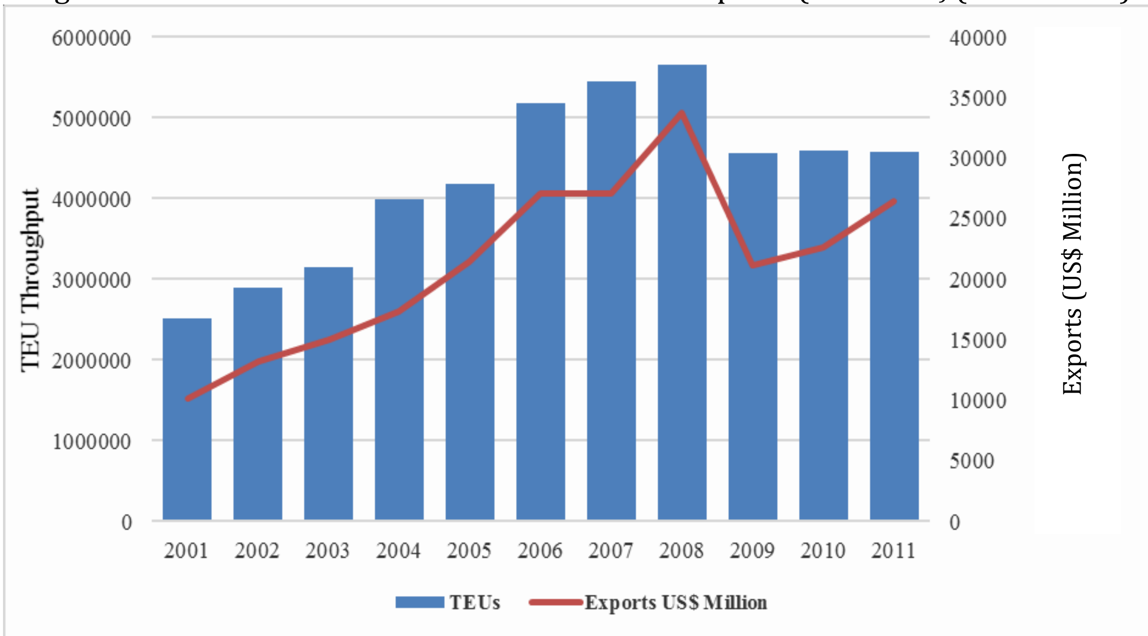
A closer look at these effects upon international trade cannot be ignored. This becomes not only a microeconomic port issue, but also a macroeconomic matter of concern. A look at the impact of the region's exports, reveal that actual TEU throughput and exports, moved in the same direction, indicating a strong link between container traffic and the region's economic growth. Exports declined by 37% during just 2008-2009 term alone. Overall, there resulted in a growth of 9% per annum, in exports during 2001-2011 (see Figure 6.3 and Table 6.2).

Table 6.2 Container Port Traffic Growth/ (Exports (US$M))
(2001-2011)

Compound Annual Growth Rate (CAGR) %	
2001-2007	*7.3 (11.5)*
2007-2011	*-1.9 (-2.2)*
2001-2011	*5.6 (9.1)*
Growth Rate 2008-2009	*-19 (-37.3)*

Source: (Data derived from Containerisation International Yearbooks, 2001-2012;, World Bank, 2014e; Author's Calculations)

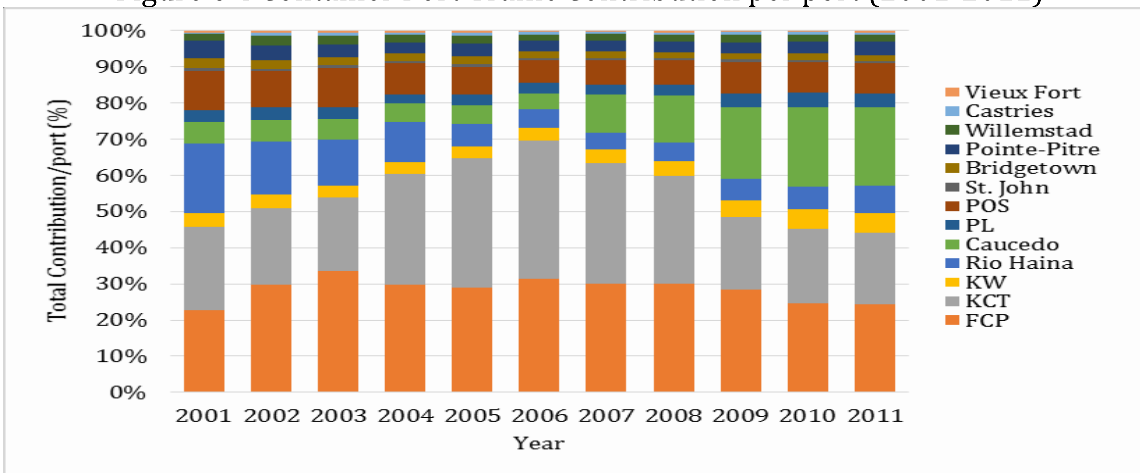
Figure 6.3 Caribbean Container Port Traffic and Exports (US$ Million) (2001-2011)



Source: (Data compiled from the Containerisation International Yearbooks, 2000-2012; World Bank, 2014e; Author's Calculations)

Moreover, ports situated within the More Developed Countries (MDC) such as The Bahamas, Jamaica, Dominican Republic, and Trinidad and Tobago account for the majority of this growth, accounting for approximately 90% of traffic. Their smaller counterparts, however situated amongst Lesser Developed Countries (LDC), handled the remaining 10% of traffic (see Figure 6.4).

Figure 6.4 Container Port Traffic Contribution per port (2001-2011)



Source: (Data derived from Containerisation International Yearbooks, 2001-2012; Calculations by Author) (See Appendix 7)

Next, summary statistics for the ports under study are discussed. Table 6.3 presents panel data for the period 2001-2011, of which, the sample consists of 69 worldwide container ports, categorized into groups. Among them, 49 are TOP ports as selected from the 2011 Containerisation International Yearbook in terms of the world's top 100 ports. These ports are located across the world and (by definition) experienced the highest averages per output and inputs, compared to the other sub-groups.

Furthermore, in the Caribbean region, there are 3 non-island ports, which border the Caribbean Sea, are located in Central and South America (NCARI), and 13 ports, which are located within the Caribbean and are island ports (CARI). Lastly, 4 island ports which belong to the SIDS group of islands, but are located in the Indian/Pacific Ocean, and so termed OSIDS ports are also included in the analysis. This rich supply of data gives us abundant 3,036 data points.

Table 6.3: Summary Statistics per Sub-Group (2001-2011)

ALL	*Container Throughput (TEU)*	*Berth Length*	*Terminal Area*	*Terminal Equipment*
Mean	1,420,758	2,960	128	20
S.E	53,502	92	5	1
Median	1,180,427	2,118	80	16
S.D.	1,473,982	2,547	142	18
Kurtosis	8	3	4	4
Skewness	2	2	2	2
Range	9,880,446	14,920	763	103
Minimum	9,554	210	3	1
Maximum	9,890,000	15,130	765	104
Sum	1,078,355,676	2,246,808	97,151	15,099
Count	759	759	759	759
TOP	*Container Throughput (TEU)*	*Berth Length*	*Terminal Area*	*Terminal Equipment*
Mean	1,861,872	3,817	168	26
S.E	65,438	110	6	1
Median	1,508,539	3,423	127	20
S.D.	1,519,224	2,552	150	19
Kurtosis	8	3	3	3
Skewness	2	1	2	2
Range	9,739,408	14,689	753	101
Minimum	150,592	441	12	3
Maximum	9,890,000	15,130	765	104
Sum	1,003,548,852	2,057,294	90,621	13,910
Count	539	539	539	539
NCARI	*Container Throughput (TEU)*	*Berth Length*	*Terminal Area*	*Terminal Equipment*

Mean	650,459	1,260	52	7
S.E.	100,200	61	6	1
Median	484,148	1,058	52	8
S.D.	575,605	352	33	5
Kurtosis	-1	-1	-2	-1
Skewness	1	1	0	0
Range	1,829,440	941	79	17
Minimum	70,362	999	14	1
Maximum	1,899,802	1,940	93	18
Sum	21,465,148	41,580	1,701	247
Count	33	33	33	33
CARI	*Container Throughput (TEU)*	*Berth Length*	*Terminal Area*	*Terminal Equipment*
Mean	327,221	797	26	6
S.E.	36,638	42	2	0
Median	150,534	600	20	4
S.D.	438,126	498	24	4
Kurtosis	3	2	3	2
Skewness	2	1	2	2
Range	1,973,518	2,275	129	19
Minimum	9,554	210	3	1
Maximum	1,983,072	2,485	132	20
Sum	46,792,657	113,962	3,678	789
Count	143	143	143	143
OSIDS	*Container Throughput (TEU)*	*Berth Length*	*Terminal Area*	*Terminal Equipment*
Mean	148,841	772	26	3
S.E.	18,063	37	3	0
Median	85,641	7 126	19	3
S.D.	119,814	2	18	1
Kurtosis	1	-1	0	-1
Skewness	2	0	1	1
Range	399,571	869	62	4
Minimum	54,862	450	8	2
Maximum	454,433	1,319	70	6
Sum	6,549,019	33,973	1,151	154
Count	44	44	44	44

Source: (Data derived from Containerisation International Yearbooks, 2001-2012); Calculations by Author) (See Appendix 7)

According to the summary statistics, container throughput for the total sample showed average throughput ranging from as low as 9,554 in CARI ports to as high as 10m, undoubtedly in TOP ports, over the eleven-year period. The sample derived a kurtosis of 8 (which is a measure of whether data is heavy/light tailed). Deviations from a normal distribution, which usually has a kurtosis of 3, shows for this sample's distribution of 8, being greater than 3, has incurred a heavier tail, or in other words, there is more data located in the tail (outliers) than expected of a normal distribution. On the other hand, a positive skewness of 2 (a measure of symmetry/lack therefore) is asymmetrical, being a positively skewed distribution. This deviation from a normal distribution is expected, as given the sample, its difference in throughput for particularly TOP versus SIDS ports are evident in port size, inputs and therefore throughput. Yet, identifying what makes TOP ports outperform its lesser counterparts is what this research seeks to understand. It is for these differences, the comparator TOP ports are chosen, and the acceptable DEA approach used to test for this.

Evidence of Port Expansion

As highlighted in Chapter 3.3 and 3.4, container ports have evolved over time. Given increases in international trade over the long run, and so port traffic, more port expansions have resulted, bringing about increments to its inputs. As shown in Table 6.4, the sample's traffic has increased over the past decade by up to 78%. In order to accommodate this rise, there has been increases to inputs, resulting in berth lengths by 18%, 41% expansions to terminals; and equipment increasing by 39% over the last decade. Based purely on these figures, this would suggest that port expansion has brought considerable improvements in efficiency, or to be more precise, considerable increases in total factor productivity through technical change. It may also suggest advantages in large sized ports, i.e. considerable economies of scale.

Table 6.4 Evolutionary Port Trend- Traffic and Inputs

ALL				
	TEU	BL	TA	TE
2001	68021211	183756.7	7139.49	1133
2002	72657907	188613.5	7486.4	1179.5
2003	79695950	195326	7912.2	1271.5
2004	87928562.33	201816	8318.4	1319.5
2005	94011564.67	211087	9049.8	1380.5
2006	105795687.5	203866	9061.6	1379.5
2007	114887732	207437.5	9286.8	1415.5
2008	117325904	211660	9605.6	1455
2009	101915199	211050	9415.8	1482
2010	114836528	214617	9775.9	1512
2011	121279430.1	217578	10099.48	1571
%Δ	**78%**	**18%**	**41%**	**39%**

Source: (Data derived from Containerisation International Yearbooks, 2001-2012; Calculations by Author) (See Appendix 7)

A further look into expansions of particularly TOP and CARI ports, show comparable patterns. While there has been port development for both groups, CARI ports have experienced higher throughput growths of up to 82% compared to 78% growths in TOP ports (see Table 6.5). This is accompanied by increases to CARIs inputs- berth length (39%) and terminal equipment (66%), which is almost double that of TOP ports (18% and 37% respectively) (see Table 6.5). Later on in this chapter, the reasoning behind these developments are explored.

Table 6.5: Evolutionary Port Trend- Traffic and Inputs: TOP vs. CARI ports

	TOP				**CARI**			
	TEU	BL	TA	TE	TEU	BL	TA	TE
2001	63703279	168857.2	6638.04	1049	2518822	8078.5	272.95	53
2002	67913797	173406	6944.9	1089.5	2897458	8491	292.5	60
2003	74383565	74383565	179428	7332.3	3152157	9286	310.4	68.5
2004	81488808	184289	7717	1215	3994853	10715	323.9	70.5
2005	87206495	193553	8443.2	1272	4184636	10722	323.9	73.5
2006	98084649	186711	8463.6	1273	5189463.5	10449	337	72.5
2007	106836401	189726.5	8678.8	1305.5	5452884	10867.5	347	74
2008	108710518	193333	8984.5	1340	5661722	11421	360.1	76
2009	94678649	192700	8794.7	1367	4562881	11259	360.1	76
2010	107261300	196102	9154.8	1394	4594554	10867.5	347	74
2011	113281391	199188	9469.585	1434	4583226.055	11249	390.4	88
%Δ	**78%**	**18%**	**43%**	**37%**	**82%**	**39%**	**43%**	**66%**

Source: (Data derived from Containerisation International Yearbooks, 2001-2012; Calculations by Author) (See Appendix 7)

In general, this confirms the fact that ports and by extension CARI ports, have engaged in port development and so expansions over the analysed decade, particularly with containerised traffic. This continues to be the forefront of maritime developments in the region as long term visions stipulate further need for port development and expansions. One however may argue, just how these investments have been affecting the region's ports, and how necessary is it to pursue these international trade agendas. This research goes on to investigate just how investment actions over the last decade, have influenced Caribbean port productivity and efficiency over time.

6.3 EMPIRICAL ANALYSIS

In this section, tests are conducted in accordance with providing answers to the primary research question and hypotheses. To recap, this research asks the question, **"As a result of port development opportunities over the past decade, how has the technical efficiency and productivity of Caribbean Ports progressed in the last decade?"**

It is with expectation, that massive investment projects, whereby the adoption of new technologies and accommodation of larger sized vessels, have significantly influenced port efficiency and productivity. It is therefore that with a *priori* expectation, that the following research hypotheses have been proposed:

Efficiency:

Hypothesis 1: *Under Constant Returns to Scale (CRS) measures, there has been no change in general port efficiency over the last decade.*

Hypothesis 2: *Given the effects of returns to scale, under Variable Returns to Scale (VRS) measures there has been a general improvement in port efficiency over the last decade.*

Hypothesis 3: *Caribbean ports are less efficient than TOP ports, but more efficient than Other Small Island Developing States (OSIDS) ports.*

***Productivity**:*

Hypothesis 4: *Total Factor Productivity (TFP) in the port sector has been positive over the last decade, and most of this have been driven by technical progress (TC) and not technical efficiency change (EC).*

Hypothesis 5: *Over the whole period, Caribbean ports have experienced higher TFP changes than TOP ports, and most of this is because of efficiency change (EC) rather than technical progress (TC).*

Hypothesis 6: *Over the whole period, Caribbean ports have experienced higher scale efficiencies in comparison to TOP ports.*

6.3.1 Technical Efficiency Analysis

In this section, tests, and analyses are done for the technical efficiencies for every container port under study, over the 11-year period. The non-parametric DEA approach is employed under different model specifications mainly constant and variable returns to scale assumptions, as specified in Chapter 5.2 and 5.3 respectively.

Technical Efficiency per sample

Summary statistics for port efficiency estimates are outlined in Table 6.6. Each port is calculated under CCR and BCC assumptions, and for the sample, average scores of 0.56 and 0.70 respectively are derived, where a value of 1.0000 reveals maximum efficiency. Under the assumption of constant and variable returns to scale, theoretical justification predicts technical efficiencies assuming VRS is usually equal to or greater than under the assumption of CRS. This is so since the production frontier more closely wraps around the data points.

Table 6.6 Summary Statistics of Port Efficiency estimates according to DEA- CCR and BCC models

	DEA-CCR	*DEA-BCC*
Mean	0.5614	0.6971
Standard Error	0.0235	0.0236
Median	0.5711	0.7044
Standard Deviation	0.1951	0.1961
Sample Variance	0.0380	0.0385
Kurtosis	-0.3981	-0.1719
Skewness	-0.2048	-0.5386
Range	0.7935	0.8191
Minimum	0.1617	0.1809
Maximum	0.9552	1
Count	69	69
Spearman Correlation		0.999

The negatively skewed distributions furthermore reveal a score of -0.20 under the CCR model and -0.54 given BCC calculations. Furthermore, a negative kurtosis of -0.398 and -0.172 implies that the distributions are more lightly tailed and flatter peaked. These findings about their distributions suggest that they are asymmetrical in nature, and so deviations from a normally distributed sample.

Closer examination suggests efficiencies are slightly skewed to the left, hence a gently rising distribution, however this will be developed later.

The first point to note of significance however that is the two sets of efficiencies are highly correlated. Indeed, a Pearson correlation coefficient is conducted to determine the correlation between CCR and BCC measures. This score ranges between +/-1, where 1 reflects a complete positive linear correlation, 0 no relation, and -1 total negative correlation. For purposes of this research, the Spearman rank correlation showed a positive coefficient of 0.99 (see Table 6.6). According to acceptable standards in the Social Sciences field, this very high value shows an acceptable and positive similarity between the two methods, in measuring and comparing the efficiency scores of the ports understudy. What it also strongly suggests is that the relaxation of the assumption of CRS made very little difference to the ranking of efficiencies of the ports in the sample.
Moreover, a graphical depiction of the evolutionary trend in efficiencies over the entire sample is shown in Figure 6.5.

Figure 6.5 Evolutionary Technical Efficiency using DEA-CCR & DEA-BCC (2001-2011)

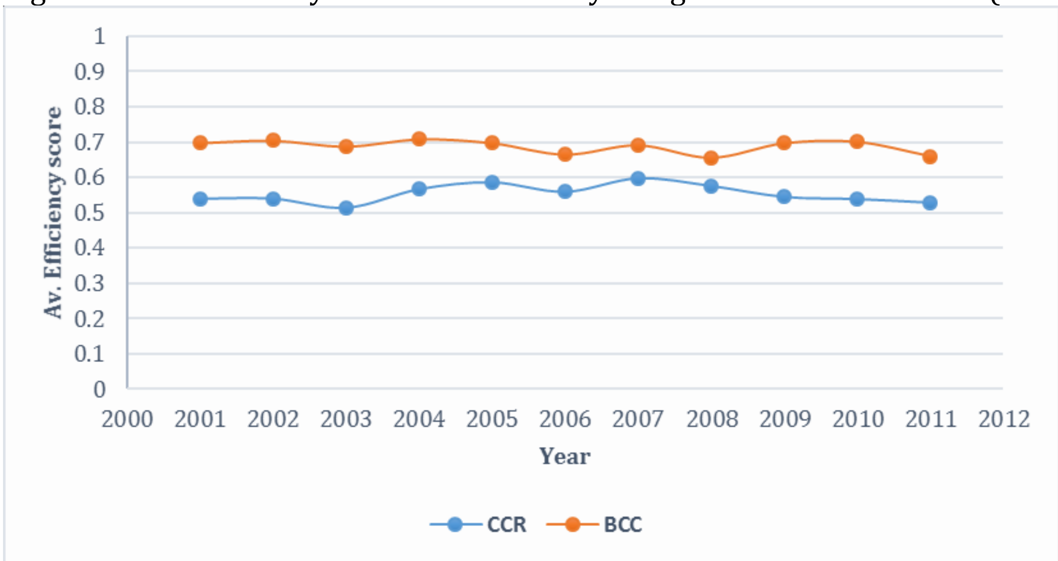


Figure 6.5 shows that average technical efficiency per annum has not deviated much over the years, this despite dips around 2007-2009 following the financial and economic crisis period. Why this occurs is because efficiency analysis is purely a year-by-year assessment, hence Figure 6.5 actually shows 11 different efficiency assessments, one for each year, rather than one assessment across the

whole period. To return to Figure 6.5, under variable returns to scale, efficiency has risen by almost 5 % during 2008-2010, after having recovered from the recessionary period. On the other hand, according to constant returns to scale, technical efficiency fell by approximately 5 % during the same period (for Figures and calculations see Appendix 10).

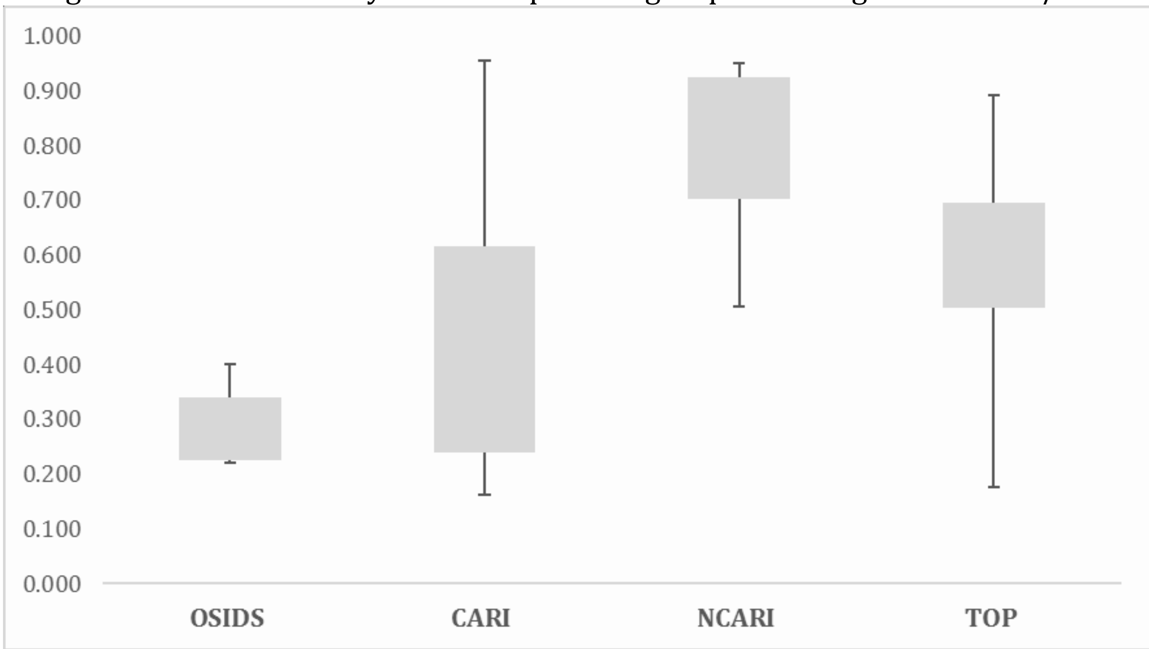
Technical Efficiency per sub group

A further break down at the summary statistics via per subgroup illustrated in Table 6.7 and Figure 6.6, shows each groups' average technical efficiencies according to the DEA- CCR and DEA-BCC models. Their average technical efficiencies reveal that the trend in Caribbean versus TOP ports for instance, received higher levels of average technical efficiencies under both models. Their respective low standard deviations under both models furthermore reveal that most of the scores were found to be around the mean value within each sub-group. Furthermore, for a breakdown of the year on year change in efficiency/ productivity per sub-group, please refer to Appendix 11.

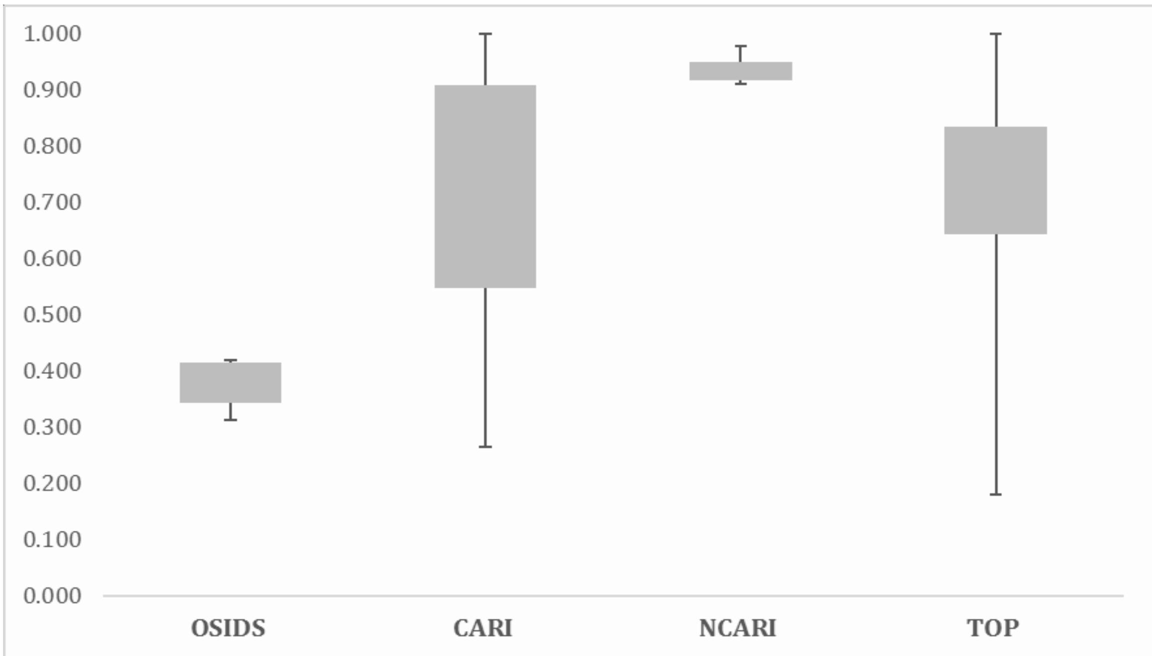
Table 6.7 Summary Statistics of Port Efficiency estimates per Sub-group according to DEA- CCR and DEA-BCC models

TOP	***DEA-CCR***	***DEA-BCC***	**CARI**	***DEA-CCR***	***DEA-BCC***
Mean	0.6016	0.7174	Mean	0.4406	0.6640
Standard Error	0.0208	0.0227	Standard Error	0.0682	0.0704
Median	0.6101	0.7195	Median	0.3249	0.6139
Standard Dev.	0.1454	0.1587	Standard Dev.	0.2458	0.2540
Sample Variance	0.0211	0.0252	Sample Variance	0.0604	0.0645
Kurtosis	0.3994	1.7699	Kurtosis	-0.3761	-1.1958
Skewness	-0.3276	-0.8097	Skewness	0.6816	-0.1113
Range	0.7149	0.8191	Range	0.7935	0.7346
Minimum	0.1763	0.1809	Minimum	0.1617	0.2654
Maximum	0.8912	1.0000	Maximum	0.9552	1.0000
Count	49	49	Count	13	13
NCARI	***DEA-CCR***	***DEA-BCC***	**OSIDS**	***DEA-CCR***	***DEA-BCC***
Mean	0.7852	0.9372	Mean	0.2927	0.3747
Standard Error	0.1404	0.0208	Standard Error	0.0425	0.0251
Median	0.8979	0.9226	Median	0.2747	0.3832
Standard Dev.	0.2431	0.0361	Standard Dev.	0.0851	0.0503
Sample Variance	0.0591	0.0013	Sample Variance	0.0072	0.0025
Kurtosis	-	-	Kurtosis	-2.1319	-3.0211
Skewness	-1.6377	1.5219	Skewness	0.6851	-0.5084
Range	0.4454	0.0675	Range	0.1793	0.1053
Minimum	0.5062	0.9107	Minimum	0.2211	0.3135
Maximum	0.9515	0.9783	Maximum	0.4004	0.4188
Count	3	3	Count	4	4

Figure 6.6 Port Efficiency estimates per Sub-group according to DEA- CCR/ BCC



	OSIDS	CARI	NCARI	TOP
Minimum	0.22	0.16	0.51	0.18
Q1	0.23	0.24	0.70	0.50
Mean	0.29	0.44	0.79	0.60
Q3	0.34	0.62	0.93	0.70
Maximum	0.40	0.96	0.95	0.89



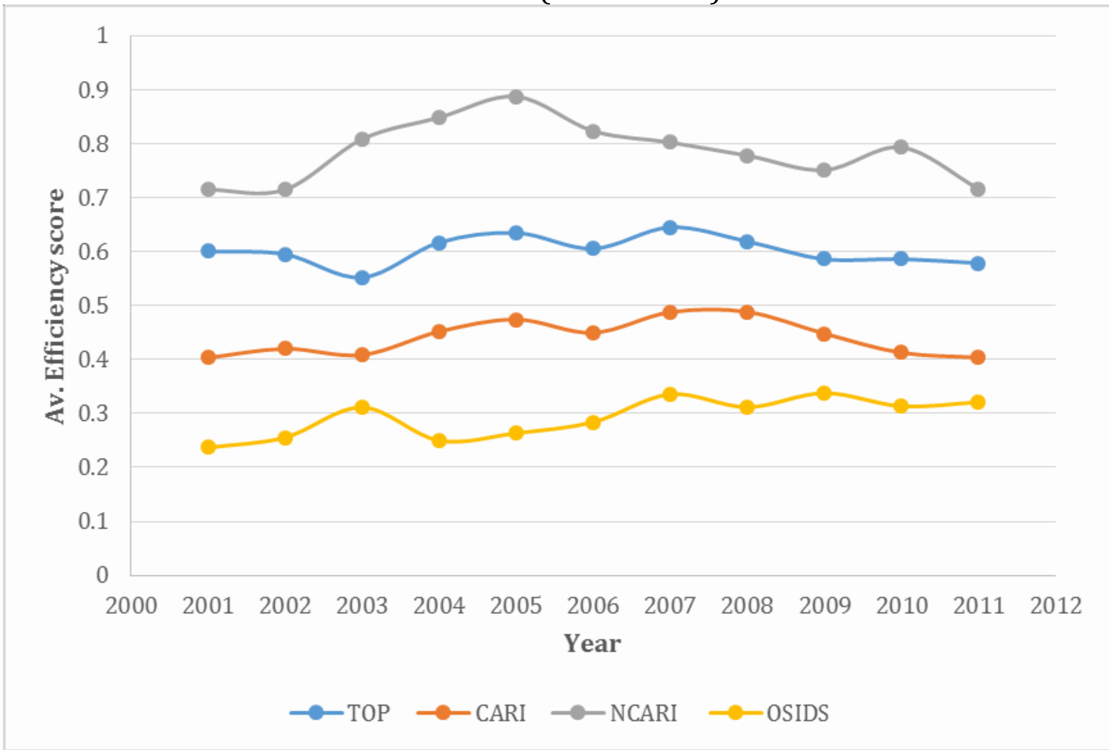
	OSIDS	CARI	NCARI	TOP
Minimum	0.31	0.27	0.91	0.18
Q1	0.34	0.55	0.92	0.64
Mean	0.38	0.66	0.94	0.72
Q3	0.41	0.91	0.95	0.84
Maximum	0.42	1.00	0.98	1.00

For each box and whisker plot, the ends of the box represent upper and lower quartiles, whereas, whiskers are the two lines outside the box that extend to the minimum and maximum observations of the sample. For illustrative purposes, overall, the SIDS ports retrieved lower average efficiency scores compared to their other counterparts on both CCR and BCC assumptions. The vast range of technical efficiencies for CARI ports for instance, show Castries port had the lowest averages across the whole period of 16% & 27%, compared to the largest score of 96% & 100% respectively. These results show a vast range between the most and least efficient ports particularly within the CARI group, where, there still exists room for improvement, with the latter having a larger gap to close with respect to the frontier or maximum value (see Figure 6.6).

