Examination of port performance in a developing economy:
A case study of Libyan ports

A thesis submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy in supply chain and logistics (DR202)

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April 2015
Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

Ismail Sghayer Almadani Elferjani

30 April 2015
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First, I would like to thank my great parents, who taught me the alphabet of this life and supported me to start my educational journey. I acknowledge with gratitude the role of my siblings, especially the oldest, who were the main driver of my success. Very special thanks to my beloved wife for her unlimited patience, forbearance and support during this arduous journey.

I am deeply indebted to my supervisor, Dr Victor Gekara, for his intellectual guidance, support and constructive criticism. Also, I would like to thank my co-supervisor, Dr Ahmad Abareshi, for his intellectual inputs in the progress of this thesis, especially the analytical parts. I must also not forget to thank the members of RMIT School of Business, IT and Logistics, especially Professor Shams Rahman, Ms Priyanka Erasmus and Ms Prue Lamont, for their support.

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Contents

Declaration ........................................................................................................................................... ii
Acknowledgements ............................................................................................................................ iii
Contents ................................................................................................................................................ iv
List of Figures ....................................................................................................................................... vii
List of Tables ....................................................................................................................................... viii
List of Abbreviations .......................................................................................................................... x
Glossary ................................................................................................................................................ xi
Abstract .............................................................................................................................................. xii

Chapter 1: Introduction ..................................................................................................................... 1
1.1 Introduction .................................................................................................................................. 1
1.2 Aims and Research Questions ...................................................................................................... 7
1.3 Structure of the Thesis .................................................................................................................. 12

Chapter 2: Libya .................................................................................................................................. 15
2.1 Introduction .................................................................................................................................. 15
2.2 Libya’s Geography and Port Hinterland ...................................................................................... 15
2.3 Libyan Politics ............................................................................................................................... 18
  2.3.1 Global Politics ....................................................................................................................... 18
  2.3.2 Local Politics and the Economy ............................................................................................ 21
2.4 Economic Landscape ................................................................................................................... 22
2.5 The Transport Industry ............................................................................................................... 31
  2.5.1 Road Transport .................................................................................................................... 31
  2.5.2 Rail Transport ...................................................................................................................... 33
  2.5.3 Air Transport ........................................................................................................................ 33
  2.5.4 Maritime Transport .............................................................................................................. 34

Chapter 3: Literature Review ............................................................................................................. 45
3.1 Introduction .................................................................................................................................. 45
3.2 Container Port Performance, Productivity and Efficiency ............................................................ 50
  3.2.1 Seaside Operations ............................................................................................................... 52
  3.2.2 Terminal Operations ............................................................................................................ 55
  3.2.3 Landside Operations ............................................................................................................. 63
3.3 The use of DEA to measure container port efficiency ................................................................. 69
  3.3.1 Strengths and Advantages of Data Envelopment Analysis .................................................. 73
  3.3.2 Weaknesses and Limitations of Data Envelopment Analysis .............................................. 75

Chapter 4: Methodology .................................................................................................................... 76
4.1 Introduction .................................................................................................................................. 76
4.2 Phase 1: Measuring Libyan Port Performance ............................................................................ 80
  4.2.1 The Research Participants .................................................................................................... 81
  4.2.2 Definition of Variables and Instrument Development ......................................................... 83
  4.2.3 The Data ............................................................................................................................... 85
Chapter 5: Descriptive Analysis and One-Way ANOVA

5.1 Introduction ............................................................ 100
5.2 Instrument Development ............................................ 100
5.3 Data Collection .......................................................... 107
5.4 Non-Response Bias ...................................................... 111
5.5 Performance Criteria .................................................. 112
  5.5.1 The Total Working Hours ........................................ 113
  5.5.2 Using Total Working Time ..................................... 114
  5.5.3 Seaside Operations ................................................ 115
  5.5.4 Terminal Operations ............................................. 118
  5.5.5 Landside Operations ............................................. 130
  5.5.6 Online Services .................................................. 136
  5.5.7 Cargo Safety ....................................................... 137
5.6 Analysis of Variance .................................................. 141
  5.6.1 The Total Working Hours ........................................ 142
  5.6.2 Seaside Operations ................................................ 143
  5.6.3 Terminal Operations ............................................. 144
  5.6.4 Landside Operations ............................................. 146
  5.6.5 Online Services and Cargo Safety .............................. 147
5.7 Summary ................................................................. 148

Chapter 6: Data Envelopment Analysis

6.1 Introduction ............................................................ 150
6.2 Variables Identification ............................................. 152
6.3 Sample Size .............................................................. 158
6.4 Empirical Findings of the BCC and CCR Analyses ............. 161
6.5 Efficiency and Return-to-Scale .................................... 162
6.6 The Effects of Port Superstructure and Infrastructure .......... 168
6.7 Conclusion .............................................................. 173

Chapter 7: Discussion

7.1 Introduction and Summary of Findings ............................ 174
7.2 Assessment .............................................................. 176
  7.2.1 Bad Politics, Poor Economic Governance and the Implications for Port Performance ...................................................... 179
  7.2.2 Implications of Management Centralisation and State Control on Port Performance ...................................................... 187

Chapter 8: Conclusion

8.1 Overview of the Research ............................................ 193
8.2 Recommendations ...................................................... 198
8.3 Study Limitations and Further Research on Port Performance .. 199
References 202
Appendices 219
List of Figures

Figure 1.1: Structure of the Thesis ................................................................. 13
Figure 2.1: Libya’s Geographical Location .................................................. 16
Figure 2.2: International Trade Routes, Gateway Ports and Hubs in the
Mediterranean Sea .................................................................................. 17
Figure 2.3: Libyan Total Gross GDP from 1980–2010 .................................. 23
Figure 2.4: Total Export and Import Value From 1980–2012 (Million $US) ...... 26
Figure 2.5: FDIs in Libya 2006–2011 ............................................................ 27
Figure 2.6: The Percentage of Libya’s Trade Partners in 2010 in Ranking Order .... 30
Figure 2.7: Total World Number of Ships and Ships’ Average Size .................. 36
Figure 2.8: Number of Ships Calling at Libyan Ports in 2008, 2010 and 2012 .... 41
Figure 2.9: Total of TEU Volumes Handled by Libyan Ports (2006–2012) ....... 42
Figure 2.10: Total Cargo Off-Loaded by Libyan Ports in 2008, 2010 and 2012
(Thousand Tons) .................................................................................. 43
Figure 2.11: Total Cargo Loaded by Libyan Ports in 2008, 2010 and 2012
(Thousand Tons) .................................................................................. 44
Figure 3.1: Port Performance Criteria ......................................................... 67
Figure 4.1: The Research Process ................................................................ 77
Figure 5.1: The Sufficiency and Efficiency of Cargo-Handling Equipment used
at Libyan Ports .................................................................................... 120
Figure 5.2: Seaside Cranes at Libyan Ports v. the Demand for Containerisation .... 122
Figure 5.3: Accuracy of Ships’ Scheduling at Libyan Ports ........................... 124
Figure 5.4: The Quality of Customs Services at Libyan Ports ....................... 133
Figure 5.5: The Level of Port Personnel Safety Awareness ............................ 138
Figure 5.6: The Likelihood of Cargo Damage in Libyan Ports ....................... 139
Figure 5.7: The Likelihood of Cargo Loss in Libyan Ports ............................. 140
Figure 6.1: Efficient Frontier for Seven MDUs with Two Inputs and One Output . 152
Figure 6.2: Port Superstructure .................................................................. 154
Figure 7.1: Framework for Understanding Port Performance in a Developing
Country Context .................................................................................. 177
Figure 7.2: Decision-Making Processes in MFZ and LPC. ............................. 190
List of Tables

Table 1.1: Regional Trade Value Statistics in US Million Dollars .............................................3
Table 1.2: LPI of Regional Countries .....................................................................................5
Table 2.1: Libya’s Trade Structure by Product Group ..............................................................29
Table 2.2: Libyan Ports ............................................................................................................38
Table 2.3: Cargo-Handling Equipment at Libyan Ports in 2010 .............................................40
Table 3.1: Port Ownership and Management Models .............................................................49
Table 4.1: Summary of Research Methods ...........................................................................79
Table 5.1: Classifying the Respondents by Sector .................................................................108
Table 5.2: Classifying the Respondents by Stakeholder Group ............................................109
Table 5.3: Classifying the Respondents by Position ...............................................................110
Table 5.4: Total Means of the Respondents Regarding the Working Hours at Libyan Ports ..........................................................................................................................113
Table 5.5: The Number and Types of Cranes Used at Libyan Ports ......................................121
Table 5.6: Storage Yard Capacity of Libyan Ports ..................................................................128
Table 5.7: One-Way ANOVA Analysis Regarding the Working Time at Libyan Ports ..........142
Table 5.8: One-Way ANOVA Analysis Regarding Water Depth ...........................................143
Table 5.9: One-Way ANOVA Analysis Regarding the Capacity of Seaside Cranes ...............144
Table 5.10: One-Way ANOVA Analysis Regarding the Ability of Libyan Ports to Provide Special Cargo-Handling Services ..............................................................145
Table 5.11: One-Way ANOVA Analysis Regarding the Capacity of Storage Space to Absorb Cargo Dedicated to the Local Market .........................................................146
Table 5.12: ANOVA Test Regarding the Number of Gate Lanes ..........................................147
Table 6.1: Facts Related to the Resources of Selected Container Ports ..................................156
Table 6.2: The Selected DMUs and Input and Output Variables ..........................................159
Table 6.3: Variable Correlations ..........................................................................................163
Table 6.4: Efficiencies and Return-to-Scale .......................................................................164
Table 6.5: The Most Frequent Referents CCR Ports and Terminals and the BCC Efficient Libyan Ports ........................................................................................................169
<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<td>AGV</td>
<td>Automated Guided Vehicle</td>
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<td>ANOVA</td>
<td>Analysis of Variance</td>
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<td>BTM</td>
<td>Boosting Telescopic Mast Crane</td>
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<td>DEA</td>
<td>Data Envelopment Analysis</td>
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<td>DRS</td>
<td>Decreasing Returns-to-Scale</td>
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<td>FMC</td>
<td>Fixed Mast Crane</td>
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<td>GC</td>
<td>General Cargo</td>
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<td>General National Congress</td>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>GNMTC</td>
<td>General National Maritime Transport Company</td>
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<td>IRS</td>
<td>Increasing Returns-to-Scale</td>
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<td>LD</td>
<td>Libyan Dinar</td>
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<td>LMA</td>
<td>Libyan Maritime Administration</td>
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<td>Ship’s Length Overall</td>
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<td>LPI</td>
<td>Logistics Performance Index</td>
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<td>MPSS</td>
<td>Most Productive Scale Size</td>
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<td>P QC</td>
<td>Panamax quay container crane</td>
</tr>
<tr>
<td>PP QC</td>
<td>Post-Panamax quay container crane</td>
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<tr>
<td>QC</td>
<td>Quay Crane</td>
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<tr>
<td>SC</td>
<td>Straddle Carrier</td>
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<td>SE</td>
<td>Scale Efficiency</td>
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<tr>
<td>SLV</td>
<td>Yard Trailers and Self-Loading Vehicles</td>
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<td>SPP QC</td>
<td>Super Post- Panamax Quay Container Crane</td>
</tr>
<tr>
<td>SPSS</td>
<td>Predictive Analytics Software Made By IBM</td>
</tr>
<tr>
<td>TE</td>
<td>Technical Efficiency</td>
</tr>
<tr>
<td>TEU</td>
<td>Twenty Equivalent Unit, which refers to the 20 foot container</td>
</tr>
<tr>
<td>US$</td>
<td>American Dollar</td>
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<td>YC</td>
<td>Yard Crane</td>
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## Glossary

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<th>Term</th>
<th>Definition</th>
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<tr>
<td>Cargo delivery time</td>
<td>The time that is taken to off-load the cargo from the ship, clear it and deliver it out of the port’s gate.</td>
</tr>
<tr>
<td>Transfer equipment</td>
<td>All types of cranes that are used to transfer containers from a ship to shore/transport vehicles or from shore/transport vehicles to a ship or from the storage yard/rail yard to transport vehicle and vice versa.</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>All vehicles that are used to transport containers horizontally from one place to another, such as: automated guided vehicles (AGVs), trucks, straddle carriers (SCs), yard trailers and self-loading vehicles (SLVs).</td>
</tr>
<tr>
<td>Free board</td>
<td>The height of a ship’s main deck above the water level.</td>
</tr>
<tr>
<td>Ship’s draft</td>
<td>The distance between the vessel’s waterline and the lowest point of the vessel, usually the keel. The draft changes if the vessel becomes heavier or lighter. Simply, draft is the depth of a vessel at any given time.</td>
</tr>
<tr>
<td>Ship’s width</td>
<td>The beam or the width of a ship is the widest horizontal distance between the two sides of a ship.</td>
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<tr>
<td>Commercial port</td>
<td>All ports used to handle merchandised goods rather than oil, oil products and ore ports.</td>
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Abstract

Efficient ports are essential for efficient national, regional and international logistics and business more generally. However, efficient port performance depends on a number of factors, including adequate and efficient facilities and technology for cargo handling, accessibility and connectivity (both seaside and landside), port location in relation to trade routes and hinterland, skills and labour, as well as appropriate managerial technologies. While some of these factors may be in the control of port management, others may be beyond their immediate control.

This study focuses on port performance in developing economies, with specific reference to Libya. Libyan ports occupy a strategic location close to the Asia-Europe international trade route, and between Africa and Europe. Therefore, they have the potential to play an important role in regional economies, acting as critical nodes in international logistics and supply chains. However, the persistently poor performance of ports across the country undermines this potential. Poor performance at the ports has, for example, pushed big carriers to bypass Libyan ports for the ports of neighbouring countries. Additionally, many traders in the region transport cargo through ports other than Libya’s.

This study was developed to examine the factors that undermine the performance of Libya’s ports, using the perspective of Libyan port stakeholders. It examines how the various factors interact to create a situation of poor performance. To achieve this, the study was developed in two phases. The first phase used an online questionnaire that included factors related to port performance extracted from the literature. The data obtained from this questionnaire were analysed using descriptive analysis and one-way analysis of variance (one-way ANOVA). The second phase was used confirm the findings of the first phase, using data envelopment analysis (DEA). Secondary data related to 25 ports, including seven Libyan ports, were used for this purpose.

The study finds that the poor performance of Libyan ports is caused by poor port infrastructure, superstructure and land transport infrastructure. However, a deeper analysis shows that the problem is much bigger than just port precinct-related
limitations. The study has also found that external factors play a major role in this situation, including political, economic and social factors. It suggests that a prevailing environment of bad politics and poor economic governance and management systems are responsible for the performance limitations at the ports. Apart from the internal political turmoil that has characterised Libya over many years, Libya has also been involved in many major conflicts with surrounding countries, a fact that undermines the position of its ports to facilitate trade in the wider regional hinterland. Internal political instability has also created a bureaucracy characterised by corruption, political patronage, ineptitude and general economic mismanagement. Thus, Libya has failed to adopt an effective local framework to drive effective investment and proper management of the ports and ensure efficient performance.

It is envisaged that the findings of this study will be useful in the formulation and implementation of appropriate policy, both within the ports and more broadly, to achieve enhanced operational efficiency. While there are important questions for port and terminal operators regarding internal operations efficiency, there are even bigger ones for government regarding establishing an enabling economic environment for investors and operators in the industry.
Chapter 1: Introduction

1.1 Introduction

This thesis discusses port performance and efficiency. It focuses more on developing African ports, particularly in Libya. The argument in this thesis is that Libyan ports could benefit greatly from their strategic location on the Asia-Europe international trade route and their expansive hinterland. They could become important facilitators of regional and international trade logistics chains, connecting the region’s trade to global supply chains. However, this has not been the case. Therefore, the purpose of this research is to understand the causes of port underperformance and to recommend ways of addressing them, to enhance ports’ capacity for efficient performance.

Ports form the key facilitating nodes in international trade making them crucial for national and regional economic prosperity (UNCTAD, 2007). Maritime transport is the dominant transport of international trade; it is the most cost-effective means of cargo transportation (UNCTAD, 2007). Additionally, the demand for container-based trade continues to grow. This is due to its advantages, including cost and time efficiency (Kozan, 2000, Wong, 2008b, Huang, 2004, Tierney et al., 2014). This escalating demand has influenced the size of container ships and consequently, ports’ roles and specifications.

This study will argue that ports whose operations contribute most substantially to overall transportation cost reductions are most likely to be preferred by shipping companies (Huybrechts et al., 2002). This is achievable by enhancing port performance and efficiency. Enhancing port performance and efficiency can be achieved by increasing port capacity, taking advantage of location (Perez-Labajos and Blanco, 2004), improving sea and landside port accessibility (Gekara and Chhetri, 2013, Lee and Jin, 2013), and incorporating information and communication technology (ICT) (Gekara and Fairbrother, 2013, Kia et al., 2000).