Whilst, each group has realized varying average efficiency scores, there has been a similar trend over the entire period under both constant and variable returns to scale assumptions. This substantiates the vulnerability of ports despite their level of development or locality, to external interferences such as economic crisis and other global impacts that affect international trade.

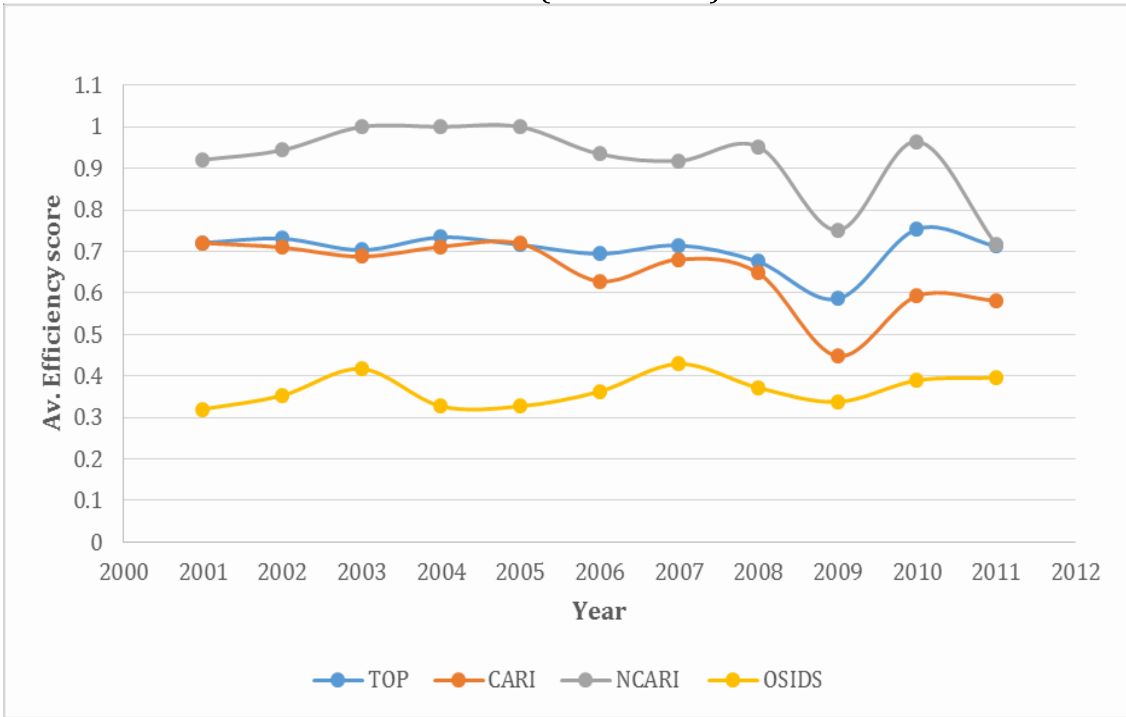
Under constant returns to scale, in earlier years, leading up to 2006, NCARI has managed to surpass the TOP group, and even thereafter, maintain efficiency scores on par with them despite its fall in the latter years. CARI and OSIDS ports on the other hand, have not succeeded in reaching the efficiency levels of TOP ports, as NCARI has (see Figure 6.7).

Figure 6.7 Evolution of Technical Efficiency per Sub-group applying DEA-CCR (2001- 2011)



Shifting focus toward the ports' efficiency results under the notion of variable returns to scale, the groups take on a different result (see Figure 6.8). While efficiency scores are higher for every group, particularly for CARI ports, the gap between them and the TOP sub-group has narrowed. A possible explanation for this, presents the possibility of the effects of scale, which will soon be investigate.

Figure 6.8 Evolution of Technical Efficiency per Sub-group applying DEA-BCC (2001- 2011)



Under both models, NCARI outperforms each sub-group, with Non-SIDS, managing to score higher average technical efficiencies compared to SIDS ports. On the other hand, within the SIDS group, CARI ports managed higher average efficiencies greater than their OSIDS counterparts did. This is evident due to pure technical and scale efficiencies, captured under the DEA-BCC model and will be elaborated later on in this chapter. Furthermore, the results of the Malmquist index prove the same as the model measures evolutionary efficiency and productivity taking into consideration the effects of pure technical and scale efficiency changes. This is further explored in Section 6.3.2.

Technical Efficiency per port

Taking a closer look into individual efficiencies, Table 6.8 and Table 6.9 investigates the scores and ranks of the ports' average technical efficiencies. Given Table 6.8 for instance, Quartile 4 (75^{th} – 100^{th} percentile) presents eighteen of the most efficient ports, whose scores range between 69% and 96%. Among them, the majority i.e. 14 are amongst the world's TOP ports, just 2 belong to Caribbean SIDS (CARI.), and 2 are Near Caribbean (NCARI). Moreover, the least efficient ports situated in quartile 1, attained scores ranging from 16% to 40%. Among this, 7 are Caribbean SIDS, 4 TOP ports, and the entire 4 Other SIDS (OSIDS) understudy.

However, under the BCC model, as shown in Table 6.9, when the effects of returns to scale are varied, more CARI ports have managed to rank among the most efficient ports. For instance, Vieux Fort and St. John, which ranked amongst the 1st Quartile under the CCR model are now placed in the 75th – 100th percentile. As two ports may be very small in nature, having a lower throughput turnaround than larger TOP ports, much of this change has therefore been the effects of scale changes brought about via expansions, over the years. This effect of scale, and its impact upon port efficiency and productivity, will be further examined later on.

Overall, the results reveal a significant observation about the similarity in efficiencies of CARI. and OSIDS ports, all of which are belong to SIDS. The majority of TOP and NCARI ports were found to be among the higher ranks- quartile 4 and 3, whilst the majority of SIDS ports found within the Caribbean (CARI.) and OSIDS retrieved lower efficiency scores primarily situated in quartile 1. This however has not been the case for every port, as Freeport, Rio Haina, Point Lisas, Caucedo and KCT, were amongst the higher ranked efficiency quartiles 3 and 4, and yet, are classified as SIDS.

Table 6.8 Average Technical Efficiency ranking per port under DEA-CCR model

Ranking	#	Port	Group	TE	Ranking	#	Port	Group	TE
Quartile 4	1	Freeport	1	96%	*Quartile 2*	37	Yokohama	0	57%
	2	Puerto Cortes	2	95%		38	Tacoma	0	56%
	3	Manzanillo	2	90%		39	Barcelona	0	56%
	4	La Spezia	0	89%		40	POS	1	55%
	5	Maarsaxlokk	0	88%		41	Leixoes	0	55%
	6	Honolulu	0	84%		42	New York	0	53%
	7	Gwangyang	0	79%		43	Osaka	0	52%
	8	Melbourne	0	79%		44	Barranquilla	2	51%
	9	Bremerhaven	0	78%		45	Zeebrugge	0	50%
	10	Hamburg	0	77%		46	Antwerp	0	50%
	11	Damietta	0	75%		47	Piraeus	0	50%
	12	Sydney	0	73%		48	Le Havre	0	49%
	13	Savannah	0	72%		49	Genoa	0	48%
	14	Felixtowe	0	72%		50	Ho Chi Minh City	0	48%
	15	Taichung	0	71%		51	Lisbon	0	47%
	16	Rio Haina	1	71%		52	Seattle	0	46%
	17	Duisburg	0	70%		53	Charleston	0	44%
	18	Vancouver	0	69%		54	Kobe	0	41%
Quartile 3	19	Penang	0	68%	*Quartile 1*	55	Oakland	0	40%
	20	Fuzhou	0	68%		56	Port Louis	3	40%
	21	Haifa	0	67%		57	Buenos Aires	0	36%
	22	Tuticorin	0	67%		58	Bilbao	0	34%
	23	Manila	0	65%		59	Bridgetown	1	32%
	24	Dammam	0	64%		60	Apra	3	32%
	25	Yantai	0	64%		61	Pointe-Pitre	1	30%
	26	Ambarli	0	62%		62	KW	1	29%
	27	Point Lisas	1	62%		63	St. John	1	24%
	28	Caucedo	1	62%		64	Noumea	3	23%
	29	Gothenburg	0	61%		65	Papeete	3	22%
	30	Nagoya	0	61%		66	Willemstad	1	21%
	31	Bangkok	0	61%		67	Vieux Fort	1	18%
	32	St. Petersburg	0	60%		68	Dunkirk	0	18%
	33	Norfolk Virginia	0	58%		69	Castries	1	16%
	34	KCT	1	57%					
	35	Montreal	0	57%					
	36	Jeddah	0	57%					

Table 6.9 Average Technical Efficiency ranking per port under DEA-BCC model

Ranking	#	Port	Group	TE	Ranking	#	Port	Group	TE
Quartile 4	1	Hamburg	0	100%	*Quartile 2*	37	Haifa	0	69%
	2	Vieux Fort	1	100%		38	Bangkok	0	68%
	3	Bremerhaven	0	99%		39	Osaka	0	68%
	4	St. John	1	98%		40	St. Petersburg	0	68%
	5	Puerto Cortes	2	98%		41	Tacoma	0	67%
	6	Freeport	1	96%		42	Dammam	0	65%
	7	Maarsaxlokk	0	94%		43	Caucedo	1	65%
	8	Melbourne	0	93%		44	Gothenburg	0	65%
	9	Barranquilla	2	92%		45	Zeebrugge	0	65%
	10	Felixtowe	0	92%		46	Montreal	0	64%
	11	Manzanillo	2	91%		47	Leixoes	0	64%
	12	Point Lisas	1	91%		48	Kobe	0	64%
	13	La Spezia	0	90%		49	Le Havre	0	63%
	14	Antwerp	0	89%		50	KCT	1	61%
	15	Savannah	0	88%		51	Genoa	0	61%
	16	Honolulu	0	87%		52	Bridgetown	1	61%
	17	Gwangyang	0	87%		53	POS	1	60%
	18	Nagoya	0	85%		54	Seattle	0	58%
Quartile 3	19	Manila	0	84%	*Quartile 1*	55	Piraeus	0	58%
	20	Vancouver	0	84%		56	Castries	1	55%
	21	Rio Haina	1	81%		57	Charleston	0	54%
	22	Yokohama	0	81%		58	Oakland	0	54%
	23	Sydney	0	80%		59	Lisbon	0	48%
	24	Tuticorin	0	78%		60	Buenos Aires	0	46%
	25	Barcelona	0	77%		61	Port Louis	3	42%
	26	Damietta	0	77%		62	Apra	3	41%
	27	Taichung	0	77%		63	Pointe-Pitre	1	36%
	28	Ambarli	0	75%		64	Bilbao	0	36%
	29	New York	0	74%		65	Papeete	3	35%
	30	Fuzhou	0	74%		66	KW	1	32%
	31	Jeddah	0	73%		67	Noumea	3	31%
	32	Norfolk Virginia	0	72%		68	Willemstad	1	27%
	33	Duisburg	0	72%		69	Dunkirk	0	18%
	34	Ho Chi Minh City	0	71%					
	35	Penang	0	70%					
	36	Yantai	0	70%					

Next, analysing the Malmquist productivity and its various decompositions are made. The main advantage of this approach is that it reveals exactly where the differences may be, concerning the impact on productivity and efficiency changes over time, for the four sub-groups. Furthermore, as was highlighted, whilst efficiency is a short run concept that is assessed through a year-by-year assessment, productivity assesses changes over time, and hence is more akin to a long run concept.

6.3.2 Productivity Analysis

Data and Preliminary Tests

The data set comprises productivity and efficiency changes for 69 ports; across 45 countries for the period 2001-2011 (see Appendix 7, page 223-241). The majority of their traffic is container trade, which is primary for the purposes of this study. To recap, the world's top ports (TOP), according to the Containerisation International organization, is used as a peer reference group, along with Central and South American ports (near Caribbean ports). The Caribbean and other SIDS port performances are therefore benchmarked against these two groups over an 11-year period, in order to identify their growth and expansion patterns, or lack thereof and so lessons learnt.

This section analyses the total factor productivities using also 69 container seaports over an 11-year time span, giving 759 observations. Among this, 49 are top ports (TOP), chosen according to the 2011 Containerisation International Yearbook. These are located across the world. Furthermore, 13 are Caribbean island ports and termed SIDS according to the United Nations (CARI), 3 ports which border the Caribbean Sea and are non-island ports (NCARI), and lastly a further 4 ports are SIDS ports, but situated within the Pacific region (OSIDS) (see Appendix 7 and Appendix 8).

The variables used in this analysis include- TEU throughput as output, and inputs- terminal area (h), berth length (m) and total equipment (see Table 6.3). Overall, this gives an abundant rich supply of 3,036 data points for our analysis.

DEA- Malmquist Decomposition of Total Factor Productivity (2001-2011)

Analysis of the Malmquist Index Summary of Annual Means

Following on from the theoretical framework presented in Section 4.4.1, the Malmquist productivity Index (MPI) has become a standard approach in productivity measurements over time.

A recap of the MPI shows growths and declines in productivity, which is a representation of the changes in efficiency and technical levels over time. Temporal changes in efficiency can be credited to two key sources of the management and business environment, namely i) *catch up effects* and ii) *frontier shift effects* (Cheon et al.., 2010, Estache et al.., 2004, Grifell and Lovell, 1993, Nishimizu and Page, 1982).

Under the *catch up effect*, also referred to as the change in efficiency change ($EFFCH_k$), depicts the port's movement toward and thereby along the production frontier. As the term implies, it shows the DMUs potential to employ the necessary managerial best practises so that it can operate on the frontier at any point in time. Here, the DMU either a) maximizes outputs given its level of inputs or varies inputs where there is minimum wastage in order to accommodate a given amount of outputs (managerial/pure efficiency change (PECH)), and/or b) responds to port demand by flexibly changing production scales (scale efficiency change (SECH)). Scale efficiency changes, are usually acquired from investment in new facilities and/or expansion of existing facilities.

Moreover, the *frontier shift effect* is, just as its name implies, a shift of the production frontier due to technical progress. Here the DMU is able to keep abreast and adapt innovative technologies in its production processes. This means employing longer term strategic planning, engaging in huge capital investments that eventually access larger markets.

Firstly, descriptive statistics for the Malmquist Index Decomposition are presented in Table 6.10. According to the results, during the period 2001 to 2011, the sample's average port productivity improved by 2.2% (*Tfpch*=1.022). Productivity gains, was primarily attributed to a 2.5% increase in technical progress

(*Techch*=1.025), followed by a 0.6% growth in scale efficiency (*Sech*=1.006). As Cowie (2017b) highlights, in the medium to longer term TFP change should primarily come from technical change, hence the results are consistent with that general observation. The majority of ports (51/69) improved their average total factor productivities during the said period, while 18/69 ports experienced a decrease in their overall averages (see Table 6.13, pages 165-166 discussed more later on).

Table 6.10 Descriptive Statistics-Malmquist Index Decomposition

	Techch	*Pech*	*Sech*	*Tfpch*
Mean	1.025	0.992	1.006	1.022
Median	1.020	1.000	1.000	1.025
S.D.	0.017	0.050	0.032	0.047
Kurtosis	-0.337	3.013	30.395	1.281
Skewness	0.692	-0.906	4.747	0.402
Minimum	0.998	0.818	0.969	0.902
Maximum	1.065	1.103	1.222	1.177
Count	69	69	69	69

Key: *Techch:* Technical Change; *Pech:* Pure Efficiency change; *Sech:* Scale Efficiency change; *Tfpch:* Total Factor Productivity change.

A further decomposition of the year-on-year, Malmquist results, as shown in Table 6.11, reveal total factor productivity changes (*Tfpch*), as well as its contributors- efficiency and technical changes. Results suggest that while total productivity has improved by 2.2 % on average per annum, this increase is primarily the result of technical change *(techch)*, which grew by 2.5% per annum (average *Techch*= 1.025). Moreover, the average change in technical efficiency showed the contrary, as efficiency declined by 0.3 % (average *Effch*= 0.997). The table also shows the impact of the financial crisis, with a large decline in TFP in 2008 to 2009, which was primarily driven by a reduction in technical change (0.96), and efficiency change due to scale efficiency declines (0.885). This latter effect would have been brought about by a sudden over capacity at most ports due to the decline in container traffic.

Table 6.11 Malmquist Index Summary Decomposition of Total Factor Productivity (2001-2011)

Year	Effch	Techch	Pech	Sech	Tfpch
2001-2002	1.023	0.993	1.015	1.008	1.016
2002-2003	0.961	1.07	0.974	0.986	1.029
2003-2004	1.095	0.979	1.03	1.063	1.071
2004-2005	1.046	0.986	0.998	1.048	1.032
2005-2006	0.953	1.114	0.951	1.002	1.061
2006-2007	1.072	0.978	1.047	1.024	1.049
2007-2008	0.955	1.042	0.93	1.027	0.995
2008-2009	0.946	0.96	1.069	0.885	0.908
2009-2010	0.973	1.113	0.993	0.98	1.083
2010-2011	0.964	1.024	0.923	1.045	0.987
Geometric Average	0.997	1.025	0.992	1.006	1.022
Pre- Crisis Period (2001-2007)	1.0236	1.0187	1.002	1.02149	1.0428
Post- Crisis Period (2007/2008-2011)	0.9594	1.0333	0.977	0.98223	0.9913

During the pre-crisis period (2001-2007), total factor productivity increased by up to, 4.3% per annum (see Table 6.11). This growth was mainly the result of progresses in technical efficiency, which grew by 2.1 % because of scale growths, which far outweighed progresses in managerial efficiency (0.2%). Whilst this is in contradiction to the earlier observation with regard to TFP being primarily driven by TC, in this case the combined influence of port expansion and the effect of increasing returns to scale is primarily driving container port TFP, although note that TC is still relatively high. Furthermore, many of the ports during these early years/stages of their development are more likely to be operating at the size of increasing returns to scale, and so focus is on enlarging their production scales. This in turn affects productivity, brought about by increasing investment opportunities.

Subsequently, the effects of the global financial crisis revealed drastic changes to progress in port performance. Ports experienced a fall in total productivity of up to 9.2% during 2008-2009 year alone. Being the most adversely affected year throughout the decade, this was primarily driven by a reduction in technical change (0.96), and efficiency change due to scale efficiency declines (0.885). This latter effect would have been brought about by a sudden over capacity at most ports due to the decline in container traffic.

On the other hand, leading up to 2011, (*post crisis period*), the average *Tfpch* during the period 2007/2008-2008/2011 showed evident signs as it declined by a little under 1% per annum. Both managerial and scale effects declined also, as investments would have fallen coupled with the decline in international trade, and so throughput. Technical progress on the other hand, revealed an increase of 3.3% per annum.

This represents a shifting outwards of the frontier curve, as productivity returns to growth. At the same time, the *catching up effect* or efficiency change (*Effch*) displays an inward movement, which is compensated for by a strong positive change in technical progress. In accordance with past researches on this finding, is also consistent with most recent findings of Wilmsmeier et al.., (2013), where a rise in productivity change brought about by technical progress resulted in a fall in technical efficiency, as now the production frontier is shifted further outward, resulting in more *catching up* on part of the port reaching optimum efficiency. To make clear, an often overlooked point with TFP assessment is that advances in technical progress cause adverse efficiency change. For example, a port which was 99% efficient in year t, if it makes no improvements in the following year yet technical progress improves by 5%, will experience a 5% decline in efficiency, i.e. it will now only be 94% efficient. This it may 'catch up' in subsequent time periods.

Overall, a departing effect of the results for *Effch* and *Techch*. While *Techch* have generally had a positive impact on *Tfpch, Effch* has tended to have a more neutral impact, for the reasons outlined above. What is surprising however over the whole period is the minimal effect of scale, hence it may have been expected that overall EC would have had a positive rather than a neutral impact. This is underlined when decomposing technical efficiency (E*ffch*) between pre and post-crisis periods, which shows that in the pre-crisis period, scale efficiency (*Sech*) grew by 2.1 % on average while pure efficiency (*Pech*) increased but by just 0.2%. Here lies the possibility of ports changing their production scales, by attempting investments in new facilities and expansion of existing operations, at the expense of production given its most efficient existing scale size. Ports are investing for mainly the purposes of growth, hence given the inputs purely relate to capital, this will likely produce short to medium term inefficiencies. Furthermore, during the post crisis period, both *Pech* and *Sech* showed a decline; however, *Pech* (-2.3%) yet had a larger adverse effect on *Effch* than did *Sech* (-1.8%). Hence all pre crisis scale gains were effectively eradicated by the decline in container traffic due to the financial crisis, thus the reason for the neutral impact of EC over the whole period. Given the relative size of the Caribbean ports (small), this would have had a larger impact on these ports efficiencies.

Generally, throughout the entire period, productivity evolution of the ports under study showed an improvement in total factor productivity *Tfpch* by 2.2 %. To put this into context, over an eleven year period this would have resulted in a total accumulated increase in productivity of 27%. Principally technological progress and scale effects have driven this change. Moreover, average technical efficiency change showed the contrary; as efficiency declined by 0.6 %. Furthermore, the decomposition of technical efficiency (*Effch*) evolution shows that on average, ports are moving closer to the minimum scale efficiency, as *Sech* improved by 0.6%. Their pure efficiency (*Pech*) however did reduce, indicating an inward move away from the production frontier. This however is due to the rise in productivity change brought about by technological progress which results in a fall in technical efficiency, as now the production frontier is shifted further outward, resulting in more *catching up* on part of the port reaching optimum efficiency. That is positive technical change creates adverse efficiency change, as the frontier shifts. It may be expected therefore, that this 0.6% reduction would be captured in subsequent (i.e. post 2011) time periods.

Analysis of the Malmquist Index Summary per Sub-Group

Moreover, following on from the results of the DEA- Malmquist, this section analyses efficiency and productivity changes per subgroup, as it places emphasis on the performance of each group. Furthermore, for a breakdown of the year on year change in efficiency/ productivity per sub-group, please refer to Appendix 11.

Productivity and Efficiency Impact

Over the entire period from 2001-2011, the majority of groups have had growths in their productivities (*Tfpch*) (see Table 6.12). The average productivity of CARI ports, actually yielded the highest growth, with 3.2%, followed by 2.8% OSIDS. The TOP group experienced a 2% average productivity growth, while NCARI ports on the other hand, suffered negative growth, with a fall of 0.5%, primarily brought about by the effects of Barranquilla's 17% decline in managerial efficiency (see Table 6.13, and Figure 6.16, later elaborated on). Of particular interest, the overall SIDS group actually outperformed (3.1%) their larger TOP counterpart (2%). The efficiency 'gap' therefore between the Caribbean and the TOP ports would appear to be closing.

Table 6.12 Malmquist Index Summary Decomposition of Total Factor Productivity by per subgroup (average 2001-2011)

Sub-Groups	***Effch***	***Techch***	***Pech***	***Sech***	***Tfpch***
TOP	0.995	1.026	0.997	0.998	1.020
CARI	1.007	1.025	0.978	1.029	1.032
NCARI	0.973	1.022	0.947	1.028	0.995
OSIDS	1.017	1.011	1.012	1.005	1.028
Geometric Average	**0.997**	**1.025**	**0.992**	**1.006**	**1.022**
SIDS	1.009	1.022	0.986	1.023	1.031

Decomposing the change in productivities, reveals the primary factor attributed toward technical progress (*Techch*) for most of the groups. The other contributor toward productivity progress, being efficiency change (*Effch*), on the other hand, has not managed to advance as quickly, hence what was outlined above with regard to the whole sample, is found to be the case across all of the subgroups.

For instance, TOP ports attained the largest progresses in technical growths of 2.6%, compared to the other groups, but at the expense of 0.5% decline in efficiency. The same is understood for NCARI ports, who incurred 2.2% growth in technical change, resulting in a 2.7% fall in efficiency progress.

Interestingly the one exception to this negative growth in efficiency, is seen for the SIDS group. Both CARI and OSIDS experienced advances in their efficiencies and technical growths. However with 1.7% efficiency change, OSIDS incurred the highest growth amongst all of the groups, and the least progress in technical change, of 1.1%. Furthermore, most of this improvement was as a result of positive increases in managerial efficiency and not scale, which saw only a minor improvement. As a group, this is the one that has seen the least expansion over the period reviewed, certainly in terms of the inputs utilized in this analysis. To a certain extent there may be some learner effects occurring here, as a lot of this gain may have arisen due to better utilization of existing inputs (a net average increase of just over 6% in the three inputs), whilst all other groups have seen considerable increases. Whilst this does suggest that not all productivity/efficiency improvement be as a consequence of investment and port expansion, another factor here will almost undoubtedly be as consequence of demand conditions. Hence the current port facilities have been able to accommodate the increase in traffic, as this increase has been more evenly spread across the week/year. Such options may not be open to larger ports.

To return to Table 6.12, CARIs technical growth of 2.5% stands closely with the world's TOP ports (*Techch*=2.6%) and on par with the sample's average (*geomean*=2.5%). CARI ports continue to employ advanced methods in their ports' operations, which is discussed further in Chapter 7. While this is so, their efficiency changes improved but only at a minuscule 0.7%, yet outweighing the sample's average (*Effch*= 0.997). This would therefore strongly suggest that the remaining efficiency 'gap' can only be bridged by eradicating scale inefficiencies, but in turn this can only be achieved if the volume of container traffic justified such an expansion in port facilities. Nevertheless, some progress has been made in this respect - comparing the sample's averages against each sub-group, CARI ports incurred the highest total productivity change (*3.2% > 2.2% sample average*). It continues to "catch up" to or employ best practice standards, in the face of keeping abreast with advances in technical progress (*0.7% > -0.3% population's sample average)*, and *2.5% = 2.5% population's sample average*).

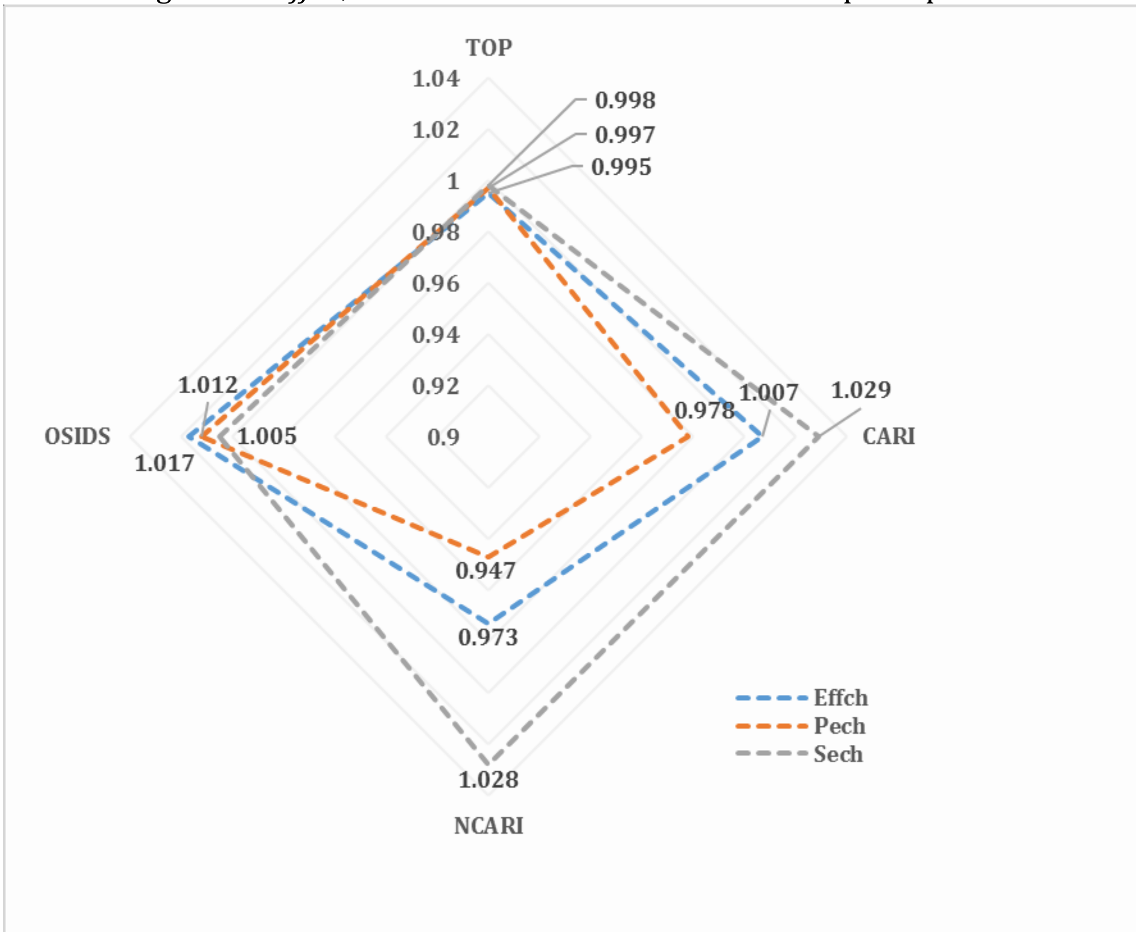
Nevertheless, it may be the case that Caribbean ports, or certainly the larger ones, have now achieved their maximum efficiency levels, as gains through scale efficiencies have been gradually eradicated. Examining the scale efficiency changes for this group does give some confirmation of this, as these have gradually been declining over the period. For example, the average over the first three years was a 2.81% improvement, but this fell to a 1.88% average improvement over the next three years, to finally a 0.02% improvement over the last four.

Overall and interestingly, SIDS ports, have managed to meet the population's standards throughout the period 2001- 2011. Their productivities *(3.1% > 2.2% population's sample average),* and efficiencies *(0.9% > -0.3% population's sample average),* have exceeded the population's sample averages. While this is so, their change in productivity growths for OSIDS have resulted chiefly from technical efficiency change, with pure efficiency being the main driver of it. Moreover, CARI ports have shown the contrary, its technical progress primarily contributed toward productivity changes, with scale efficiency being the main driver of efficiency changes.

Managerial and Scale Impact

Additionally a further look into the decomposition of technical efficiency reveals the impact managerial and scale efficiencies have had. For instance, scale efficiency has managed to progress quicker than managerial efficiency for the majority of groups (see Figure 6.9).

Figure 6.9 *Effch*, *Sech* and *Pech*- Radar Plot Sub-Group comparison



CARI and NCARI experienced the largest increases in scale effects, having up to 2.9% and 2.8% growths respectively. On the other hand, TOP ports had the least progress, having an actual decline of 0.2%. In contrast, managerial efficiency declined for the majority of ports, given TOP (-0.3%), CARI (-2.2%) and mainly the NCARI (-5.3%) sub-groups. Taken at face value, this would suggest that if it had not been for scale improvements, these ports, particularly the CARI and NCARI groups, would have experienced adverse (rather than neutral) efficiency change, and of quite substantial declines. This may be related to the DEA approach to MPI assessment and in particular the apportionment of EC between managerial and scale efficiencies, as certainly with regard to the CARI and TOP groups, the difference in the overall effect of EC between the two is very marginal. As a consequence, the positive effect of scale efficiency change may be overstated, and hence to compensate, in a similar manner the adverse effect of managerial efficiency may also be overstated. This is an area that needs further research.

Particularly, CARI and NCARI ports incurred quicker progresses in *Sech* than *Pech,* as for these ports, the impact of increasing their production scale via growing investments and expansions, may result in the deterioration of *Pech,* given new capacities, which is needed, to operate at optimal capacity. Hence, the slowing progression of efficiency. On the other hand, OSIDS experienced the opposite, given its 0.5% growth in scale efficiency, but yet a 1.2% progress in managerial efficiency.

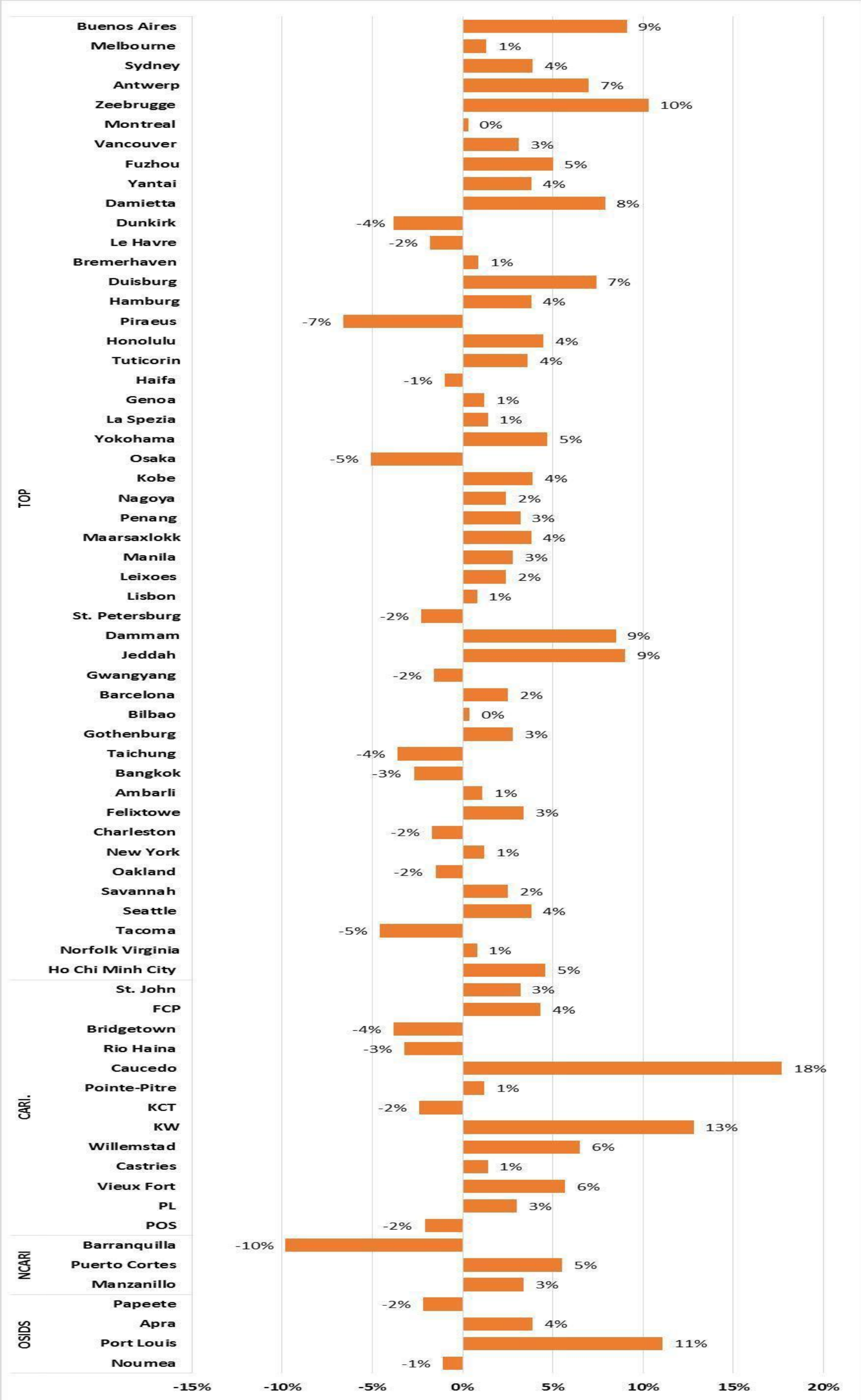
Looking back at the performances of SIDS versus TOP ports, the results of Table 6.12, indicate that there has been a progressive movement toward narrowing the gap between both groups. While there was greater technical progress for TOP (2.6%) than SIDS (2.2%) ports, the efficiencies of SIDS grew faster (0.9%), taking them closer toward the frontier, than TOP ports which actually declined indicated by a 0.5% movement shift away from the frontier. This growth for SIDS is attributed to higher scale efficiency (2.3%), brought about by investment opportunities. Major ones in the Caribbean region, over the past decade, are discussed in Chapter 7.

Since SIDS ports are usually smaller scale and yield lesser throughput (compared to TOP ports), when they begin to grow, focus on enlarging their production scales. This however is achieved at the expense of attaining optimal production as evident in pure efficiency which declined by 1.4%. Overall, it leads to higher total productivity, as they operate at the size of increasing returns to scale (*tfpch*=3.1%). TOP ports however declined by 0.5% because of negative growths in pure and scale efficiencies, however as stated, certainly with regard to pure (managerial) inefficiency this may well have been eradicated after the end of the period analyzed. With reference to scale however, since TOP ports are usually larger scale ports and so yield more throughput (compared to smaller ports), will likely be operating at the size of decreasing returns to scale, and as Cheon (2008) highlights, this probably means some loss of focus on internal practices, in other words, x-inefficiency (Leibenstein, 1966). Given the market in container traffic, this loss of scale economies through oversizing may be inevitable, and in fact may actually be ‘efficient’, as the transaction costs of constructing a new container terminal in order to accommodate traffic growth may far outweigh any loss of scale economies in the existing facilities.

Analysis of the Malmquist Index Summary per Port

Considering individual ports in the population's sample reveals that 72% or 50 out of 69 ports had improvements in their productivities. Among them, those worth mentioning are CARI Port Caucedo, who experienced the highest growth of 17.7%. This finding is also consistent with the investigation conducted by Wilmsmeier et al. 2013. On the other hand, Barranquilla recorded the lowest, given its fall in productivity of up to 10% (see Table 6.13, Figure 6.10).

Figure 6.10 Evolutionary Average Total Factor Productivity Growth per port (2001-2011)



For 52 of the total number of ports, technical change is the primary determinant of total productivity change. Of this total, 82 % of TOP ports, followed by 67 % for NCARI ports, and 62% of CARI ports, lead regarding technological progress being the main driver of total productivity changes. The OSIDS groupings have managed to keep abreast and engaged with technological improvements but not to the extent of their counterparts, with 50 % of these ports embracing technological progress as the main source of productivity growths (see Table 6.13).

Moreover, the performances of 33 ports out of the 69, which is almost half of the sample study, show a positive change in technical efficiency. This is an optimistic sign as it indicates a closer move toward the production frontier for these ports. Delving further into the specific groups, only 45 % of the TOP category had growth in technical efficiency. On the other hand, NCARI and CARI ports have managed to outperform the other groups, having 67% and 54% respectively, of its ports with technical growth (see Table 6.13).

Decomposing technical efficiency allows us to look further at its changes due to the effects of changes in pure and scale efficiencies. For those ports experiencing growths in their technical efficiencies, both effects have played a key part in influencing this. Nevertheless, for 58% of these ports, pure efficiency have had a greater impact than scale efficiency. Overall, looking at the SIDS group, for CARIs technical efficiency growths, it has been primarily due to scale effects, while for OSIDS ports, the reverse holds, i.e. pure efficiency, has outweighed scale effects (see Table 6.13).

Table 6.13 Malmquist Index Summary Decomposition of Total Factor Productivity per port (average 2001-2011)

#	Port	Group	Effch	Techch	Pech	Sech	Tfpch
1	Buenos Aires	TOP	1.094	0.998	1.076	1.016	1.091
2	Melbourne		0.986	1.028	0.995	0.991	1.013
3	Sydney		1.039	1	1.03	1.009	1.039
4	Antwerp		1.014	1.055	1.007	1.007	1.07
5	Zeebrugge		1.08	1.021	1.066	1.013	1.103
6	Montreal		1.004	0.999	0.993	1.012	1.003
7	Vancouver		1.012	1.019	1.008	1.004	1.031
8	Fuzhou		0.992	1.059	1.006	0.986	1.05
9	Yantai		1.015	1.023	1.001	1.013	1.038
10	Damietta		1.021	1.057	1.022	0.999	1.079
11	Dunkirk		0.938	1.025	0.934	1.004	0.962
12	Le Havre		0.961	1.022	0.973	0.988	0.982
13	Bremerhaven		0.992	1.017	1.007	0.985	1.009
14	Duisburg		1.068	1.006	1.066	1.002	1.074
15	Hamburg		0.997	1.041	1	0.997	1.038
16	Piraeus		0.925	1.01	0.904	1.022	0.934
17	Honolulu		1	1.045	1	1	1.045
18	Tuticorin		1.016	1.02	0.999	1.017	1.036
19	Haifa		0.979	1.012	0.987	0.992	0.99
20	Genoa		0.987	1.026	0.973	1.014	1.012
21	La Spezia		0.997	1.018	0.999	0.998	1.014
22	Yokohama		1.001	1.046	1.004	0.997	1.047
23	Osaka		0.943	1.007	0.947	0.996	0.949
24	Kobe		1.035	1.004	1.005	1.03	1.039
25	Nagoya		1.003	1.02	0.994	1.009	1.024
26	Penang		1.003	1.029	1.003	1	1.032
27	Maarsaxlokk		1.022	1.015	1.023	1	1.038
28	Manila		1.015	1.012	1.003	1.012	1.028
29	Leixoes		1.02	1.004	1.01	1.01	1.024
30	Lisbon		0.995	1.014	0.997	0.998	1.008
31	St. Petersburg		0.971	1.007	1.001	0.969	0.977
32	Dammam		1.029	1.054	1.029	1.001	1.085
33	Jeddah		1.028	1.06	1.056	0.974	1.09
34	Gwangyang		0.967	1.017	0.992	0.975	0.984
35	Barcelona		1.01	1.015	1.017	0.994	1.025
36	Bilbao		0.988	1.015	0.991	0.998	1.004
37	Gothenburg		1.008	1.02	1.001	1.007	1.028
38	Taichung		0.946	1.019	0.959	0.987	0.964
39	Bangkok		0.971	1.001	0.973	0.999	0.973
40	Ambarli		0.996	1.016	1	0.996	1.011
41	Felixtowe		0.979	1.057	1	0.979	1.034
42	Charleston		0.947	1.038	0.951	0.996	0.983
43	New York		0.975	1.039	0.977	0.998	1.012

44	Oakland		0.958	1.028	0.968	0.99	0.985
45	Savannah		0.98	1.046	1.005	0.976	1.025
46	Seattle		0.989	1.049	0.997	0.992	1.038
47	Tacoma		0.896	1.065	0.913	0.981	0.954
48	Norfolk Virginia		0.974	1.034	0.982	0.992	1.008
49	Ho Chi Minh City		1.015	1.03	1.029	0.986	1.046
50	St. John	CARI.	1.019	1.013	1	1.019	1.032
51	FCP		1.012	1.031	1.012	1	1.043
52	Bridgetown		0.942	1.021	0.894	1.053	0.962
53	Rio Haina		0.949	1.02	0.964	0.984	0.968
54	Caucedo		1.109	1.061	1.088	1.02	1.177
55	Pointe-Pitre		0.973	1.039	0.965	1.008	1.012
56	KCT		0.934	1.045	0.952	0.981	0.976
57	KW		1.094	1.031	1.099	0.996	1.128
58	Willemstad		1.049	1.015	1.045	1.004	1.065
59	Castries		0.999	1.015	0.818	1.222	1.014
60	Vieux Fort		1.057	1.001	1	1.057	1.057
61	PL		1.013	1.017	0.977	1.036	1.03
62	POS		0.959	1.021	0.941	1.019	0.979
63	Barranquilla	NCARI	0.884	1.02	0.827	1.069	0.902
64	Puerto Cortes		1.029	1.025	1.016	1.013	1.055
65	Manzanillo		1.013	1.021	1.01	1.003	1.034
66	Papeete	OSIDS	0.972	1.007	0.947	1.026	0.978
67	Apra		1.036	1.003	1.046	0.991	1.039
68	Port Louis		1.098	1.012	1.103	0.995	1.111
69	Noumea		0.969	1.021	0.959	1.01	0.989
Mean			**0.997**	**1.025**	**0.992**	**1.006**	**1.022**
Median			**0.999**	**1.020**	**1.000**	**1.000**	**1.025**

What the breaking down to port efficiency level shows is that the overall mean values can mask some strong gains in port productivity/efficiency. Within the comparator groups, the improvements in productivity made at Zeebrugge, Dammam and Buenos Aires of the TOP group tend to stand out, with the effects of pure efficiency and technical change driving mainly this, whilst the rest of the ports generally fall in the range of plus/minus two to three percent. This will broadly reflect the maturity of this subset, as all of these ports are well established and have been operating over a very long period. Within the CARI group, both Caucedo and KW stand out (17.7% and 12.8% TFPCH respectfully), however this is almost certainly due to what could be called the 'OSIDS effect' highlighted earlier. In other words, both ports are relatively small and the rise in traffic over the period reviewed has led to better utilisation of the inputs, hence large increases in productivity.

6.4 HYPOTHESIS TESTING

This section serves to test the hypotheses derived in Chapter 4, by using the efficiency and productivity results obtained in this chapter. By doing so, the relevant performance justifications and theoretical underpinning of the operation of the ports and its performances are analysed.

Efficiency:

Hypothesis 1: *Under the Constant Returns to Scale (CRS) measure, there has been no change in general port efficiency over the last decade.*

This hypothesis is tested by tracking the year on year average efficiencies for every port in the sample, using the DEA- Malmquist efficiencies (reported in Appendix 10 and summarised in Figure 6.5). Each ports' year 1 versus year 11 average efficiency scores, are tested, using the non-parametric Mann-Whitney U test.

This is tested given the following null hypothesis, which states that there has been no change in port efficiency versus the alternative hypotheses that there has been a general change. This is depicted as:

$$H_o = PEccr_1 = PEccr_{11}$$

$$H_1 = PEccr_1 \neq PEccr_{11}$$

At the conventional critical value of 5%, the Mann-Whitney test indicates that the average port efficiency, for the sampled ports under the period in review was not significantly different from the average port efficiency in year 11, but only a negligible difference, having yielded a p-value (probability value) of 0.359 (35.9%). Thus, the null hypothesis is not rejected, suggesting that there has been no change in general port efficiency over the last decade under the CRS measure, is upheld.

Hypothesis 2: *Given the effects of scale, under Variable Returns to Scale (VRS) measures there has been a general improvement in port efficiency over the last decade.*

Under VRS assumptions, a change in inputs result in a greater than proportionate increase in output. This hypothesis is tested by tracking the year on year average efficiencies for every port in the sample, using the DEA- Malmquist efficiencies (as reported in Appendix 10). Each ports' year 1 versus year 11 average efficiency scores, are tested and validated, using again the non-parametric Mann-Whitney U test.

The alternative hypothesis claims that there has been an improvement in port efficiency, against the null hypothesis, which is hoped to disprove, that, port efficiency has deteriorated, or has at most remained the same over the last decade. This is represented by:

$$H_0 = PE_{BCC1} \geq PE_{BCC11}$$

$$H_1 = PE_{BCC1} < PE_{BCC11}$$

At the conventional critical value of 5%, and 20.7% p-value according to the one-tailed Mann-Whitney U test, the null hypothesis cannot not be rejected. This therefore suggests that average port efficiency for the sampled ports under the period in review, has in fact declined, and claims that there has been an improvement in average port efficiency over the last decade from 2001-2011 is rejected.

Hypothesis 3: *Caribbean ports are less efficient than TOP ports, but more efficient than Other Small Island Developing States (OSIDS) ports.*

To test this hypothesis, the year on year average efficiencies for each sub-group in the sample (TOP, CARI, and OSIDS; NCARI is not tested due to its small sample size) is derived, and shown in the DEA- Malmquist efficiencies (as reported in Appendix 11). The hypothesis is tested given each groups year 1 versus year 11 average efficiency scores. This is conducted using again the non-parametric Mann-Whitney U test.

These two hypotheses are to be proven in both scenarios respectively, and the alternative hypotheses are to be proven. These are written as:

Scenario 1:

$H_0 = PE_{CARI} \geq PE_{TOP}$

$H_1 = PE_{CARI} < PE_{TOP}$

Scenario 2:

$H_0 = PE_{CARI} \leq PE_{OSIDS}$

$H_1 = PE_{CARI} > PE_{OSIDS}$

Here, the conventional critical value of 5% is used, given a one-tailed Mann- Whitney U test. In scenario 1, results of the Mann-Whitney U test confirms a p- value equal to 1%, which is less than the 5% significance level. The null hypothesis is therefore rejected in favour of the alternative, and average efficiencies over the past decade for CARI ports have been less than that of TOP ports.

For scenario 2, testing the hypothesis, the results of the Mann-Whitney U test confirms a p-value of 21%, which is greater than the 5% significance level. The null hypothesis therefore cannot be rejected, which concludes that CARI ports have not been more efficient or is as equally efficient as OSIDS ports. In some respects this is a surprising result, since according to the DEA results, given that on pure values, the difference in the mean efficiencies is almost the same as the gap between TOP and CARI i.e. (CARI 44.06% v OSIDS 29.27%) as opposed to (CARI 44.06% v TOP 60.16%) (see Table 6.7, page 145). It may well be therefore that this result is as a consequence of the small number of ports in the OSIDS sector, and that perhaps if there was data available on more ports in this subset, this too would be a significant result. As stated however, the hypothesis is unproven.

Productivity:

Hypothesis 4: *The Total Factor Productivity (TFP) in the port sector has been positive over the last decade, and most of this have been driven by technical progress (TC) and not efficiency change (EC).*

In many respects this aspect has already been covered in the preceding analyses, hence all that is sought here is to formally confirm this through statistical testing. Firstly the Wilcoxon test is used to test the first part of the hypothesis, which claims that TFP has been positive over the last decade for the entire sample. This is represented by:

$$H_0 = TFP = 0$$

$$H_1 = TFP > 0$$

The test is conducted on TFP greater than 0, representing a positive change in productivity, or equal to 0 depicting a fall or constant change in productivity per annum. According to the Wilcoxon test, at a 0% p-value, the null hypothesis is rejected at the 5% significance level. Considering the entire sample, the test confirms that TFP has in fact improved over the period under review. The null hypothesis is therefore rejected in favour of the alternative.

This progress is therefore attributable mainly to technical progress and not efficiency change. The hypotheses are therefore written as:

$$H_0 = TC = EC$$

$$H_1 = TC > EC$$

Where the alternative hypothesis tests TC being greater than EC, and the null hypothesis otherwise, or TC equal to EC. This is tested by means of the Mann-Whitney test, having derived a 0% p-value. The null hypothesis is too rejected in favour of the alternative hypothesis, which states that TC has improved quicker than EC over the entire period.

Results from the tests approve that total factor productivity in the port sector has in fact been positive over the last decade, and this has been mainly driven by technical progress (TC).

Hypothesis 5: *Over the whole period, Caribbean ports have experienced higher TFP changes than TOP ports, and most of this is because of efficiency change (EC) rather than technical progress (TC) progress.*

To confirm this hypothesis, the Mann- Whitney test is introduced which tests the following:

$$H_0 = EC_{CARI} = TC_{CARI}$$

$$H_1 = EC_{CARI} > TC_{CARI}$$

Where the alternative to be tested asserts that productivity is a result of efficiency change rather than technical progress. At a p-value of 8.3%, the null hypothesis cannot be rejected at the 5% significance level. Considering the Caribbean's sample, the Mann- Whitney test confirms that productivity is in fact driven by technical progress (see Table 6.12, page 159).

Hypothesis 6: *Over the whole period, Caribbean ports have experienced higher scale efficiencies in comparison to TOP ports.*

For this hypothesis, the average scale efficiencies over the entire period for CARI and TOP ports are used. Again, the Mann- Whitney test is employed to test the null and alternative hypothesis:

$$H_0 = SECH_{CARI} = SECH_{TOP}$$

$$H_1 = SECH_{CARI} > SECH_{TOP}$$

Where the alternative asserts that scale effects have had a greater positive impact in the Caribbean, than for TOP ports. According to the results of the Mann Whitney test, derives a 0.5% p-value, at the 5% conventional level, the null hypothesis has to be rejected. In favour of the alternative, the hypothesis holds that scale efficiency gains in the Caribbean have been greater than for TOP ports.

6.5 CONCLUSION

This chapter presents summary statistics and then test results of this analysis. Background information on container port traffic and its trend over the years, are first discussed and the trends over time, and market-shares, for each sub-group, particularly with reference to the Caribbean are also outlined. Interestingly the effects of the crisis, pre and post are singled out to determine just how the impact may have been on the region's container traffic.

Next, summary statistics are furthermore reported, per sub-group, which also allows for identification of differences/similarities and so on. Thereafter, technical efficiency tests applying both CCR and BCC models are conducted and thereafter results analysed; moreover, the Malmquist productivity tests are then conducted and analysed. All results retrieved using the Data Envelopment Analysis Program (DEAP) software and directed toward answering the research hypotheses.

The next chapter reflects on these findings in the context of Caribbean port development over the past decade, and attempts to further understand how the development initiatives, may/not have contributed toward influencing efficiency/productivity, in accordance with results retrieved in this current chapter.

CHAPTER SEVEN

DISCUSSION OF RESULTS AND REFLECTION ON PORT DEVELOPMENT IN THE CARIBBEAN

7.1 INTRODUCTION

This chapter firstly reviews the results of this research and validates the hypotheses in section 7.2. Moreover, the implications for these are presented in section 7.3. Thereafter an assessment of port development to an observation of more recent port development initiates undertaken, ongoing and proposed for Caribbean, are mentioned in section 7.4. This enables a reflection on whether these initiatives are in line with the thesis findings and a consideration of what other factors have influenced these decisions, thus ultimately allowing a discussion of the value of academic research to port policy. Subsequently, this leads onto section 7.5, where policy implications for the proposed recommendations (past, present and future) are presented, leading to future research direction, provided in the following chapter.

7.2 VALIDATING RESEARCH HYPOTHESES

Chapter 2 looked at the current set up of Caribbean ports; their challenges faced, and proposed responses to improving these. The primary research question was derived: **"How has the technical efficiency and productivity of Small Island Developing States ports progressed over the last decade, due to port development opportunities?"** and in order to answer it, six research hypotheses were proposed. The results of the analysis were derived in Chapter 4, which are summarised briefly here before moving on to the discussion.

Efficiency:

Hypothesis 1: *Under Constant Returns to Scale (CRS) measures, there has been no change in general port efficiency over the last decade.*

According to economic theory, under the CRS assumption, every DMU (or port) is assumed to assumed to perform at an optimal scale level, where an increase in inputs result in a proportionate increase in the output levels. In the long run, it is expected that DMUs move toward CRS by adjusting its size. This may involve changes to the ports' operating strategies, by scaling up or down of size, so that it achieves optimal scale over time. According to the test result for this hypothesis, during the period covered by the sample, diminutive to no change can be seen, as average efficiencies changed from 54.4% in 2001 to 54% in 2011. According to the Mann- Whitney test of 35.9% p-value at the conventional 5% level, and the DEA result, economic theory is therefore upheld and confirmation approved, that there has been no change in general port efficiency, over the last decade, under the CRS assumption.

Hypothesis 2: *Given the effects of Variable Returns to Scale (VRS) measures, there has been a general improvement in port efficiency over the last decade.*
As seen in Chapter 4, under the VRS assumption, a change in inputs result in a greater proportionate increase in output. As discussed in section 3.3, containerisation has become a rising trend within the maritime industry, and has necessitated the need for adequate port facilities, that position the port for success in this newly logistics orientated environment (Notteboom, 2007).

Increasingly employment of capital investments in the form of physical and human assets are largely associated with an expansion/improvement of port facilities. This is because as international trade increases, larger ship sizes are built, to accommodate more throughput in hope of reaping economies of scale. With this rise in throughput, ports are purchasing more equipment, likely to employ more port staff, and expanding their terminal area.

Today, many ports have dramatically improved their operations taking on board these trends within the industry. This has resulted in large capital investments and port expansions, which have affected productivity and efficiency. However, while this is so, one cannot deny the effects of the financial crisis, which would have impacted adversely international trade, and so container traffic. It is for these reasons that, while overall worldwide trend, it is with expectation port efficiency should improve with the effects of scale adjustments, the international crisis would have an abating impact upon efficiencies as resources would be underutilised.

The findings of this hypothesis reveal that according to the DEA results, efficiency did in fact decline from 70.6% in year 1 to 67% in year 11. This is too consistent with the Mann- Whitney test, which proved that the hypothesis cannot be accepted, and claims that there has been an improvement in port efficiency over the last decade is rejected, as efficiency declined by approximately 4%.

Furthermore, the findings of this hypothesis prove that as average annual scale adjustments have been made over the last decade (*sech*=+0.6%), managerial adjustments have not managed to keep abreast of this progress (*pech*= -0.8%) (see Table 6.12) resulting in an overall fall in efficiency. This implies that progresses to average annual efficiency has not been influenced by optimal managerial practises, but rather the effects of scale adjustments.

Why this is found to be the case is almost certainly due to the impact of the financial crisis in 2008, in which it has already been highlighted that any scale efficiency gains achieved in the earlier part of the period were eradicated because of the decline in container traffic during and post crisis periods.

This finding is also consistent with the work of Wang et. al. (2005) who investigated the average technical efficiencies of forty top container ports dispersed throughout the world. Findings show that the waning in efficiency has even extended to over 20 years, as it declined by 5%, falling from 87% in 1992 to 82% in 1999.

Hypothesis 3: *Caribbean ports are less efficient than TOP ports, but more efficient than Other Small Island Developing States (OSIDS) ports.*

TOP ports, just as its name implies, are considered more efficient than their CARI counterparts. This is so, as these ports, have had greater access to resources and potential port investors over the years. It is likely that a faster rate of technical change for TOP ports will increase the efficiency gap between themselves and CARI ports, as they are likely to improve their efficiencies quicker. TOP ports are also benchmarks to which other ports compare themselves to, as seen over the years in academic researches.

It is therefore with expectation that Caribbean ports are likely to be less efficient than TOP ports, which according to the Mann- Whitney test results, claims that CARI ports are less efficient than TOP ports cannot be rejected. This result is too consistent with the DEA findings of the group's average port efficiencies under the period in review, with a 60% average for TOP ports, and CARI 44%.

On the other hand, the hypothesis that Caribbean ports are more efficient than OSIDS ports cannot be accepted according to the Mann-Whitney test. This test result is however inconsistent with the DEA findings of the group's average port efficiencies under the period in review. According to DEA results, CARIs port efficiency was 44% whereas OSIDS received an average score of 29%, meaning the former has been more efficient than its OSIDS counterparts have over the ten-year period (2001-2011). Therefore, while the DEA and significance tests show differing conclusions, one plausible explanation for this disagreement could be the smallness of the OSIDS sample size in this instance. For this reason the claim that Caribbean ports are more efficient than OSIDS ports, is unproven.

***Productivity**:*

Hypothesis 4: *Total Factor Productivity (TFP) in the port sector has been positive over the last decade, and most of this have been driven by technical progress (TC) and not efficiency change (EC).*

As shown in Chapter 3, ship sizes have increased, in hope of reaping economies of scale, to meet rising international trade demands. This has led to increasingly employment of capital and human investments, which is largely associated with expansion/improvement of terminal/port facilities. Today, ports have dramatically improved their operations taking on board these developments. This has resulted in productivity improvements.

Moreover, as seen in Chapter 4, production is the process of transforming inputs into outputs. The ratio/relationship through which inputs are converted into output/s, are referred to productivity. Total productivity or total factor productivity (TFP) as this hypothesis will test, gives an overall sense of how a DMU/s may be performing, incorporating inputs wholly to produce an output.

Changes to TFP is attributed to two components- technical efficiency (*catch up effect*) and technological progress *(frontier shift effect)*.

Technical progress is the result of a DMU/s keeping abreast with, and adaptive to innovative technologies in its production processes. This suggests, employing longer term strategic planning, engaging in huge capital investments that eventually access larger markets. These may consist of and port facilities provided for full cellular container ships, electronic data interchange, Super post- panama ships and so on.