Previous studies on the African continent have shown that a developing economy can benefit from greater connectivity to global markets, improved trade and reduced transport costs, by improving port facilities (Gekara and Chhetri, 2013). Therefore, Libyan ports can be potentially important nodes for international trade between
regional land-locked countries and the rest of the world. Further, they can become important trade hubs in the region, due to their strategic locations.

As such, the context of this research is the Libyan ports industry. Libya is a spacious developing country that occupies a strategic location at the centre of the south coast of the Mediterranean Sea, along the key Asia-Europe international trade route. Its coastline is about 1,970 kilometres in length. Libya is surrounded by six countries: Egypt, Sudan, Chad, Niger, Algeria and Tunisia. Two of these countries (Chad and Niger) are land-locked and depend entirely on transit countries such as Libya, Nigeria and Benin for sea transportation access.

In total, the Libyan ports industry comprises 20 ports. Seven of these ports are general cargo ports, which handle containers, bulk cargo, roll on/roll off (RO/RO) and dry bulk. These include Tripoli, Benghazi, Misurata ‘Qasr Ahmed port’, Khoms, Tobruk, Derna and Zuwarah. They are all state owned and operated by two public companies under the authority of the Libyan Marine Transport and Ports Authority (LMTPA). The other 11 ports are oil and petrochemical ports, which handle all the oil trade, the main driver of Libya’s economy. Another port, called Misurata Steel port, handles steel trade through the Misurata Steel Complex.

Ninety per cent of Libya’s international trade, which mainly comprises imports, is processed by its ports (Choi, 2003). Despite the dramatic increase in demand for containerisation (Beškovnik, 2009), the maximum container throughput of all Libyan ports has not exceeded one million TEUs per year since being built. This indicates that Libyan ports are underperforming.

To achieve efficient performance, container ports—including Libyan ports—have to improve their capacities by adopting strategies such as new port designs, sophisticated infrastructure, long term planning, more effective cargo-handling equipment, larger storage yards, advanced information technology and software programming (Chang et al., 2008, Asteris et al., 2012, Beškovnik, 2008, Blonigen and Wilson, 2008). However, despite the increase of trade volume in the region (ITC, 2015), the small capacity of Libyan ports has limited the throughput of Libyan ports, compared to other ports in the region,
Table 1.1: Regional Trade Value Statistics in US Million Dollars

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<td>107,272</td>
<td>132,002</td>
<td>102,139</td>
<td>113,979</td>
<td>134,915</td>
<td>152,537</td>
<td>151,796</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Imports</td>
<td>289,611</td>
<td>329,976</td>
<td>391,237</td>
<td>418,728</td>
<td>287,502</td>
<td>315,547</td>
<td>362,835</td>
<td>325,835</td>
<td>332,267</td>
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<tr>
<td>Exports</td>
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<td>214,061</td>
<td>253,754</td>
<td>279,231</td>
<td>223,132</td>
<td>246,265</td>
<td>298,171</td>
<td>285,936</td>
<td>310,964</td>
</tr>
<tr>
<td>France</td>
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<tr>
<td>Imports</td>
<td>475,857</td>
<td>529,902</td>
<td>611,364</td>
<td>695,004</td>
<td>540,502</td>
<td>599,172</td>
<td>700,852</td>
<td>663,269</td>
<td>668,658</td>
</tr>
<tr>
<td>Exports</td>
<td>434,354</td>
<td>434,354</td>
<td>539,731</td>
<td>594,505</td>
<td>464,113</td>
<td>511,651</td>
<td>581,542</td>
<td>556,576</td>
<td>566,879</td>
</tr>
<tr>
<td>Malta</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Imports</td>
<td>3,865</td>
<td>4,396</td>
<td>4,947</td>
<td>5,141</td>
<td>4,034</td>
<td>5,732</td>
<td>7,396</td>
<td>7,896</td>
<td>7,525</td>
</tr>
<tr>
<td>Exports</td>
<td>2,431</td>
<td>2,847</td>
<td>3,158</td>
<td>3,029</td>
<td>2,280</td>
<td>3,717</td>
<td>5,279</td>
<td>5,646</td>
<td>5,206</td>
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<tr>
<td>Egypt</td>
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<td></td>
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</tr>
<tr>
<td>Imports</td>
<td>19,812</td>
<td>20,594</td>
<td>27,031</td>
<td>52,751</td>
<td>44,912</td>
<td>53,003</td>
<td>62,282</td>
<td>69,866</td>
<td>66,666</td>
</tr>
<tr>
<td>Exports</td>
<td>10,366,216</td>
<td>11,985,054</td>
<td>13,823,121</td>
<td>15,971,873</td>
<td>12,310,033</td>
<td>15,050,924</td>
<td>18,055,465</td>
<td>18,003,055</td>
<td>17,974,395</td>
</tr>
</tbody>
</table>

including Italian, Maltese, Egyptian and Tunisian ports. As a result, no Libyan commercial ports are ranked in the top one hundred ports list, in terms of the volume of cargo handled or container traffic (Aquaviários, 2012, AAPA, 2012, AAPA, 2008a, AAPA, 2009).

There is strong evidence that regional trade has been on the increase, as demonstrated in Table 1.1. For example, the trade volume trends of the countries in the region, such as Italy, Malta, France, Spain and Turkey, which are close to Libya, clearly show an increase similar to that in the countries that share a border with Libya, such as Egypt, Tunisia and Algeria. In addition, even the land-locked countries that share a border with Libya have experienced increasing trends in trade volume. However, despite Libyan ports being the most appropriate for handling this trade, not much of it passes through Libyan ports. This shows that the underperformance of Libyan ports is not because of the volume of trade in the region.

A number of challenges have prevented Libyan ports from taking optimal advantage of location opportunities. The literature specifically notes that these challenges have undermined Libyan ports from efficiently facilitating regional trade movement, particularly to the land-locked countries south of Libya (Rodrigue and Notteboom, 2010). For instance, only about 8.86 per cent of Chad’s imports and 8.33 per cent of its exports are handled through Libya (Ministry of Infrastructure and Facilities, 2011). Similarly, Niger uses the Nigerian and Benin ports for its international trade movement (Global trade, 2013). Moreover, these challenges have undermined Libyan ports from becoming trading hubs to facilitate the transhipment of international trade cargo, like the Maltese Marsaxlokk terminals. Thus, Libyan ports are ranked poorly internationally, significantly contributing to the consistently poor rating of the country in terms of its trade logistics performance in the World Bank’s logistics performance index (LPI) (see Table1.2). In these rankings, the World Bank uses six key dimensions to benchmark countries’ performance, including:

- The efficiency of the clearing process
- The quality of trade and transport-related infrastructure, such as ports, roads, rails and information technology
- The ease of arranging competitively priced shipments
• The competence and quality of logistics services
• The ability to track and trace consignments
• The timeliness of shipments in reaching destinations within the scheduled/expected delivery time.

In 2010, Libya was ranked 132 out of 155 countries (Bank, 2015). At that time, all the country’s organisations were working under the Gaddafi regime. Libya was ranked below all the regional countries, including the two land-locked countries. After the uprising of 2011, despite the insecurity, the overall LPI of Libya increased to 84 and 85 for 2012 and 2014, respectively (Bank, 2015). This was because of improvements in logistics quality and competency, the implementation of IT services for tracking and tracing consignments, and an increased reliability of delivery times. Additionally, the clearing process was faster, due to the lack of implementation of laws. However, during the same period, nothing changed regarding infrastructure; therefore, the rank of the quality of trade and transport-related infrastructure did not change (Bank, 2015).

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall LPI rank</th>
<th>Customs</th>
<th>Infrastructure</th>
<th>International shipments</th>
<th>Logistics competence</th>
<th>Tracking &amp; tracing</th>
<th>Timeliness</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>17</td>
<td>17</td>
<td>14</td>
<td>28</td>
<td>12</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Italy</td>
<td>22</td>
<td>23</td>
<td>20</td>
<td>37</td>
<td>18</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Spain</td>
<td>25</td>
<td>22</td>
<td>25</td>
<td>48</td>
<td>24</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>Lebanon</td>
<td>33</td>
<td>29</td>
<td>41</td>
<td>69</td>
<td>19</td>
<td>49</td>
<td>29</td>
</tr>
<tr>
<td>Turkey</td>
<td>39</td>
<td>46</td>
<td>39</td>
<td>44</td>
<td>37</td>
<td>56</td>
<td>31</td>
</tr>
<tr>
<td>Tunisia</td>
<td>61</td>
<td>73</td>
<td>65</td>
<td>22</td>
<td>109</td>
<td>102</td>
<td>58</td>
</tr>
<tr>
<td>Malta</td>
<td>64</td>
<td>55</td>
<td>48</td>
<td>64</td>
<td>52</td>
<td>104</td>
<td>117</td>
</tr>
<tr>
<td>Egypt</td>
<td>92</td>
<td>122</td>
<td>106</td>
<td>110</td>
<td>54</td>
<td>101</td>
<td>81</td>
</tr>
<tr>
<td>Niger</td>
<td>106</td>
<td>132</td>
<td>97</td>
<td>102</td>
<td>98</td>
<td>115</td>
<td>83</td>
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<tr>
<td>Chad</td>
<td>115</td>
<td>96</td>
<td>126</td>
<td>91</td>
<td>145</td>
<td>96</td>
<td>102</td>
</tr>
<tr>
<td>Algeria</td>
<td>130</td>
<td>141</td>
<td>122</td>
<td>98</td>
<td>129</td>
<td>138</td>
<td>136</td>
</tr>
<tr>
<td>Libya</td>
<td>132</td>
<td>116</td>
<td>107</td>
<td>140</td>
<td>121</td>
<td>143</td>
<td>124</td>
</tr>
</tbody>
</table>


All these failures seem to be due to deficiencies in the capacity of Libyan logistics-related institutions, including ports. The conclusion is that they are caused, directly
or indirectly, by persistent political and economic mismanagement. In this regard, much blame can be laid on the constant conflicts between Libya and its neighbouring countries during Gaddafi’s regime. All of these political issues led to Libya’s isolation from the international community, along with a lack of economic cooperation between Libya and the international community in general, and neighbouring countries in particular. Examples include Libya’s failure to establish effective trade corridors with its land-locked neighbours because of political conflicts between Libya and its southern neighbours—no railways or roads. Likewise, there is very little hinterland connection infrastructure with any of the neighbouring countries. This is mostly because of political instability in the region. During Gaddafi’s regime, this was largely due to Libya’s interference in the affairs of its neighbours in pursuit of regional dominance. In addition, sanctions implemented by the international community between 1992 and 2003, because of the internationally condemned behaviour of the regime, affected all aspects of the economy and starved the country of essential capital investment in key infrastructure, thus greatly undermining Libya’s international trade capacity (Fraenzel, 2009). The capacity of its ports to grow and perform optimally was consequently also undermined.

Secondly, considering that all ports in Libya are state owned and operated, political and economic mismanagement has resulted in a failure to invest in vital economic infrastructure, especially ports. The desire to retain power and control of all aspects of the country meant that the state, particularly the Gaddafi regime, refused to allow private sector participation in port development and management. This has had an influence on decisions regarding port resourcing and management. In addition, in the 1970s and 1980s, Libya formed a number of laws and regulations to discourage private sector participation. Further, there were no secure investment laws to encourage foreign or local investors to establish businesses in Libya, especially after the nationalisation of private companies. The absence of a private sector minimised competition between ports, and this is reflected in the inability of Libya’s ports to perform to a high standard.

Regarding economic factors, Libya focuses on oil exportation, which is the main driver of its economy. This has prompted the LMTPA to emphasise oil ports over
general cargo and container ports. Additionally, nationalising the industrial and agricultural sectors, excluding the private sector, and controlling and monitoring foreign exchange measures have undermined trade productivity and made Libya reliant on imports for all of its needs. These actions have also minimised the cargo volumes handled by Libyan ports, which discouraged the Libyan government from investing in these ports, deploying costly equipment and developing infrastructure.

A limited port capacity influences port performance in both developed and developing economies. Evidence of this is that new generation container ships are served by a small number of container ports. These include developed ports, such as Rotterdam and Hamburg and developing ports, such as Shanghai. Although the literature contains a number of studies conducted on the factors that influence container port performance in developed economies, few have focused on African ports. Further, the literature shows that very few of these studies have focused on Libyan ports. Therefore, there is a need for an enhanced, empirically driven understanding of the impediments to African port performance. This study plays an important role in creating this understanding. Additionally, the results of this research contribute to performance and efficiency theories by offering an empirical model that can be used as a decision support tool for port performance optimisation.

1.2 Aims and Research Questions

As noted and explained earlier, Libyan ports could play a vital role in the international trade of the North African and Mediterranean Sea regions. They could also be important access nodes for southern land-locked and Mediterranean countries. However, the performance of Libyan ports has been persistently poor compared to other ports located on the north coast of the Mediterranean. Taking the closest Maltese terminals of Marsaxlokk port as an example, they handled 2.37 million TEUs and served 1,862 ships in 2010 (Freeport, 2012), compared to 61,4041 TEUs and 3,961 ships handled by all Libyan ports (SPC, 2012, Libyan Maritime Administration, 2013, Misurata Free Zone, 2013). The large number of ship calls and the small volume of TEUs handled by Libyan ports shows that the larger ships owned by major carriers do not call at Libyan ports. As the Marsaxlokk and Libyan ports are located close to each other, this means there are some performance-related problems forcing international carriers to bypass Libyan ports and use neighbouring
countries’ ports instead. This is reflected in the total throughput of Libyan ports. Hence, they are not ranked among the top one hundred ports in terms of container traffic and volume of handled cargo (AAPA, 2008b, AAPA, 2009, AAPA, 2012, Aquaviários, 2012).

Apart from the lack of literature about Libyan ports, investigating the problem of Libyan ports’ performance is important because they do not live up to their potential role in developing the regional and global economy. Additionally, because of this poor performance, the cost of doing business through the ports is prohibitively high. The factors of underperformance are not identified in the literature. Therefore, the aim of this research is to investigate and highlight the factors that undermine container and general cargo port performance and efficiency in Libya, against the background of global trade transport connectivity. The ultimate objective is to investigate the performance and efficiency of container ports, to develop an empirical model for container port evaluation, and to develop criteria for improving container port performance and efficiency. Weaknesses in the Libyan container ports industry are detected, leading to suggestions for improvement. Policy recommendations are developed to assist government and businesses, particularly the ports, to establish an enabling environment and structures for improved performance.

To address these objectives, the study was developed in two phases. The first phase examined and highlighted the factors undermining the performance of four Libyan container and general cargo ports against the background of global trade transport connectivity. This was investigated from the perspective of local Libyan port stakeholders. These four main Libyan ports are Tripoli, Benghazi, Misurata and Khoms. The factors considered in this phase, which were derived from the literature, included cost, time, safety of cargo at port, port accessibility, port reliability, service flexibility, online services and productivity on the ship side and terminal side. The cost factor included the cost of cargo handling, customs clearance and land transport. The time factor consisted of the total cargo-handling time and free dwell time. The cargo safety factor included cargo damage, cargo loss and the labour competency. The factor of port accessibility included seaside accessibility and landside accessibility. Port reliability encompassed the reliability of ships’ scheduling, cargo-handling facilities and the customs clearance process. The service flexibility factor
consisted of the flexibility to provide berthing on arrival and the ability to provide a variety of handling services. The online factor discussed online services provided by Libyan ports. These included online monitoring of ship movements and cargo tracing, online customs services and online transactions. Shipside productivity included the capacity of quay cranes (QCs) and the efficiency of cargo loading and off-loading operations to and from the ship. Terminal side productivity included the capacity of storage yards, cargo-transport equipment and stacking equipment. To examine these factors against stakeholders’ experiences and perceptions, an online questionnaire was developed and administered to around 200 different stakeholders. Descriptive analysis was used to analyse the data. Due to the different interests of port stakeholders, it was expected that every stakeholder group would have a different perspective regarding the variables used. Therefore, one-way analysis of variance (one-way ANOVA) was also used to determine whether there were significant differences among the total means of the stakeholders’ perspectives.

The second phase of the study evaluated the efficiency of seven Libyan ports against 18 container ports and terminals related to Libya’s trading partners. This phase examined Libyan port performance in comparison to other international competitors. According to the findings of the first phase, variables related to port infrastructure and superstructure had the greatest influence on port performance. Therefore, secondary data related to these variables were used for this comparison. Data envelopment analysis (DEA) was employed to analyse this secondary data. The second phase included only those variables that had an influence on Libyan port performance and that were under the control of port management. In terms of port infrastructure, these variables included water depth, berth length and storage yard area. In terms of superstructure, these variables included seaside cranes, cargo transport equipment and stacking equipment. Land transport infrastructure was excluded, as it is not under port management.