Given this background, it is with expectation that port productivity has improved over the last decade, and this driven primarily by technical progress. Moreover, this illustrates that the rate of *catch up* has not been as fast as the *frontier shift effect.* In other words, the progresses in managerial practises and adequate training to accommodate new practises, have not adapted as quickly to the implementation of advances in technological developments. Bearing in mind that this is also consistent with Hypothesis 1, which stated that there has been no efficiency change over the long run period, under the CRS assumption.

As reported, results are derived by the DEA- Malmquist test, also known as the total factor productivity change (TFPCH) measurement. According to this, there has been an improvement in productivity, with an average of 2.2% per annum, over the ten- year period. Furthermore, the main contributor to this change has been the result of 2.4% per annum improvements in technical progress, contrasting the annual rate technical efficiency, which has remained more or less constant (0.997), over the same period. Bearing in mind that this is consistent with Hypothesis 1, which stated that there has been no efficiency change under the CRS assumption. The hypothesis is further validated applying the Wilcoxon and Mann-Whitney tests, which confirms that in fact total factor productivity has been positive over the last decade, and TC drove this.

Hypothesis 5: *Over the whole period, Caribbean ports have experienced higher TFP changes than TOP ports, and most of this is because of efficiency change (EC) rather than technical progress (TC).*

Since Caribbean ports are usually characterised for their smaller scaled operations and lesser throughput (compared to TOP ports), when they begin to grow, they focus on enlarging their production scales. This however is achieved at the expense of attaining optimal production as evident in pure efficiency which declined by 1.4%. Overall, it leads to higher total productivity, brought about by increasing investment opportunities, as they operate at the size of increasing returns to scale (*tfpch*=3.2%). This effect of scale adjustments highly impacting efficiency change is also consistent with the findings of Wilmsmeier et al.. (2013) and Suarez-Aleman et al.. (2016).

On the contrary, TOP ports efficiencies however declined by 0.5%, due to negative growths in both pure and scale efficiencies. This is the probable instance, since TOP ports which are usually larger scale ports and so yield more throughput (compared to smaller ports), will likely be operating at the size of decreasing returns to scale, which means that they are not properly focusing on internal practices and sizing there production scales to improve efficiency (Cheon, 2008).

Over the decade, ports have continued to engage in massive investment projects, whereby the adoption of new technologies and accommodation of larger sized vessels, have significantly influenced port productivity. Looking at the world's TOP ports and its progresses over the past decade, in actuality the productivities of Caribbean ports have grown at a faster rate (3.2% p.a.), than their significant TOP counterparts (2 % p.a.). On the other hand, the main contributor to the Caribbean's growth has been the outcome of technical progress (2.5% p.a.) and not efficiency change (0.7% p.a.) according to the DEA-Malmquist results. Considering the Caribbean's sample, the Mann- Whitney test confirms that productivity has in fact been driven by technical progress. The claim that the Caribbean's TFP changes are driven by EC rather than TC is therefore rejected. While this is so, note mentioning is that the effects of scale (2.9% which is a decomposition of efficiency change), have outweighed technical progress (2.5%).

Hypothesis 6: *Over the whole period, Caribbean ports have experienced higher scale efficiencies in comparison to TOP ports.*

Comparing to the world's TOP ports, the Caribbean's gain in efficiencies have grown at a faster rate than their larger counterparts. This however is the result of scale effects. As previously mentioned, and depicted in Table 6.5, port development has occurred over the analysed decade, throughout the region. This has taken the form of expansions, among others. Additionally, berth lengths (39%), terminal areas (43%) and equipment (66%) have increased to accommodate the rise in container throughput. With this being so, a 2.9% per annum gains through scale effects have been the result.

This shows that the region's port strategy and initiatives have played a key role in influencing port performance over the past decade. Many ports have progressed over the years via port upgrades, thereby affecting its scale efficiencies positively.

Moreover, since Caribbean ports are usually characterised for their smaller scaled operations and lesser throughput (compared to TOP ports), are more likely to be operating at the size of increasing returns to scale, since focus is on enlarging their production scales. This is brought about by increasing investment opportunities, and is also consistent with the findings of Wilmsmeier et al.. (2013) and Suarez-Aleman et al.. (2016).

Having further validated the hypothesis according to the Mann-Whitney test, the claim holds that scale efficiency gains in the Caribbean (2.9%) have in fact been greater than TOP ports (-0.2%).

As this research has acknowledged the practical contribution for Caribbean, the following section attempts to investigate the past, current and proposed port development initiatives, by international organizations concerning the region. An observation of the initiatives, present better understanding into the DEA results, but also assists in foreseeing proposals for more scholarly informed recommendations thereafter.

7.3 IMPLICATION OF RESULTS

This overall analysis and validating the research hypotheses based on mainly the Caribbean, have revealed a wealth of evidences about port development and performance- productivity and efficiency over the past decade.

Referring back to the research question of this thesis, ***"How has the technical efficiency and productivity of Small Island Developing States ports progressed over the last decade, due to port development opportunities?"*** One can conclude that due to port development opportunities over the years, port efficiency and productivity have progressed for the Caribbean's Small Island Developing States, over the last decade.

The Caribbean has experienced efficiency and productivity gains from two main sources: adjustment of production scales (scale efficiency) and technical progress. This effect of scale adjustments highly impacting total productivity is also consistent with the findings of Wilmsmeier et al.. (2013b) and Suarez-Aleman et al.. (2016). Most significantly, scale effects have contributed toward productivity gains, more so than the technical progress.

Comparing to the world's top ports, in actuality the Caribbean's efficiency and productivity gains have grown at a faster rate than their greater counterparts. This however is the result of scale effects, as smaller ports are more likely to be operating at the size of increasing returns to scale, and focusing on enlarging their production scales thereby impacting productivity.

The results of this analysis reveal that the region's port strategy and initiatives have played a key role in influencing port performances over the past decade. Many ports have progressed over the years via port upgrades, thereby affecting scale efficiencies positively. Yet, results reveal that managerial efficiency has not managed to improve as quickly.

These findings imply that directing investment resources whereby managerial/operational practices which bring about optimal production (therefore impacting pure efficiency), must take priority. With this at the forefront, the impact of this, facilitate keeping abreast with scale and technical progresses. These can include, but are not limited to, managerial and operational practices such as labour restructuring and reforms, optimization of terminals, movement from part to full utilization of terminals, introduction of 24/7 working (dock & gate practice), and dock labour reforms to name a few. These are discussed in more detail in the concluding chapter.

The research (based on 2001-2011 data) has concluded that Caribbean should not focus on major infrastructure investments, yet many of these ports have indeed made port upgrades in recent years. Therefore, the following section investigates current and proposed port development initiatives within the region. This will assist in better understanding what the development initiatives are currently and have been, to what degree they are in line with the research findings and what this means for future port policy.

7.4 PORT DEVELOPMENT INITIATIVES IN THE CARIBBEAN

7.4.1 Recent Port Development Initiatives

While port development via investments and expansions have been the occurrence over the past decade, one may argue whether this has been the best possible means of improving port performance, reflected in productivity gains. Or, could development come about because of pressures from the industry, or continuous technological developments in the maritime industry acting as a stimulus to promote port development. Whatever the reason may be, this research seeks to determine whether the Caribbean's port development initiatives over the years, have impacted positively or not the productivity gains of these ports.

One of the aims of the Inter-American Development Bank (IADB) has been to provide trade related assistance to Latin America and the Caribbean (LAC) countries. The "Aid for Trade" fund initiative has been a means through which assistance is given. The "Aid for Trade" fund initiative is a multi-donor fund, which consists of worldwide private and public sector groups. Assistance is provided in the form of grants and/or technical assistance, with the objective of ports gaining increased market access and being better integrated into the global economy.

Over the years, the IADB has provided trade related assistance to the Caribbean region. Table 7.1 shows a rise in the actual disbursements for the improvement of port infrastructure and operations, among others. From 2002 to 2009 disbursements surged by 330%, from 98.1 million USD to 422.4 million USD. Of these countries, the top four - Suriname (961%), Guyana (785%), Haiti (741%), and Jamaica (263%), recorded the largest increases in disbursements respectively. These countries are amongst the largest within the region in terms of their population and area, which may account for its larger degree of investments. On the other hand, smaller countries such as Antigua and Barbuda (67%), Grenada (62%) and Montserrat (45%), showed a decline in disbursements.

Table 7.1 Aid for Trade to CARICOM, USD millions (2009 constant)
Building productive capacity & Economic Infrastructure

Country	**2002–2005 avg.**	**2006**	**2007**	**2008**	**2009**
Antigua and Barbuda	5.4	2.3	0.2	0.5	1.8
Barbados	1.4	N/A	N/A	0.1	8.4
Belize	1.3	3.4	4.8	10.6	9.6
Dominica	10.6	6.6	10.7	11.3	22.7
Grenada	6	0.8	0.7	1.9	2.3
Guyana	6.8	3.4	9.3	35	60.2
Haiti	19.5	35	60.1	78.7	164
Jamaica	18.4	23	40	73.2	66.8
Montserrat	6.6	7.5	1.4	4.2	3.6
St. Kitts-Nevis	2.2	5.2	0.8	0.4	2.3
St. Lucia	8	3.8	6.4	12.7	18.1
St. Vincent & Grenadines	4.4	3.1	9.9	17.6	12.1
Suriname	4.6	4.8	28.5	39.3	48.8
Trinidad and Tobago	2.9	2.3	3.7	0.4	1.7
Grand Total	**98.1**	**101.2**	**176.5**	**285.9**	**422.4**

Source: (CARICOM, 2013)

The region continues to improve the operations of its ports in order to accommodate more traffic, especially in the light of Panama's canal expansion completed in 2016. Major development initiatives recently completed, ongoing and proposed are outlined in a recent Caribbean Development Bank report (CDB, 2016). These span from expansions of berths, further dredging, new and updated equipment, terminal/port specialization and expansion, the set-up of logistics zones/industrial areas, and new ports/terminals (see Table 7.2).

Table 7.2 Main Developments for Caribbean Ports and Enhancing Efficiency

• **St. John's, Antigua & Barbuda:** Renegotiation with labour union to reduce workforce and modernize working conditions in order to reduce overall labour costs and enhance reliability of service. Removal of sheds, rehabilitation quays and separation of stevedoring services and truck handling to allow for more efficient handling of containers. Acquisition of new mobile cranes. Implementation of terminal operating system and integration with customs to reduce the manual labour required, accelerate the procedures for port users and obtain information about port operations. Estimated cost \$10M USD, project duration: 2016-2020.
• **Freeport (FCP), Bahamas:** Freeport Container Port is planning to expand its current port. The expansion works include excavation works to create an additional 1,125m of quay. Additionally, an extra berth of 558m can be created. All the expansion works would create an additional 2M TEU capacity. The FCP handles solely transhipment containers. The expansion is based on the expectation that the demand for transhipment will increase due to the widening of the Panama Canal.
• **Bridgetown, Barbados:** Renegotiation of working conditions with labour unions is already in progress. Modernization of gang sizes and working times are required to reduce labour costs. BPI is to co-develop a new cruise berth to allow additional berthing space for cargo vessels during cruise season. Further, it is recommended that the removal of sheds and lengthening of quay. Estimated cost \$320M USD, project duration: 2016-2020.
• **Limón, Costa Rica:** In 2008, JAPDEVA (the regional port authority) presented a new port master plan. The master plan highlighted JAPDEVA's vision for terminalisation of activities, i.e., by creating a new dedicated container terminal in Moín to alleviate the efficiency and accessibility issues and to create a dedicated cruise port in Limon to further develop the regional economy. The terminal will be developed in a phased approach, with phase 1 to be completed in 2017 with 1.3M TEU capacity.
• **Port Mariel, Cuba:** With the aid of Brazilian financing, Cuba is developing a deep-water port in Mariel. The \$900 M dollar investment entails the creation of a Special Development Zone spanning over a 465-square-kilometer area, a container terminal, and industrial areas. The port should be able to handle about 850,000 TEU per annum, triple the capacity of the container port in Havana. The port will be able to handle the New Panamax vessels. The port is already open for operations, but subsequent phases are still to be executed.
• **Roseau, Dominica:** The cargo pier requires rehabilitation as it is quite old. Further, removal of cargo sheds would create additional storage area on the terminal. Estimated cost N/A, project duration: Long term
• **DP World Caucedo, Dominican Republic:** DP World Caucedo is about to expand its current container terminal with additional quay length and a substantial logistic zone (40ha in the first phase plus option on 80ha). The first part of the logistics center has begun operations in 2014 under free zone status for logistics activities.

• **Port Lafito, Haiti:** Port Lafito S.A. is developing a multi-purpose port and terminal in Lafiteau area in Haiti with an estimated initial design throughput capacity of just over 70,000 TEU and capable of handling Panamax vessels. The officials from Port Lafito have presented their plans to become a transhipment hub hoping to handle Post Panamax ships. Operations started in June 2015 with the first 450m of quay. The second 450m is planned to be operational mid-2016.

• **Goat Island, Jamaica:** China Harbour Engineering Company (CHEC) has reportedly signed a framework agreement for a US$1.5 billion transhipment port at Goat Island. The port development is part of a larger development project that would create a logistic zone. The port would be developed to accommodate Super Post Panamax vessels.

• **Kingston Freeport Container Terminal, Kingston Jamaica:** The privatization of the Kingston Container Terminal has been completed in 2016, and resulted in a 30-year concession to Terminal Link (part of CMA-CGM). Under the agreement, about $260M USD should be invested in completing dredging works to 14.2m and new equipment to increase the total capacity to 3.2M TEU.

• **St. Georges, Grenada:** Renegotiation of working conditions to reduce the costs of labour and improve operational efficiency. Removal of the large cargo shed on the quay would free up space and allow for more efficient container handling operations; additionally, some of the pavement requires rehabilitation. A more advanced and integrated IT system would reduce manual labour (thereby reducing labour costs) and enable more efficient operations. Estimated cost: $30M USD, project duration: 2016-2018.

• **Port of Pointe-à-Pitre, Guadeloupe:** In Guadeloupe's proposal to support economic development, it has embarked on a port expansion project over the period 2014 to 2020, for the dredging and building of additional docks with a 350 metre mooring quay to cater for larger ships. It will also improve its existing terminal, allowing creation of new facilities and transhipment traffic. The estimated cost of this is project is 30mEUR, primarily contributed by the EUs Regional Development Fund.

• **Basseterre, St. Kitts:** St. Kitts requires restructuring of the cargo pier, implying the demolition of the warehouse on the quay. This would allow for more efficient handling of the containers, eliminating unnecessary moves. Implementation of an IT system to limit the amount of administrative labour and to reduce the administrative burden for port users. Estimated cost $50M USD, project duration: Long term.

• **Castries, St. Lucia:** SLASPA has agreed to an extension of the port's existing berths, as well as additional works for the three mooring dolphins. Construction work started in January 2017 and is expected to be completed to the end of 2017.

• **Kingstown, St. Vincent:** Terminal design should be optimized, in accordance with best practices. Additionally, the port entrance road should be improved, in order to reduce congestion. In order to ensure continued operations, the Port of Kingstown requires additional equipment, as the current backup is in a dilapidated state, resulting in downtime. An integrated IT system would reduce manual labour (thereby reducing labour costs) and enable more efficient operations. Estimated cost $125M USD, project duration: 2016-2020.

• **Point Lisas, Trinidad:** Point Lisas aims to improve its port by upgrading systems, human resources, equipment and roads. This is the result of an estimated 150mUSD cost over a 10 year expansion plan. This first phase involves an initiative for 2016-2017 and include- infrastructure: rehabilitation of berths, container storage area, and reefer racks; technology- implementation of TOS, more reliable/safer data transmission systems;

equipment- additional handling equipment (terminal trucks, reach stackers), formalised arrangements for better service providers for equipment rehabilitation and on-going maintenance; systems- revised HR policies and performance management, better training of staff and terminal workers to develop vocational qualifications and certifications; new services- express processing service facilities for importers, priority warehousing facilities, un-stuffing, and temporary storage.

• **Port of Spain, Trinidad & Tobago:** Negotiations with the labour unions is required to modernize the working conditions in order to reduce labour costs of the organization. New gantry cranes are to reduce the downtime of the equipment and to ensure continued operations to shipping lines. The port authority should establish a separate entity for the Terminal Operator PPOS in order to obtain a clear separation of tasks and responsibilities and to enable private sector involvement in the future. Estimated cost $60M USD, project duration: 2016-2018.

Source: (CDB, 2016)

For instance, KCT, Jamaica has plans to complete dredging works in order to accommodate larger vessels, and also to invest in new equipment. While this so, results for KCT, shows that as port developments have occurred over the past years (see Table 7.1), yet results show, there has resulted in adverse impacts upon scale (-4.8%) and pure (-2%) efficiencies . Bearing this in mind, most recent development plans, such as that stated by the CDB, 2016 report, reveal that this may in fact result in a worsening of its efficiencies (already having declined by 6.6% p.a.) (see Table 6.14).

On the other hand, FCP, Bahamas for instance, has plans to expand its current port and also create additional berths. With this strategy, its scale efficiency is likely to be impacted, but, even more so, its annual's average 1.2% (see Table 6.14) positive change in managerial efficiencies over the past decade, is likely to be adversely impacted. This is so, as development initiatives are focused toward impacting scale efficiency solely, at the expense of adjusting managerial expertise also in order to accommodate for this change.

Furthermore, Port of Pointe-à-Pitre in Guadeloupe has embarked upon expansion initiatives, with hopes of supporting the country's economic development. These include dredging and building an additional docks with a 350 metre mooring quay to cater for larger ships, and improving on existing terminal by allowing creation of new facilities. With hopes of reaping the benefits of this project, the effects are likely to impact on scale efficiency, but, since no policy recommendations are mentioned about managerial expertise or internal practises, then the already average -3.5% (see Table 6.14) decline in pure efficiency, is likely to worsen.

The same can be said for Castries port of St. Lucia. It has agreed to a recent extension of the port's existing berths, which construction work started in January 2017 and is expected to be completed to the end of 2017. Given the port's massive scale efficiencies incurring an average of up to 22% per annum, inadequately accommodating for impacts upon internal operations, have resulted in 18% average per annum declines in its pure efficiencies. Once again as the port continues to engage in port expansion projects without considering the impact upon internal operations, can furthermore inhibit managerial efficiencies (see Table 6.14).

Moreover, Point Lisas port of Trinidad and Tobago, aims to improve its port by upgrading its systems, human resources, equipment and roads. While this is projected to cost up to 150M USD over a 10 year expansion plan, its first phase involves rehabilitation of existing facilities, upgrading of IT systems, additional handling equipment, revised HR policies and performance management, training of staff and terminal workers to develop vocational qualifications and certifications; and other new services such as priority warehousing facilities, un-stuffing, and temporary storage.

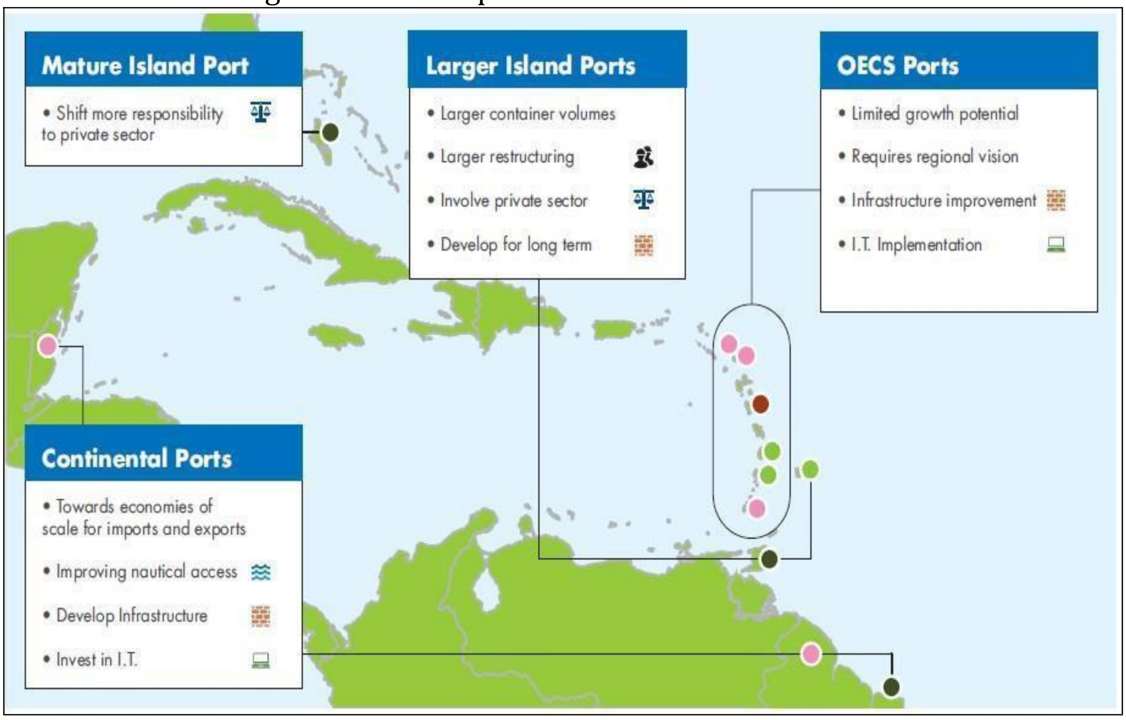
For this port, incorporating initiatives that influence scale but also managerial efficiencies is key in affecting the port's overall efficiency moving forward. For instance, Point Lisas' pure efficiencies have fallen by 2.3% on average p.a. (see Table 6.14), therefore implementing initiatives which do not attempt to improve internal operations whilst engaging in port expansionary projects, will likely impede progresses to pure efficiency. For Point Lisas, this has not been the case, as the port has incorporated initiatives of port expansions, together with improving its human capital and systems upgrades.

Similarly, some other investment initiatives have incorporated improvements to internal operations, together with rehabilitation of dilapidated facilities where necessary, instead of solely port expansions. For example, declining pure efficiencies at the Port of Spain (of up to 6% p.a.), and Bridgetown (10.6% p.a.) may likely adjust favourably given improvements to working conditions, modernization of working practices and IT systems upgrading, as recommended.

Moreover, for some ports, the issue of rehabilitation is necessary, given dilapidated facilities and equipment which will impact performance. For ports such as St. John's, Kingstown, Bridgetown, and Basseterre, this is pertinent.

Furthermore, with Table 7.2 displaying some of the current and near future developments of Caribbean ports, Figure 7.1 shows key longer-term development visions. Based on the ports current operations and bottlenecks to facilitating international trade, development visions are conveyed for CARI ports. Most OECS ports require infrastructural improvements to their existing infrastructures and superstructures that may be outdated. Furthermore, IT implementation may be lacking, and so hinders the progress of a quicker and more efficient flow of information across stakeholders. Of this, the key underlying determinant requiring attention includes infrastructural development, which is mainly amongst OECS ports and the larger island ports such as the Port of Spain, and Bridgetown.

Figure 7.1 Development Vision of Caribbean Ports



Source: (CDB, 2016)

Larger island ports such as Bridgetown, Barbados and Port of Spain, Trinidad attract considerable volumes of traffic. The long-term vision however is to attract more traffic, which will be achieved through port reform measures attracting more of the private sector; this also means port expansions of existing facilities.

Moreover, according to the Caribbean Development Bank (2016), the overall objective of port infrastructure investment is to enhance efficiency in the Caribbean port industry, with the overall aim of reducing costs for existing traffic as well as increasing capacity for future growth. For instance a study conducted by the World Bank (2012), indicated that shipping and port handing costs contributed up to 35% of the costs of consumer goods imported from Costa Rica to St. Lucia. According to the CDB (2016), by improving port efficiency in the Caribbean, the problem of high import and export costs, growth in price levels, and eventual impact upon poverty are reduced, hence the motivation for policymakers to act.

Given the test results of this research presented in Chapter 6, while one cannot rule out infrastructural investments, the proposed recommendations given the CDB report prove that each port necessitates differing investments combinations, be it, managerial and/or scale impacts, as the relevant port objective necessitates.

Moreover, having considered the test results of this academic research, together with policy recommendations and current port expansion actions of Caribbean ports, there seems to be differing interests, as to the objective of the port, and what it wants to accomplish. For instance, while this research has investigated the port performance via productivity and efficiency assessments, and will therefore offer recommendations thereafter based on these results, this may not be the current interest of Caribbean ports as has been observed previously. This implies that potentially other factors are influencing the ports' decisions, and which may not be not to increase efficiency, but actually due to reasons of competition, accommodating larger ships, attracting new markets, offering more logistics services, and so on.

Therefore, while measuring port efficiency and productivity analysis is integral, there are always other contextual factors influencing port policy. On the other hand, these actions may be influencing investment decisions differently, at the expense of efficiency/ productivity gains. Overall what is observed, is that scale and technical effects have had a greater impact upon productivity, but at the expense of improving managerial efficiencies. With the relevant policy recommendations tailored to influence this, achieving greater efficiency and productivity gains can be achieved. This however being the region's ports' objective.

7.4.2 Port Development Recommendations by Donor Organizations

This section seeks to evaluate the recommendations proposed by the various international donor organizations such as the World Bank, Caribbean Development Bank, UNCTAD and CARICOM. The Caribbean region remains appreciative of the financial assistance and guidance for improving their maritime industry. Nevertheless, adequate support, backed by comprehensive academic research, renders better decision-making and distribution of port investments. This must be the forefront of decision making, especially when levels of funding in the magnitude observed previously, is at hand.

This research has assisted in better understanding port efficiency and productivity relating to SIDS ports, an area where there has been little academic research. In addition, this research presents also practical contribution to policy makers, donors and decision makers of the Caribbean maritime industry.

Before recommendations are presenting arising out of this research, firstly those delivered by some of the donor organizations relating to investments are assessed. According to the CARICOM (2013), CDB, (2016), and UNCTAD, (2014), *"port investments"* are required. While investments is key in port development and improving productivity, careful consideration is must take for the areas this is directed toward. With reference to Tables 7.1 and Figure 7.1, one of the key areas proposed for investments over the years, have been in the areas of terminal/berth/draught expansions, machine/ equipment acquisitions, and so on.

Furthermore, the recommendations cited for enhancing port efficiency, and its estimated costs according to the CDB, are based on efficiency scores retrieved from partial productivity analysis on seven dimensions. These include productivity (berth moves/hour), labour (TEU/employee), infrastructure (quality), nautical access (maximum vessel draught), equipment (no. of cranes installed), Information

Technology, and autonomy (public vs. private involvement). Now the benefit of employing partial productivity methods in measuring port efficiency/productivity is that it allows for identification of areas where improvements can be made. It also appreciates benchmark analysis with the other ports under study, while being easy to understand and calculate.

These investment recommendations, have presented an array of lending options put forward by the CDB with cost estimates as high as 320m USD at Bridgetown port for instance, and an overall total cost of over 600m USD to Caribbean (see Table 7.2). As put forward by the CDB, "*this study has revealed the need for port investments in a majority of the ports.*" (CDB, 2016).

Firstly, before rash decisions are made, firstly considering the methodology employed, in arriving at these results are looked at. Partial productivity analysis was used, which looks at output over a single input ratio. This however, does not address the problem of factor trade-offs. Furthermore, as investment decisions are based on this method, caution must be taken, as the CDB analysis does not include performances over time, which looks at panel data. Moreover, another flaw of this approach is that it does not decompose productivity pointing toward the contributors of port productivity in the case of scale effects, pure technical efficiency and technological progress.

Due to these issues, a more accurate approach that overcomes these flaws could have been employed. It is for practical reasons such as these, this research has employed TFP analysis rather than partial productivities. Results derived from the DEA- Malmquist analysis, as in the case of Caribbean prove that technological progress and scale effects have been the main motivators of improving productivity over the years.

This effect of scale adjustments highly impacting total productivity is also consistent with the findings of Wilmsmeier et al.. (2013) and Suarez-Aleman et al.. (2016). These findings could not be possible applying partial productivity analysis. While port development initiatives have proven to improve productivity by increases to scale efficiency and technological progress, this has been at the expense of pure technical efficiency gains.

So, what is occurring are progresses from pure efficiency have weakened, as Caribbean ports are not fully utilizing their existing capacity which actually is a form of x-inefficiency. In other words, the rate of catch up has been slower than the rate of progress. While it is the proposal of the CDB in many of the ports' recommendations to engage more investments and expansionary projects, this will result in further underutilization of port resources, increasingly negatively affecting technical efficiency and even productivity.

According to the CDB, (2016), UNCTAD, (2014), and CARICOM, (2012), *"port investments"* are required regarding Caribbean ports. With reference to previously Tables 7.1, Table 7.2 and Figure 7.1, one of the key areas proposed for investments over the years have been in the areas of terminal/berth/draught expansions and machine/ equipment acquisitions. Some benefits from investment are claimed to be positively related to employment be it direct and/or indirect types, which in turn not only benefits the port, and the industry, but overall the local economy (Rodrigue, 2017).

While this is so, since the port is the gateway through which throughput enters/exits any economy, its success largely depends upon the level of throughput it can accommodate and the quality and cost of the handling services it provides. If the port develops and does not have sufficient amounts of throughput to match this development, then capacity is underutilized and inefficiency can result.

This presents the problem of x- inefficiency, which arises due to organizational slack, when ports are employing more resources than needed for output, resulting in unused capacity. In this case, investments may actually not be feasible, as the return would be too low, also and at the expense of not diverting it to other more profitable areas in the industry.

Furthermore, size does not guarantee increasing efficiency/ productivity. Having a larger port is not always the end goal of every port. As Pinnock and Ajagunna, (2012) put it, *"transhipment is not the answer for all Caribbean ports."* Actually, smaller ports particularly belonging to the OECS group, may actually progress more as feeder ports, accommodating traffic from larger transhipment and regional ports.

While Caribbean development have progressed quicker than for instance the world's Top ports over the past decade, their average technical efficiencies still remain within the lower ranked quartiles. The primary cause of this has been the decline in pure efficiency changes. Internal operations such as managerial/operational practices have not been able to progress as quickly so to bring about optimal production, where ports operate along the production frontier.