Despite Libya being in a strategic location, and despite the generally accepted argument that ports are key elements to regional development, Libyan ports have not taken the opportunity available to them. The region is definitely growing in terms of trade, but this trade is facilitated by other ports in the region, such as the Maltese Marsaxlokk terminals. In contrast, Libyan ports are avoided because of their poor
performance. To find out why this is the case, this thesis has answered the key research question: What are the main factors that undermine Libyan ports from attaining optimum performance in the facilitation of regional and international trade?

To answer this question, the following key questions are examined:

1. **What are the criteria of measuring port performance?** Port performance is multi-dimensional. Each port stakeholder assesses port performance from different angles, based on the stakeholder’s interests and the nature of their business. For instance, carriers’ concerns about seaside accessibility and the efficiency of loading and off-loading operations, which depends on the efficiency of QC. That is because the efficiency of loading and off-loading operations influences a ship’s turnaround time and the reliability of a ship’s schedules. In contrast, freight forwarders have concerns about the reliability and efficiency of cargo clearance processes, rather than seaside accessibility. Therefore, to have comprehensive measurement criteria, this thesis has incorporated the literature of port performance and efficiency intensively, and has developed a comprehensive multi-dimensional imperial model for measuring port performance, as shown in Chapter 3. These criteria were tested against local stakeholder expectations and experiences. The main factors of this model are seaside productivity, terminal side productivity, cargo safety, port accessibility, port reliability, service flexibility, online service, time and cost.

2. **In what ways does the state of existing infrastructure undermine the performance of Libyan container ports?** All of the above measurement criteria depend mainly on the existing infrastructure and port superstructure. Infrastructure consists of port water depth, berth length and the area of port storage yard. These factors control the size of container ships that can be served by a port and the volume of containers on board that ship needing to be stored in a port. It also consists of road and rail networks. While these two factors are not under the control of the port, they do influence the efficiency of container flow between a port and its hinterland. Through this question, the study critically examines the ability of Libyan ports to handle the new generations of mega container ships and absorb the larger volumes of cargo that are carried by these ships.
3. To what extent does the capacity of Libyan container ports’ superstructure affect performance? In answering this question, the study investigates the efficiency and reliability of the cargo-handling equipment used at Libyan ports. It also investigates the flexibility of the service provided by a port and the ability of its equipment to handle customer needs and attract more shipping lines. Port superstructure includes all container-handling equipment, such as QCs, transport and stacking equipment. The literature illustrates that efficient container ports use sophisticated and advanced container-handling equipment. Employing such equipment depends on a number of factors, including the volume of container traffic, port capital and the port area. However, each type of handling equipment has different throughput and, therefore, a different performance.

4. How has the prevailing political situation in Libya contributed to the underperformance of the ports? Through this question, the study highlights the disadvantages of performance-related politics in taking corrective action aimed at enhancing port performance. Port performance is influenced by a number of local and global political factors. Locally, port governance structure, local trading laws, investment and finance, as well as the transformation from capitalism to socialism, have influenced port performance. In addition, Libya is politically unstable. Despite Libya’s alliance with some countries, it has experienced conflict with other countries, including neighbouring ones. These conflicts have prevented Libya from establishing strategic plans to link its ports with the wide hinterland. These conflicts have also undermined the volume of trade between Libya and these countries, which is the core of port activities.

By answering these research questions, this thesis will contribute to the body of knowledge on port performance. It is expected to bridge the gap in the present literature in the area of container ports’ performance and efficiency in developing countries, particularly in Africa. To answer these questions and give recommendations for enhancing performance and efficiency, the study has used a purely quantitative approach, divided into two phases. The first phase highlights the most influential factors on port performance through an online questionnaire sent to around 200 local stakeholders of Libyan ports. The primary data obtained from local
stakeholders were analysed using two statistical techniques: descriptive analysis and one-way ANOVA.

The most influential factors on performance were then used in the second phase to evaluate the efficiency of seven Libyan container ports, alongside those of 18 international trading partner container ports. Secondary data were used for this purpose, analysed by DEA.

1.3 Structure of the Thesis

The thesis is divided into eight chapters (see Figure 1.1). The second chapter provides a background on Libya. This includes demographic information and a brief historical account of Libya’s politics and economy during the era of the former regime and post-revolution. It then illustrates how Libya’s politics have affected its economy, as well as port connectivity and performance. It also provides some information about Libya’s international trade, trading partners and the main imports and exports. Additionally, this chapter discusses the transportation industry in general and emphasises Libyan ports and maritime transport.

Chapter 3 critically reviews the literature of port performance and efficiency. It focuses on the operations of seaside, terminal side and landside, which sets the platform for discussions in the following chapters. It also highlights the common methodologies and methods used to assess port performance and evaluate efficiency. From this critical review, a conceptual model was developed and the key factors of port performance were highlighted.

Chapter 4 discusses the methodology and outlines the methods used in this study. It highlights the methodological paradigm and justifies the use of the selected approach. It also discusses the relevant variables, data collection method and the most appropriate analytical techniques that serve the purpose of this study.

The analysis of this study was split into two chapters. Chapter 5 includes the descriptive analysis and one-way ANOVA, and Chapter 6 includes the DEA. Chapter 5 presents the empirical data analysis and results of the primary data collected via the quantitative online questionnaire. This chapter critically considers
Figure 1.1: Structure of the Thesis
the factors that influence port performance and examines their effect on performance from the perspective of local stakeholders.

In contrast, Chapter 6 considers the factors that have emerged as being most influential on port performance, and uses them as input variables to evaluate the efficiency of seven Libyan ports against 18 container ports and terminals belonging to Libya’s trading partners. It also examines the effects of the existing infrastructure and superstructure on Libyan ports’ efficiency using the two basic DEA models. The first applied model is DEA-CCR, under input-oriented, variable returns-to-scale, to measure the global technical efficiency. The second applied model is DEA=BCC, under input-oriented, constant return-to-scale, to measure the local pure technical efficiency.

Chapter 7 provides an extensive discussion of the main findings of both the descriptive and DEA analysis. It provides a comprehensive explanation for why Libyan ports have not acquired efficient performance, by bringing together the main themes in the empirical chapters to address the research questions. It also considers the different types of influences such as political, economic and social factors, as well as the way Libyan ports are operated and owned.

Finally, Chapter 8 provides a conclusion to the study. It summarises the thesis and highlights its theoretical and empirical contributions. It also makes some recommendations to improve the performance of Libyan ports, and suggests some further research to fill the gap in the literature about port performance. Finally, it lists the limitations of this study.
Chapter 2: Libya

2.1 Introduction

The purpose of this chapter is to establish the contextual background to the research. It examines the political, social and economic landscape in Libya and the direct and indirect influence this has had on the nation’s economic performance, with specific reference to the port industry. To do this, this chapter is organised as discussed in the following paragraphs.

The first section highlights the geographic, social and demographic features of the country. To identify the reasons for underperformance, the second section looks at Libya’s international and local politics, tracing the history of Libya’s politics from independence and therefore, the impact of Libya’s politics on its economy.

The third section looks at Libya’s economy since independence until the post-revolution period in February 2011, and illustrates the main driver of Libya’s economy. It also briefly highlights the laws that control trade productivity. This is followed by a discussion about the main imports and exports, as well as the trading partner countries. All of the above are reviewed because international trade is a key determinant of port activity, which depends on economic performance, formed and controlled by politics. The last section discusses the Libyan transportation industry and emphasises Libyan ports and maritime transport, to determine how politics and economic underperformance are linked to Libyan ports.

2.2 Libya’s Geography and Port Hinterland

Libya is a spacious developing country located at the centre of the south coast of the Mediterranean Sea, with a total land area of 1,759,540 square kilometres (world, 2012, CIA, 2012). It is surrounded by six countries: Egypt, Sudan, Chad, Niger, Algeria and Tunisia. Chad and Niger are land locked (see Figure 2.1). Sudan does not have a coast on the Mediterranean Sea. Libya (in the seventeenth position) is one of the largest nations in the world and is recognised as the fourth largest country of
Figure 2.1: Libya’s Geographical Location

Source: Google (2012).
the African continent (world, 2012, CIA, 2012). It has 4,348 kilometres of land boundaries: in the south, it shares a border of 1,055 kilometres with Chad, 354 kilometres with Niger and 383 kilometres with Sudan. In the east, it shares a border of 1,115 kilometres with Egypt and 982 kilometres with Algeria; and with Tunisia in the west, it shares a border of 459 kilometres (CIA, 2012).

Source: (Rodrigue and Notteboom, 2010).

**Figure 2.2: International Trade Routes, Gateway Ports and Hubs in the Mediterranean Sea**
Libya has 20 ports distributed along a coastline of about 1,770 kilometres in length. The main commercial ports are Tripoli, Khoms and Misurata in the west, and the port of Benghazi in the east. These ports are considered the main supply points for Libyan cities (including the inner cities), as they handle the majority of Libya’s international trade. However, none of Libya’s ports is a hub port.

Libyan ports therefore have a potentially large hinterland, which extends to include landlocked neighbouring countries. Furthermore, it is strategically located close to the Asia-Europe international trade route (see Figure 2.2), which passes through the Mediterranean Sea (Rodrigue and Notteboom, 2010), as well as between Europe and Africa. All indications therefore suggest that Libyan ports have great potential to perform a key role as logistical nodes within the region.

2.3 Libyan Politics

Libya has a long history of political instability, which has negatively affected its socio-economic performance (Indexmundi, 2012). For more than four decades the country lived under a dictatorship. Globally, the aggressive political behaviour of the former Libyan leader isolated Libya from the international community (Mateos, 2005). In addition to faulty local systems of governance, this isolation has affected Libyans socially, politically and economically.

2.3.1 Global Politics

During the era of the former regime, Libya had unsustainable alliances with a number of countries and organisations. These included alliances with some western counties. However, most of these alliances were demolished due to the conflicting political decisions of the Gaddafi regime. Increasingly therefore Libyan political activity focused more on the region. The regime built alliances with Arabic countries, the African Union and western Arabic countries, including Libya, Tunisia, Algeria, Morocco and Mauritania. Libya has been a member of the Arab League since 28 March 1945 (League of Arab States, 2015). The Arab League is a forum for the coordination of member states’ political positions and trading coordination. It discusses matters of common concern, as well settling some Arab disputes and limiting conflicts (League of Arab States, 2015). Aside from being a member of the
Arab League, Libya’s first alliances were with Egypt, Sudan and Syria. However, when the Egyptian regime realigned with the United States of America (USA) and recognised Israel, the Libyan regime turned south to Yemen and Ethiopia (Mateos, 2005). During the Gaddafi regime, Libya had chronic conflicts with a number of Arabic countries, including Tunisia, Egypt and Sudan (Noonpost, 2015, Zaki, 2014). In addition, in 1979, Gaddafi sent his troops to support the Ugandan army in its war against Tanzania. In the same year, it attacked Tunisia (Noonpost, 2015). Libya was also involved in the wars of Vietnam and Cambodia against American occupation, and it played a significant role in the Lebanese civil war in the 1980s. Libya benefitted little from these wars, only gaining notoriety, and lost a great deal of its wealth and people. Furthermore, Libya has chronic conflicts with some of the western countries (Davis, 1987). These conflicts led to implementing international sanctions on Libya and air strike on Tripoli and Benghazi in 1986, which widened to include a total ban on direct export and import trade, commercial contact and travel-related activities with Libya (Oakes, 2011).

The invasion of Iraq by western countries, which ended in the execution of the former president Saddam Hussein, was a clear message to the Libyan former president to change his key policies with the west. At that time, western countries threatened Libya and Iran with invasions similar to Iraq, on the basis that they were sources of terrorism. Consequently, Libya surrendered two Lockerbie suspects for trial in 1999, which culminated in the settlement of the Lockerbie case in 2003. On 19 December 2003, Libya announced that it had agreed to abandon its weapons of mass destruction programme and allow international inspections (Jentleson and Whytock, 2006).

To strengthen his regional political position, Gaddafi pursued more cooperation and engaged in less subversion, reconciling with Egypt, establishing and being a member of the Arab Maghreb Union, signing a peace agreement with Chad and concluding integration pacts with Sudan (Jentleson and Whytock, 2006). Due to the differing views of the Libyan former leader and other Arab leaders, Libya turned to western Arab countries and established the Arab Maghreb Union. The announcement of this union was on 17 February 1989 and included Libya, Tunisia, Algeria, Morocco and Mauritania (Jentleson and Whytock, 2006).
In a bid to be recognised as Africa’s ‘Elder Statesman’, in 1998 former president Gaddafi shifted his orientation from the Arabic world to Africa. He signed a number of treaties to support African countries using Libyan oil revenue. For instance, on 4 February 1998, Libya and three other African countries—Mali, Chad and Niger—established the Sahel Sahra organisation. Later, the members of this organisation increased to 23 African countries. The budget of this organisation was mostly provided by Libya (Moqatel, 2000). On 9 September 1999, Gaddafi and some other African leaders established the African Union, 40 per cent of the budget of which was provided by the Libyan government.

Apart from the 1999 sanctions, during the uprising of 17 February 2011, the international community imposed sanctions on Gaddafi’s regime in response to the aggressive repression of demonstrations. The torrent of sanctions began with the USA, just 10 days after the uprising. This was followed quickly by sanctions imposed by the United Nations (UN), the European Union (EU), the United Kingdom (UK) and other countries (Mewawalla and Cheney, 2011). The UN-imposed sanctions included an arms embargo, an asset freeze and a travel ban on Gaddafi, certain of his family members and other individuals (Mewawalla and Cheney, 2011). The EU’s sanctions included, among others, an assets freeze on a number of individuals; a ban on trade with Libya in equipment that might be used for repression; and a ban on the satisfaction of any claims in connection with any contract or transaction, the performance of which was affected by UN and EU sanctions on Libya. Additionally, the UK took action to implement the UN financial sanctions without waiting for the EU to implement them. All of these sanctions were implemented quickly, due to knowledge of the aggressive, extreme and unpredictable reactions of Gaddafi, based on his history and considering the potential interests of these countries (Mewawalla and Cheney, 2011).

During the revolution, the Libyan transitional council succeeded in gaining recognition from many countries, which helped the Libyans to win the war against Gaddafi’s regime (Black, 2011). However, after the 2011 revolution, Libya experienced a radical transformation of its political system. For around two-and-a-half years, the elected General National Congress (GNC) failed to work with the three elected governments, due to conflicts of interest, corruption, identities and
loyalties. Consequently, the national security forces have very little legitimacy and reach, and have been replaced by an array of diverse revolutionaries, such as factional militias, unregulated armed groups and jihadist groups (Combaz, 2014). All of these groups are supported by different members of the GNC. This has affected Libya’s security, making the country of great concern to the international community in terms of terrorism and economic matters. An example of a security breach is the attack on the American Embassy in Benghazi, which led to the killing of the American ambassador and three of his companions (Kirkpatrick and Myers, 2012). Still other examples include the attack on the UK ambassador in 2012 (BBC, 2012), the kidnapping of the Jordanian ambassador (Aljazeera, 2014a) and the Tunisian embassy cultural attaché in Tripoli (ABC, 2015), not to mention the daily killings, kidnappings and missing civilians and army officers.

It is clear that Libya has had a long history of political instability. It has been involved in many wars and has supported many conflicts, creating enemies both abroad and in the surrounding countries. Consequently, Libya is isolated from the international community, which has affected it politically, economically and socially. However, despite attempting to restore its political position by abandoning some of the former president’s beliefs and joining other unions, these actions have not served Libya economically. This is because most of these activities were funded and supported by Libya, particularly those with the African nations.

2.3.2 Local Politics and the Economy

Libya’s political history has not only been internationally chaotic but also locally messy. Socio-economic governance over the past forty years has been directed by the Green Book, which bears great similarity to the Communist Manifesto and was introduced by Gadaffi towards the end of the 1980s (Pack, 2013). The Green Book is divided into three parts. The first part, which was published in 1975, discusses the problems of democracy. Part two was published in early 1978 and discusses the ‘Solution of the Economic Problem: “Socialism”’, with a brief examination of the relationship between workers (producers) and employers (owners). The application of part two on ownership began a few months after this part was published. The third part was published in 1980 and discusses ‘The Social Basis of the Third Universal Theory’ (al-Qaddafi, 1975). The book was a blueprint for Libya’s economic, social
and political policies. Perhaps the greatest of this document is its restriction on private property and business ownership, which gives great power to the state to control the business environment.