7.5 CONCLUSION

This chapter has reviewed and discussed the hypotheses, formulated based on traditional economic theory of production theory. The specifics of this research compared to other research, measured, analysed and compared port efficiency and productivity over the ten-year period (2001-2011). It was looked at from the realm of how port policy/development strategies have affected efficiency/productivity over time. Furthermore, it contributed to the discussion on port development in SIDS ports in the Caribbean region, as no other research has been conducted on this group of ports before. Moreover, this research goes further, by not only assessing port development initiatives in the Caribbean region, in an attempt to determine how policies have influenced performance, but also, what and how it may influence future performance. This presents a more thorough support, as to the recommendations arising out of this research in the following chapter.

CHAPTER EIGHT

CONCLUSION, RECOMMENDATIONS, LIMITATIONS, AND AREAS FOR FURTHER RESEARCH

This chapter encapsulates the research conducted in this thesis by firstly presenting an overall summary of the research and its major research contributions section 8.1. Having done this, policy recommendations for SIDS ports particularly of the Caribbean region are made in section 8.2, which should aid in better directing port investments that bring about increasing port productivities. The limitations of this research are looked at in section 8.3, and areas for further research are proposed in section 8.4.

8.1 SUMMARY OF RESEARCH AND CONTRIBUTIONS

Economic growth remains an objective of every nation; this does not exclude lesser-developed countries such as the Small Island Developing States (SIDS). One way of attaining economic growth is by focusing attention on tackling the challenges faced by transport and trade logistics. These challenges constitute a key policy concern for the sustainable development of SIDS' ports and become not only a port concern but also a national concern, as directing adequate funding and resources to improve port efficiency, has become a top priority for the United Nations (on an international level), and CARICOM (regional level). From this concern, Chapter 1 presented the research question and hypotheses were formulated to be investigated in this research.

This research presented a framework that sought to measure, analyse and compare port efficiency and productivity over the ten-year period (2001-2011). This was looked at from the perspective of how port policy and development strategies have affected efficiency and productivity over time. The research attempted to present insight into SIDS ports, with reference mainly to the Caribbean. It was with intentions that this research would also produce policy recommendations that could be implemented in other port types and regions of the world particularly for international (UNCTAD), regional (CARICOM) and country level decision makers.

Chapter 2 presented an overview of the Caribbean, its macro and micro economies, indicating their progresses or lack thereof over the past decade. Particularly, focus was concentrated on the region's large dependence and openness to international trade and trade related matters and arrangements, since it presented a direct impact on port performance. The chapter then examined port types, their management models and the main hindrances to port progress they have faced over the past decade. The primary aim of this chapter was to bring to the reader's attention the progresses of the Caribbean economy over the years, and chiefly its international trade being very much trade dependent, which in turn relies heavily on port development and progress.

Chapter 3 focused on the academic literature on the general composition of the port itself, its various management models and the evolutionary trends in containerization that have all influenced port development and its determinants over time. One of which has been the physical structure of the port. As ports continue to develop, it influences efficiency and productivity over time, which revealed the need for adequate research.

Chapter 4 concentrated on the theoretical literature that connects factors of production to output, being the production theory of the firm. This theory played a vital role in measuring the performances and progresses of each port, by evaluating the inputs, and how they relate to output being container throughput. The theoretical approach had its merits and was applicable over the past decades in microeconomics. However, the uniqueness of the container port industry, given its complex nature and interrelatedness of key stakeholders, different operational levels, objectives, and so on, all together utilizing the port itself, proved that that the existing theory of production may not have adequately provided definitive insights which are directly applicable to the port industry.

This economic theory however had been the most widely used in measuring efficiency/ productivity analysis in the port industry, and was proven helpful in past researches and certainly for this research. On the backdrop of the production theory, applied within the port industry, this research was structured in accordance with attempting to empirically measure and explains evolutionary efficiency/productivity among SIDS, of particular the Caribbean.

Furthermore, contemporary methods of measuring efficiency and productivity were studied and compared. This chapter emphasised the vast number of alternative approaches classed into parametric and non-parametric approaches that could be adopted, each having their respective strengths and weaknesses. Having understood these approaches, investigation was then conducted on the empirical research pertaining to the port industry efficiency and productivity analysis. This captured cross sectional as well as panel data analysis. In the end, a decision for employing and justifications of using the non-parametric DEA based test was employed. The chapter concluded by deriving hypotheses through which to answer the overall research question.

Understanding the production theory and its relevance toward measuring efficiency/productivity analysis, an efficiency measurement system that outlines the relevant steps for carrying out the next steps of research, was employed. Chapter 5 shows justifications in accordance with literature review, about the objective of the research and what the author wanted to accomplish, choosing the relevant inputs and output for analysis, data collection, going about the iterative processes, through which the final sample and size is determined as the way forward. Thereafter the DEA- based model was specified according to the mathematical programming software, which was employed.

Chapter 6 presents the results of applying the model to the sample data. Firstly, background information on container port traffic and its trend over the years are first discussed highlighting its trends over time, market-shares, over the entire sample and for each sub-group, particularly with reference on the Caribbean. Benchmarking analysis is also presented, where this would institute on a purely empirical basis, the starting point for a port or sub-group to learn how to and further improve its efficiency/productivity. Thereafter, results of the DEA tests were explained into two sections- efficiency and productivity analysis. Technical efficiencies for the sample and each sub-group were tested applying CCR and BCC methods. Each method presented comparable and convincing efficiency scores for the sample, according to previous academic research, and a high acceptable Spearman correlation score supported this. Moreover, the DEA based Malmquist productivity analysis on panel data was found, and its various decomposition was analysed over time. Moreover, these results assisted in evaluating all of the research hypotheses and answering the research question.

Having derived the results, next, Chapter 7 discussed these findings in the context of port development initiatives undertaken, ongoing and proposed for Caribbean. In addition, drawing on information from Chapter 2, the region's openness to international trade showed an even greater need to improve port operations where maximum productivity is achieved. Furthermore, the level of international, regional and local level donor and investments showed the assortment of funding that have been directed to the industry and recommended with particular reference to the physical determinant of port development concept as shown in chapter 3.

Referring back to the research question of this thesis, ***"How has the technical efficiency and productivity of Small Island Developing States ports progressed over the last decade, due to port development opportunities?"*** This research concludes that the Caribbean has experienced efficiency and productivity gains from two main sources: adjustment of production scales (scale efficiency) and technical progress. This effect of scale adjustments highly impacting total productivity is also consistent with the findings of Wilmsmeier et al., 2013b and Suarez-Aleman et al., 2016. Most significantly, scale effects have contributed toward productivity gains, more so than the technical progress.

This research question has been broken down into six relevant research hypotheses, for which results reveal that:

- *Hypothesis 1: Under Constant Returns to Scale (CRS) measures, there has been no change in general port efficiency over the last decade. (Hypothesis cannot be rejected)*

- *Hypothesis 2: Given the effects of returns to scale, under Variable Returns to Scale (VRS) measures there has been a general improvement in port efficiency over the last decade. (Hypothesis is rejected)*
- *Hypothesis 3: Caribbean ports are less efficient than TOP ports, but more efficient than Other Small Island Developing States (OSIDS) ports. (Hypothesis cannot be rejected, and undetermined for the latter part)*
- *Hypothesis 4: The Total Factor Productivity (TFP) in the port sector has been positive over the last decade, and most of this have been driven by technical progress (TC) and not technical efficiency change (EC). (Hypothesis cannot be rejected)*
- *Hypothesis 5: Over the whole period, Caribbean ports have experienced higher TFP changes than TOP ports, and most of this is because of efficiency change (EC) rather than technical progress (TC) progress. (Hypothesis is rejected)*
- *Hypothesis 6: Over the whole period, Caribbean ports have experienced higher scale efficiencies in comparison to TOP ports. (Hypothesis cannot be rejected).*

Efficiency at Caribbean ports has improved over the decade analysed, as ports endeavour to improve their performance over time. However, technical efficiencies (rate of catch-up) have increased at a slower rate than their technical change (rate of progress), as ports undertake long-term capital investments in an attempt to improve their performances without adequately initially exploiting existing resources, capacities and/or internal practises. Top ports are usually considered to be more efficient than SIDS ports because they are generally situated within the developed world context. This gives them access to potentially more resources and potential port investors, which explains the result that a faster rate of technical change for TOP ports has increased the efficiency gap between them and SIDS ports, as they are able to improve their efficiencies much quicker than SIDS. Since scale effects in port operations are known to be considerable, however, with growing traffic levels, this result was partially offset by higher scale efficiency gains in the SIDS as they sought to improve their port size- capacity and operations.

This type of research has not necessarily been conducted for SIDS ports, particularly of the Caribbean. Efficiency/productivity empirical researches have in recent years been investigated with Caribbean ports being both SIDS and Non-SIDS but also coupled with South American ports, the latter being a primary focus, or research on other regions of the world. These findings have resulted in a number of policy recommendations.

8.2 RECOMMENDATIONS

The findings suggest that maximizing the efficient use of existing capacities for particularly the Caribbean and considering thereafter port expansion can possibly be the most feasible option for improving technical efficiency. It is likely that massive port investments in port expansion may not be the most viable option for improving efficiency.

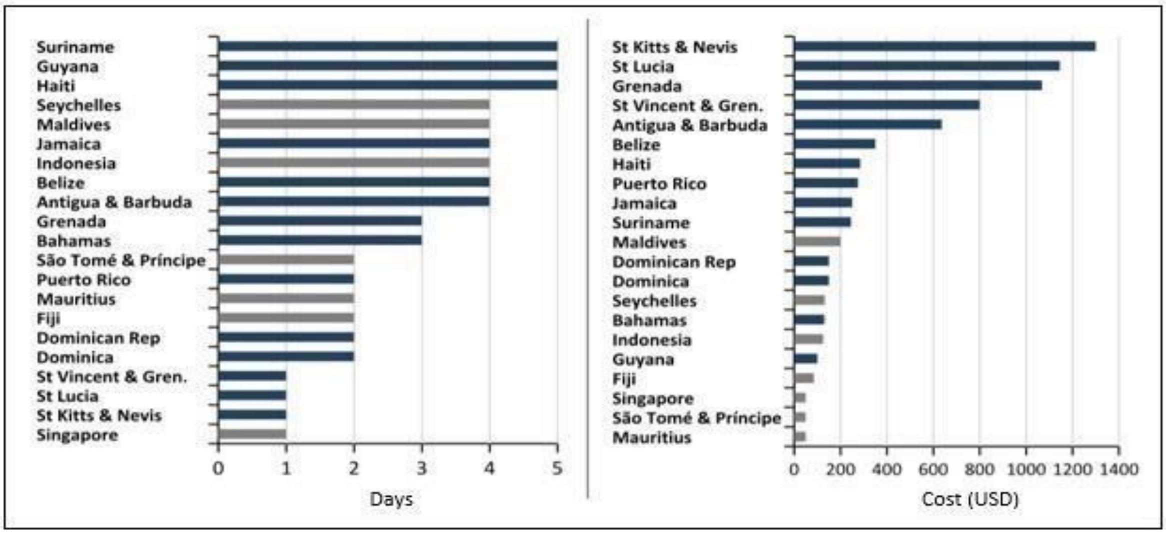
Implementing policies and practices that curb the impediments of port inefficiency requires the participation of every key stakeholder. When countries of similar characteristics can form collaborative ties, they stand a greater chance of yielding larger returns on the international front, than doing so individually. According to the IADB, it becomes more beneficial when small islands of similar characteristics situated within close proximity stay together, against external forces. This is because of their incapability of successfully, individually engaging larger economies (Moreira and Mendoza, 2007). Therefore, responses to seaport inefficiency require an integrated assessment.

8.2.1 Legislation

Engaging in harmonization of legislation where there is transparency and accountability within the maritime industry and throughout the region may include issues relating to national customs legislation, where dialogue and information exchange within regional customs administrations and even relating to countries external to the region are facilitated. This may actually promote a faster and more efficient flow of customs information, reduction in unnecessary bureaucratic intervention, resulting in reductions in the time freight moves from one island to another.

According to Pinnock and Ajagunna (2012), customs and excise taxes account for, on average, up to 35% of GDP in the Caribbean; this however is less than 4% in developed countries. The ports' clients are therefore faced with higher handling fees, making them uncompetitive and cost inefficient compared to other regions. For instance, in Jamaica, it can take an average of up to 4 days and $250 for freight to clear customs and inspection, whereas in Mauritius, which is also an island nation situated in the Indian Ocean, the time and cost is half the time and five times less the cost respectively (Pinnock and Ajagunna, 2012). This is even greater for those ports of the OECS (see Figure 8.1).

Figure 8.1 Customs and Inspection: The Caribbean vs. other Island/Countries



Source: (World Bank, 2012)

Therefore, legislation that embarks on a smoother flow of information exchange, capacity building of customs officials via adequate training, strengthening trade information portals, modernizing customs infrastructures and improving its security are some of the ways in which the customs side of CARICOM can improve. In addition to legislation, this may also include areas of technical and advisory services, and ICT investments (CARICOM 2013).

8.2.2 Modernisation

Secondly, modernisation is necessary in order to best accommodate 21st century vessels. Some of the ports are faced with dilapidated infrastructures and outdated equipment. This includes having to update quays, the removal of unnecessary sheds to create additional storage area, and rehabilitation of quays. Furthermore, some of the current equipment is in dilapidated state resulting in downtime.

Therefore, the acquisition of new equipment and its proper maintenance must be taken into consideration.

8.2.3 Information Technology

Moreover, technology is a major contributor in port productivity. It enhances performance over paper work, since information can be processed at a quicker rate. Ports connect multiple parties on the seaside and landside, therefore the exchange of information from every party is relevant. The various IT systems relevant for efficient cargo handling in the Caribbean include systems which integrate customs, terminal operations and the port community.

Automated System for Customs Data (ASYCUDA) is a computerized customs management system. It is employed by almost all Caribbean ports and handles matters pertaining to most foreign trade procedures, such as handling customs declarations, accounting procedures, transit and suspense procedures.

Secondly, Terminal Operation Systems (TOS) looks at the management of the movement and storage of cargo in and around the port. According to the CDB, the cost of implementing this into port operations can amount up to $1.5M for smaller ports, while increasing as port size does.

Furthermore, Port Community System (PCS) is an electronic platform that connects multiple systems of the port community. These include actors along the transport and logistics supply chains from both public and private sector, integrated within a single window. It provides information regarding import and export of freight, customs declarations, tracking and tracing of freight through the whole logistics chain, maritime and other statistics, and so on.

Implementing these systems into port operations can yield great benefits. The ports' factors of production such as labour, and equipment can be better allocated to other operations thereby minimizing time, wastage and cost. Furthermore, the systems allows for management to better plan workloads as they process real time information. According to the CDB, these IT systems for instance have reduced the time truckers stay at the port, by up to 50%, resulting in an average turnaround time of less than 25 minutes (CDB, 2016).

For instance, Table 8.1 shows the level of IT currently implemented in Caribbean. Thankfully, the majority of ports have employed the ASYCUDA customs system in their operations. This is however not the situation for other systems, especially among OECS ports. For instance, Roseau, Dominica, utilizes the TOS system, but have not yet integrated it with the billing department. This means that more labour is needed to carry out the task in preparing financial bills, which could have been avoided if the system was fully integrated with other divisions of the port.

Table 8.1 Information Technology in Caribbean

	Port, Country	***Customs system***	***TOS***	***Integrated System***	***PCS***
OECS	Basseterre, St. Kitts	Yes	No	No	No
	St. John's, A&B	No	No	No	No
	Roseau, Dominica	Yes	Yes	Yes	No
	Castries, Saint Lucia	Yes	Yes	Yes	Yes
	Kingstown, SVG	Yes	Yes	No	No
	St. George's, Grenada	Yes	Yes	No	No
Non-OECS	Bridgetown, Barbados	Yes	Yes	Yes	Yes
	POS, Trinidad	Yes	Yes	Yes	Yes
	Nassau, Bahamas	Yes	Yes	Yes	Yes

Source: (CDB, 2016)

In non-OECS ports on the other hand, all systems are implemented to ensure an efficient flow of information throughout the transport/ logistics supply chains. There are however, different progressive levels. For instance, the TOS system of POS, Trinidad is not yet fully functioning at optimum performance, as all parties utilizing the system require the relevant training, which is currently lacking.

Overall, the IT systems of these ports have improved compared to times past. Looking ahead, the proper training across every division using it is required, if these systems are to be fully utilized. Furthermore, proper integration of the systems and with various stakeholders along the transport/logistics supply chains are needed, in order to ensure a smooth and efficient flow of freight. If these issues are addressed through proper training and collaboration, then cost, wastage, and time is minimized.

8.2.4 Regional Port Information Centralisation: Data and Research

No policy is effective without adequate and extensive research that supports its justification. The region does not have in place a systematic approach to collecting, organizing and analysing port industry data. Furthermore, no central base has been set up where data can be deposited and used by research bodies. Usually, research bodies such as the CDB or UNECLAC who require data will approach the individual ports. This frequently results in delays and even the possibility of ports' unwillingness to share data, due to lack of concern. Certainly this will require the support and co-operation of the region's governmental bodies.

A region wide centralised freight database should be established and monitored by a governing body. This overseer can take the form of officials of the CDB at the regional level, who is in charge of collecting and ensuring data quality. They then make the data available to also the UNECLAC and/or WB at the international front who engage in extensive research, which guides future potential port investments and progress. This will means gathering data on port efficiency/productivity indicators over a cross section of ports, involving time series data.

Furthermore, regular quarterly or bi-annual meetings can be put in place, where the CDB/UNECLAC/WB (the governing bodies) can meet with each countries' port management to discuss and give feedback and progresses of the central database system. Moreover, perhaps a penalty system can be introduced or legislative orders passed whereby if ports are delayed in sending data, a warning is issued, and if this is yet ignored without adequate justifications, a fee penalty can be issued to the port, at fault.

According to a World Bank report, (2012), the UNECLAC attempted to develop an international trade database for the Caribbean region. The purpose of this database would be to collect and store port related data, for the use of analysis and report writing by UNECLAC. This was finally achieved and made available quite recently in 2017: http://perfil.cepal.org/l/en/start.html.

Furthermore, research should encompass impact studies that undertake collective economic, social and environmental impacts not only for a single port/ country, but also for all of the Caribbean economies. The region consists of mainly small islands, with similar characteristics, situated within close proximity, and integrated under CARICOM initiative. This shows the vulnerability of Caribbean ports given regional developments.

For instance, what does the expansion of Panama's Canal imply for Caribbean, and their ports? Would port expansion be essential or directing traffic to other ports- using the hub and spoke method, what role would feeder ports maybe play, or are there other means of efficiently accommodating possibly a rise in traffic throughout the region?

Comprehensive research that necessitates proper data collection needs to be in place in order to provide answers to questions such as these. This will help the region to better assess potential port investments not considering only one individual country, but all economies, as a common Caribbean Community (CARICOM), influencing the progress of regional port development.

8.2.5 Regional Logistics & Supply Chain: Data and Research

Since the port's operations are deeply integrated into the logistics and supply chain system, careful consideration should also be given to this as it also affects the overall progress of the maritime industry. To ensure that all levels are met, recommendations can be split into the local and regional level.

Local level

In every country, the Ministry of Trade can establish regular platforms. At these meetings, key logistics stakeholders are allowed to voice their concerns and suggestions as to ways of reducing logistics bottlenecks. Stakeholders may include the Truckers Association, the Ministry of Transport and Infrastructures, manufacturing industry, dry port officials, port authorities, freight forwarders and even academic institutions to name a few.

The interesting aspect of this platform is that it will support academic and non-academic expertise, providing a more holistic approach to the information given about each country's logistics system. This furthermore will show stakeholders the importance of their contribution in overcoming bottlenecks, by hearing their concerns and showing them the value of their contribution.

This form of information sharing can feed into the central database system too as discussed previously. This involves the co-operation of many stakeholders in order for the database to be a success.

Regional level

With the use of local level intervention and information dissemination, a key logistics representative for each country can potentially gather for bi-annually regional meetings. At the regional meeting, discussions are held with the aim of addressing and dealing with overarching concerns in Caribbean logistics. This will facilitate information sharing while at the same time recognizing the similarities and/or differences in each country logistics system. It will furthermore accommodate better allocation of regional port investments.

8.2.6 Labour Training/ Reformation

As ports expand and employ more technological equipment and procedures in their operations, labour must be up to date on these changes. As looked at previously, information technology in customs, at the terminal, and encompassing the entire port community shows the need for labour to be trained adequately. Furthermore, if there is going to be a local/regional level of port and logistics database, then the way in which data is collected, stored and reported, will also render the need for trained individuals. Moreover, with the use of new and advanced superstructures such as cranes, and other terminal equipment, cannot complete tasks, if workers are incompetent. For instance the labour force of Port of Spain, Trinidad and Tobago, is said to be aging, and has not grown abreast with the introduction of IT operations at the port (CDB, 2016).

Particularly for the OECS, training is limited due to budget constraints. While ports may lack the financial resources to train its workers, a lack of training can actually result in larger costs to the port. Arising from quicker breakdowns, lack of maintenance of machinery/equipment, impossible to get maximum work done since workers are not aware of how to use the machinery, negatively affecting efficiency and resulting in increased cost. Moreover, this can be worsening especially if labour is already a large portion of operational costs (see Table 8.2).

Table 8.2 Port Labour in the Caribbean

Port, Country	***Number of Employees***	***Share of Operational costs***	***Gang size (workers)***	***Trade Union Status***	***Training***
Basseterre, St. Kitts	Total: 260	unknown	18	Yes, strong union	Limited
St. Johns, A&B	Total: 260 Operations: 160	62%	20	Yes, strong union	Limited
Roseau, Dominica	Seaport: 260	60%	17	Yes, but a good relation	Limited
Castries, Saint Lucia	Seaport: 270	50%	15	Yes, but a good relation	Limited
Kingstown, SVG	Total: 270	45%	13	Yes, but a decent relation	Limited
St. George's, Grenada	Total: 188	unknown	23	Yes, strong union	Limited
Bridgetown, Barbados	Total: 500 Operations: 130	60%-65%	14	Yes, strong labour union which prevents modern working standards	Active through Caribbean Maritime Institute
Port of Spain, TnT	PPOS: 1146 Operations: 832	75%	23	Yes, strong union	Limited
Nassau, Bahamas	Operations: 210	28%	12	Yes, but presence of multiple terminal operators limits power of the individual union	Yes, on-site training

Source: (CDB, 2016)

Furthermore, with a heavily unionized workforce as is the case with many Caribbean ports, it can become difficult to introduce new ways of getting tasks completed, and can take a lengthy time. For instance in Port of Spain, Trinidad and Tobago, 23 workers handle a vessel from quay to stacking in the terminal. However getting this number to reduce conflicts with the views of trade unions (CDB, 2016).

Overall, port investments directed toward adequate training is pertinent. Furthermore, while there may not be any immediate solution to the issues of unionized labour and resistance to change, a medium to long-term solution can be put in place. Trade unions together with the involvement of the government need to see the importance of modernisation and technological advancement in port progress. While jobs may be lost as a result, the government can introduce compensation package for redundant workers, but this can be politically difficult to achieve.

8.2.7 Private/Public Port Partnership

A strong presence of political interference is observed in Caribbean ports, and this is mainly in the smaller ones (see Figure 2.20). Many operate within a Public service port management model, which means the public authority or government, is chiefly responsible for the ports' major investment decisions at the end of the day. Since this is usually collected from budget revenues, it can take a long time to source, delaying timely investments. Furthermore, in many instances, government/political interference limits ports operating at optimal efficiency, as this is usually not the primary objective of the government, compared to private firms.

Many researches have investigated and seen the benefits of private involvement in port operations. It improves efficiency as factors of production are better allocated with the aim of minimizing wastage and maximizing output, while also reducing the financial port investment burden of the government. This is evident in the results for some of the ports such as Freeport, Bahamas, and Caucedo, Dominican Republic, are private ports and rank amongst the top quartile in efficiency performance. Furthermore, landlord ports which carry some degree of private involvement, such as Rio Hania, Dominican Republic have also ranked amongst the top quartile in efficiency performance and port development, compared to public ports.

Overall, funding and support that encompasses a private/public partnership can be the way forward. While one can draw from reference to the progress of these ports, further academic research should be pursued in order to determine whether a shift toward more privatization for Caribbean ports is the way forward.

8.3 LIMITATIONS OF RESEARCH

It is recognised that this research has some limitations. Firstly, the panel dataset includes data for the period 2001-2011. Data that is more recent was not included partly due to a lack of data availability beyond the researcher's control, and because the research commenced in 2014, not long after the end of the data series. In any case, the aim of the research was not to reveal how efficient each port is at the present time, but to analyse changes in efficiency and productivity over time that can be used to derive findings generalizable to other ports and indeed to the same ports in the present time. The time series element is more important than bringing the series up to date, although that remains a goal of future research.

Furthermore, while cleaning data would have improved the decision making process, there may be set backs to this. Firstly, this process reduced the sample size, as initially one hundred ports were considered. For instance, the OSIDS group had just four ports, which could have been a plausible reason for hypothesis three being unproven (see page178). Furthermore, the ports finally chosen were those up to +/-2 standard deviations away from the sample's mean.

As previously mentioned in chapter five, using three standard deviations though having a wider data cut- off point and so increasing the sample size for analysis, it created to large a dispersion from the sample's average and reducing considerably the average efficiencies. Therefore every port that had partial productivities in excess of each input's respective average +/-3 standard deviations was removed. Those ports for which their partial productivities still stood outside this range, and occurring for the majority of their years and for inputs, were removed from the analysis and DEA tests were conducted on this new data set. The average DEA efficiency scores were then compared to past academic related research as shown in Table 4.1 and 4.2, particularly Serebrisky et al.., (2016), Suarez-Aleman et al. (2016) and Wilmsmeier et al. (2013b) which investigated the Caribbean region. If average efficiencies scores were very low, they were removed from the analysis and retested at +/-3 standard deviations.

If further DEA tests still showed lower average efficiency scores incomparable to past academic research, then two standard deviations was introduced. As it is predicted +/-3 standard deviations created to wide a dispersion, significantly lowering average efficiency scores. Attempts were then made at +/-2 standard deviations. The same procedure continued, where every port that had partial productivities in excess of the input's respective average +/-2 standard deviations was removed. Those ports for which their partial productivities still stood outside this range, and occurring for the majority of their years and for inputs, were removed from the analysis and DEA tests were further conducted on this new data set. Satisfactory results were retrieved at +/-2 standard deviations, which were also convincing and comparable to average efficiency scores of past research and journal publications. The dataset most convincing to move forward with were those ports, which had partial productivities for each input closest to the overall respective means. Those ports that had individual averages of about +/-2 standard deviations or lesser were proceeded with, as these ports average efficiency scores were also comparable to past academic articles as just previously mentioned.

Another issue lies with the combination of inputs used being terminal area, berth length and equipment. While these variables provide essential information about the port's operations and its progress and they are commonly used variables in most port studies, they do not however capture the entirety of the port's performance. For instance, labour being a crucial factor of production, could not be included in the analysis, because of lack of data availability. A container terminal depends crucially on the efficient use of labour, land and capital, which means it affects efficiency/productivity significantly. If labour is excluded regardless of how capital intensive the industry may be, its results are not fully reflective of performance. Having such data could affect the efficiencies of the ports and so results. For further explanation please refer back to Section 5.3.1.

On the other hand, the standard output variable- annual TEU throughput/port, was used in this research. This however did not take into consideration other outputs the port may be involved with such as general cargo. Again, if these other output information was made available possibly they could have been included to estimate the efficiency of multiple output ports. However, the decision was taken to focus on container handling, as is also the case in many port studies.

Lastly, as the expectation of optimizing efficiency would be the objective of every port, this may not always be the circumstance. Optimizing efficiency may not be the sole determining factor as there may be other factors influencing decision-making and so port performance, such as capacity to handle the latest generation of ultra-large container vessels because of competition from other ports as well as the expectations of the shipping lines. It becomes difficult to incorporate this into the analysis and to measure them, as to how best port efficiency may be impacted by these other factors.

8.4 AREAS FOR FURTHER RESEARCH

This research has shed light into further areas of investigation. Firstly, research that encompasses impact studies, undertaking collective economic, social and environmental impacts for the region can be of priority. This can include the present state of the economy, unemployment rate, level of economic growth, balance of payments and so on. This is because internal factors of the port, but also external factors can actually impede/facilitate port performance.

Secondly, the focus of this research is to examine the technical efficiencies of Caribbean ports. It has however ignored the financial performance of the ports under study, concerning the influence of factor prices on inputs. Measuring both allocative and technical efficiencies can show their internal relationship, and present an optimum efficiency. This is so since optimum technical efficiency may not necessarily mean financial success or survival.

Lastly, correcting for some of the limitations can present areas for further research. For instance, replicating the analysis with more recent data as availability permits is a possibility. Furthermore, due to the lack of data on other SIDS ports, it was difficult to compare results to Caribbean, and come to a better understanding of the similarities and differences of regions. In addition, more inputs/outputs can be included, such as labour and/or general cargo.

Finally, the discussion chapter shed light on how the past, present and future development strategies of Caribbean ports could be considered from a qualitative perspective. For a more informed consultation of the ports themselves, this would mean interviewing and submitting questionnaires to port managers. It would present a more holistic view of the port's progresses and hindrances, also understanding the concerns of the people who make the port function.

Upon completion and achievement of the PhD, a softcopy version will first be directed to the Port Authority, and Ministry of Trade and Industry of the Republic of Trinidad and Tobago; the latter being the funder of this scholarship. In September of 2018, the researcher will report back to the Ministry of Trade and Industry, and give a face to face formal presentation of the findings to both authorities. Furthermore, email discussions have already been made with the Director of Economics from the Caribbean Development Bank, and Chief Trade at CARICOM who have expressed a keen interest in the research and its findings, as it pertains to one of the goals for CARICOM's Trade Strategy, which is enhancing port performance and facilitating trade expansion in the Caribbean region, of which measuring port performance plays a key role. The research will also be directed to them on the first instance, via a softcopy version.

APPENDICES

Appendix 1 Value of Imports and Exports by CARICOM countries: 2000-2012 Current US$ Million

VALUE OF IMPORTS BY CARICOM COUNTRIES : 2000-2012 Current US$ Million															
Country	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**TOTAL**	**% of CARICOM**
Barbados	1,448	1,386	1,382	1,513	1,735	2,017	2,132	2,216	2,434	2,045	2,240	2,346	2,295	25,189	9.25
Jamaica	3,192	3,403	4,771	4,860	5,268	6,118	7,216	7,889	9,799	6,352	6,555	7,721	7,838	80,982	29.74
Trinidad & Tobago	3,698	3,935	4,030	4,259	5,241	6,277	6,879	8,112	10,042	7,462	6,586	9,551	9,105	85,179	**31.28**
Antigua & Barbuda	498	487	474	535	592	683	818	932	952	706	679	642	688	8,687	3.19
Bahamas, The	2,964	2,820	2,672	2,759	3,019	3,700	4,417	4,489	4,452	3,728	3,895	4,522	4,988	48,426	17.78
Dominica	183	166	156	157	174	196	199	236	287	264	264	265	251	2,800	1.03
Grenada	310	280	272	311	319	396	402	436	452	361	380	395	396	4,711	1.73
St. Kitts and Nevis	249	242	257	256	242	280	321	346	437	366	364	362	347	4,069	1.49
St. Lucia	446	403	401	500	500	595	707	747	820	648	787	816	756	8,127	2.98
St. Vincent & Grenadines	200	209	215	241	272	291	326	402	431	388	389	377	402	4,144	1.52
TOTAL	**13,189**	**13,331**	**14,630**	**15,392**	**17,362**	**20,553**	**23,417**	**25,808**	**30,106**	**22,321**	**22,140**	**26,998**	**27,068**	**272,314**	**100.00**

VALUE OF EXPORTS BY CARICOM COUNTRIES : 2000-2012 Current US$ Million															
Countries	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**TOTAL**	**% of CARICOM**
Barbados	1323	1252	1211	1379	1436	1712	1939	2044	2090	1905	2054	1719	1795	21858	8.07
Jamaica	-	-	3184	3453	3820	3908	4778	5095	5737	4179	4143	4387	4502	47186	17.42
Trinidad & Tobago	4829	4882	4529	5857	7220	10589	15029	14224	20117	10120	11381	15008	13042	136826	**50.50**
Antigua & Barbuda	467	445	428	463	534	545	548	581	625	562	524	538	542	6802	2.51
Bahamas, The	2807	2589	2934	2901	3161	3482	3558	3888	3797	3117	3223	3443	3735	42635	15.74
Dominica	145	121	123	118	130	129	144	148	157	148	174	191	160	1889	0.70
Grenada	236	197	173	180	198	149	162	210	208	187	184	196	206	2485	0.92
St. Kitts and Nevis	150	153	153	165	194	227	236	233	235	175	208	243	257	2629	0.97
St. Lucia	377	328	319	390	464	525	440	457	536	544	609	573	604	6166	2.28
St. Vincent & Grenadines	179	176	178	173	185	201	212	212	210	192	183	183	188	2473	0.91
TOTAL	**10,512**	**10,142**	**13,233**	**15,079**	**17,342**	**21,467**	**27,046**	**27,092**	**33,712**	**21,129**	**22,683**	**26,480**	**25,031**	**270,948**	**100.00**

Export data for Jamaica in 2000 and 2001 were not available; data was not available for all countries at constant US$ million.

Source: (World Bank, 2014e)

Appendix 2 CARICOM Export and Import Volume Index 2000-2013

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	AVG.
Antigua and Barbuda	100	87	84	97	119	175	141	101	91	70	62	70	74	82	97
Bahamas, The	100	81	89	76	78	82	95	102	100	92	77	72	83	84	86
Barbados	100	99	95	88	85	89	114	110	87	73	77	72	87	74	89
Dominica	100	75	75	74	66	63	58	49	46	37	40	30	37	39	56
Grenada	100	103	91	90	68	61	52	61	49	51	40	43	48	51	65
Jamaica	100	98	95	96	97	94	94	105	106	72	61	64	71	71	87
St. Kitts and Nevis	100	94	124	130	127	105	119	100	145	109	92	125	123	129	116
St. Lucia	100	95	100	152	161	101	130	128	185	215	256	165	172	183	153
St. Vincent and the Grenadines	100	90	83	85	77	87	75	84	74	64	50	41	46	52	72
Trinidad and Tobago	100	104	100	113	121	138	157	141	143	98	107	107	87	87	115
CARICOM Export Volume Index	**100**	**93**	**94**	**100**	**100**	**99**	**104**	**98**	**103**	**88**	**86**	**79**	**83**	**85**	

Antigua and Barbuda	100	97	102	103	103	107	121	128	108	77	64	49	54	59	91
Bahamas, The	100	98	89	87	85	91	97	95	83	74	66	62	70	67	83
Barbados	100	95	93	100	109	111	109	104	98	83	78	72	75	75	93
Dominica	100	90	80	83	85	90	86	93	105	107	99	86	81	84	91
Grenada	100	90	86	104	88	116	101	114	102	87	91	84	85	86	95
Jamaica	100	105	111	106	103	107	117	132	137	96	89	91	92	88	105
St. Kitts and Nevis	100	98	104	98	83	90	102	103	113	108	95	80	74	81	95
St. Lucia	100	107	93	114	108	103	114	108	87	96	100	80	73	78	97
St. Vincent and the Grenadines	100	120	113	125	132	130	135	147	144	136	126	106	114	114	125
Trinidad and Tobago	100	113	115	114	126	124	127	138	145	121	100	123	117	115	120
CARICOM Import Volume Index	**100**	**101**	**99**	**104**	**102**	**107**	**111**	**116**	**112**	**99**	**91**	**83**	**84**	**85**	

Source: (World Bank, 2014e)

Appendix 3 Travel & Tourism Total Contribution to Gross Domestic Product (% share)

	2009	2010	2011	2012	2013
Anguilla	45.9	50.7	53.1	56	57.1
Antigua and Barbuda	71.8	68.2	65	64.4	62.8
Aruba	71.3	79.3	73.2	82.8	84.1
Bahamas	41.4	44.3	45.2	47.2	46
Barbados	40.8	39.2	39.8	37.6	36.2
Cayman Islands	19.7	21.3	23.1	24.9	25.3
Cuba	10.6	10.1	10.1	9.9	9.8
Dominica	25.9	30.1	35.1	34.4	31.9
Dominican Republic	16	14.9	14.4	14.5	15.2
Former Netherlands Antilles	36	34.1	39.4	45	46.8
Grenada	20.3	20.5	20.9	20.2	20.3
Guadeloupe	15.5	14.9	15.3	15	15.2
Haiti	7.5	3.2	4	4.3	4.1
Jamaica	28.2	27.4	25.6	25.4	25.5
Martinique	10.5	9.8	11.8	11.6	11.9
Puerto Rico	5.9	5.4	6.4	6.7	7
St Kitts	20.7	20.3	21.4	21.9	22.5
St Lucia	35.6	34.4	36.5	38.2	38.7
St Vincent and the Grenadines	20	20.2	21.8	21.9	21.1
Trinidad & Tobago	4	4.6	7.4	7.6	8.2
UK Virgin Islands	71.8	80.2	79.4	79.7	76.9
US Virgin Islands	28.7	26.5	27.6	31.5	31.7

Source: (World Travel and Tourism Council, 2014)

Appendix 4 CARICOM Intra and Extra Regional Trade as a % of Total CARICOM Trade

Year 2012	**Total US$ Mn**	**%Extra-reg./Total**	**%Intra-reg./Total**
Intra-regional Imports	2240		(2240/27068)*100 **=8%**
Intra-regional Exports	2032		(2032/25031)*100 **=8%**
Extra-regional Imports	19775	(19775/27068) *100 =**73%**	
Extra-regional Exports	12663	(12663/25031) *100 =**51%**	
CARICOM Total Imports	27,068		
CARICOM Total Exports	25,031		

Source: (CARICOM, 2014)

Appendix 5 CARICOM Intra- regional Imports & Exports 2000-2012 US$ Million

CARICOM Intra- regional Imports: 2000-2012 US$ Million														
CARICOM	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**%Contribution**
Barbados	229	218	158	285	349	403	429	154	443	376	523	600	616	28
Jamaica	398	433	395	470	557	826	671	1,191	1,623	658	822	1,017	858	38
Trinidad & Tobago	126	100	76	81	90	98	97	118	122	109	108	140	217	10
Antigua & Barbuda	42	-	-	-	-	78	85	49	-	52	40	43	45	2
Bahamas, The	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dominica	40	36	35	38	43	52	54	63	71	50	52	68	61	3
Grenada	58	53	53	60	65	89	73	118	111	89	100	88	81	4
St. Kitts & Nevis	37	34	30	38	37	42	45	44	55	40	32	30	27	1
St. Lucia	79	78	69	78	120	101	150	202	241	199	187	237	231	10
St. Vincent & the Grenadines	49	51	50	45	64	73	89	99	102	107	98	104	104	5
TOTAL	**1,058**	**1,003**	**866**	**1,095**	**1,325**	**1,762**	**1,693**	**2,038**	**2,768**	**1,680**	**1,962**	**2,327**	**2,240**	**21,817**
%change						**162**				**-39**			**33**	
						2000-2008				**2008-2009**			**2009-2012**	

CARICOM Intra- regional Exports: 2000-2012 US$ Million														
Countries	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**%Contribution**
Barbados	118	108	100	100	105	139	151	184	157	137	145	194	157	8
Jamaica	49	51	49	51	52	47	53	56	66	66	65	68	83	4
Trinidad & Tobago	975	1,023	673	1,019	860	1,998	2,426	1,763	3,256	1,417	2,043	2,025	1,659	82
Antigua & Barbuda	10	-	-	-	-	27	-	23	-	97	7	9	7	0
Bahamas, The	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dominica	31	26	23	26	25	25	26	24	25	20	26	25	29	1
Grenada	12	13	12	10	9	13	14	13	16	14	13	15	9	0
St. Kitts & Nevis	3	1	1	1	1	1	2	2	3	5	6	7	9	0
St. Lucia	13	16	23	27	36	34	50	117	73	57	70	79	40	2
St. Vincent & the Grenadines	23	25	20	20	21	25	25	35	44	41	32	34	39	2
TOTAL	**1,234**	**1,263**	**901**	**1,254**	**1,109**	**2,309**	**2,747**	**2,217**	**3,640**	**1,854**	**2,407**	**2,456**	**2,032**	**25,423**
%change						**195**				**-49**			**10**	
						2000-2008				**2008-2009**			**2009-2012**	

Data for The Bahamas and some for Antigua and Barbuda were not available
Source: (CARICOM, 2014)

Appendix 6 CARICOM Extra-regional Imports & Exports: 2000- 2012 US$ Million

CARICOM Extra-regional Imports: 2000- 2012 US$ Million															
Countries	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**TOTAL**	**%**
Barbados	927	851	839	910	1,064	1,202	1,200	1,145	1,304	1,047	1,065	1,176	1,107	**13837**	8.168048
Jamaica	2,793	2,970	3,170	3,147	3,260	4,057	4,372	5,560	6,774	4,407	4,405	5,598	5,737	**56250**	33.20465
Trinidad and Tobago	3,221	3,513	3,021	3,862	4,812	5,634	6,429	7,578	9,467	6,783	6,339	9,413	11,398	**81470**	48.09213
Antigua and Barbuda	297	-	-	-	-	447	586	524	-	380	322	263	295	**3114**	1.838209
Bahamas, The	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dominica	108	94	80	89	102	114	113	133	161	175	162	154	151	**1636**	0.965739
Grenada	181	159	145	193	188	245	225	247	266	204	218	247	210	**2728**	1.610352
St. Kitts and Nevis	159	155	172	167	146	168	204	229	270	273	239	218	199	**2599**	1.534202
St. Lucia	283	231	246	315	431	385	442	609	583	419	460	468	425	**5297**	3.126845
St. Vincent and the Grenadines	113	136	128	140	161	167	183	227	271	226	240	228	253	**2473**	1.459824
TOTAL	**8082**	**8109**	**7801**	**8823**	**10164**	**12419**	**13754**	**16252**	**19096**	**13914**	**13450**	**17765**	**19775**	**169404**	
%change									**53.76439**	**-27.1366**			**42.12304**		
									2005-2008	2008-2009			2009-2012		

CARICOM Extra-regional Exports 2000- 2012 US$ Million															
Countries	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**TOTAL**	**%**
Jamaica	1,259	1,173	1,070	1,144	1,360	1,467	1,936	2,168	2,365	1,250	1,272	1,549	1,627	**19640**	14.98916
Trinidad and Tobago	3,343	3,319	2,580	4,223	5,688	7,666	11,791	11,656	15,392	7,688	8,880	12,850	10,500	**105576**	80.57514
Antigua and Barbuda	13	-	-	-	-	93	-	76	-	109	28	20	22	**361**	0.275514
Bahamas, The	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dominica	23	17	18	13	16	17	15	13	15	14	9	6	9	**185**	0.141191
Grenada	64	46	27	30	23	15	11	21	14	15	12	17	30	**325**	0.248039
St. Kitts and Nevis	30	30	34	48	41	33	37	32	49	33	26	39	40	**472**	0.360228
St. Lucia	33	47	39	35	66	30	44	668	88	196	146	58	36	**1486**	1.134109
St. Vincent and the Grenadines	27	20	19	11	16	15	13	13	8	9	9	4	4	**168**	0.128217
TOTAL	**4947**	**4804**	**3903**	**5653**	**7383**	**9556**	**14137**	**14778**	**18228**	**9583**	**10667**	**14726**	**12663**	**131028**	
%change									**90.74927**	**-47.427**			**32.14025**		
									2005-2008	2008-2009			2009-2012		

Data for The Bahamas and some for Antigua and Barbuda were not available

Source: (CARICOM, 2014)

Appendix 7 Primary Data for 69 ports investigated

Group	Country	Category*	Year	TEU	BL	TA	TE
St. John	Antigua and Barbuda	1	2001	19000	366	3	6
St. John	Antigua and Barbuda	1	2002	20000	366	3	6
St. John	Antigua and Barbuda	1	2003	21700	366	3	6
St. John	Antigua and Barbuda	1	2004	22800	366	3	6
St. John	Antigua and Barbuda	1	2005	26100	366	3	6
St. John	Antigua and Barbuda	1	2006	30800	366	3	6
St. John	Antigua and Barbuda	1	2007	34081	366	3	6
St. John	Antigua and Barbuda	1	2008	32600	366	3	6
St. John	Antigua and Barbuda	1	2009	29150	366	3	6
St. John	Antigua and Barbuda	1	2010	24615	366	3	6
St. John	Antigua and Barbuda	1	2011	26018	366	3	6
Buenos Aires	Argentina	0	2001	650261	4504	124	23
Buenos Aires	Argentina	0	2002	482762	4472	124	23
Buenos Aires	Argentina	0	2003	590677	4439	123	23
Buenos Aires	Argentina	0	2004	1138503	4973	127	20
Buenos Aires	Argentina	0	2005	1075173	4908	127	28
Buenos Aires	Argentina	0	2006	1624077	4728	127	28
Buenos Aires	Argentina	0	2007	1710896	4818	127	28
Buenos Aires	Argentina	0	2008	1781100	4908	127	27
Buenos Aires	Argentina	0	2009	1412462	4908	127	27
Buenos Aires	Argentina	0	2010	1730831	4908	127	27
Buenos Aires	Argentina	0	2011	1851687	4728	127	28
Melbourne	Australia	0	2001	1423520	3524	110	10
Melbourne	Australia	0	2002	1631718	3624	130	14
Melbourne	Australia	0	2003	1721067	3724	150	17
Melbourne	Australia	0	2004	1836759	3794	150	16
Melbourne	Australia	0	2005	1862993	3794	150	16
Melbourne	Australia	0	2006	2031859	3574	150	18
Melbourne	Australia	0	2007	2206852	3574	150	18
Melbourne	Australia	0	2008	2113020	3574	150	17
Melbourne	Australia	0	2009	2047480	3015	146	16
Melbourne	Australia	0	2010	2322135	3015	146	17
Melbourne	Australia	0	2011	2443000	2995	121	19
Sydney	Australia	0	2001	1009342	2770	59	12
Sydney	Australia	0	2002	1160747	2770	59	12

Sydney	Australia	0	2003	1270216	3740	100	18
Sydney	Australia	0	2004	1376341	2790	99	15
Sydney	Australia	0	2005	1445465	2790	99	16
Sydney	Australia	0	2006	1620121	2790	99	16
Sydney	Australia	0	2007	1778370	2790	99	16
Sydney	Australia	0	2008	1784017	2790	99	16
Sydney	Australia	0	2009	1531000	2000	83	16
Sydney	Australia	0	2010	1986000	2000	83	16
Sydney	Australia	0	2011	2054000	2000	83	16
Freeport	Bahamas	1	2001	570000	914	40	7
Freeport	Bahamas	1	2002	860000	914	40	7
Freeport	Bahamas	1	2003	1057879	914	40	7
Freeport	Bahamas	1	2004	1184800	1036	49	9
Freeport	Bahamas	1	2005	1211500	1036	49	12
Freeport	Bahamas	1	2006	1632000	1036	49	12
Freeport	Bahamas	1	2007	1643000	1035	49	12
Freeport	Bahamas	1	2008	1702000	1033	49	12
Freeport	Bahamas	1	2009	1297000	1036	49	12
Freeport	Bahamas	1	2010	1125000	1036	49	12
Freeport	Bahamas	1	2011	1116272	1036	49	20
Bridgetown	Barbados	1	2001	67203	215	6	2
Bridgetown	Barbados	1	2002	68259	215	6	3
Bridgetown	Barbados	1	2003	70146	215	6	3
Bridgetown	Barbados	1	2004	82059	733	6	3
Bridgetown	Barbados	1	2005	88759	740	6	3
Bridgetown	Barbados	1	2006	98500	740	10	3
Bridgetown	Barbados	1	2007	99626	740	10	3
Bridgetown	Barbados	1	2008	87555	740	10	3
Bridgetown	Barbados	1	2009	75015	740	10	3
Bridgetown	Barbados	1	2010	80424	740	10	3
Bridgetown	Barbados	1	2011	77051	740	10	3
Antwerp	Belgium	0	2001	4218176	12901	464	75
Antwerp	Belgium	0	2002	4777387	11458	479	82
Antwerp	Belgium	0	2003	5445436	10014	494	88
Antwerp	Belgium	0	2004	6050442	12120	507	##
Antwerp	Belgium	0	2005	6482061	14354	743	##
Antwerp	Belgium	0	2006	7018911	14355	722	##
Antwerp	Belgium	0	2007	8175952	13738	733	96
Antwerp	Belgium	0	2008	8663736	13120	743	93
Antwerp	Belgium	0	2009	7309639	13120	685	93
Antwerp	Belgium	0	2010	8468475	13120	765	93
Antwerp	Belgium	0	2011	8664243	15130	738	91
Zeebrugge	Belgium	0	2001	875927	7887	221	21
Zeebrugge	Belgium	0	2002	958885	7561	240	20
Zeebrugge	Belgium	0	2003	1012674	7235	259	19

Zeebrugge	Belgium	0	2004	1196755	7693	290	21
Zeebrugge	Belgium	0	2005	1407933	7488	270	21
Zeebrugge	Belgium	0	2006	1653493	8440	306	21
Zeebrugge	Belgium	0	2007	2020723	8338	305	21
Zeebrugge	Belgium	0	2008	2209665	8235	305	20
Zeebrugge	Belgium	0	2009	2328198	8235	250	20
Zeebrugge	Belgium	0	2010	2389879	8235	287	20
Zeebrugge	Belgium	0	2011	2207257	8485	416	20
Montreal	Canada	0	2001	989427	3570	75	14
Montreal	Canada	0	2002	1054603	3570	75	14
Montreal	Canada	0	2003	1108837	3570	75	14
Montreal	Canada	0	2004	1226296	3565	80	14
Montreal	Canada	0	2005	1254560	3565	80	14
Montreal	Canada	0	2006	1288910	3565	80	14
Montreal	Canada	0	2007	1363021	3935	89	16
Montreal	Canada	0	2008	1473914	4305	99	18
Montreal	Canada	0	2009	1247690	3565	99	19
Montreal	Canada	0	2010	1331351	3565	99	19
Montreal	Canada	0	2011	1400000	3565	99	19
Vancouver	Canada	0	2001	1146577	4258	133	14
Vancouver	Canada	0	2002	1458242	4145	146	15
Vancouver	Canada	0	2003	1539058	4031	158	16
Vancouver	Canada	0	2004	1664900	4019	158	16
Vancouver	Canada	0	2005	1767379	4019	158	18
Vancouver	Canada	0	2006	2207730	4019	158	19
Vancouver	Canada	0	2007	2307289	3997	158	19
Vancouver	Canada	0	2008	2492107	3974	158	19
Vancouver	Canada	0	2009	2152462	3330	158	20
Vancouver	Canada	0	2010	2514309	3141	178	23
Vancouver	Canada	0	2011	2510000	3141	178	29
Fuzhou	China	0	2001	418000	1050	39	4
Fuzhou	China	0	2002	480000	1050	39	6
Fuzhou	China	0	2003	590000	1050	39	7
Fuzhou	China	0	2004	707900	1050	67	7
Fuzhou	China	0	2005	954826	1050	67	7
Fuzhou	China	0	2006	1012000	1050	67	10
Fuzhou	China	0	2007	1202000	1354	100	11
Fuzhou	China	0	2008	1177000	1658	133	12
Fuzhou	China	0	2009	1222700	1658	133	12
Fuzhou	China	0	2010	1318958	1658	133	12
Fuzhou	China	0	2011	1450853	1658	133	12
Yantai	China	0	2001	246169	467	25	4
Yantai	China	0	2002	267493	467	25	4
Yantai	China	0	2003	284562	753	47	6
Yantai	China	0	2004	290000	753	47	6

Yantai	China	0	2005	551000	1073	47	6
Yantai	China	0	2006	1779107	1782	67	12
Yantai	China	0	2007	1250000	1782	67	12
Yantai	China	0	2008	1532000	1883	86	16
Yantai	China	0	2009	1401000	1886	86	17
Yantai	China	0	2010	1527308	2013	86	17
Yantai	China	0	2011	1709000	2013	86	22
Barranquilla	Colombia	2	2001	83520	1058	93	1
Barranquilla	Colombia	2	2002	78453	1058	93	1
Barranquilla	Colombia	2	2003	73386	1058	93	1
Barranquilla	Colombia	2	2004	81818	1058	93	1
Barranquilla	Colombia	2	2005	90251	1058	93	1
Barranquilla	Colombia	2	2006	98683	1058	93	1
Barranquilla	Colombia	2	2007	95175	1058	93	1
Barranquilla	Colombia	2	2008	70362	1058	93	1
Barranquilla	Colombia	2	2009	70687	1058	93	1
Barranquilla	Colombia	2	2010	103869	1058	93	1
Barranquilla	Colombia	2	2011	148093	1058	93	5
Caucedo	Dominican Republic	1	2001	151980	600	50	3
Caucedo	Dominican Republic	1	2002	172940	600	50	4
Caucedo	Dominican Republic	1	2003	186497	600	50	5
Caucedo	Dominican Republic	1	2004	204975	600	50	5
Caucedo	Dominican Republic	1	2005	214865	600	50	5
Caucedo	Dominican Republic	1	2006	231328	600	50	5
Caucedo	Dominican Republic	1	2007	574441	600	50	5
Caucedo	Dominican Republic	1	2008	736879	600	50	5
Caucedo	Dominican Republic	1	2009	906279	600	50	5
Caucedo	Dominican Republic	1	2010	1004901	600	50	5
Caucedo	Dominican Republic	1	2011	993561	600	50	5
Rio Haina	Dominican Republic	1	2001	487827	834	32	3
Rio Haina	Dominican Republic	1	2002	430561	834	32	3
Rio Haina	Dominican Republic	1	2003	395664	1216	30	3
Rio Haina	Dominican Republic	1	2004	435201	1216	30	3
Rio Haina	Dominican Republic	1	2005	268738	1216	30	3
Rio Haina	Dominican Republic	1	2006	269747	1216	30	3
Rio Haina	Dominican	1	2007	248695	1216	30	3

	Republic						
Rio Haina	Dominican Republic	1	2008	283229	1216	30	3
Rio Haina	Dominican Republic	1	2009	277949	1216	30	3
Rio Haina	Dominican Republic	1	2010	288417	1216	30	3
Rio Haina	Dominican Republic	1	2011	352340	1216	30	3
Damietta	Egypt	0	2001	639325	1110	58	19
Damietta	Egypt	0	2002	750185	1110	58	19
Damietta	Egypt	0	2003	956045	1110	58	19
Damietta	Egypt	0	2004	1262946	1110	60	19
Damietta	Egypt	0	2005	1132886	1110	60	19
Damietta	Egypt	0	2006	829748	1110	60	19
Damietta	Egypt	0	2007	999193	1080	80	18
Damietta	Egypt	0	2008	1142184	1050	100	16
Damietta	Egypt	0	2009	1213187	1050	60	16
Damietta	Egypt	0	2010	1192000	1050	62	16
Damietta	Egypt	0	2011	1205036	1050	60	16
Dunkirk	France	0	2001	150592	906	26	46
Dunkirk	France	0	2002	160816	1261	26	45
Dunkirk	France	0	2003	161856	1616	26	43
Dunkirk	France	0	2004	200399	1616	26	41
Dunkirk	France	0	2005	204563	1590	26	41
Dunkirk	France	0	2006	204853	1590	26	41
Dunkirk	France	0	2007	197000	1735	37	42
Dunkirk	France	0	2008	215000	1880	49	42
Dunkirk	France	0	2009	212000	1880	49	42
Dunkirk	France	0	2010	200858	1880	49	42
Dunkirk	France	0	2011	207000	1950	49	43
Le Havre	France	0	2001	1525000	4150	175	22
Le Havre	France	0	2002	1720459	5113	172	23
Le Havre	France	0	2003	1977000	6075	168	23
Le Havre	France	0	2004	2150000	6075	168	23
Le Havre	France	0	2005	2118509	6075	205	30
Le Havre	France	0	2006	2130000	6075	205	30
Le Havre	France	0	2007	2656167	6540	233	34
Le Havre	France	0	2008	2488654	7005	261	38
Le Havre	France	0	2009	2240714	7005	261	38
Le Havre	France	0	2010	2358077	7005	261	38
Le Havre	France	0	2011	2485660	6265	295	40
Papeete	French Polynesia	3	2001	60330	450	8	2
Papeete	French Polynesia	3	2002	59899	450	8	2
Papeete	French Polynesia	3	2003	65514	450	8	2
Papeete	French Polynesia	3	2004	66421	450	8	2
Papeete	French Polynesia	3	2005	71226	450	10	3

Papeete	French Polynesia	3	2006	65575	454	10	3
Papeete	French Polynesia	3	2007	69508	454	10	3
Papeete	French Polynesia	3	2008	70336	454	10	3
Papeete	French Polynesia	3	2009	63807	454	10	3
Papeete	French Polynesia	3	2010	62497	454	10	3
Papeete	French Polynesia	3	2011	62719	454	10	3
Bremerhaven	Germany	0	2001	2972882	4470	279	41
Bremerhaven	Germany	0	2002	3031587	4255	253	37
Bremerhaven	Germany	0	2003	3189853	4040	227	33
Bremerhaven	Germany	0	2004	3469253	4040	227	33
Bremerhaven	Germany	0	2005	3735574	4040	227	33
Bremerhaven	Germany	0	2006	4428203	4090	240	33
Bremerhaven	Germany	0	2007	4892239	4090	259	42
Bremerhaven	Germany	0	2008	5500709	4470	279	51
Bremerhaven	Germany	0	2009	4535842	4470	279	51
Bremerhaven	Germany	0	2010	4871297	5260	279	51
Bremerhaven	Germany	0	2011	5920000	5260	436	51
Duisburg	Germany	0	2001	340000	1230	26	7
Duisburg	Germany	0	2002	360000	1230	26	7
Duisburg	Germany	0	2003	500000	1230	26	7
Duisburg	Germany	0	2004	607000	1230	26	7
Duisburg	Germany	0	2005	712000	1230	26	7
Duisburg	Germany	0	2006	787000	1530	37	8
Duisburg	Germany	0	2007	901000	1790	40	9
Duisburg	Germany	0	2008	1006000	2050	43	10
Duisburg	Germany	0	2009	935000	2050	43	10
Duisburg	Germany	0	2010	951248	2050	43	9
Duisburg	Germany	0	2011	992497	1700	108	6
Hamburg	Germany	0	2001	4688669	7993	384	60
Hamburg	Germany	0	2002	5373999	8108	395	62
Hamburg	Germany	0	2003	6138000	8223	407	64
Hamburg	Germany	0	2004	7003479	9163	506	66
Hamburg	Germany	0	2005	8087545	9248	541	73
Hamburg	Germany	0	2006	8861545	9248	541	73
Hamburg	Germany	0	2007	9890000	9248	540	71
Hamburg	Germany	0	2008	9737000	9248	538	68
Hamburg	Germany	0	2009	7007704	9148	573	88
Hamburg	Germany	0	2010	7900000	9148	593	88
Hamburg	Germany	0	2011	9010000	9148	582	91
Piraeus	Greece	0	2001	1165797	3100	90	15
Piraeus	Greece	0	2002	1404939	3100	90	15
Piraeus	Greece	0	2003	1605135	3100	90	15
Piraeus	Greece	0	2004	1541563	3100	90	16
Piraeus	Greece	0	2005	1394512	3100	90	16
Piraeus	Greece	0	2006	1403408	3100	90	16