The combined effect of bad politics and poor economic management has been economic underperformance and social uncertainty and insecurity (Combaz, 2014; Khan and Mezran, 2013; Nkala, 2015). The socio-economic and political landscape has, for many years been characterised by dictatorship, oppression, corruption and economic mismanagement, leading to the internal conflicts leading to the removal of the regime and execution of Gaddafi in 2011 (Mejia, 2012; Stephen, 2013). Even after the 2011 revolution, which promised positive transformation all round and a relief from dictatorial oppression and economic mismanagement, the situation has further deteriorated into civil war and heightened insecurity. The old vices of oppression, corruption and nepotism persist. As a result of the deteriorating political environment, many countries have withdrawn their ambassadors and reduced their diplomatic missions due to the proliferation of attacks on the same (HRW, 2015).

2.4 Economic Landscape

When Libya became independent in 1951, it was classified by the UN as one of the world’s poorest countries and depended on international aid programmes (Butler, 2012). Discovering oil in 1959 changed the economic situation completely (Husien, 2007), and moved Libya into the forefront of global economies (Butler, 2012). However, the Gaddafi regime transformed the economy from a capitalist-oriented to a socialist-oriented economy in 1969 (Alafi, 2010) through the implementation of the Green Book, leading to economic stagnation. Because the Green Book discourages any form of private business investment ownership and personal savings, most Libyans rely entirely on paid work (Alam et al., 2009). This has greatly undermined living standards for the majority of Libyans, apart from those associated with the ruling elite.

Furthermore, during Gaddafi’s era, over-reliance on oil has undermined economic diversification (Combaz, 2014). Oil and gas contribute to around 95 per cent of export earnings (Emporiki Bank, 2012, CIA, 2012), 80 per cent of government revenue and 65 per cent of GDP (Indexmundi, 2012). Other sector which
significantly contribute to the economy include the construction and service sectors, which account for around 20 per cent of GDP, and have only recently expanded significantly (CIA, 2012).

However, even with the economic underperformance largely caused by political patronage and general mismanagement, the potential of the economy is evident. The statistics for example show a positive GDP trend during the sanctions period (UNCTAD, 2011a) (see Figure 2.3).

![Figure 2.3: Libyan Total Gross GDP from 1980–2010](image)


For background, Libya has experienced three eras of economic change. The first era was between 1970 and 1977, when the regime increased the state's role in the national economy and international trade. During that period, all insurance, trade, automotive and automotive spare parts and commercial agency activities were nationalised. However, the private sector remained active in some instances (Mustafa, 2007).

Between 1978 and 1988 the government formed a number of laws and resolutions that discouraged the private sector in economic activities, including international trade (Mustafa, 2007). An example of these resolutions that discouraged international trade is resolution number 1315 of 1981. This resolution prohibits 86 types of goods, sharply reducing imports. Another resolution for the same purpose is
resolution number 1339, also instituted in 1981. This resolution requires a licence in advance to import goods. However, not all importers can obtain such licences. This resolution had a significant effect on the volume of imports and the importers themselves (Bayan Economy, 2000). Therefore, importers have tended to find illegal ways to import particular goods required by the local market. In the meantime, these resolutions (in addition to the low productivity of the public sector) affected the performance of Libyan ports by decreasing the volume of international trade.

Due to increased restrictions on the private sector, some capital owners quit the country and invested their money overseas. From 1973 until 1993, the government established some measures to control and monitor foreign exchange, to protect the value of the local currency and to prevent the migration of capital. These measures included linking the Libyan Dinar (LD) to the American dollar (US$) at a fixed exchange rate, which is 1US$ = 0.29679 LD. This was done in February 1973 (U.S. Department of state, 2011). This procedure made the LD sustainable against other currencies until 1986. On 13 March 1986, the Libyan government made every one LD = 2.8 US$ to give the exchange rate more flexibility (as the government claimed). Suddenly and surprisingly, the government issued a resolution on 14 February 1999 and made the exchange rate 1 US$ = 3.25 LD for the public, despite the official rate being 1 US$ = 0.50 LD for officials and loyalists (Obaidi, 2014). These policies significantly affected Libyans who required medical treatment overseas, and private traders. In contrast, it affected the productivity of national economic units and the productivity of individuals negatively, especially in the service sector (Alrubaie, 2004). It also led to fiasco-led investments, corruption and increased national expenses (Obaidi, 2014).

Another example of these measures is the government restricting international trade exchange, banning some imports totally, and other imports partially, to protect local production. During this period, the so-called ‘currency black market’ emerged, corruption increased (Combaz, 2014), with the country experiencing a severe lack of durables, automobiles and some types of imported food. However, due to these polices, Libya experienced a sharp reduction in international trade exchange and an economic recession. Additionally, due to the implemented laws, which affected the manner of marketing channels and the sourcing and methods of providing
Commodities in the 1980s, the Libyan economy experienced a shortage of commodities, leading to an emerging black market (Husien, 2007). Apart from the negative impact on the performance of the national economy, all of these combined factors had a negative effect on Libya’s port industry, due to the drop in international trade transported by sea. The combination of falling world oil prices, international economic sanctions and Gaddafi’s economic mismanagement took a heavy toll on Libya’s economy. These were more than just economic statistics, as economic discontent began to fuel political instability (Jentleson and Whytock, 2006).

Due to the absence of private sector competition and the restrictions on many imports, production efficiency and product quality declined (Alrubaie, 2004). In addition, tax and customs income also declined, which led to a continuing deficit in the public budget and increased the amount of public debt.

These changes (in the exchange rate of the LD, banning some imports and getting importing licences in advance) have increased corruption in the country. Therefore, the trade volume handled by the Libyan ports has declined. Additionally, because of these procedures, Libya is counted among the most world’s most corrupt countries (Economist, 2013, UN, 2004). This includes corruption within the Libyan ports themselves. Corruption has a series of socio-economic effects, which directly impede economic development, because it raises transaction costs and uncertainty in the economy. It also skews the process of policy making, undermines state legitimacy and the rule of law (Otman and Karlberg, 2007). It leads to wider income disparities and lays a larger burden on medium and small businesses, who need to set aside a larger share of their income and time to deal with corruption. (Otman and Karlberg, 2007).

When these new laws and resolutions failed, in 1989 the regime changed its approach, trying to find alternatives for oil, and encouraging privatisation. However, there has been no progress in formulating a strategy to stimulate the non-oil economy and establish the building blocks for sustainable, diversified, private sector-led economic growth (bank, 2014). The uncertain environment and delayed public capital projects have undermined and stalled investment as a private sector activity (bank, 2014). In addition, only small foreign businesses, other than oil-related initiatives, have been set up, due to the lack of trust and secure investment laws.
These policies, in addition to the drop in real GDP, reduced the amount of imported goods in the local market (see Figure 2.4). It placed great strain on government spending, and increased Libya’s debt replacement problems, which all negatively influenced living standards (Butler, 2012).

![Figure 2.4: Total Export and Import Value From 1980–2012 (Million $US)](chart)

Source: (UNCTAD, 2011c).

**Figure 2.4: Total Export and Import Value From 1980–2012 (Million $US)**

This drop in exporting and importing reached its lowest level in 1995 (see Figure 2.4) and then increased sharply for the next 13 years (UNCTAD, 2011c). During this period, the demand for imported consuming goods was strong; despite the majority of consumer needs being imported under the former regime, many western products were not easy to access in the country (EUROMONITOR, 2011).

Despite Libya having large reserves of oil, natural gas and gold, it has a low development base to offer strong economic growth (EUROMONITOR, 2011). In 2003, Libya reintegrated globally. It has since witnessed significant development and growth in recent years due to attracting greater foreign investment, especially in the oil sector (Fraenzel, 2009). This has had a positive impact on Libyan port activities, due to the increase in imported commodities.

The decline of foreign direct investment (FDI) inflow and outflow for Libya is clear in Figure 2.5. After accepting responsibility for terrorist activities, and undertaking
procedures such as ensuring and securing local and foreigner investors’ rights, inflows increased in 2006. However, outflows decreased to a quarter of the value of inflows. In 2007, both flows increased to be almost the same. In 2008 and 2009, the inflows decreased slightly compared to 2007. In contrast, the outflows maintained their increase, to reach a peak in 2008, before dropping sharply in 2009.

In 2010, the former regime established law number nine, regarding encouraging local and foreign investors to invest in Libya (U.S. Department of state, 2011). This law gave a package of exemptions to investors. For instance, all the equipment and technologies used for a project are tax-free. It also gave an exception to equipment used for projects—such as spare parts, transport means, furniture, raw materials and advertising materials—from any taxes for five years from the start date of the project. The exemptions also covered income tax, production tax, exporting products and some other taxes. This law also provided some investment security clauses, to encourage foreign investors (bank, 2014). However, despite all of these measures, in 2010 the inflow FDI decreased to nearly 50 per cent, whereas the outflow doubled (see Figure 2.5).

In 2011, the inflows dropped to zero and the outflows reached their minimum value because of the uprising. Moreover, the recent Libyan and Egyptian revolutions resulted in the decline of FDI in Africa by 50 per cent in 2011 (UNCTAD, 2012).

![Figure 2.5: FDIs in Libya 2006–2011](image)

During the uprising in 2011, the Libyan economy collapsed, due to the decline in all economic activities, including oil-based ones. In 2012, oil production witnessed some recovery. In 2013, the economy had only just got back to where it was prior to the uprising (Khan and Mezran, 2013). However, the government has largely paid only lip service to economic policies. This is due to conflicts between the parties, tribes and groups, extensive patronage, intermediation and corruption. It is also because of insecurity, high state autonomy, low levels of regulation and the fragmentation of society, which raises problems of trust, personal initiative-taking and legitimacy (Combaz, 2014). In addition to the weakness of the GNC and the transitional governments, the new Libyan political economy is fraught with difficulty and uncertainty.

As mentioned above, oil is the main driver of the Libyan economy. Therefore, closing the oilfields and ports for about nine months, as well as exploding some oil pipes in Libya’s east, had a significant effect on the Libyan economy. High spending trends, in addition to the undiversified economy, high unemployment, weak economic guidance, the lack of private sector and foreign participation, and the weak banking system, have severely eroded the country’s wealth (Combaz, 2014).

Due to destruction caused by the war, Libya has needed a huge amount of different materials to rebuild affected cities, promote infrastructure and establish new factories. Therefore, LD 19.3 billion was dedicated from the 2013 budget to development and rebuilding projects. However, no major projects have been seen on the ground since the revolution. Additionally, rebuilding the country requires professional foreign and local companies. However, insecurity concerns are the main deterrent to foreign investors (EUROMONITOR, 2011, Dabrowska, 2012). The demand for using Libyan ports has increased. This is reflected in the bigger volume of cargo handled by Libyan ports in 2012 and 2013 (Libyan ports company, 2013).

Import and Export with Libya’s Trading Partners

As the Libyan economy depends strongly on oil, Libya is considered one of the least diversified markets in the world in terms of exports (Dabrowska, 2012). The export basket is not varied at all, with the oil industry representing 95 per cent of all exports (Emporiki Bank, 2012, UNCTAD, 2011a), and only four per cent comprising industrial supply (see Table 2.1) (CETMO, 2010). Meanwhile, Libya is largely

Table 2.1: Libya’s Trade Structure by Product Group

<table>
<thead>
<tr>
<th>Year</th>
<th>Export Total value (millions of dollars)</th>
<th>All food items</th>
<th>Fuels</th>
<th>Ores, metals, precious stones and nonmonetary gold</th>
<th>Manufactured goods</th>
<th>Chemical and transport equipment and transport goods</th>
<th>Machinery goods</th>
<th>Other manufactured goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>7 244</td>
<td>0.2</td>
<td>0.0</td>
<td>92.0</td>
<td>0.0</td>
<td>7.4</td>
<td>4.1</td>
<td>0.1</td>
</tr>
<tr>
<td>2005</td>
<td>30 948</td>
<td>0.1</td>
<td>0.0</td>
<td>95.0</td>
<td>0.6</td>
<td>3.9</td>
<td>2.7</td>
<td>0.1</td>
</tr>
<tr>
<td>2010</td>
<td>46 310</td>
<td>0.3</td>
<td>0.0</td>
<td>95.8</td>
<td>1.0</td>
<td>2.9</td>
<td>1.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Import</td>
<td>2005</td>
<td>5 033</td>
<td>21.6</td>
<td>0.9</td>
<td>4.4</td>
<td>69.6</td>
<td>8.9</td>
<td>31.1</td>
</tr>
<tr>
<td>2010</td>
<td>11 188</td>
<td>15.8</td>
<td>0.6</td>
<td>9.7</td>
<td>3.1</td>
<td>67.3</td>
<td>6.0</td>
<td>35.6</td>
</tr>
<tr>
<td>2010</td>
<td>24 647</td>
<td>16.9</td>
<td>0.7</td>
<td>9.3</td>
<td>3.0</td>
<td>68.9</td>
<td>5.7</td>
<td>36.6</td>
</tr>
</tbody>
</table>


Manufactured goods dominated the imports basket during the period 2005 to 2010, with an average of 68.1 per cent, followed by machinery and transport equipment, with an average of 36 per cent (UNCTAD, 2011a) (see Table 2.1). 75 per cent of food consumed in Libya is imported (Emporiki Bank, 2012).

The majority of Libyan international trade has been with developed economies. In 2010, the principal export trading partner of Libya was the EU (see Figure 2.6) (CETMO, 2010). The total volume of trade with developed economies was about 72.6 per cent of Libya’s total international trade in 1995. This percentage decreased by about 11 per cent in 2005, and reached less than 50 per cent in 2010 (UNCTAD, 2011c). The EU, which was the dominant partner, represented 67.4 per cent of the total imports and exports in 1995 (UNCTAD, 2011a). Due to the political conflicts with European countries, this percentage declined again to 57.8 per cent in 2005, and continued decreasing to 42.5 per cent in 2010 (UNCTAD, 2011c). More specifically regarding the EU, as the principal export trading partner of Libya, Italy is Libya’s dominant export trading partner. It receives almost 50 per cent of exports from Libya and provides 30 per cent of Libya’s imports (CETMO, 2010). This is followed by Germany, with 12.8 per cent, France with 7.9 per cent and Spain with 7.3 per cent. Other destinations received 31.6 per cent of Libyan exports (Fraenzel, 2009).
Figure 2.6: The Percentage of Libya’s Trade Partners in 2010 in Ranking Order

Libya also has trading partners from developing economies, including in Africa, Latin America and Asia (UNCTAD, 2011c). During the period 1995 to 2010, while the trade between Libya and the developed economies declined, the volume of trade between Libya and the developing economies nearly doubled. For instance, the total volume of trade with the eastern, southern and south-eastern Asian economies, which are the principal trading partners among the developing economies, increased from 9.3 per cent in 1995 to 20.9 per cent in 2010 (UNCTAD, 2011c). Trade volume with Africa also increased slightly, from 8.9 per cent in 1995 to 11 per cent in 2010; trade with western Asia recorded an increase from 7.3 to 12.7 per cent; and trade with the Latin American developing economies increased from 1.9 to 3.1 per cent (UNCTAD, 2011c). Conversely, international trade with neighbouring land-locked countries is minimal (Ministry of Infrastructure and Facilities, 2011, Global trade, 2013), due to the lack of hinterland connectivity caused by chronic conflicts with Chad.

Libya’s dependency on oil is reflected in the fact that 11 specialised oil and gas ports and terminals handle hydrocarbon cargo. Conversely, manufactured goods, food,
machinery and transport equipment, which are the main imports for domestic use, are handled by seven Libyan commercial ports: Tripoli, Misurata, Khoms, Benghazi, Tobruk, Derna and Zuwarah. None of these ports is a hub port, used for re-transhipping international trade. This is shown by Libyan port statistics regarding loaded and off-loaded cargo. The above implies that the Libyan commercial ports are connected globally with a number of international ports related to some developed and developing trading partners, to import the required commodities (see Figure 2.6). This study incorporates investigation of a number of these ports to measure and compare the performance of Libyan ports. The statistics also show only minor trade between Libya and its neighbouring land-locked countries, which implies that the Libyan ports are not used efficiently to support the regional economy. The next section provides some information about the Libyan transport system.

2.5 The Transport Industry

Transport in Libya comprises three main modes: land, air and maritime. All of these are provided by the Libyan Ministry of Transport. Land transport is mainly by road, due to the absence of rail networks in Libya (outlook, 2012, RABA, 2013, RABA, 2012). Air transport is mainly used for passenger transport, whereas only a small proportion of international trade is transported by air. Maritime transport dominates international freight to and from Libya (Libyan Maritime Administration, 2013), due to its cost efficiency and the ability to transport large volumes of freight using free natural passages (UNCTAD, 2007).

2.5.1 Road Transport

It is argued that a port with a strategic location close to the main world trade lanes, with good landside connections, provides the basic requirements for port users to assess their port selection options (Tongzon and Heng, 2005). In addition, infrastructure stands out as the main driver of logistical performance indicator of progress for middle- and low-income countries (Arvis et al., 2012).

Until 1986, Libya had a paved road network of about 34, 000 kilometres to connect its ports, cities and agricultural areas (RABA, 2012). Further, surfaced roads existed between the north and the southern oases of Al Kufrah, Sabha and Marzuq. These
roads have done much to end the isolation of these remote settlements (Butler, 2012). However, due to the international sanctions on Libya, all aspects of its infrastructure have been left underdeveloped, including roads (Fraenzel, 2009). Not signing any new contracts to extend the road network, from 1986 up to 2003, made the situation worse (RABA, 2012). However since 2008, the authority in charge of roads, bridge and land transport commenced the maintenance of old roads and paved some other new roads.

Regionally, a major project concerns the freeway that connects the Tunisian boarder with the Egyptian border, with a length of 1,700 kilometres (RABA, 2013). However, the Libyan ports are still disconnected from Chad and Niger. For instance, the distance between Qasr Ahmed port and Abeche in Chad is around 2,865 kilometres. Due to the lack of proper road networks, the average speed in Libyan is 50 kilometres a day and in Chad, 150 kilometres a day; about 16 days is required to transport freight between these two countries (Comtois et al., 2012). In addition, most of the direct routes through the Aozou strip are not accessible, due to mines placed there during the war between Libya and Chad (Comtois et al., 2012). Similarly, due to the lack of proper roads, it takes 19 days to cross the 3,500 kilometres between Misurata and Agades in Niger (Comtois et al., 2012). This makes transport costs extremely high, which disconnects Libyan ports from the land-locked countries.

Regarding land freight transport, there are no state owned companies for freight transport in Libya. Therefore, land transport services are provided by small private companies, which transport 80 per cent of goods. The remaining 20 per cent is transported by the freight owners themselves (CETMO, 2010). In 2009, the number of vehicles dedicated to goods transport was 77,624 trucks. Fifty-eight per cent were non-articulated trucks and 42 per cent were articulated (CETMO, 2010). However, land transport is costly and the delivery time is long, due to the absence of rail transport and the extreme road congestion caused by the absence of public transport, especially in the big cities. The congestion and lack of rail has also had a negative impact on the efficiency of cargo flow from and to Libyan ports.
2.5.2 Rail Transport

Rail transport is the most efficient transport means on land (Transystems, 2011, Kozan, 1997, Kozan, 2000, SCI, 2010). However, Libya has not had a functional railway network since independence. Some lines were built by Italian colonial forces, and more were built during World War II, but all have been demolished (bulletin, 2010).

In September 2008, construction of a 554 kilometres double-track railway project was started by the Russian Railways Company in the eastern part of Libya, to connect Benghazi city and Sirt, parallel to the coastline (Gazette, 2008). In addition, another 352 kilometres long line between Al Khoms and Sirt supposed to be constructed by China Railway Construction Corporation, by 2013. An 800 kilometres line is also expected to be extended from iron-ore deposits in the south, to the port of Misurata (Gazette, 2008). Further, the Railways Executive Board confirmed in 2001 that work was underway on a line from the Tunisian border to Tripoli and Sirt, but this has not been completed yet (RPEMB, 2013). The potential rail network is expected to prevent congestion in and around the big cities and will contribute significantly to the efficiency of land freight flow.

2.5.3 Air Transport

Libya has 16 airports. Seven are international airports, three are national airports, and six civil and air force airports. All of the civil and air force airports are national airports, except one located in Tripoli, called Metiqa airport, which is used internationally (Libyan Civil Aviation Association, 2012).

The Arab region has become increasingly important in terms of air transport. However, it seems Libya has been left behind (CAPA, 2012). This is because the government of Gaddafi’s regime did not pay more attention to its airlines and airports, whereas nearby Middle Eastern countries (e.g., United Arab Emirates (UAE), Egypt and Qatar) started to develop some of the largest global hubs (CAPA, 2012). What made this sector worse was that Libya’s air fleet lost five airplanes during the uprising in 2011, and remains 15 airplanes in working order (CAPA, 2012). Later in 16 July 2014, another 12 airplanes were destroyed when Misurata’s militias attacked Tripoli airport (BBC, 2014). Tripoli airport was completely closed.
due to total damage in its terminal and severe damage in the control tower and other main airport facilities (Aljazeera, 2014b).

Libyan airports are mainly used for passengers. For instance, they handled 2,344,771 in 2010, whereas air freight reached 16.55 million ton-kilometres in the same year (Fedec and Sousa., 2012). This amount of freight is very small, compared to the freight handled by sea.

2.5.4 Maritime Transport

Compared to other coastal countries, including smaller ones such as Malta, Libya has not paid great attention to the essential maritime transport and ports sector. There is no doubt that Libya is affected by international sanctions, which have left the country underdeveloped in all aspects of its infrastructure, including ports (Fraenzel, 2009). The lack of infrastructure has negatively influenced the throughput of Libyan ports compared to other North African ports (AICD, 2009). However, state monopoly, corruption and centralisation in decision making have had the most influence on the development of this vital sector (outlook, 2012). In addition, politics, bureaucracy, region trade productivity and port connectivity have had a great impact on Libya’s trade capacity, which has influenced the productivity of Libyan ports.

In terms of the port industry, the private sector is not involved in Libya’s ports. However, the only area that consists of both public and private sectors is shipping and freight forwarding, which includes about 300 local companies (CETMO, 2010). Private carriers have a growing presence in maritime transport; the General National Maritime Transportation Company (GNMTC) was the only national and public maritime transport company until 2003. Like any other Libyan industry, GNMTC has suffered from the international embargoes, as Surveyor (2009) has argued. However, when the son of Gaddafi, who started his seafaring career in 1993, quickly rose to take charge of the maritime industry in Libya (Smith, 2012), this company was bankrupted on purpose. Before the bankruptcy, the company monopolised the maritime transport sector. It owned 38 ships; thirteen were general cargo ships, with four RO/RO ships, 17 oil tankers and four passenger ships (GNMTC, 2009). However, because the former regime relied on oil as the main driver of the national
economy, GNMTC focused on oil and oil product tankers. To act as a saviour, Gaddafi’s son helped GNMTC to own 14 oil tankers, seven product carriers and two liquefied petroleum gas (LPG) carriers. Some of these ships were joint-ventured with the Arab Maritime Petroleum Transport Company (AMPTC) (GNMTC, 2009).

The turning point for the Libyan maritime sector in general, and GNMTC specifically, was when 1,907 of GNMTC’s employees were released in a single resolution, to other sectors in October 2003 (GNMTC, 2009). All of these employees were experienced and highly ranked crews. Later on, the company cut its employment from 3,700 to 600, to save costs (Surveyor, 2009). Some of these employees obtained high-level positions in Libyan ports.

Generally, despite Libya having a long coastline on the Mediterranean Sea, and being close to international trade lanes, its merchant fleet consists of only 167 ships. These include 19 oil tankers, nine general cargo ships and 139 other types of ships, such as tugs, pilot boats and other service vessels (UNCTAD, 2011b). The majority of these oil tankers are ostensibly owned by GNMTC; however, there is some evidence to show that they were actually controlled by Gaddafi’s son (Saul, 2011). During the 2011 uprising, the international community implemented a combination of sanctions and a freeze on Gaddafi family’s assets. Consequently, several tankers laid-up off Singapore and Malta. The 24 tankers entered into service again after the owners paid the operational costs to some of ship management companies (Saul, 2011). However, the general cargo ships are owned by two small private shipping lines and the other ships are state owned, to provide services within the ports.

The total gross tonnage (GT) of the Libyan fleet is 865,000. Oil tankers dominate this volume by 788,000 GT; the other types of tankers and general cargo ships supply 50 GT, due to their high numbers. The lowest GT for the general cargo fleet is 27,000 GT (UNCTAD, 2011b).

Despite the dramatic demand for containerisation during recent decades, and the increase in container ship numbers and capacity (see Figure 2.7), Libya does not own any such ships. In addition, Libya does not have a single specialised container terminal to meet the dramatic development and demand for containerisation. Surprisingly, Libya has only two specialised quay container cranes, deployed in Qasr
Ahmed port in Misurata. This shows the impact of bureaucracy in Libya’s maritime industry, as decision makers do not respond quickly to market requirements and trends, and act accordingly.

Evidence for this is that the Libyan market share of the total world maritime business is quite low. Its population represented 0.10 per cent of the world total in 2011. In 2009, Libyan port traffic in TEUs recorded 0.03 per cent of the world total and trade value 0.19 per cent, measured by US dollars, which contributed 0.11 per cent to the total world GDP. In 2010, Libya recorded 0.0 per cent in shipbuilding GT, container ships operation TEU and ship scraping DWT, whereas it recorded 0.11 per cent in ship registration DWT, 0.08 in officers headcount; and 0.09 in ratings’ headcount (UNCTAD, 2011b).

2.5.4.1 Libyan ports

Ports are one of the key nodes of international trade (Francis, 2008). They are used to facilitate ships used to transport international trade. Similarly, the majority of Libyan trade is handled by Libyan ports. This study focuses on Libyan ports’
performance and efficiency, as they are affected by the underperformance of Libya’s economy. This means that economic institutions like ports do not have proper management. Therefore, they do not have sufficient investment in infrastructure and superstructure. Using ports as an example, this thesis examines the way in which political trends have impacted upon economic performance and therefore port performance. The following section provides information about Libyan ports.

There are 20 ports on the Libyan coastline (see Table 2.2). All these ports are owned and operated by the public sector, under the authority of the Libyan Maritime Administration (LMA). Seven of these ports are commercial rather than oil ports, which are used to handle general cargo, containers, RO/RO and dry bulk. These ports are Tripoli, Benghazi, Misurata ‘Qasr Ahmed port’, Khoms, Derna, Tobruk and Zuwarah. There is also another small sized commercial harbour close to Derna port, called Ras el Hilal, which is used for leisure boats.

All of these ports are operated by a state owned company, called the SPC. This company was established according to law number 21 of 1985. However, only Qasr Ahmed port in Misurata is an autonomous port. It is operated by Misurata Free Zone (MFZ) Company under resolution number 33 of 2006. MFZ has succeeded in making this port Libya’s top port. Qasr Ahmed port is located within the boundaries of MFZ. Therefore, the management of MFZ is close to the operations and port users. This ensures the management of MFZ is up-to-date with port performance and customer needs. Due to operating only one port and having its own budget, MFZ has managed to establish some strategic plans. These include employing more advanced cargo-handling equipment that is different from those employed in other ports operated by SPC. This is reflected in the volume of cargo handled compared to the other ports. Moreover, just after the war in 2014, this port celebrated the opening of a new dock, 804 metres in length (Zaroog and Westcott, 2014). MFZ also planned to build a new port and container terminal 20 metres in depth, close to Qasr Ahmed. Operating ports close to each other enables MFZ to monitor the performance of these ports and respond to any needs or deficiencies. The SPC could not achieve this as all of its ports are far away from central management, which makes the responses to ports’ needs very weak. All Libyan ports operate from 8am to 5pm. This includes cargo operation, customs services and some other key facilities.
Table 2.2: Libyan Ports

<table>
<thead>
<tr>
<th>Port’s name</th>
<th>Cargo type</th>
<th>Operator</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Tripoli</td>
<td>Container, GC, dry bulk &amp; RO/RO</td>
<td>SPC</td>
<td>32° 54.0' N, 013° E</td>
</tr>
<tr>
<td>2 Benghazi</td>
<td>Container, GC, dry bulk &amp; RO/RO</td>
<td>SPC</td>
<td>32°07.0' N, 020° E</td>
</tr>
<tr>
<td>3 Qasr Ahmed</td>
<td>Container, GC, Dry bulk &amp; RO/RO</td>
<td>MFZ</td>
<td>32° 21.0' N, 015° E</td>
</tr>
<tr>
<td>4 Khoms</td>
<td>Container, GC, dry bulk &amp; RO/RO</td>
<td>SPC</td>
<td>32° 40.0' N, 014° E</td>
</tr>
<tr>
<td>5 Derna</td>
<td>Container, GC, dry bulk &amp; RO/RO</td>
<td>SPC</td>
<td>32° 46.0' N, 022° E</td>
</tr>
<tr>
<td>6 Tobruk</td>
<td>Container, GC, dry bulk &amp; RO/RO</td>
<td>SPC</td>
<td>32° 04.0' N, 024° E</td>
</tr>
<tr>
<td>7 Zwarra</td>
<td>GC &amp; bulk</td>
<td>SPC</td>
<td>32° 55.0' N, 012° E</td>
</tr>
<tr>
<td>8 Ras el Hilal</td>
<td>Small GC</td>
<td></td>
<td>32° 55.0' N, 022° E</td>
</tr>
<tr>
<td>9 Misurata</td>
<td>Industrial ‘ORE’</td>
<td>Misrata Steel Co</td>
<td>32° 22.0' N, 015° E</td>
</tr>
<tr>
<td>10 Marsa al Hariga</td>
<td>Petroleum</td>
<td>Arabian Gulf Oil Company</td>
<td>32° 04.0' N, 024° E</td>
</tr>
<tr>
<td>11 Mellitah</td>
<td>Petroleum</td>
<td>ENI Oil Ltd</td>
<td>32° 53.0' N, 012° E</td>
</tr>
<tr>
<td>12 Es Sidra</td>
<td>Petroleum</td>
<td>Waha Oil Co of Libya Ltd</td>
<td>30° 38.0' N, 018° E</td>
</tr>
<tr>
<td>13 Zawia Terminal</td>
<td>Petroleum</td>
<td>Zawia Refining Co</td>
<td>32° 47.0' N, 012° E</td>
</tr>
<tr>
<td>14 Bouri</td>
<td>Petroleum</td>
<td>ENI Oil Ltd</td>
<td>33° 54.0' N, 012° E</td>
</tr>
<tr>
<td>15 Aljurf Terminal</td>
<td>Petroleum</td>
<td>Mabrouk Oil Operations</td>
<td></td>
</tr>
<tr>
<td>16 Marsa El Brega</td>
<td>Petroleum, other liquid, GC, dry bulk, RO/RO</td>
<td>Sirte Oil Co &amp; SPC</td>
<td>30° 24.0' N, 019° E</td>
</tr>
<tr>
<td>17 Ras Lanuf</td>
<td>GC &amp; petroleum</td>
<td>Veba Oil Operations BV &amp; SPC</td>
<td>30° 30.0' N, 018° E</td>
</tr>
<tr>
<td>18 Rasco Harbour</td>
<td>Petroleum</td>
<td>Ras Lanuf Oil &amp; Gas Processing Co</td>
<td>30° 30.0' N, 018° E</td>
</tr>
<tr>
<td>19 Zueitina</td>
<td>Petroleum</td>
<td>Zueitina Oil Co</td>
<td>30° 51.0' N, 020° E</td>
</tr>
<tr>
<td>20 Abu Kammash</td>
<td>Petrochemicals</td>
<td>Abu Kammash for Petrochemicals</td>
<td>33° 04.0' N, 011° E</td>
</tr>
</tbody>
</table>

The other 11 oil and petrochemical ports and terminals are mainly used to export Libyan oil, gas and petrochemicals. In contrast, Ras Lanuf port also handles general cargo and Marsa El Brega port handles general cargo, RO/RO and dry bulk. The steel port in Misurata is only used to receive ore for the Misurata Steel Complex.

Despite the fact that international trade routes pass through a similar distance between Africa and Europe, all gateways and hub ports are located in Europe. There are no hub ports in North Africa to serve the region and supply land-locked countries located south of Libya (Rodrigue and Notteboom, 2010). For instance, 86.84 per cent of Chad’s imports and 78.08 per cent of its exports in 2009 were sent through Cameroon, whereas only 8.86 per cent of its imports and 8.33 per cent of its exports were sent through Libya (Ministry of Infrastructure and Facilities, 2011). Similarly, Niger’s main trade partners are the EU, Japan and the USA, which use Nigeria and Benin’s ports (Global trade, 2013).