Piraeus	Greece	0	2007	1373138	3100	90	16
Piraeus	Greece	0	2008	433582	3100	90	16
Piraeus	Greece	0	2009	664895	3100	90	16
Piraeus	Greece	0	2010	513319	3100	90	16
Piraeus	Greece	0	2011	505868	3594	78	12
Pointe-Pitre	Guadeloupe	1	2001	122558	600	25	3
Pointe-Pitre	Guadeloupe	1	2002	118013	600	25	3
Pointe-Pitre	Guadeloupe	1	2003	110073	600	25	3
Pointe-Pitre	Guadeloupe	1	2004	116042	600	30	3
Pointe-Pitre	Guadeloupe	1	2005	154263	600	30	3
Pointe-Pitre	Guadeloupe	1	2006	154432	600	30	3
Pointe-Pitre	Guadeloupe	1	2007	168839	600	30	3
Pointe-Pitre	Guadeloupe	1	2008	170729	600	30	3
Pointe-Pitre	Guadeloupe	1	2009	142692	600	30	3
Pointe-Pitre	Guadeloupe	1	2010	150534	600	30	3
Pointe-Pitre	Guadeloupe	1	2011	165093	600	30	4
Apra	Guam	3	2001	140158	830	13	4
Apra	Guam	3	2002	140990	830	13	4
Apra	Guam	3	2003	149517	830	13	4
Apra	Guam	3	2004	78224	830	13	4
Apra	Guam	3	2005	83867	830	13	4
Apra	Guam	3	2006	82207	830	13	3
Apra	Guam	3	2007	99630	830	13	3
Apra	Guam	3	2008	99908	830	13	3
Apra	Guam	3	2009	157096	830	13	3
Apra	Guam	3	2010	183214	830	13	3
Apra	Guam	3	2011	193475	830	13	3
Honolulu	Hawaiian Is.	0	2001	944963	1046	67	9
Honolulu	Hawaiian Is.	0	2002	980840	1317	70	9
Honolulu	Hawaiian Is.	0	2003	994763	1588	74	9
Honolulu	Hawaiian Is.	0	2004	1077468	1588	74	9
Honolulu	Hawaiian Is.	0	2005	1097826	1245	70	9
Honolulu	Hawaiian Is.	0	2006	1125382	1245	70	9
Honolulu	Hawaiian Is.	0	2007	1124389	1245	70	9
Honolulu	Hawaiian Is.	0	2008	1000000	1245	70	9
Honolulu	Hawaiian Is.	0	2009	968326	1245	70	9
Honolulu	Hawaiian Is.	0	2010	1021745	1245	70	9
Honolulu	Hawaiian Is.	0	2011	1752723	1283	70	9
Puerto Cortes	Honduras	2	2001	338932	999	14	6
Puerto Cortes	Honduras	2	2002	352984	999	14	6
Puerto Cortes	Honduras	2	2003	399839	999	14	8
Puerto Cortes	Honduras	2	2004	466697	999	14	8
Puerto Cortes	Honduras	2	2005	468563	999	14	8
Puerto Cortes	Honduras	2	2006	507946	999	14	8
Puerto Cortes	Honduras	2	2007	553139	999	14	8

Puerto Cortes	Honduras	2	2008	572382	999	14	8
Puerto Cortes	Honduras	2	2009	484148	999	14	8
Puerto Cortes	Honduras	2	2010	538853	999	14	8
Puerto Cortes	Honduras	2	2011	576752	999	14	8
Tuticorin	India	0	2001	203079	540	12	3
Tuticorin	India	0	2002	214238	540	12	3
Tuticorin	India	0	2003	223400	710	17	3
Tuticorin	India	0	2004	307310	880	22	3
Tuticorin	India	0	2005	321060	1051	28	4
Tuticorin	India	0	2006	377102	1051	28	4
Tuticorin	India	0	2007	450398	1051	28	4
Tuticorin	India	0	2008	438548	1051	28	4
Tuticorin	India	0	2009	439948	1051	28	4
Tuticorin	India	0	2010	467752	1051	28	4
Tuticorin	India	0	2011	475916	1051	28	4
Haifa	Israel	0	2001	571645	2518	30	12
Haifa	Israel	0	2002	615257	2518	30	12
Haifa	Israel	0	2003	679163	2518	30	12
Haifa	Israel	0	2004	1033056	2518	30	12
Haifa	Israel	0	2005	1122580	2518	50	12
Haifa	Israel	0	2006	1053098	2518	50	12
Haifa	Israel	0	2007	1148628	2518	50	16
Haifa	Israel	0	2008	1262000	2518	50	20
Haifa	Israel	0	2009	1140000	3468	50	28
Haifa	Israel	0	2010	1236552	3468	50	28
Haifa	Israel	0	2011	1235000	3468	71	28
Genoa	Italy	0	2001	1526526	5141	130	22
Genoa	Italy	0	2002	1531254	5241	131	22
Genoa	Italy	0	2003	1605946	5341	131	22
Genoa	Italy	0	2004	1628594	5341	171	14
Genoa	Italy	0	2005	1624964	9219	459	16
Genoa	Italy	0	2006	1657113	5490	429	20
Genoa	Italy	0	2007	1855026	7605	449	28
Genoa	Italy	0	2008	1766605	9720	469	36
Genoa	Italy	0	2009	1533627	9720	469	36
Genoa	Italy	0	2010	1758858	9720	469	36
Genoa	Italy	0	2011	1793722	5313	151	31
La Spezia	Italy	0	2001	974646	1297	33	7
La Spezia	Italy	0	2002	975005	1297	33	9
La Spezia	Italy	0	2003	1006641	1297	38	12
La Spezia	Italy	0	2004	1040438	1297	38	12
La Spezia	Italy	0	2005	1024455	1297	33	14
La Spezia	Italy	0	2006	1136664	1297	43	14
La Spezia	Italy	0	2007	1187040	1598	43	14
La Spezia	Italy	0	2008	1246139	1899	43	14

La Spezia	Italy	0	2009	1046063	1748	43	15
La Spezia	Italy	0	2010	1285455	1438	33	11
La Spezia	Italy	0	2011	1370000	1698	43	12
Kingston Container Terminal	Jamaica	1	2001	579245	1262	55	10
Kingston Container Terminal	Jamaica	1	2002	616045	1448	68	12
Kingston Container Terminal	Jamaica	1	2003	641177	1633	82	14
Kingston Container Terminal	Jamaica	1	2004	1223856	1633	82	14
Kingston Container Terminal	Jamaica	1	2005	1495120	1633	82	14
Kingston Container Terminal	Jamaica	1	2006	1983072	1633	82	14
Kingston Container Terminal	Jamaica	1	2007	1807925	2059	92	17
Kingston Container Terminal	Jamaica	1	2008	1690097	2485	102	19
Kingston Container Terminal	Jamaica	1	2009	914318	2485	102	19
Kingston Container Terminal	Jamaica	1	2010	946016	2485	102	19
Kingston Container Terminal	Jamaica	1	2011	906846	2310	132	19
Kingston Wharf	Jamaica	1	2001	94785	1278	22	5
Kingston Wharf	Jamaica	1	2002	103914	1278	24	5
Kingston Wharf	Jamaica	1	2003	102500	1278	26	5
Kingston Wharf	Jamaica	1	2004	136767	1644	26	5
Kingston Wharf	Jamaica	1	2005	132100	1644	26	5
Kingston Wharf	Jamaica	1	2006	170484	1644	26	5
Kingston Wharf	Jamaica	1	2007	208867	1644	26	4
Kingston Wharf	Jamaica	1	2008	225844	1644	26	3
Kingston Wharf	Jamaica	1	2009	203440	1479	26	3
Kingston Wharf	Jamaica	1	2010	255348	1644	26	4
Kingston Wharf	Jamaica	1	2011	242865	1644	26	4
Kobe	Japan	0	2001	2010343	9655	223	52
Kobe	Japan	0	2002	1992949	9380	216	52
Kobe	Japan	0	2003	2045714	9105	208	52
Kobe	Japan	0	2004	2176830	8095	195	52
Kobe	Japan	0	2005	2262066	9595	192	50
Kobe	Japan	0	2006	2412767	6985	177	39
Kobe	Japan	0	2007	2472808	6985	177	39
Kobe	Japan	0	2008	2556300	6985	177	39
Kobe	Japan	0	2009	2247024	6985	177	39
Kobe	Japan	0	2010	2556291	6985	174	37
Kobe	Japan	0	2011	2470000	7975	189	44
Nagoya	Japan	0	2001	1872272	3755	122	24
Nagoya	Japan	0	2002	1927244	3555	118	29
Nagoya	Japan	0	2003	2073995	3355	113	33

Nagoya	Japan	0	2004	2303541	3355	113	38
Nagoya	Japan	0	2005	2491198	3355	113	38
Nagoya	Japan	0	2006	2751677	3755	137	39
Nagoya	Japan	0	2007	2896221	3930	169	54
Nagoya	Japan	0	2008	2816827	4105	202	66
Nagoya	Japan	0	2009	2112738	3705	146	66
Nagoya	Japan	0	2010	2548851	3705	146	66
Nagoya	Japan	0	2011	2623138	3320	141	57
Osaka	Japan	0	2001	1508539	3835	90	17
Osaka	Japan	0	2002	1514662	3868	101	21
Osaka	Japan	0	2003	1607778	3900	113	24
Osaka	Japan	0	2004	1725565	3785	113	24
Osaka	Japan	0	2005	1802309	4435	130	26
Osaka	Japan	0	2006	2231516	3785	130	26
Osaka	Japan	0	2007	2309820	4110	130	26
Osaka	Japan	0	2008	2242939	4435	130	26
Osaka	Japan	0	2009	1126000	4435	130	22
Osaka	Japan	0	2010	1264000	4435	130	22
Osaka	Japan	0	2011	1467000	4435	220	22
Yokohama	Japan	0	2001	2303780	5690	178	40
Yokohama	Japan	0	2002	2364516	5325	176	40
Yokohama	Japan	0	2003	2504628	4960	173	40
Yokohama	Japan	0	2004	2717631	5830	173	40
Yokohama	Japan	0	2005	2873277	5830	211	40
Yokohama	Japan	0	2006	3199883	4040	191	38
Yokohama	Japan	0	2007	3428112	4595	200	38
Yokohama	Japan	0	2008	3481485	5150	210	38
Yokohama	Japan	0	2009	2797994	5150	210	38
Yokohama	Japan	0	2010	3280191	5150	210	38
Yokohama	Japan	0	2011	3083432	5390	210	38
Penang	Malaysia	0	2001	614945	931	58	8
Penang	Malaysia	0	2002	634042	931	58	8
Penang	Malaysia	0	2003	688171	931	58	8
Penang	Malaysia	0	2004	772024	931	83	8
Penang	Malaysia	0	2005	795289	1000	83	8
Penang	Malaysia	0	2006	849730	1100	83	9
Penang	Malaysia	0	2007	925991	1100	83	11
Penang	Malaysia	0	2008	929639	1100	83	13
Penang	Malaysia	0	2009	958476	1100	83	13
Penang	Malaysia	0	2010	1106098	1100	67	18
Penang	Malaysia	0	2011	1198843	1100	67	18
Maarsaxlokk	Malta	0	2001	1165070	2646	48	18
Maarsaxlokk	Malta	0	2002	1244232	2646	48	17
Maarsaxlokk	Malta	0	2003	1300000	2646	48	16
Maarsaxlokk	Malta	0	2004	1461174	2646	55	16

Maarsaxlokk	Malta	0	2005	1321000	2646	55	16
Maarsaxlokk	Malta	0	2006	1600000	2426	62	20
Maarsaxlokk	Malta	0	2007	1901180	2536	63	20
Maarsaxlokk	Malta	0	2008	2334182	2646	65	20
Maarsaxlokk	Malta	0	2009	2250000	2646	67	23
Maarsaxlokk	Malta	0	2010	2370729	2646	68	23
Maarsaxlokk	Malta	0	2011	2360000	2426	68	22
Port Louis	Mauritius	3	2001	161634	1319	29	6
Port Louis	Mauritius	3	2002	198177	1215	49	6
Port Louis	Mauritius	3	2003	280000	1110	70	5
Port Louis	Mauritius	3	2004	209118	1110	70	5
Port Louis	Mauritius	3	2005	253772	1110	69	5
Port Louis	Mauritius	3	2006	359265	1000	44	5
Port Louis	Mauritius	3	2007	417896	1000	44	5
Port Louis	Mauritius	3	2008	454433	925	44	6
Port Louis	Mauritius	3	2009	406862	1110	44	6
Port Louis	Mauritius	3	2010	401991	1110	44	6
Port Louis	Mauritius	3	2011	438695	1110	32	6
Noumea	New Caledonia	3	2001	54862	700	34	2
Noumea	New Caledonia	3	2002	61464	700	34	2
Noumea	New Caledonia	3	2003	66192	700	34	2
Noumea	New Caledonia	3	2004	69464	700	34	2
Noumea	New Caledonia	3	2005	72106	700	34	2
Noumea	New Caledonia	3	2006	76632	700	34	2
Noumea	New Caledonia	3	2007	83205	700	34	2
Noumea	New Caledonia	3	2008	86243	700	34	2
Noumea	New Caledonia	3	2009	85039	700	34	2
Noumea	New Caledonia	3	2010	90574	700	34	2
Noumea	New Caledonia	3	2011	95277	750	25	6
Willemstad	NL Antilles	1	2001	48937	500	16	3
Willemstad	NL Antilles	1	2002	80741	500	16	3
Willemstad	NL Antilles	1	2003	81212	500	16	3
Willemstad	NL Antilles	1	2004	85500	500	16	3
Willemstad	NL Antilles	1	2005	89229	500	16	3
Willemstad	NL Antilles	1	2006	90759	512	16	3
Willemstad	NL Antilles	1	2007	97271	506	16	3
Willemstad	NL Antilles	1	2008	97649	500	16	3
Willemstad	NL Antilles	1	2009	97913	500	16	3
Willemstad	NL Antilles	1	2010	93603	500	16	3
Willemstad	NL Antilles	1	2011	91748	500	16	3
Manzanillo	Panama	2	2001	959674	1465	37	10
Manzanillo	Panama	2	2002	954685	1465	37	10
Manzanillo	Panama	2	2003	1125780	1465	37	10
Manzanillo	Panama	2	2004	1473159	1665	45	12
Manzanillo	Panama	2	2005	1580649	1665	49	12

Manzanillo	Panama	2	2006	1331267	1665	52	12
Manzanillo	Panama	2	2007	1279894	1803	52	14
Manzanillo	Panama	2	2008	1600000	1940	52	16
Manzanillo	Panama	2	2009	1406030	1940	52	16
Manzanillo	Panama	2	2010	1599676	1940	52	18
Manzanillo	Panama	2	2011	1899802	1940	52	18
Manila	Phillipines	0	2001	2296151	6705	206	26
Manila	Phillipines	0	2002	2462169	7492	206	29
Manila	Phillipines	0	2003	2552187	8278	206	32
Manila	Phillipines	0	2004	2696878	8278	194	32
Manila	Phillipines	0	2005	2665015	8382	194	31
Manila	Phillipines	0	2006	2719585	8097	194	30
Manila	Phillipines	0	2007	2869447	7675	192	30
Manila	Phillipines	0	2008	2977606	7252	200	30
Manila	Phillipines	0	2009	3148569	7247	168	30
Manila	Phillipines	0	2010	3439542	7252	168	30
Manila	Phillipines	0	2011	3460000	7252	200	30
Leixoes	Portugal	0	2001	244000	900	15	4
Leixoes	Portugal	0	2002	199036	900	15	4
Leixoes	Portugal	0	2003	208572	900	15	4
Leixoes	Portugal	0	2004	227220	900	15	4
Leixoes	Portugal	0	2005	233294	900	15	4
Leixoes	Portugal	0	2006	249570	900	18	4
Leixoes	Portugal	0	2007	282693	900	18	5
Leixoes	Portugal	0	2008	293109	900	18	5
Leixoes	Portugal	0	2009	450058	900	18	5
Leixoes	Portugal	0	2010	481784	900	18	5
Leixoes	Portugal	0	2011	513824	1263	22	8
Lisbon	Portugal	0	2001	450000	1866	31	9
Lisbon	Portugal	0	2002	487529	1875	32	9
Lisbon	Portugal	0	2003	554405	1883	33	9
Lisbon	Portugal	0	2004	511560	1883	33	9
Lisbon	Portugal	0	2005	513061	1883	33	9
Lisbon	Portugal	0	2006	512501	1883	33	9
Lisbon	Portugal	0	2007	554774	1868	33	11
Lisbon	Portugal	0	2008	556062	1852	33	12
Lisbon	Portugal	0	2009	500857	1852	33	12
Lisbon	Portugal	0	2010	512789	1852	33	12
Lisbon	Portugal	0	2011	536111	1852	33	12
St. Petersburg	Russia	0	2001	478659	1556	25	14
St. Petersburg	Russia	0	2002	580639	1626	30	16
St. Petersburg	Russia	0	2003	649812	1696	34	17
St. Petersburg	Russia	0	2004	773467	2313	49	30
St. Petersburg	Russia	0	2005	1119346	2313	49	30
St. Petersburg	Russia	0	2006	1449958	2313	60	24

St. Petersburg	Russia	0	2007	1697720	2203	81	23
St. Petersburg	Russia	0	2008	1983110	2203	102	22
St. Petersburg	Russia	0	2009	1341850	2203	117	22
St. Petersburg	Russia	0	2010	1931382	2393	127	24
St. Petersburg	Russia	0	2011	2197000	2927	263	29
Dammam	Saudi Arabia	0	2001	489544	960	50	17
Dammam	Saudi Arabia	0	2002	563149	960	50	17
Dammam	Saudi Arabia	0	2003	632776	960	50	17
Dammam	Saudi Arabia	0	2004	440411	960	50	17
Dammam	Saudi Arabia	0	2005	454640	960	50	17
Dammam	Saudi Arabia	0	2006	941828	960	50	17
Dammam	Saudi Arabia	0	2007	1087395	1200	50	20
Dammam	Saudi Arabia	0	2008	1247039	1440	50	22
Dammam	Saudi Arabia	0	2009	1227392	1440	50	22
Dammam	Saudi Arabia	0	2010	1333094	1440	50	22
Dammam	Saudi Arabia	0	2011	1492315	1440	72	22
Jeddah	Saudi Arabia	0	2001	1180427	2899	228	31
Jeddah	Saudi Arabia	0	2002	1366902	2899	228	32
Jeddah	Saudi Arabia	0	2003	1777165	2899	228	33
Jeddah	Saudi Arabia	0	2004	1002628	2899	237	33
Jeddah	Saudi Arabia	0	2005	1043617	2899	237	33
Jeddah	Saudi Arabia	0	2006	2907723	2899	228	33
Jeddah	Saudi Arabia	0	2007	3067563	2790	240	33
Jeddah	Saudi Arabia	0	2008	3325749	2680	252	33
Jeddah	Saudi Arabia	0	2009	3091312	2680	252	33
Jeddah	Saudi Arabia	0	2010	3830857	3732	252	39
Jeddah	Saudi Arabia	0	2011	3875728	4100	314	43
Gwangyang	South Korea	0	2001	856407	3700	21	12
Gwangyang	South Korea	0	2002	1076426	3700	32	13
Gwangyang	South Korea	0	2003	1184842	3700	42	14
Gwangyang	South Korea	0	2004	1321862	3700	137	15
Gwangyang	South Korea	0	2005	1441261	3700	137	15
Gwangyang	South Korea	0	2006	1755813	3700	137	16
Gwangyang	South Korea	0	2007	1722676	3700	137	16
Gwangyang	South Korea	0	2008	1810048	3700	137	16
Gwangyang	South Korea	0	2009	1830317	3700	137	16
Gwangyang	South Korea	0	2010	2084892	3700	137	16
Gwangyang	South Korea	0	2011	2253000	3700	137	16
Barcelona	Spain	0	2001	1411054	4506	93	41
Barcelona	Spain	0	2002	1461232	4506	93	39
Barcelona	Spain	0	2003	1652366	4506	93	36
Barcelona	Spain	0	2004	1916494	4820	124	42
Barcelona	Spain	0	2005	2071481	4822	128	43
Barcelona	Spain	0	2006	2318241	4824	128	40
Barcelona	Spain	0	2007	2610099	4958	116	38

Barcelona	Spain	0	2008	2569550	5091	104	36
Barcelona	Spain	0	2009	1800213	4048	105	28
Barcelona	Spain	0	2010	1945735	4498	105	28
Barcelona	Spain	0	2011	2034693	5878	105	33
Bilbao	Spain	0	2001	481000	2096	30	14
Bilbao	Spain	0	2002	455020	2107	41	15
Bilbao	Spain	0	2003	448565	2118	53	15
Bilbao	Spain	0	2004	338189	2118	53	15
Bilbao	Spain	0	2005	503804	2118	53	15
Bilbao	Spain	0	2006	523113	2118	53	15
Bilbao	Spain	0	2007	554557	1823	56	15
Bilbao	Spain	0	2008	557355	1527	59	14
Bilbao	Spain	0	2009	443464	1500	49	9
Bilbao	Spain	0	2010	531457	1500	49	9
Bilbao	Spain	0	2011	610131	1500	49	9
Castries	St. Lucia	1	2001	9554	310	3	3
Castries	St. Lucia	1	2002	23003	310	3	3
Castries	St. Lucia	1	2003	22792	310	3	3
Castries	St. Lucia	1	2004	24956	733	3	3
Castries	St. Lucia	1	2005	29667	733	3	3
Castries	St. Lucia	1	2006	32112	448	12	2
Castries	St. Lucia	1	2007	36117	448	12	2
Castries	St. Lucia	1	2008	35950	448	12	2
Castries	St. Lucia	1	2009	30186	448	12	2
Castries	St. Lucia	1	2010	30648	448	12	2
Castries	St. Lucia	1	2011	29550	448	12	2
Vieux Fort	St. Lucia	1	2001	14975	210	5	1
Vieux Fort	St. Lucia	1	2002	18749	210	5	1
Vieux Fort	St. Lucia	1	2003	22149	210	5	1
Vieux Fort	St. Lucia	1	2004	28429	210	5	1
Vieux Fort	St. Lucia	1	2005	31080	210	5	1
Vieux Fort	St. Lucia	1	2006	24155	210	5	1
Vieux Fort	St. Lucia	1	2007	19465	210	5	1
Vieux Fort	St. Lucia	1	2008	39190	210	5	1
Vieux Fort	St. Lucia	1	2009	21756	210	5	1
Vieux Fort	St. Lucia	1	2010	21831	210	5	1
Vieux Fort	St. Lucia	1	2011	26144	210	5	1
Gothenburg	Sweden	0	2001	596000	2700	155	8
Gothenburg	Sweden	0	2002	645533	2883	155	8
Gothenburg	Sweden	0	2003	665870	3065	155	8
Gothenburg	Sweden	0	2004	732300	3486	155	8
Gothenburg	Sweden	0	2005	771679	3486	155	8
Gothenburg	Sweden	0	2006	811508	3486	155	8
Gothenburg	Sweden	0	2007	840550	3486	155	8
Gothenburg	Sweden	0	2008	862500	3486	155	7

Gothenburg	Sweden	0	2009	724900	3486	155	7
Gothenburg	Sweden	0	2010	796000	3486	155	7
Gothenburg	Sweden	0	2011	887000	4586	155	9
Taichung	Taiwan	0	2001	1069355	1800	40	7
Taichung	Taiwan	0	2002	1193657	1800	67	7
Taichung	Taiwan	0	2003	1246027	1800	94	13
Taichung	Taiwan	0	2004	1245185	1800	94	13
Taichung	Taiwan	0	2005	1228915	1800	94	13
Taichung	Taiwan	0	2006	1198530	1800	94	13
Taichung	Taiwan	0	2007	1250000	1800	94	13
Taichung	Taiwan	0	2008	1221500	1800	94	13
Taichung	Taiwan	0	2009	1193000	1800	94	13
Taichung	Taiwan	0	2010	1356952	1800	94	13
Taichung	Taiwan	0	2011	1380000	1800	94	13
Bangkok	Thailand	0	2001	1069179	3217	48	10
Bangkok	Thailand	0	2002	1136293	3611	66	13
Bangkok	Thailand	0	2003	1172126	4004	85	15
Bangkok	Thailand	0	2004	1318000	4079	85	17
Bangkok	Thailand	0	2005	1349246	4154	93	17
Bangkok	Thailand	0	2006	1451366	4154	93	17
Bangkok	Thailand	0	2007	1558511	4154	93	17
Bangkok	Thailand	0	2008	1451951	4154	93	17
Bangkok	Thailand	0	2009	1222048	4154	93	18
Bangkok	Thailand	0	2010	1452829	4154	93	18
Bangkok	Thailand	0	2011	1467302	4154	89	18
Point Lisas	Trinidad and Tobago	1	2001	81602	510	5	5
Point Lisas	Trinidad and Tobago	1	2002	95058	510	5	5
Point Lisas	Trinidad and Tobago	1	2003	98368	510	5	5
Point Lisas	Trinidad and Tobago	1	2004	99000	510	5	5
Point Lisas	Trinidad and Tobago	1	2005	120749	510	5	5
Point Lisas	Trinidad and Tobago	1	2006	147136	510	5	5
Point Lisas	Trinidad and Tobago	1	2007	156016	510	5	5
Point Lisas	Trinidad and Tobago	1	2008	175000	645	8	5
Point Lisas	Trinidad and Tobago	1	2009	164183	645	8	5
Point Lisas	Trinidad and Tobago	1	2010	184257	645	8	5
Point Lisas	Trinidad and Tobago	1	2011	175901	645	8	5
Port of Spain	Trinidad and Tobago	1	2001	271156	480	12	3
Port of Spain	Trinidad and Tobago	1	2002	290175	707	16	7

Port of Spain	Trinidad and Tobago	1	2003	342000	934	20	11
Port of Spain	Trinidad and Tobago	1	2004	350468	934	20	11
Port of Spain	Trinidad and Tobago	1	2005	322466	934	20	11
Port of Spain	Trinidad and Tobago	1	2006	324939	934	20	11
Port of Spain	Trinidad and Tobago	1	2007	358541	934	20	11
Port of Spain	Trinidad and Tobago	1	2008	385000	934	20	11
Port of Spain	Trinidad and Tobago	1	2009	403000	934	20	11
Port of Spain	Trinidad and Tobago	1	2010	388960	934	20	11
Port of Spain	Trinidad and Tobago	1	2011	379837	934	20	13
Ambarli	Turkey	0	2001	2417255	4586	80	27
Ambarli	Turkey	0	2002	571623	4586	80	27
Ambarli	Turkey	0	2003	772873	4586	80	27
Ambarli	Turkey	0	2004	1190000	4496	80	28
Ambarli	Turkey	0	2005	1185768	3630	80	26
Ambarli	Turkey	0	2006	1446267	5090	80	27
Ambarli	Turkey	0	2007	1940000	5090	80	27
Ambarli	Turkey	0	2008	2262000	5090	80	27
Ambarli	Turkey	0	2009	1836030	5090	80	27
Ambarli	Turkey	0	2010	2540353	5090	80	27
Ambarli	Turkey	0	2011	2690000	5090	80	27
Felixtowe	United Kingdom	0	2001	2800000	3300	208	37
Felixtowe	United Kingdom	0	2002	2750000	3334	208	38
Felixtowe	United Kingdom	0	2003	2500000	3459	208	39
Felixtowe	United Kingdom	0	2004	2700000	3459	208	39
Felixtowe	United Kingdom	0	2005	2700000	3729	208	41
Felixtowe	United Kingdom	0	2006	3000000	3729	208	41
Felixtowe	United Kingdom	0	2007	3300000	3729	153	38
Felixtowe	United Kingdom	0	2008	3200000	3729	160	35
Felixtowe	United Kingdom	0	2009	3100000	3729	152	30
Felixtowe	United Kingdom	0	2010	3400000	4062	156	31
Felixtowe	United Kingdom	0	2011	3519000	4062	156	38
Charleston	United States of America	0	2001	1528034	3103	214	27
Charleston	United States of America	0	2002	1592835	3103	199	28
Charleston	United States of America	0	2003	1690846	3102	183	28
Charleston	United States of America	0	2004	1863917	3102	183	28
Charleston	United States of America	0	2005	1986586	3102	183	29
Charleston	United States of America	0	2006	1884000	3102	183	29

Charleston	United States of America	0	2007	1750000	3102	183	29
Charleston	United States of America	0	2008	1370000	3102	183	29
Charleston	United States of America	0	2009	1277760	3102	183	32
Charleston	United States of America	0	2010	1383533	3102	183	32
Charleston	United States of America	0	2011	1380000	3102	183	32
New York/Jersey	United States of America	0	2001	3316276	7098	525	42
New York/Jersey	United States of America	0	2002	3749014	7834	546	48
New York/Jersey	United States of America	0	2003	4067812	8569	568	53
New York/Jersey	United States of America	0	2004	4478480	9037	568	53
New York/Jersey	United States of America	0	2005	4792922	9037	568	71
New York/Jersey	United States of America	0	2006	5092806	9037	568	71
New York/Jersey	United States of America	0	2007	5299105	8326	562	69
New York/Jersey	United States of America	0	2008	5265053	7615	557	66
New York/Jersey	United States of America	0	2009	4561831	7615	607	70
New York/Jersey	United States of America	0	2010	5292020	7615	557	70
New York/Jersey	United States of America	0	2011	5503486	7615	557	70
Norfolk Virginia	United States of America	0	2001	1303797	3330	396	17
Norfolk Virginia	United States of America	0	2002	1437779	3330	396	17
Norfolk Virginia	United States of America	0	2003	1646279	3330	396	17
Norfolk Virginia	United States of America	0	2004	1808933	3330	396	17
Norfolk Virginia	United States of America	0	2005	1981955	3330	396	18
Norfolk Virginia	United States of America	0	2006	1612000	3330	396	18
Norfolk Virginia	United States of America	0	2007	1765000	3819	442	21
Norfolk Virginia	United States of America	0	2008	2083278	4307	489	23
Norfolk Virginia	United States of America	0	2009	1745228	3801	425	23
Norfolk Virginia	United States of America	0	2010	1895018	4560	513	23
Norfolk Virginia	United States of America	0	2011	1900000	4560	513	23
Oakland	United States of America	0	2001	1643585	4415	171	24
Oakland	United States of America	0	2002	1707827	5775	248	31

Oakland	United States of America	0	2003	1923136	7134	324	38
Oakland	United States of America	0	2004	2047504	7134	324	38
Oakland	United States of America	0	2005	2273990	7124	324	38
Oakland	United States of America	0	2006	2391598	6881	307	38
Oakland	United States of America	0	2007	2387911	6071	303	36
Oakland	United States of America	0	2008	2236244	5260	300	33
Oakland	United States of America	0	2009	2051442	6881	269	38
Oakland	United States of America	0	2010	2330302	5523	347	37
Oakland	United States of America	0	2011	2342504	6541	325	37
Savannah	United States of America	0	2001	1077486	2322	453	13
Savannah	United States of America	0	2002	1327939	2322	453	14
Savannah	United States of America	0	2003	1521728	2322	453	15
Savannah	United States of America	0	2004	1662008	2322	453	15
Savannah	United States of America	0	2005	1901520	2322	486	15
Savannah	United States of America	0	2006	2160168	2700	486	18
Savannah	United States of America	0	2007	2604509	2828	486	21
Savannah	United States of America	0	2008	2616162	2955	486	21
Savannah	United States of America	0	2009	2356512	4713	567	22
Savannah	United States of America	0	2010	2825179	4713	567	24
Savannah	United States of America	0	2011	2982000	4713	567	30
Seattle	United States of America	0	2001	1315109	4361	174	25
Seattle	United States of America	0	2002	1438872	4208	189	25
Seattle	United States of America	0	2003	1486465	4055	204	25
Seattle	United States of America	0	2004	1775858	4055	204	25
Seattle	United States of America	0	2005	2087929	4055	204	25
Seattle	United States of America	0	2006	1987360	3307	203	26
Seattle	United States of America	0	2007	1973504	3365	203	26
Seattle	United States of America	0	2008	1704492	3423	203	25
Seattle	United States of America	0	2009	1584596	3423	203	24

Seattle	United States of America	0	2010	2113548	4246	229	30
Seattle	United States of America	0	2011	2030000	4231	229	30
Tacoma	United States of America	0	2001	1320274	2053	178	18
Tacoma	United States of America	0	2002	1470834	2055	178	19
Tacoma	United States of America	0	2003	1738068	2057	178	19
Tacoma	United States of America	0	2004	1797560	2057	178	19
Tacoma	United States of America	0	2005	2066447	3478	259	24
Tacoma	United States of America	0	2006	2067186	2959	215	24
Tacoma	United States of America	0	2007	1924934	2959	229	24
Tacoma	United States of America	0	2008	1861358	2959	244	24
Tacoma	United States of America	0	2009	1545855	2959	244	26
Tacoma	United States of America	0	2010	1455467	2959	259	26
Tacoma	United States of America	0	2011	1107096	2959	225	26
Ho Chi Minh City	Vietnam	0	2001	204215	441	18	27
Ho Chi Minh City	Vietnam	0	2002	1171428	2595	107	28
Ho Chi Minh City	Vietnam	0	2003	1471030	4704	202	54
Ho Chi Minh City	Vietnam	0	2004	1674187	4704	202	66
Ho Chi Minh City	Vietnam	0	2005	1911016	4704	158	68
Ho Chi Minh City	Vietnam	0	2006	2327631	4704	202	66
Ho Chi Minh City	Vietnam	0	2007	3172000	4704	202	66
Ho Chi Minh City	Vietnam	0	2008	3432000	4704	202	66
Ho Chi Minh City	Vietnam	0	2009	3563246	4704	202	66
Ho Chi Minh City	Vietnam	0	2010	3856000	5434	259	75
Ho Chi Minh City	Vietnam	0	2011	4674326	5722	259	79

*Ports categorized: TOP=0, Caribbean=1, Near Caribbean= 2, Other SIDS (OSIDS) =3

Appendix 8 Sample Ports per Sub-group

#	Port	Country	Code	Group	#	Port	Country	Code	Group
1	Buenos Aires	Argentina	0		36	Bilbao	Spain	0	
2	Melbourne	Australia	0		37	Gothenburg	Sweden	0	
3	Sydney	Australia	0		38	Taichung	Taiwan	0	
4	Antwerp	Belgium	0		39	Bangkok	Thailand	0	
5	Zeebrugge	Belgium	0		40	Ambarli	Turkey	0	
6	Montreal	Canada	0		41	Felixtowe	UK	0	
7	Vancouver	Canada	0		42	Charleston	US	0	
8	Fuzhou	China	0		43	New York	US	0	**TOP**
9	Yantai	China	0		44	Oakland	US	0	
10	Damietta	Egypt	0		45	Savannah	US	0	
11	Dunkirk	France	0		46	Seattle	US	0	
12	Le Havre	France	0		47	Tacoma	US	0	
13	Bremerhaven	Germany	0		48	Norfolk Virginia	US	0	
14	Duisburg	Germany	0		49	Ho Chi Minh City	Vietnam	0	
15	Hamburg	Germany	0		50	St. John	Antigua & Barbuda	1	
16	Piraeus	Greece	0		51	FCP*	Bahamas	1	
17	Honolulu	Hawaiian Is.	0		52	Bridgetown	Barbados	1	
18	Tuticorin	India	0	**TOP**	53	Rio Haina	DR	1	
19	Haifa	Israel	0		54	Caucedo	DR	1	**CARI.**
20	Genoa	Italy	0		55	Pointe-Pitre	Guadeloupe	1	
21	La Spezia	Italy	0		56	KCT	Jamaica	1	
22	Yokohama	Japan	0		57	KW	Jamaica	1	
23	Osaka	Japan	0		58	Willemstad	NL Antilles	1	
24	Kobe	Japan	0		59	Castries	St. Lucia	1	
25	Nagoya	Japan	0		60	Vieux Fort	St. Lucia	1	
26	Penang	Malaysia	0		61	PL#	Trinidad	1	
27	Maarsaxlokk	Malta	0		62	POS	Trinidad	1	
28	Manila	Philippines	0		63	Barranquilla	Colombia	2	
29	Leixoes	Portugal	0		64	Puerto Cortes	Honduras	2	**NCARI.**
31	St. Petersburg	Russia	0		65	Manzanillo	Panama	2	
32	Dammam	Saudi Arabia	0		66	Papeete	French Polynesia	3	
33	Jeddah	Saudi Arabia	0		67	Apra	Guam	3	
34	Gwangyang	South Korea	0		68	Port Louis	Mauritius	3	**OSIDS**
35	Barcelona	Spain	0		69	Noumea	New Caledonia	3	

*Freeport Container Port, #Point Lisas

The efficiency measures for the MPI can be generated from any efficiency assessment method, and in this case DEA is used to generate these. As above, in what follows all of these are specified in terms of the primal multiplier problem in standard form.

The four measures to be calculated therefore are:

Production in year t against the frontier in year t. This is as specified above, but with subscripts added to identify the time period:

Max: $PE_{it/t} = \mu(TEU_{it})$

Subject to: $v^B BL_{it} + v^A TA_{it} + v^E TE_{it} = 1$

$$\mu TEU_{jt} - \left(v^B BL_{jt} + v^A TA_{jt} + v^E TE_{jt}\right) \leq 0, j = 1,2, \ldots ,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad (1)$$

Production in year s against the frontier in year s. As s is the previous year, this just equates to t – 1, however for completeness is given below:

Max: $PE_{is/s} = \mu(TEU_{is})$

Subject to: $v^B BL_{is} + v^A TA_{is} + v^E TE_{is} = 1$

$$\mu TEU_{js} - \left(v^B BL_{js} + v^A TA_{js} + v^E TE_{js}\right) \leq 0, j = 1,2, \ldots ,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad (2)$$

Production in year t against the frontier in year s is found by:

Max: $PE_{it/s} = \mu(TEU_{it})$

Subject to: $v^B BL_{it} + v^A TA_{it} + v^E TE_{it} = 1$

$$\mu TEU_{js} - \left(v^B BL_{js} + v^A TA_{js} + v^E TE_{js}\right) \leq 0, j = 1,2, \ldots ,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad (3)$$

Production in year s against the frontier in year t:

Max: $$PE_{is/t} = \mu(TEU_{is})$$

Subject to: $$v^B BL_{is} + v^A TA_{is} + v^E TE_{is} = 1$$

$$\mu TEU_{jt} - \left(v^B BL_{jt} + v^A TA_{jt} + v^E TE_{jt}\right) \leq 0, j = 1,2, \dots ,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad (4)$$

In these last two cases, the efficiency of the firm is not constrained to an upper value of 100%, and in the case of the former DEA program (current to previous), this would be an indicator of technical progress.

Once the four efficiency measures are estimated, efficiency change is calculated as:

$$EC_{it} = \frac{PE_{it/t}}{PE_{is/s}} \qquad (5)$$

Hence if the firm's production level in year t is found to be nearer the respective production frontier that in year s, PE_{itt} will be greater than PE_{iss}, consequently equation 5 will produce a value greater than one, representing an efficiency improvement. Values less than one represent an efficiency decline.

Technical change is calculated as:

$$TC_{it} = Geomean\left[\left(\frac{PE_{is/s}}{PE_{is/t}}\right), \left(\frac{PE_{it/s}}{PE_{it/t}}\right)\right] \qquad (6)$$

In this case, if the firm's production position in year s to the production frontier in year s ($PE_{is/s}$) is found to be nearer to the frontier than year s production position would have been to the frontier in year t ($PE_{is/t}$), this would clearly represent technical progress over the two time periods, which in the case of equation 5.12 would produce a value greater than one,. The same applies for the year t comparator and the average (the geometric mean) is taken of the two.

As before, TFP is the multiplication of EC and TC.

Following Fare et al. (1994), efficiency change can be further broken down into scale effects and 'pure' efficiency change, which in this case will be defined as managerial efficiency. For each DMU in the data set, this requires the estimation of two further linear programs, both of which apply the VRS assumption to the estimation: Let PME_i = the managerial (pure) efficiency of Port I, hence the problems to be solved are:

Max: $$PME_{is} = \mu(TEU_{is}) - z_{is}$$

Subject to: $$v^B BL_{is} + v^A TA_{is} + v^E TE_{is} = 1$$

$$\mu(TEU_{js}) - \left(v^B BL_{js} + v^A TA_{js} + v^E TE_{js}\right) - z_i \leq 0, \quad j = 1,2,\dots,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad (7)$$

Max: $$PME_{it} = \mu(TEU_{it}) - z_{it}$$

Subject to: $$v^B BL_{it} + v^A TA_{it} + v^E TE_{it} = 1$$

$$\mu(TEU_{jt}) - \left(v^B BL_{jt} + v^A TA_{jt} + v^E TE_{jt}\right) - z_i \leq 0, \quad j = 1,2,\dots,69$$

$$\mu, v^B, v^A, v^E \geq 0 \qquad (8)$$

Managerial efficiency change therefore is given by:

$$MEC_{it} = \frac{PME_{it}}{PME_s} \qquad (9)$$

And scale efficiency change by:

$$SEC_{it} = \frac{PE_{it}{}_{/t}/PME_{it}}{PE_{is}{}_{/s}/PME_{is}} \qquad (10)$$

Appendix 10 Descriptive Statistics per annum using CRS & VRS estimates for the entire sample

		2001			2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		DEA-CCR	DEA-BCC
	Port	Area	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS		
1	Buenos Aires	0	0.20	0.29	0.17	0.23	0.18	0.26	0.42	0.50	0.29	0.41	0.42	0.59	0.45	0.58	0.46	0.54	0.44	0.51	0.47	0.58	0.49	0.61	0.36	0.46
2	Melbourne	0	0.88	1.00	0.70	0.95	0.67	0.88	0.84	0.97	0.86	0.93	0.76	0.80	0.88	0.89	0.85	0.86	0.75	1.00	0.74	1.00	0.76	0.95	0.79	0.93
3	Sydney	0	0.59	0.71	0.80	0.92	0.48	0.65	0.68	0.77	0.68	0.72	0.68	0.71	0.80	0.81	0.78	0.78	0.77	0.84	0.88	1.00	0.87	0.95	0.73	0.80
4	Antwerp	0	0.42	0.90	0.47	0.89	0.47	0.89	0.47	0.86	0.48	0.80	0.47	0.79	0.61	0.83	0.64	0.89	0.52	1.00	0.51	1.00	0.49	0.96	0.50	0.89
5	Zeebrugge	0	0.26	0.41	0.28	0.44	0.35	0.48	0.40	0.50	0.49	0.55	0.53	0.57	0.69	0.70	0.75	0.77	0.64	0.99	0.60	0.93	0.56	0.78	0.50	0.65
6	Montreal	0	0.48	0.62	0.60	0.73	0.55	0.70	0.66	0.73	0.67	0.70	0.62	0.64	0.62	0.62	0.57	0.58	0.53	0.59	0.49	0.58	0.50	0.58	0.57	0.64
7	Vancouver	0	0.51	0.68	0.57	0.81	0.64	0.83	0.75	0.88	0.72	0.80	0.78	0.83	0.87	0.88	0.90	0.91	0.69	0.92	0.63	0.93	0.58	0.74	0.69	0.84
8	Fuzhou	0	0.66	0.67	0.59	0.61	0.57	0.57	0.76	0.76	1.00	1.00	0.73	0.74	0.79	0.80	0.67	0.68	0.56	0.79	0.55	0.78	0.61	0.71	0.68	0.74
9	Yantai	0	0.61	0.75	0.61	0.78	0.33	0.34	0.37	0.38	0.68	0.71	1.00	1.00	0.76	0.76	0.67	0.67	0.67	0.75	0.66	0.76	0.71	0.76	0.64	0.70
10	Damietta	0	0.67	0.67	0.72	0.74	0.74	0.80	1.00	1.00	0.87	0.89	0.48	0.49	0.58	0.59	0.66	0.66	0.87	0.91	0.83	0.89	0.82	0.84	0.75	0.77
11	Dunkirk	0	0.22	0.23	0.21	0.21	0.21	0.21	0.23	0.23	0.24	0.24	0.22	0.23	0.15	0.16	0.12	0.12	0.13	0.13	0.11	0.12	0.12	0.12	0.18	0.18
12	Le Havre	0	0.50	0.71	0.50	0.71	0.57	0.80	0.68	0.82	0.53	0.61	0.48	0.54	0.56	0.56	0.45	0.47	0.41	0.61	0.38	0.58	0.33	0.54	0.49	0.63
13	Bremerhaven	0	0.74	0.93	0.76	0.98	0.68	0.99	0.80	1.00	0.93	1.00	0.94	1.00	0.85	1.00	0.76	1.00	0.75	1.00	0.72	1.00	0.68	1.00	0.78	0.99
14	Duisburg	0	0.43	0.44	0.47	0.49	0.63	0.67	0.71	0.77	0.85	0.90	0.70	0.73	0.73	0.75	0.71	0.72	0.82	0.84	0.77	0.78	0.83	0.84	0.70	0.72
15	Hamburg	0	0.70	1.00	0.71	1.00	0.65	1.00	0.80	1.00	0.89	1.00	0.84	1.00	1.00	1.00	0.99	1.00	0.58	1.00	0.60	1.00	0.68	1.00	0.77	1.00
16	Piraeus	0	0.54	0.71	0.71	0.88	0.71	0.91	0.73	0.82	0.66	0.70	0.59	0.64	0.62	0.62	0.19	0.19	0.32	0.36	0.22	0.25	0.25	0.26	0.50	0.58
17	Honolulu	0	1.00	1.00	0.85	0.91	0.73	0.81	0.89	0.91	0.93	0.93	0.86	0.88	0.90	0.92	0.77	0.77	0.69	0.76	0.65	0.73	1.00	1.00	0.84	0.87
18	Tuticorin	0	0.56	0.75	0.64	0.83	0.50	0.61	0.75	0.83	0.60	0.67	0.64	0.74	0.81	0.96	0.76	0.83	0.75	0.83	0.71	0.77	0.66	0.74	0.67	0.78
19	Haifa	0	0.57	0.58	0.64	0.65	0.74	0.75	1.00	1.00	0.71	0.71	0.64	0.64	0.66	0.69	0.67	0.70	0.66	0.68	0.64	0.68	0.46	0.51	0.67	0.69
20	Genoa	0	0.47	0.71	0.53	0.72	0.48	0.69	0.81	0.96	0.75	0.81	0.56	0.59	0.48	0.48	0.33	0.34	0.24	0.43	0.24	0.45	0.41	0.54	0.48	0.61
21	La Spezia	0	1.00	1.00	1.00	1.00	0.91	0.91	0.88	0.90	0.96	0.97	0.78	0.79	0.79	0.82	0.80	0.80	0.72	0.75	1.00	1.00	0.97	0.99	0.89	0.90
22	Yokohama	0	0.52	0.73	0.54	0.85	0.52	0.84	0.54	0.90	0.54	0.77	0.60	0.86	0.66	0.82	0.64	0.76	0.57	0.76	0.59	0.83	0.53	0.76	0.57	0.81
23	Osaka	0	0.60	0.83	0.60	0.82	0.51	0.74	0.56	0.75	0.52	0.68	0.60	0.79	0.65	0.77	0.61	0.68	0.39	0.46	0.38	0.48	0.34	0.48	0.52	0.68
24	Kobe	0	0.30	0.58	0.34	0.61	0.33	0.59	0.34	0.66	0.37	0.64	0.44	0.69	0.46	0.65	0.46	0.63	0.49	0.65	0.50	0.70	0.43	0.61	0.41	0.64

25	Nagoya	0	0.64	0.85	0.65	0.94	0.65	0.96	0.71	1.00	0.74	1.00	0.60	0.94	0.51	0.79	0.42	0.64	0.52	0.68	0.62	0.77	0.66	0.80	0.61	0.85
26	Penang	0	0.74	0.75	0.72	0.73	0.64	0.64	0.73	0.74	0.80	0.82	0.66	0.68	0.61	0.62	0.51	0.52	0.60	0.68	0.73	0.80	0.76	0.77	0.68	0.70
27	Maarsaxlokk	0	0.79	0.80	0.85	1.00	0.89	1.00	0.80	0.92	0.74	0.79	0.76	0.88	0.87	1.00	1.00	1.00	1.00	1.00	0.96	1.00	0.98	1.00	0.88	0.94
28	Manila	0	0.57	0.93	0.59	0.86	0.53	0.78	0.63	0.83	0.64	0.76	0.61	0.72	0.69	0.71	0.69	0.71	0.81	1.00	0.77	1.00	0.66	0.96	0.65	0.84
29	Leixoes	0	0.52	0.63	0.46	0.55	0.46	0.56	0.46	0.57	0.48	0.59	0.45	0.53	0.46	0.53	0.46	0.52	0.85	1.00	0.78	0.87	0.63	0.69	0.55	0.64
30	Lisbon	0	0.47	0.47	0.51	0.51	0.55	0.56	0.47	0.49	0.48	0.49	0.46	0.48	0.48	0.49	0.46	0.46	0.45	0.47	0.40	0.40	0.44	0.45	0.47	0.48
31	St. Petersburg	0	0.61	0.62	0.64	0.64	0.63	0.63	0.48	0.51	0.70	0.71	0.70	0.81	0.61	0.78	0.63	0.74	0.49	0.60	0.63	0.79	0.45	0.63	0.60	0.68
32	Dammam	0	0.60	0.61	0.62	0.63	0.57	0.58	0.40	0.41	0.41	0.41	0.62	0.64	0.64	0.65	0.70	0.71	0.83	0.84	0.89	0.90	0.80	0.81	0.64	0.65
33	Jeddah	0	0.45	0.49	0.50	0.57	0.53	0.73	0.30	0.38	0.31	0.38	0.65	0.87	0.69	0.87	0.75	0.94	0.76	1.00	0.70	1.00	0.60	0.84	0.57	0.73
34	Gwangyang	0	1.00	1.00	1.00	1.00	0.93	0.98	0.64	0.74	0.71	0.76	0.74	0.77	0.77	0.78	0.78	0.78	0.70	0.91	0.71	0.94	0.72	0.92	0.79	0.87
35	Barcelona	0	0.50	0.57	0.52	0.81	0.58	0.87	0.47	0.79	0.50	0.77	0.53	0.83	0.64	0.94	0.67	0.87	0.60	0.68	0.55	0.69	0.56	0.68	0.56	0.77
36	Bilbao	0	0.50	0.50	0.37	0.41	0.28	0.33	0.19	0.22	0.29	0.31	0.29	0.31	0.29	0.31	0.28	0.29	0.39	0.39	0.40	0.42	0.45	0.46	0.34	0.36
37	Gothenburg	0	0.46	0.50	0.47	0.51	0.55	0.58	0.63	0.69	0.71	0.72	0.68	0.70	0.75	0.78	0.84	0.84	0.57	0.65	0.57	0.65	0.50	0.51	0.61	0.65
38	Taichung	0	1.00	1.00	1.00	1.00	0.63	0.78	0.72	0.78	0.72	0.73	0.63	0.63	0.69	0.70	0.65	0.65	0.62	0.73	0.62	0.76	0.58	0.66	0.71	0.77
39	Bangkok	0	0.76	0.84	0.71	0.84	0.52	0.68	0.60	0.68	0.60	0.64	0.58	0.64	0.67	0.67	0.60	0.60	0.55	0.61	0.57	0.67	0.57	0.64	0.61	0.68
40	Ambarli	0	0.97	1.00	0.23	0.35	0.32	0.45	0.45	0.63	0.46	0.59	0.53	0.69	0.69	0.89	0.78	0.88	0.69	0.77	0.82	1.00	0.93	1.00	0.62	0.75
41	Felixtowe	0	0.94	1.00	0.88	1.00	0.62	0.88	0.68	0.89	0.64	0.78	0.53	0.76	0.64	0.97	0.64	0.85	0.84	1.00	0.78	1.00	0.76	1.00	0.72	0.92
42	Charleston	0	0.55	0.67	0.55	0.68	0.47	0.66	0.53	0.68	0.61	0.67	0.46	0.54	0.44	0.47	0.33	0.36	0.31	0.41	0.33	0.44	0.32	0.41	0.44	0.54
43	New York	0	0.60	0.94	0.58	0.87	0.51	0.79	0.63	0.79	0.54	0.61	0.50	0.59	0.55	0.59	0.55	0.64	0.40	0.79	0.45	0.82	0.47	0.75	0.53	0.74
44	Oakland	0	0.49	0.72	0.38	0.57	0.34	0.50	0.40	0.49	0.44	0.52	0.43	0.48	0.48	0.48	0.46	0.47	0.37	0.56	0.33	0.59	0.32	0.52	0.40	0.54
45	Savannah	0	0.61	0.74	0.70	0.82	0.67	0.86	0.83	0.93	0.93	1.00	0.81	0.85	0.89	0.90	0.85	0.87	0.59	0.94	0.59	0.97	0.50	0.78	0.72	0.88
46	Seattle	0	0.39	0.56	0.42	0.56	0.39	0.56	0.53	0.63	0.62	0.70	0.53	0.56	0.55	0.55	0.47	0.47	0.41	0.60	0.41	0.63	0.35	0.54	0.46	0.58
47	Tacoma	0	0.71	0.80	0.76	0.88	0.73	0.94	0.76	0.92	0.64	0.72	0.60	0.63	0.58	0.58	0.53	0.54	0.35	0.57	0.29	0.51	0.24	0.32	0.56	0.67
48	Norfolk Virginia	0	0.54	0.73	0.57	0.74	0.64	0.85	0.79	0.90	0.81	0.89	0.60	0.64	0.60	0.61	0.62	0.63	0.42	0.68	0.41	0.67	0.42	0.61	0.58	0.72
49	Ho Chi Minh City	0	0.57	0.72	0.49	0.63	0.27	0.44	0.33	0.50	0.41	0.62	0.35	0.60	0.47	0.75	0.49	0.77	0.65	0.96	0.59	0.83	0.66	0.96	0.48	0.71
50	St. John	1	0.17	1.00	0.20	0.87	0.24	0.95	0.22	1.00	0.26	1.00	0.28	1.00	0.29	1.00	0.27	1.00	0.28	1.00	0.21	1.00	0.21	1.00	0.24	0.98
51	FCP	1	0.76	0.78	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.91	0.85	0.88	0.96	0.96

52	Bridgetown	1	0.41	1.00	0.41	1.00	0.40	1.00	0.40	0.74	0.45	0.77	0.29	0.43	0.29	0.42	0.25	0.34	0.24	0.36	0.22	0.32	0.23	0.33	0.32	0.61
53	Rio Haina	1	1.00	1.00	0.84	1.00	0.87	1.00	1.00	1.00	0.66	0.79	0.61	0.76	0.60	0.76	0.64	0.73	0.51	0.60	0.48	0.56	0.59	0.69	0.71	0.81
54	Caucedo	1	0.35	0.43	0.33	0.38	0.27	0.31	0.31	0.36	0.36	0.41	0.32	0.37	0.83	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.62	0.65
55	Pointe-Pitre	1	0.29	0.35	0.26	0.33	0.24	0.29	0.29	0.34	0.38	0.45	0.35	0.44	0.40	0.51	0.39	0.44	0.26	0.31	0.25	0.29	0.22	0.24	0.30	0.36
56	KCT	1	0.56	0.56	0.45	0.51	0.34	0.41	0.66	0.75	0.90	0.92	1.00	1.00	0.77	0.77	0.62	0.64	0.38	0.43	0.34	0.41	0.28	0.34	0.57	0.61
57	KW	1	0.14	0.16	0.17	0.19	0.15	0.16	0.21	0.23	0.20	0.22	0.24	0.26	0.38	0.44	0.52	0.59	0.41	0.46	0.40	0.44	0.35	0.40	0.29	0.32
58	Willemstad	1	0.13	0.17	0.22	0.27	0.19	0.23	0.22	0.27	0.22	0.28	0.21	0.27	0.24	0.31	0.23	0.28	0.26	0.33	0.22	0.27	0.20	0.26	0.21	0.27
59	Castries	1	0.09	1.00	0.23	1.00	0.25	1.00	0.24	1.00	0.30	1.00	0.11	0.17	0.13	0.21	0.13	0.18	0.11	0.17	0.10	0.15	0.09	0.13	0.16	0.55
60	Vieux Fort	1	0.11	1.00	0.15	1.00	0.16	1.00	0.22	1.00	0.24	1.00	0.17	1.00	0.14	1.00	0.28	1.00	0.18	1.00	0.16	1.00	0.18	1.00	0.18	1.00
61	PL	1	0.47	0.92	0.58	1.00	0.65	1.00	0.58	1.00	0.72	1.00	0.81	1.00	0.79	1.00	0.54	0.71	0.59	0.81	0.59	0.82	0.53	0.73	0.62	0.91
62	POS	1	0.76	1.00	0.61	0.68	0.56	0.59	0.53	0.57	0.49	0.52	0.47	0.47	0.49	0.50	0.51	0.52	0.60	0.67	0.50	0.54	0.50	0.55	0.55	0.60
63	Barranquilla	2	0.51	1.00	0.46	1.00	0.49	1.00	0.56	1.00	0.66	1.00	0.67	1.00	0.68	1.00	0.48	1.00	0.39	1.00	0.52	1.00	0.15	0.15	0.51	0.92
64	Puerto Cortes	2	0.75	0.86	0.81	0.91	0.94	1.00	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	0.95	0.98
65	Manzanillo	2	0.88	0.91	0.88	0.93	1.00	1.00	1.00	1.00	1.00	1.00	0.80	0.80	0.72	0.75	0.86	0.86	0.86	0.87	0.87	0.90	1.00	1.00	0.90	0.91
66	Papeete	3	0.25	0.46	0.27	0.48	0.28	0.50	0.27	0.47	0.22	0.32	0.19	0.28	0.20	0.30	0.20	0.27	0.21	0.30	0.17	0.25	0.18	0.27	0.22	0.35
67	Apra	3	0.34	0.42	0.35	0.45	0.38	0.47	0.18	0.23	0.20	0.25	0.20	0.26	0.24	0.32	0.23	0.29	0.46	0.61	0.46	0.59	0.49	0.66	0.32	0.41
68	Port Louis	3	0.19	0.20	0.22	0.23	0.37	0.38	0.31	0.31	0.37	0.38	0.49	0.53	0.60	0.66	0.52	0.53	0.45	0.46	0.40	0.40	0.49	0.52	0.40	0.42
69	Noumea	3	0.17	0.21	0.18	0.26	0.22	0.31	0.24	0.30	0.26	0.37	0.26	0.38	0.30	0.44	0.29	0.39	0.24	0.34	0.23	0.32	0.12	0.14	0.23	0.31
Mean			0.54	0.71	0.55	0.71	0.52	0.70	0.57	0.72	0.59	0.71	0.57	0.67	0.60	0.70	0.58	0.66	0.55	0.71	0.55	0.71	0.54	0.67	0.56	0.70

Appendix 11 Efficiency and Productivity Change per sub-group

TFPCH	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	geomean
TOP	0.9828	1.018	1.07627	1.02733	1.08383	1.03244	0.9785	0.91105	1.09795	1.00885	1.02027
CARI	1.1453	1.01	1.13833	1.04778	0.98245	1.10413	1.06731	0.85559	1.01061	0.99629	1.03241
NCARI	0.9908	1.077	1.12286	1.04213	0.99682	0.98271	0.97853	0.90749	1.22087	0.71288	0.99439
OSIDS	1.0506	1.199	0.8029	1.02871	1.09741	1.12864	0.98957	1.05911	1.04688	0.93304	1.0281
TECHCH	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	geomean
TOP	0.9954	1.09	0.96699	0.99043	1.1195	0.97416	1.0422	0.95985	1.10824	1.02507	1.0256
CARI	0.9903	1.054	1.002	0.97184	1.11807	0.98721	1.04249	0.95561	1.1207	1.02507	1.02526
NCARI	1.0045	0.963	1.05273	0.98176	1.07012	1.00883	1.04295	0.96812	1.11161	1.02792	1.02218
OSIDS	0.9674	0.979	0.9943	0.98578	1.06551	0.97311	1.04396	0.96954	1.14269	0.99869	1.01061
EFFCH	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	geomean
TOP	0.9875	0.934	1.11308	1.03725	0.96828	1.05996	0.93868	0.94925	0.99078	0.98429	0.99485
CARI	1.1568	0.958	1.13583	1.07801	0.87888	1.11857	1.02369	0.89535	0.90192	0.97185	1.00699
NCARI	0.987	1.118	1.06655	1.06127	0.93172	0.97446	0.93861	0.93733	1.09829	0.69363	0.97294
OSIDS	1.0862	1.225	0.80781	1.04329	1.03003	1.16027	0.94788	1.0928	0.91624	0.93449	1.01746
PECH	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	geomean
TOP	1.0059	0.964	1.0409	0.98839	0.97618	1.01883	0.92466	1.10125	1.0173	0.9424	0.99678
CARI	1.0156	0.929	1.09021	1.02735	0.83264	1.14257	0.9399	0.9476	0.93131	0.96479	0.97853
NCARI	1.0261	1.06	1	1	0.92986	0.97889	1.04434	1.00629	1.00794	0.55006	0.9465
OSIDS	1.127	1.223	0.77305	1.01863	1.07897	1.16716	0.8825	1.14803	0.89682	0.90601	1.01185
SECH	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	geomean
TOP	0.9817	0.969	1.06925	1.04934	0.99181	1.04043	1.01529	0.86196	0.97389	1.04432	0.99803
CARI	1.1389	1.031	1.04196	1.04925	1.05571	0.97918	1.08908	0.94478	0.9685	1.00722	1.02907
NCARI	0.9617	1.054	1.06655	1.06127	1.002	0.99563	0.89858	0.93141	1.08991	1.26102	1.02792
OSIDS	0.9634	1.002	1.04448	1.02445	0.95435	0.99398	1.07402	0.95192	1.02146	1.03113	1.00538

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