The lack of efficient ports in North Africa, particularly in Libya, ensures that shipping lines avoid Libyan ports and use European ports instead. Apart from port connectivity, port efficiency is associated with the technology of handling equipment used at that port. Taking container handling as an example, most container ports across the world, whether fully automated or semi-automated, use quay container cranes with different types and specifications to deal with ship operations at seaside. In addition, fully automated container ports use AGVs to transport containers from the seaside to the storage yard and vice versa. Then the container is stacked in the storage yard using rail-mounted gantries (RMG) or rubber tyred gantries (RTG), depending on the adopted equipment. Within the semi-automated container ports, SCs are used to transport and stake containers. However, such equipment does not exist in Libyan ports. All Libyan ports still use conventional cargo-handling equipment to handle containers, except Qasr Ahmed port (see Table 2.3). Qasr Ahmed port has two specialised QC and two RTG cranes, although there are some limitations on its recent capacity, due to deficiencies in container-handling equipment. Therefore, Qasr Ahmed port, which is the best-equipped Libyan commercial port, cannot be used as a hub port in the region.
Table 2.3: Cargo-Handling Equipment at Libyan Ports in 2010

<table>
<thead>
<tr>
<th>Port’s name</th>
<th>Crane no.</th>
<th>Type of crane</th>
<th>Truck</th>
<th>AGV</th>
<th>Forklift</th>
<th>Trailer</th>
<th>Tractor</th>
<th>SC</th>
<th>Reach stacker</th>
<th>RMG</th>
<th>RTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>3</td>
<td>Boosting Telescopic mast 40 T</td>
<td>0</td>
<td>0</td>
<td>43</td>
<td>22</td>
<td>24</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Boosting Telescopic mast 50–80 T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Fixed mast crane 60–100 T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benghazi</td>
<td>3</td>
<td>Boosting Telescopic mast 50–80 T</td>
<td>0</td>
<td>0</td>
<td>45</td>
<td>17</td>
<td>21</td>
<td>0</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Boosting Telescopic mast 30–40T</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>3</td>
<td>Fixed mast crane 60–100 T</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brega</td>
<td>1</td>
<td>Boosting Telescopic mast 50–80 T</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Fixed mast crane 60–100 T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobruk</td>
<td>1</td>
<td>Boosting Telescopic mast 50–80 T</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Boosting Telescopic mast 30–40T</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derna</td>
<td>2</td>
<td>Boosting Telescopic mast 50–80 T</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Boosting Telescopic mast 30-40T</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>2</td>
<td>Panamax quay container cranes</td>
<td>0</td>
<td>0</td>
<td>26</td>
<td>30</td>
<td>30</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Boosting Telescopic mast 50–80T</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Fixed mast crane 60–100T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khoms</td>
<td>2</td>
<td>Fixed mast crane 60–100 T</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>14</td>
<td>18</td>
<td>0</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Boosting Telescopic mast 50–80 T</td>
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<tr>
<td></td>
<td>1</td>
<td>Boosting Telescopic mast 30–40T</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ras Lanouf</td>
<td>1</td>
<td>Boosting Telescopic mast 50–80 T</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Boosting Telescopic mast 30–40 T</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zwarah</td>
<td>1</td>
<td>Boosting Telescopic mast 50–80 T</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The lack of efficient and sufficient handling equipment has had a negative impact on the number of ships calling into Libyan ports and the throughput of these ports. For instance, in terms of the number of ship calls, Libyan commercial ports (rather than oil and steel ports) serviced 3,128 cargo ships in 2008 (SPC, 2011, Misurata Free Zone, 2013). The number of ship calls increased in 2010 to 3,961 (SPC, 2011, Esaheri, 2012, Misurata Free Zone, 2013). Due to the instability of the country in 2011, this figure decreased to 3,357 ships compared to 2010 (Libyan Maritime Administration, 2013, Misurata Free Zone, 2013) (see Figure 2.8). However, this number was very low in 2011 due to the small number of Libyan ships (UNCTAD, 2011b); the majority of the ships that called at Libyan ports were foreign flagships (CETMO, 2010). Further, the largest container ships that can visit Libyan ports are from the third generation of ships of the Panamax class. Libyan ports cannot accommodate larger ships than this class due to water depth restrictions. The deepest Libyan ports are Qasr Ahmed and Khoms ports, with a maximum water depth of 13 metres (Libyan ports company, 2013, Misurata Free Zone, 2013); the draft Panamax container ships are 12 metres (Maersk, 2011).


**Figure 2.8: Number of Ships Calling at Libyan Ports in 2008, 2010 and 2012**
Figure 2.8 shows that the top four Libyan commercial ports for call numbers in 2008, 2010 and 2012 were Qasr Ahmed port in Misurata (ranked first), followed by Tripoli, then Benghazi, and then Khoms. In 2010, the same ports had the same ranks. However, note that Tripoli port experienced a drop of 18.6 per cent in the number of calls, compared to 2008 (SPC, 2011). In contrast, Khoms port recorded more than double the 2008 calls in 2010 (SPC, 2011). This change was due to the prime minister’s resolution to stop container-handling in Tripoli port and use Khoms port instead, to prevent road congestion in Tripoli (Ghashat, 2011). In 2012, the increase in ship calls at Tripoli, Khoms and Benghazi port was nearly the same, whereas Qasr Ahmed port received 1,244 ships in 2012, nearly the same number as 2010.

In terms of cargo volumes, the throughput of all Libyan ports is very low compared to other international ports in the region. Taking containerisation as an example, there has been a dramatic increase in the global container trade, which reached about 150 million TEUs in 2010 and is still increasing (UNCTAD, 2011b). Similarly, Libya experienced an increase in container trade from 320,609 TEUs in 2006, to 614,041 TEUs in 2010. These then decreased to 358,171 TEUs in 2012 (see Figure 2.9).


**Figure 2.9: Total of TEU Volumes Handled by Libyan Ports (2006–2012)**
This decline in TEUs was due to the security instability and changing of interim governments within these two years. However, the total throughput of all Libyan ports’ in TEUs did not reach even one million per annum during the period between 2004 and 2012 (SPC, 2011), which is about 0.03 per cent of the world total (UNCTAD, 2011b).

From Table 2.1, showing Libya’s trade structure by product group, all commercial ports are used predominately to off-load imported goods. This is due to the high dependency of Libya on imported food, manufactured goods, machinery and transport equipment, as well as low Libyan exports other than oil, which do not exceed four per cent of Libyan exports (UNCTAD, 2011a). Therefore, the statistics show that the total amount of off-loaded goods by Libyan ports in 2008, 2010 and 2012 is much larger than that of loaded goods (see Figures 2.10 and 2.11). Despite Qasr Ahmed port being the dominant port in cargo loading compared to other ports, the total cargo loaded by this port in these three years did not exceed 1.5 million ton.

![Graph showing total cargo off-loaded by Libyan ports in 2008, 2010, and 2012](source)


**Figure 2.10: Total Cargo Off-Loaded by Libyan Ports in 2008, 2010 and 2012 (Thousand Tons)**

Tripoli port will be used to highlight the differences between the amount of off-loaded and loaded cargo handled by Libyan ports. The amount of cargo off-loaded
by Tripoli port in 2008 was two million ton, compared to 7,850 ton loaded in the same year. Another example is the total amount of cargo off-loaded by Qasr Ahmed port in 2010, at 3.2 million ton. In contrast, the loaded amount for the same years by the same port was only 291,007 ton. This reflects the weaknesses of local economic policies regarding investment in agriculture and manufacturing.


**Figure 2.11: Total Cargo Loaded by Libyan Ports in 2008, 2010 and 2012**  
(Thousand Tons)

In Figure 2.10, a sharp increase in the amount of cargo off-loaded by Khoms port can be seen, along with a sharp decrease in the amount of off-loaded cargo at Tripoli port. This was due to the prime minister’s resolution to use Khoms port instead of Tripoli ports for container handling, to prevent road congestion in Tripoli (Ghashat, 2011). However, according to CETMO (2010) more than 50 per cent of Libyan trade in these goods passed through Qasr Ahmed port and the remainder was distributed among the other commercial ports.
Chapter 3: Literature Review

3.1 Introduction

Ports compete against each other to attract users, to handle more cargo and increase revenue. The main strategy of competition is to provide a good service quality, as required by port stakeholders, in less time and for less cost. This can be achieved if a port performs efficiently. Reviewing the literature of port performance provides more insights and understandings that help to identify the related constructs. Therefore, this chapter examines the literature on port performance, taking into consideration the performance of seaside, terminal side and landside operations, to identify the most influential factors that influence port performance.

Ports are closely associated with international trade. International trade is one of the main mechanisms for improving economies and eradicating poverty (Córdoba et al., 2008, Francis, 2008). Both ancient and modern histories show that trade is the strongest method for increasing income (Francis, 2008). The ancient civilisations of Rome, Egypt and Carthage depended on trade for their development (Francis, 2008). There are many studies discussing the role of international trade in improving a country’s status, all of which agree that international trade is the key element for increasing national income, and consequently reducing poverty (Córdoba et al., 2008, Francis, 2008).

Currently, more than two-thirds of international trade is carried by ships (Vasiliauskas and Barysienė, 2008, UNCTAD, 2008). Previously, maritime general cargo was transferred and transported piece by piece, which was inefficient. This increased ships’ operating time and cost, by making sea freight labour ineffective and costly (Wong, 2008a). To reduce transport times and the cost of general maritime cargo, containerisation was introduced in the 1960s, and now dominates sea-born trade (Solomenikovs, 2007, Vasiliauskas and Barysienė, 2008). This demand continues to grow.
Containerisation is the most efficient way to tranship many types of cargo. Its effect is to reduce overall transportation costs by shrinking cargo-handling times and increasing the speed of transport, by streamlining handling at all transfer points between the different transport modes (Kozan, 2000, Wong, 2008b, Huang, 2004, Tierney et al., 2014).

Recently, the main considerations have been general transport costs and time. Transportation costs are determined by many factors, including the efficiency of the port (Chang et al., 2008), which is in turn determined by the nature and status of the port’s infrastructure and superstructure (Huybrechts et al., 2002). Cost is one of the most important competitive factors, as port users are ultimately concerned with the total cost associated with using a specific port or terminal (Chang et al., 2008). From this perspective, Yap and Lam (2006) found that lower handling fees and good service quality at container terminals may attract more customers to use their facilities. Moreover, Huybrechts et al. (2002) found that those ports whose operations contributed most substantially to overall transportation cost reductions were most likely to be preferred by shipping companies, which appear to have become the principal player in determining the choice of port.

Similarly, time is considered an important performance indicator for port stakeholders. High operating costs for container terminals and ships, as well as high capitalisation of ships, port equipment and containers, demand a reduction in unproductive time spent at port (Steenken et al., 2004b). This is a serious constraint in a business where lost time translates immediately into higher costs (CSIL, 2012). Consider two ports, the first of which operates 24 hours a day, seven days a week, and the second of which operates only 12 hours a day, on weekdays. If a ship arrives at the second type of port after working hours or during the weekend, the ship may need to wait until the second day or beginning of the next week for some key procedures, such as customs checks, to be performed. This waiting time increases a ship’s operational costs, and may affect the whole ship’s timetable. Conversely, if the port can use the 24 working hours while the ship is at port, this increases port throughput. Evidence shows that all ports with high container traffic per annum work 24 hours a day, seven days a week. However, shifting port operations from a 12-hour to a 24-hour schedule is unlikely to bring sustainable performance improvements.
when the landside connectivity is insufficient and other factors outside the port remain the same. This could only lead to containers piling up inside the port (Gekara and Chhetri, 2013).

Ports derive their revenue from cargo handling (UNCTAD, 2007). Therefore, effective strategies that aim to attract more users are necessary to increase the volume of handled goods. This can be achieved by exploiting the advantage of being close to international trade routes, increasing port capacity and providing a range of additional activities aimed at client satisfaction, based on market demand (Perez-Labajos and Blanco, 2004).

Due to the high demand of containerisation and the dramatic increase of container ships’ size and capacity (Liu, 2010a), seaports have changed to meet this demand (Gekara and Chhetri, 2013). To enhance performance, ports have to improve their capacities (Bonney, 2014) by adopting strategies such as new port designs, sophisticated infrastructure, long term planning, introducing more effective cargo-handling equipment (UNCTAD, 2007, Vasiliauskas and Barysienė, 2008), expanding storage yards (Alessandri et al., 2007, Liu, 2009), and incorporating ICT (Gekara and Fairbrother, 2013, Kia et al., 2000) and software programming (Alessandri et al., 2007, Beškovnik, 2009, Chang Ho et al., 2004).

Deploying efficient container-handling equipment is crucial to providing a good service to customers (Myung-Shin, 2003) and minimising ships’ turnaround time (Beškovnik, 2009, Lau and Zhao, 2008). Moreover, port performance is an important determinant of shipping costs (Martinez-Zarzoso et al., 2008, Acosta et al., 2007, Chang et al., 2008, Clark et al., 2004). This is because ports with good infrastructure are likely to be more efficient and have lower seaport costs, whereas inefficient ports increase handling costs (Clark et al., 2004).

Aside from the container-handling equipment, an important determinant of port performance is the use of new ICT to manage seaside, terminal and land operations (Beškovnik, 2008). Due to the increased demand for containerisation, the competition among container port terminals has become quite remarkable. Port operations are nowadays unthinkable without effective and efficient use of ICT (Steenken et al., 2004b). Better information flow is one of the keys to a port’s
success (Bonney, 2014). ICT has therefore become a crucial part of accurate and rapid transfers, processing huge volumes of data in international transport firms and port organisations (Kia et al., 2000). Rapid and accurate information exchange between ports and their users is crucial for efficient cargo transport. Therefore, many ports have introduced ICT to enhance the efficiency of their performance. Using ICT reduces bureaucracy, and thus transaction time and costs. This includes online customs services, cargo tracking, tracking ship movement and online transactions. This improves cash flow, reduces paperwork, improves efficiency and provides a real-time opportunity to manage finances (Jeon, 2011).

Gekara and Fairbrother (2013) have illustrated that, through advanced ICT technologies, modern and highly efficient ports have been able to integrate and manage operations, further reducing their labour force. This has allowed them to cut costs, ensured efficient data and information management and exchange, and ultimately enhanced their operations visibility. An example of this is Singapore port. The application of ICT in the port of Singapore has resulted in more efficiency and better performance (Vis and de Koster, 2003). Myung-Shi (2003) conducted a comparison study of service quality at 15 major container ports and found that both cost and port facility groups emerged as the highest priority, followed by customer convenience and information. Further, previous studies on ports on the African continent have illustrated that a developing economy can benefit from greater connectivity to global markets, improved trade and reduced transport costs, by improving port performance (Gekara and Chhetri, 2013).

One of the most important determinants of port performance is the model of ownership and administration adopted. This determined the structure and level of capital investment and influences the levels of technology, skills and essential infrastructure. Ports can be classified according to the type of ownership and administration. The different categories of ownership include state, autonomous, municipal and private ownership. Ports may also be classified based on the management models they adopt; for example, public service ports, tool ports, landlord ports and private service ports (Alderton, 2013). Table 3.1 provides a summary of the ownership and control of various components and functions, based on the ownership and management type.
### Table 3.1: Port Ownership and Management Models

<table>
<thead>
<tr>
<th>Type</th>
<th>Infra</th>
<th>Super</th>
<th>Labour</th>
<th>Other services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public service port</td>
<td>Public</td>
<td>Public</td>
<td>Public</td>
<td>Mostly public</td>
</tr>
<tr>
<td>Tool port</td>
<td>Public</td>
<td>Public</td>
<td>Private</td>
<td>Public/Private</td>
</tr>
<tr>
<td>Landlord port</td>
<td>Public</td>
<td>Private</td>
<td>Private</td>
<td>Public/Private</td>
</tr>
<tr>
<td>Private service port</td>
<td>Public</td>
<td>Private</td>
<td>Private</td>
<td>Mostly private</td>
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</tbody>
</table>


Port reforms around the world over the past few decades have led to port privatisation and adoption of the landlord port model as the predominant one for many countries (Czerny et al., 2014). In this category, the state owns the port and provides all required infrastructure. It then leases out the port or the terminals to private stevedoring companies, which provide all the superstructure (Alderton, 2008). This is largely due to the many benefits gained from an injection of private sector capital, technology and management systems and skills (Ghashat et al., 2011).

One of the major drivers for such reforms, particularly driven by the World Bank’s structural reforms for developing companies in the 1990s, was the release of these essential economic institutions from the shackles of public sector bureaucratic inefficiencies, management ineptitudes and political patronage (Bank, 2007). A number of studies conclude that public ports failed to achieve the desired performance goals (Brooks and Cullinane, 2007, Alderton, 2013). All of Libya’s ports remain state owned and/or controlled, and therefore fall under the public service port model. Similarly, the literature shows that the private sector involvement in Libyan port industry is essential for attaining high performance (Ghashat, 2011, Ghashat et al., 2011).

There is a rich and extensive literature in the area of port performance, productivity and efficiency. A review of this will develop a strong base for the current study. This review will identify the key port performance factors and thus extract the relevant constructs for the analysis of Libya’s container port performance. Therefore, this chapter defines the productivity and efficiency, and highlights the criteria, of measuring port productivity. It also reviews the literature of port performance in the three key operational phases: seaside operations, terminal operations and landside operations. It then reviews the literature of evaluating container port efficiency using
DEA. From this critical review of the performance literature, this study will develop an empirical model to measure the performance of Libyan ports from the perspective of Libyan stakeholders.

3.2 Container Port Performance, Productivity and Efficiency

‘Performance’ is generally understood as industry jargon to assess an organisation’s success in achieving some level of its strategic goals (Feng et al., 2013). Logistics performance may be defined as the extent to which a firm’s goals are achieved (Bonney, 2014). Port performance criteria are often found as determinants of port competitiveness, or factors influencing port competitiveness (Tongzon and Heng, 2005).

Performance is multi-dimensional and no one measure suffices for performance (Bonney, 2014). As highlighted earlier, port performance can be measured by service quality, port throughput, seaside accessibility, landside connectivity, storage facilities and capacity, cargo dwell time, port efficiency, technology, transaction processes, cost, ships’ turnaround time, and the variety of services provided (Liu, 2009, Haezendonck et al., 2011, Yan et al., 2009, Le-Griffin, 2008, Acosta et al., 2011, Myung-Shin, 2003, Yap and Lam, 2006, Perez-Labajos and Blanco, 2004, David Xiaosong Peng et al., 2011, Wu and Goh, 2010). These factors can be categorised into three categories or measures: port productivity, port efficiency and service quality.

One of the most crucial measures of container port performance is its productivity. Measuring productivity in container ports on a regular basis is crucial for finding opportunities in development and optimisation (Beškovnik, 2008). Productivity and efficiency are the two main concepts of economic performance (Liu, 2010a). Generally, the concept of productivity is defined as a ratio of the volume measure of output, to the volume measure of input used (Chinda, 2010a, Mangat, 2006, Liu, 2010a, Kao et al., 1995, Fried et al., 1993, Coelli, 2005). Port operators and authorities can only control the resources within the port. Therefore, port productivity only consists of the productivity of seaside and terminal operations. However, the productivity of landside includes the productivity of land transport, which is not under the control of the port.
High productivity implies either fewer inputs are needed to produce more output, or more output is produced by the same amount of input in a certain period (Chinda, 2010a, Mangat, 2006). In addition, productivity growth is defined as the net change in output due to changes in efficiency and technical aspects (Fried et al., 1993). Therefore, productivity measures the efficiency with which a production activity converts inputs to outputs (Kao et al., 1995). Mangat (2006) adds that productivity is a comprehensive measurement of how efficiently and effectively firms satisfy five aims, which are: objective achievement, trend-productivity measured over a period of time, efficiency of the process, effectiveness and comparability with other firms.

Further, there is also a strong relationship between efficiency and productivity, where efficiency is measured by productivity (Mangat, 2006, Kao et al., 1995). Efficiency is defined as the performance of any firm compared to the benchmark (Liu, 2010a). It refers to improving productivity via internal cooperation, without consuming extra inputs (Stuebs and Sun, 2010). Additionally, economic efficiency refers to the productivity of goods and services (i.e., productivity) from a given quantity (i.e., cost) of resources; ‘labour efficiency as a measure of labour productivity per unit of labour cost’ (Stuebs and Sun, 2010).

From the above definitions, high port productivity implies high performance in a shorter time, using minimal resources. It could be measured by port throughput, or crane throughput, or by the number of containers processed per acre per year, or by the number of ship calls, or ships’ turnaround time, port revenue, truck turnaround time, gate utilisation, container dwell time, idle rate of equipment, service quality, customer satisfaction or market share (Ashar, 1990, Beškovnik, 2008, Beškovnik, 2009, Cullinane et al., 2006, Doyle and Green, 1994, Kozan, 2000, Le-Griffin and Murphy, 2006, Liu, 2010a, Stuebs and Sun, 2010, Wong, 2008a). However, measurements of total throughput, such as TEUs per year, or TEUs per acre of terminal area, are commonly used to gauge the partial productivity of ports (Le-Griffin and Murphy, 2006). Additionally, container throughput is the most important indicator for container terminal and port output, as it relates closely to cargo-handling facilities and services. Further, it is the primary basis for comparison of container ports and terminals. It is also the most appropriate and analytically tractable indicator of port production effectiveness (Cullinane et al., 2006).
Therefore, total container throughput is included in this study as an output variable for measuring port efficiency.

Returning to container port operations, container-handling processes in marine container ports are comprised of several subsystems. Disturbance in container port productivity could be due to an individual operational issue, such as seaside operations, landside operations or terminal operations. Conversely, it could be due to problems within more than one operational part. Both probabilities affect the performance of the entire port. Enhancing container port productivity is achieved by using port resources efficiently and in a good manner as one unit. Moreover, solving the problems of each subsystem individually does not provide an optimal solution for the whole system. It only shifts the bottleneck from one subsystem to another.

The optimal operations management of seaside, terminal and landside resources depends on both infrastructure and port superstructure. They are the main influential factors on container port productivity, due to their high cost (Coto-Millan et al., 2000). They are actually the main influential factors on port performance. This is because, in addition to their influence on port productivity, they influence the quality of service provided by the port, as well as port efficiency, which is represented by time and cost. Therefore, container ports must be efficient by achieving maximum results with limited resources (Beškovnik, 2008). The potential result is high productivity, providing the required service with minimum time and cost.

To understand port performance, productivity and efficiency, we have to examine the three key operational phases of terminal work in detail. These include seaside operations, landside operations and terminal operations. The totality of port performance is made up of these three separate but inter-connected and coordinated operations. In this study, we shall designate them as seaside operations, terminal operations and landside operations. The study is mainly concerned with the first two operations; that is, seaside operations and sea-land operations.

3.2.1 Seaside Operations

Seaside operations relate to the approach, docking and berthing of ships before the cargo operations stage. The factors crucial to the efficiency of these operations include sufficient draft, approach channel dimensions, pilotage services and
docking/berthing services and facilities. Port operators, especially those operating large transhipment hubs, always seek to improve their services by ensuring a smooth berthing process (Lee and Jin, 2013).

Transport cost is influenced by the size of a shipment, where larger sized shipments decrease transport costs (Clark et al., 2004) and increase port throughput. Moreover, instead of delivering a couple of thousand containers using two or three ships, one big ship may dump several thousand containers on a terminal during a single port call (Bonney, 2014). This saves docking time, which can be used in cargo-handling operations. In contrast, a lumpy volume, aggravated by late ship arrivals, ensures complications for terminal operators, truckers and other supply chain participants (Bonney, 2014). Therefore, to benefit from this advantage, container ship size and capacity have increased dramatically. In 2013, Maersk introduced the largest container ship, known as Triple E Maersk class, with 18,000 TEUs capacity, 400 metres long, 59 metres wide, 73 metres high and 14.5 draft (Maersk, 2012). Due to the dramatic increase in ship size, port accessibility is considered one of the most important factors influencing port performance, as it controls the size of the ships that can enter the port. Therefore, sufficient water depth and suitable berth length to allow safe docking of the inbound ships, are crucial to commence cargo operations (Acosta et al., 2007).

These two port resources, water depth and berth length, have been the subject of many studies. For instance, the length of a terminal and the number of deep-water piers are used by Lin and Tseng (2007b) to establish a competitive strategy aimed at enhancing port productivity. Additionally, Acosta et al. (2007) use the port of Ageciras Bay to study the competitiveness between Mediterranean ports from the supply perspective. The study includes infrastructure factors associated with container transhipment and maritime access to the port by large container ships. The results illustrate that those representing greater competitive advantages are associated with the maritime accessibility of ships to the port. Haezendonck, Broek and Jans 2011 (2011) also include sea accessibility among 25 determinants of competitiveness at the port of Antwerp. This study also concluded that port accessibility is directly related to government action, which is an important factor to attract users.
Similarly, Cullinane et al. (2005) use the berth length (among other factors) to examine the relationship between port efficiency and privatisation. Berth length is also used by Wu (2009b) to measure the performance of 28 container ports. Jose (2001) used berth length combined with other variables to measure the efficiency of a number of Australian ports. The efficiency of seaside operations could be influenced by berth design, and the number and specifications of the QCs dedicated to those berths. In this perspective, Nam et al. (2002) found that sharing QCs with adjacent berths can increase productivity.

Berthing on arrival or berth availability is an important competitive advantage that influences port choice decisions (Chang et al., 2008). Generally, it could be said that berth allocation problems occur due to the unavailability of suitable berths to accommodate inbound container ships. This lack of berths could be due to insufficient numbers of efficient QCs dedicated to a certain berth. Inefficient QCs slow the total handling rate of QCs, due to technical or operational reasons. This might also be due to long QC idle times while the crane is waiting for transport vehicles to pick up the off-loaded containers under the QC, or to bring containers from a storage yard. This longer vehicle turnaround time may occur due to congestion or a lack of transport vehicles to serve a certain ship or QC. It might also be due to the longer time taken by yard cranes (YCs) to retrieve outbound containers, because of the vertical stacking caused by lack of space. All of this shows the integrity of port subsystems, where any deficiency in any subsystem affects the entire operation.

The effect of berth allocation problems in a particular container port does not only affect the performance of that port, but may also extend to other container ports (Ilmer, 2008). Good performance in any container port minimises ships’ turnaround time, where time lost translates immediately into higher costs (CSIL, 2012); consequently, it positively affects the performance of the next port of call for the same container ship. In contrast, any ship’s delay caused by the previous port might disturb the berthing plans of the next port of call. This is supported by Ilmer (2008), who illustrates an overview of the development of northern European container port investments and the expected balance between supply and demand in that area in 2010. He states that non-adherence to berthing windows—because of ship delays
caused by congestion in provirus ports and last minute notification of ships’ arrival time—puts further pressure on terminal capacity in certain ports. Further, terminal performance is affected by ships’ arrival times and the efficiency of container handling.

Using this point, and to enhance the efficiency of berth usage, Jam Dai et al. (2008) investigated berth allocation problems and proposed a local search algorithm to solve static berth allocation problems. Another perspective is provided by Imai, Nishimura and Papadimitriou (2008), who addressed a variation of berth allocation problems at multi-user terminals. The study focused on busy container ports in developing countries. A genetic algorithm-based heuristic was developed to reduce the total service time of container ships at the external terminals, when such ships were expected to exceed specific waiting times at the allocated terminals.

This brief literature review has shown the importance of water depth and berth length in port performance. This importance appears clearly when new generation container ships, such as Triple E mega container ships, were entered into service. Only a small number of container ports, which have a number of competitive advantages, can serve this type of container ship. These competitive advantages include a berth’s shape and length suiting the length of all these types of container ships and deep water to allow safe docking. Therefore, variables such as water depth and berth length are included in this study.

3.2.2 Terminal Operations

Terminal operations are very important factors for port performance (Beškovnik, 2008). They start after the inbound container ship crosses the fairway channel that suits its draft, and moors alongside a suitable berth. Terminal operations include the entire operations of container handling, starting from loading/off-loading containers and ending with container transhipping. These operations involve all the resources dedicated to handle the containers inside the terminal or the port.

Most cargo damage at port occurs in sea-land operation cargo. Safety, including cargo loss and damage, is another important factor influencing port performance (Gekara and Chhetri, 2013). Cargo damage was investigated by (Brooks and Schellinck, 2013) in combination with some other factors, to measure the
effectiveness of operations in meeting customer requirements. However, the study found that cargo damage is the least important determinant of overall service performance for both shipping lines and supply chain partners.

Terminal operations could be affected by the technical and operational specifications of both transfer and transport equipment. Transfer equipment includes all types of cranes used to transfer containers between a ship and shore/transport vehicles, or between a storage/rail yard and transport vehicle. In contrast, transport equipment includes all vehicles used to transport containers horizontally within the port. These include AGVs, trucks, SCs, yard trailers and SLVs. Both transfer and transport equipment should be used efficiently to increase productivity.

QCs are the first interface between seaside operations and sea-land operations. The QC is perhaps the most important equipment in cargo-handling process (SCI, 2010, Lu et al., 2012) and their operating efficiency has direct and indirect impacts on port throughput (Lu et al., 2012). Efficient QC scheduling and utilisation simplifies berth allocation problems. It controls ships’ service times. Consequently, it influences ships’ turnaround times and port productivity (Zhang and Jiang, 2008). The efficiency of terminal operations is influenced by the specifications of the QC; for example, fully or semi-automated QC, crane height, outreach, move rate and safe working load (SWL). All of these are manufacturing specifications and cannot be controlled by port operators. However, the port operators can control the way of using such QCs; for example, QC scheduling, which is essential for efficient performance. Due to the importance of QC scheduling, it is discussed by a number of researchers. For instance, Kim and Park (2004) developed a mixed integer program and attempted to solve QC scheduling problems, to enhance the efficiency of container movement. Their study focused on speeding up the container handling between ships and port and minimising ships’ turnaround times. Similarly, QC scheduling is investigated by Lu et al. (2012), who aim at enhancing container movement speed. Another perspective is provided by Legato et al. (2012), who provided a rich model for QC scheduling. This study covered important issues of practical relevance like safety requirements, crane-individual service rates, ready times and due dates for cranes and precedence relations among container groups. All
of the above studies aimed at enhancing the efficiency of QCs, which reflects on the efficiency of terminal operations and port performance in general.

As mentioned earlier, berth allocation plans are closely associated with the performance of QCs. Due to the importance of this relationship between seaside operations and sea-land operations, Zhou and Kang (2008) and Liang, Huang and Yang (2009) discuss QC and berth allocation problems, to minimise handling, waiting and delay times of container ships. Zhou (2008) proposed a programming model under stochastic environments, which can effectively treat related random factors. Meanwhile, Liang (2009) used a combined generic algorithm with heuristics to solve the same problem. Both studies were great efforts to deal with seaside problems.

Additionally, terminal operations could be influenced by berth shape and the number and specifications of QCs dedicated to that berth. In studying the impact of sharing QCs and berths on port productivity, Nam et al. (2002) applied a computer simulation program on the Gamman container terminal in Pusan, Korea as a case study. The results of four different operational scenarios revealed that sharing QC with adjacent berths could increase productivity. Chen et al. (2011) also discussed QC scheduling and developed a mixed integer programming model by considering the unique features of the QC scheduling problem at indented berths.

Storage yard space, which is a part of port infrastructure, is one of the vital elements in container port performance and productivity. It determines the volume of containers that can be stored and processed, storage mode, number and type of handling equipment (Ioannou et al., 2000a, Wiese et al., 2010, Alessandri et al., 2007). A wider study in analysing the main causes of unproductivity in the container movement process was conducted by Chen (1999). The findings illustrated that many factors influenced operational efficiency and caused non-productive moves. These included shortage of storage capacity, poor quality of container information received, and operational rules. It was also found that higher container storage had a serious impact on the number of unproductive moves and on delivery operations.

To absorb many more containers in a small storage yard, containers are stacked vertically. This requires special and expensive stacking equipment to perform this
task. In a vertical stacking mode, double handling is required in some cases to retrieve lower containers, which increases operational times, and therefore container port performance (Alessandri et al., 2007, Kozan, 2006). It may also affect QC performance, and consequently a ship’s turnaround time (Steenken et al., 2004a). In contrast, within larger storage areas, more containers can be stored and processed. In this case, it might not be necessary to deploy high stacking equipment. However, deploying extra horizontal transport vehicles is required to accelerate container movement and avoid QC idle time. Therefore, a higher investment for vehicles is needed, and operational costs will be increased as well. These are considered as inputs in measuring port efficiency (Fried et al., 1993, Fried et al., 2000, Pérez-Reyes and Tovar, 2009). Therefore, the optimal amount of storage area is a very important factor for port performance and efficiency. For these reasons, storage space and the type and number of container-handling equipment are included in this study.

In this perspective, a cost model was developed by Huang and Chu (2004) to determine the most economical container-handling equipment used in container ports. The study included the cost of land, labour, equipment procurement, maintenance and handling efficiency. The results illustrate that YCs can be more economically operated only if their annual throughput was larger than the procurement cost and interest rate, and the number of handlings per container was smaller. Leading from this study, container-handling costs are influenced by superstructure costs, which include the cost of machinery and used technology.

Another perspective is provided by Ioannou (2000a). The study used Los Angeles and Long Beach ports as case studies to investigate the impact of the cost of various technologies and concepts, and the traffic network outside the port on container port capacity. The most important results related to cost function showed that the price of land and the price of AGVs affected the average cost of container handling. Moreover, the high cost of land forced the port to increase its productivity by using advanced technology. This showed that land and handling equipment are crucial elements that should be considered for measuring container port performance.

In addition, not only the space of storage yards is important, but the storage yard design is also a crucial element for container port performance. As block dimensions
and layout control the efficiency of container stacking and retrieval, they consequently affect the performance of all handling equipment and ships’ service times. Regarding the yard layout improvement perspective, Lee and Chao (2009) proposed a heuristic model, to develop a movement plan to improve the layout of an export container yard. They claimed that pre-marshalling exported containers reduced ships’ turnaround times, as it avoided the longer time used to retrieve containers when the ship was alongside. In studying storage yard design, Petering and Murty (2009) investigated the effect of block length and yard crane deployment systems on overall performance. The results illustrated that the long-run average QC rate depended on both storage block length and the system that deployed YCs among blocks in the same size. In contrast, Petering (2009) studied the effect of block width and storage yard layout on the productivity of marine container ports. The results showed that the optimal block width ranged between six to 12 rows, depending on the amount of equipment deployed, and the size, shape and throughput of the terminal.

In some ports, storage yards cannot be expanded due to land scarcity (Ioannou et al., 2000a). Storage space as an individual problem has been well investigated by many authors. For example, Zhang et al. (2003), who developed a rolling-horizon model for storage yard optimisation, believed that this problem was related to all container port resources. The model showed a significant reduction in workload imbalance in the yard.

Another factor influencing container port performance, by affecting the total transport and operational cost, is the location of each container in the storage yard. This factor has a strong impact on handling equipment numbers and routing. This appears clearly when the retrieved container is located in the lower layer in the block, or when two containers are located in two different blocks (Ilmer, 2008). In the first case, all upper containers have to be double handled to pick up the lower container. In the second case, to save on operating time, it is necessary to assign stacking equipment to each block. Both cases require more time and handling equipment: time and productivity moves are very important for container port performance.
In studying these factors, Hadjiconstantinou and Ma (2009) used the Piraeus container terminal as a case study, to evaluate SC deployment policies. They proposed an optimisation model to determine optimal container location and SC movement, to minimise the overall container storage and handling cost. The two SC deployment policies investigated were shared SC and non-shared SC. The shared SC policy is: SC can move to another yard block to perform container handling when there is no container assigned to its block. The results showed that deploying SCs under a shared policy makes SC perform up to their capacity. The total waiting time at a yard is about four times higher than with a non-share SC policy, due to the movement between blocks without carrying containers. In solving optimisation problems, particularly with the strategic planning of container ports, (Alessandri et al., 2007) proposed a simple model, using a set of queues to represent container positions within the port. That included container transfer, transport and storage. All of the above studies showed the effect of the storage yard on the amount of container transport and stacking equipment, and port performance in general.

In estimating the optimal equipment combination of the stevedoring system, Choi (2003) analysed the combined productivity of container port stevedoring systems, taking Busan port as the case study. He demonstrated the savings effect by using mean waiting time rates according to equipment combinations. The results showed that a bottleneck occurred in transfer cranes due to an insufficient number of yard tractors. Leading from this study, container port resources should work together as one unit and any failure in any part could affect the whole process. Further, (Ottjes et al., 2002) investigated the influences causing peaks of variation in import and export flow and container dwell times. They illustrated that the influences causing peaks were due to the need for stacking space and handling, and transportation equipment in the container port.

Hence, storage yard capacity and layout play a vital role in container port performance, and influence the used transport and transfer equipment. Therefore, container classification (import and export) and storing management are important to reach optimal utilisation of the storage yard resource. In carrying out studies on more expensive transport equipment, (Soriguera et al., 2007) investigated the internal transport subsystem in container ports managed by SCs. The aim of this study was to
optimise the internal transport cycle. The study proposed a simulation model to determine the optimal number of SCs. It pointed out that dividing storage yards into import and export areas and using a single cycle SC strategy increased productivity. A simulation study was also carried out by (Guenther et al., 2006). They claimed that the efficient use of transportation equipment determined the performance of the entire port. They focused only on dual-load AGVs (two 20 foot container or one 40 foot container). The results showed that operating dual-load AGVs, instead of single-load ones, may improve the AGV’s performance considerably, contributing to container port performance.

Related to operational aspects, a number of research projects have discussed the scheduling of transfer and transport equipment to enhance port performance. One such study was conducted by Nishimura et al. (2005), who developed a heuristic model to solve trailer scheduling problems assigned to a specific QC until the work was finished. The study also proposed many efficient trailer assignment methods, called dynamic routing. The findings illustrated that dynamic routing decreased travel distance and generated substantial savings in trailer fleet size, and reached up to a 15 per cent overall cost reduction. Another perspective is provided by Chen et al. (2012). This study discussed the optimisation of operation scheduling in container port, based on mix cross-operation. This operation allowed yard trailers to be shared by different YCs in different berths to decrease yard trailers’ travel distances. It was found that mix cross-operations can decrease yard trailers’ empty travel distance to a great extent, and that integrating scheduling methods can reduce the operational costs of container terminals significantly.

Transport equipment can affect QC performance when there is a lack or misuse of transport vehicles. The lack or misuse of such vehicles increases QC idle time, and consequently increases ships’ turnaround times and reduces productivity. A wider study was conducted by (Kozan and Preston, 1999), who analysed the major factors that influenced container transfer efficiency through lower throughput times. A genetic algorithm was developed to schedule container transfer at multimodal terminals. The study simulated the effects of handling equipment, an alternative number of containers, terminal layout, storage capacities and policies, to analyse the system. The study found that the high number of yard machines had a strong effect
on transfer time. In addition, decreasing the maximum height of storage blocks dramatically increased the transfer time.

In conducting more integrated studies related to container port resources, which include seaside resources, transfer, transport resources and storage resource, Stahlbock and Voß (2008) provided a comprehensive overview of container-handling operations and container transfer and transport equipment. In this study, they conducted a comprehensive survey on routing problems that arose in the container port domain. This study included scheduling of berths, QC, AGV, multi-trailer, SC, trucks and stacker cranes. The study is considered important in understanding container port operational mechanisms.

Regarding the scheduling problems of QCs, transport vehicles and YCs to enhance port performance, Lau and Zhao (2008) developed a mixed integer programming model, called the multi-layer genetic algorithm. They managed to schedule three different types of automated containers handling equipment: QCs, YCs and AGVs. The results showed that deploying a large number of AGVs might not improve performance. Regarding the same problem, another perspective was provided by Zhang and Jiang (2008). They developed a simulation software package to evaluate the efficiency of the dynamic scheduling method, in order to improve its performance. The study included the scheduling problem of QC, YC and trucks instead of the AGVs. The findings showed that dynamic scheduling increased port efficiency by about eight per cent, as opposed to static scheduling.

All the above studies aimed at enhancing container port performance; for example, increasing port throughput, increasing storage capacity, speeding up container movement, minimising ship’s turnaround times, minimising handling fees and improving cargo delivery time. To achieve that, a port has to own sufficient and efficient cargo-handling equipment, such as QCs with special specifications relating to SWL, moves rate, spreader type and maximum outreach. Further, it has to own an optimal number of efficiency transport and stacking equipment. It can also be concluded that the storage yard, as infrastructure, is an important element for container port performance. In some container ports, the storage yard cannot be expanded, due to land scarcity. Storage yard influences the stacking mode (‘vertical/horizontal’), the volume of containers to be processed, and the type and
number of transport and stacking equipment. Its importance appears more clearly when a port receives a new generation container ship with a large volume of containers on board.

All of these resources have to be managed and operated as one system, because any failure in any subsystem influences the entire operation. Therefore, evaluating the performance of these resources on a regular basis is essential to determine the destructive factors that impede optimal performance, to take the necessary measures to prevent their effect (Beškovnik, 2008). Therefore, it is vital to include the number and the type of QCs, transport equipment, stacking equipment and storage yard area in this research to examine container port performance and efficiency.

3.2.3 Landside Operations

Throughout maritime history, commercial port competitiveness has been determined by their physical characteristics and geographical location, as well as their relationship to a landside transportation system (Le-Griffin, 2008). Therefore, successful and efficient ports are often those that are well connected to their hinterlands by adequate and effective transport corridors (Gekara and Chhetri, 2013, Chang et al., 2008). As a consequence, rail and road transport networks are required to optimise container flow, increase port productivity and minimise a ship’s turnaround time (Parola and Sciomachen, 2005, Transystems, 2011).

Transport infrastructure investment plays an important role in determining both the efficiency and sustainability of freight transport activity (Woodburn, 2013, Le-Griffin, 2008). The increase of flow in the container supply chain is largely driven by the growth in demand for container transportation (Panova and Korovyakovsky, 2013). Since the 1950s, containerisation has improved the efficiency in intermodal transportation and has intensified competition among ports (Wan et al., 2013). However, the dramatic increase in container ship capacity has led to congestion problems at and around ports.

A number of studies have investigated the influence of road transport on container port performance. For instance, Wan et al. (2013) investigated the impacts of urban road congestion and road capacity expansion on seaport container throughput in the USA. The study found that a port’s container throughput was statistically
significantly associated with congestion delays on its own urban roads, as well as delays on its rival’s roads.

In comparing road and sea freight transport based on private and social costs, Sambracos and Maniati (2012) found that sea transport was significantly more competitive than road transport to transport freight between port of Patras and Eleusis in Greece. However, road transport is fast and flexible.

Despite the fact that trucks provide door-to-door service, which cannot be provided by rail intermodal services, congestion impedes the use of this option (Van Schijndel and Dinwoodie, 2000). Congestion affects the reliability of all parties of a container logistics chain, including container terminals. In contrast, one of the advantages of rail use is preventing congestion, which accelerates container delivery time, consequently minimising transport costs and supporting maritime container trade. From this perspective, Van Schijndel and Dinwoodie (2000) found that an average of between 7.5 and 14.5 per cent of trucks’ working time is spent in congestion, and a vehicle cost simulation attributed seven per cent of transport costs to congestion. Therefore, a combination of rail and road (rail-truck) is crucial for land transport efficiency (Hansen, 2004, Kia et al., 2003, Niérat, 1997), which reflects on the cargo flow between a port and its hinterland. However, the use of each method depends on a number of factors, such as distance between nodes, container flow volume and weight, as well as the distance between container ports and intermodal terminals.

In studying the comparison between road and rail intermodal transport, (Niérat, 1997) discussed the issue in terms of market area in France. He concluded that rail intermodal transport was more attractive for lighter loads and unbalanced traffic. In contrast, road transport was more attractive for heavier and balanced ones. Further, all transportation means depended on and complemented each other.

Rail transport is an efficient way to transport large volume of containers for long distances (Hansen, 2004, Kia et al., 2003). Therefore, a number of studies have investigated the impact of rail transport on container port performance (Woodburn, 2013, Transystems, 2011, SCI, 2010, Kozan, 1997, Kozan, 2000, Dinwoodie, 2006, Ashar, 1990, Economic research centre, 2000, Reis et al., 2013, Gekara and Chhetri, 2013, Niérat, 1997). All of these studies illustrated that rail connectivity was
essential for efficient container flow between ports and their hinterland, which was associated with port performance.

Apart from railway and road connections and services, terminal gates determined the performance level of the port (Beškovnik, 2008). Gate processes have a great influence on the congestion at ports (Brooks and Schellinck, 2013); long truck queues at gates often limited the efficiency of a container port (Chen et al., 2013). Moreover, the optimum utilisation of port gates shortens container storage time at a yard, so that the storage capacity can be utilised more efficiently (Chen et al., 2013). The gate process depends on a number of factors, such as the number of gate lanes and customs clearance procedures. Introducing container inspection processes in a seaport impedes the current workflow schedule of container operations and incurs additional management and operation costs (Lee et al., 2008). In addition, in many developing economy ports, corruption, bureaucracy and lack of new ICT-based technologies stifle port operations (Gekara and Chhetri, 2013).

The above literature review illustrates that container flow strongly influences port performance. Landside accessibility is vital for efficient container flow between a port and its hinterland. Road transport provides door-to-door service, which cannot be provided by rail transport. However, rail transport is more efficient to transport freight over long distances. This shows that both intermodal transport means complement each other and are important for port reliability and cargo delivery time.

Gate processes also have an influence on port performance. Efficient gate processes accelerate container flow and increase storage yard capacity. However, the number of gate lanes, the efficiency of customs clearance procedures and the use of ICT have a direct influence on gate utilisation.

The above literature has illustrated that port performance is influenced by a number of factors related to seaside, terminal and landside operations. These factors were divided into three main categories: productivity, service quality and efficiency (see Figure 3.1).

Port productivity refers to shipside and terminal productivity. Shipside productivity depends on the capacity of the container-handling equipment used to load and off-load the ship. The capacity of this equipment depends on the number and type of
QCs used. In contrast, terminal productivity depends on the number and type of the transport equipment used for container transport, as well as the stacking equipment used to stack containers at the storage yard. Moreover, it depends on storage yard capacity, which also depends on the stacking equipment number and type. It is also influenced by the efficient use of these resources. All of these factors are under the control of the port authority and operator.

Service quality is another factor that influences port performance. Due to rapidly changing contexts of operations and competition, the ports have to offer an innovative variety of additional activities and services, aimed at generating value to meet customer demand and command customer preference and loyalty (Misurata Free Zone, 2013). These demands and requirements are port accessibility, reliability, flexibility, cargo safety and online services. All of these requirements depend on port infrastructure and superstructure. Port accessibility is a focal factor for port performance, as it determines the volume of containers to be processed. Port accessibility consists of seaside accessibility and landside accessibility.

Due to increased container ship sizes, a small number of container ports can serve these mega ships and their large shipments. Water draft is important to ensure safe passage for deep draft container ships. Moreover, these larger ships require long berths for safe docking to commence container-handling operations.

Ports are interface points between the sea and the land. To avoid containers piling up at ports and to accelerate container flow, proper landside accessibility is essential. Landside accessibility consists of road and rail transport. Road transport provides door-to-door service. However, congestion impedes the efficiency of this method. Contrarily, rail transport is more cost-efficient to transport freight over long distances. Therefore, a combined road and rail transport network is important to reduce the load on road networks, enhance the reliability of cargo delivery and reduce total transport cost.

Inadequate and inefficient port facilities, poor hinterland transport networks and inefficient cargo clearance procedures have led to slow ship turnaround and cargo off-take, as well as chronic ship congestion, which is the case of most of the
Figure 3.1: Port Performance Criteria

- **Productivity**
  - Terminals
  - Ships
  - Port
  - Cargo handling in and out
  - Cargo of dry cargo (km and
  - Cargo loss and damage
    - Brooks and Schellinck, 2013
  - Labour competency
    - Haezendonck et al., 2011
  - Storage yard capacity
    - Hadjiconstantinou and Ma, 2009
  - Staking equipment capacity
    - Yang and Shen, 2013
  - Ships' movement
  - Customs service
  - Cargo handling
    - Online service (Gekara and Fairbrother, 2013)
  - Cargo delivery time
    - Haezendonck et al., 2011

- **Service Quality**
  - Reliability
    - Customs clearance process (Myung-Shin, 2003)
    - Berth availability (Kwon et al., 2008)
  - Flexibility
    - Handling services (Kim, 2003)
    - Cargo handling to and from the ship
      - Kim and Park, 2004
  - Accessibility
    - Seaside accessibility (Kwon et al., 2003)
    - Land side accessibility (Myung-Shin, 2003)

- **Efficiency**
  - Cost
    - Cargo handling fees (Yuen et al., 2012)
    - Customs clearance fees (Myung-Shin, 2003)
    - Land transport cost (Gonzalez and Trujillo, 2008)
  - Time
    - Free cargo dwell time
      - Ottjes et al., 2002
    - Total cargo handling time
      - Lv et al., 2010
    - Ship's turnaround time
      - Myung-Shin, 2003
  - Berth availability
    - Imai et al., 2008
  - Handling services
    - Lau and Zhao, 2008
  - Cargo handling to and from the ship
    - Kim and Park, 2004
  - Cargo delivery time
    - Haezendonck et al., 2011
  - Customs clearance process
    - Myung-Shin, 2003
African ports (Gekara and Chhetri, 2013). Eventually, this affects the reliability of ships’ scheduling, transport and handling costs, as well as port performance. In addition, the lack of adequate and efficient container-handling facilities affects the flexibility of port services and undermines the ability of a port to handle irregular shipments with irregular weights and sizes. Further, longer ship turnaround times, caused by the lack of adequate and efficient container-handling facilities, prevents a port from providing berthing on arrival.

Apart from using ICT to manage port operations, it is important to improve port service quality. Online service simplifies customs clearance processes, enables port users to set up their plans and reduces bureaucracy, all of which influence port performance. Increased port throughput is not the only port performance indicator. Another service quality factor that influences port performance is cargo safety. Delivering cargo without damage or loss increases the reliability of the port, which is one of the most influential factors in port performance.

Efficiency is another factor that influences port performance, because it is a port choice criterion. The main components of efficiency are the associated factors of time and cost: time lost translates immediately into cost (CSIL, 2012). The efficiency of container-handling equipment influences the total handling time and ships’ turnaround time, both of which influence port performance. In addition to these, free dwell time influences the utilisation and capacity of storage yards. Moreover, the efficiency of container-handling equipment influences cargo-handling fees; and customs clearance fees depend on customs legislation and clearance processes. Land transport costs depend on the method of land transport and infrastructure.

Port performance depends on both infrastructure and superstructure factors. Some of these factors are under the control of the port authority and operator, whereas other factors may be considered exogenous. The objective of this study is to examine which of these factors are most influential in the performance of Libyan ports. This is based on the understanding that port performance is contextual and some factors are more influential that others in determining a port’s performance, depending on prevailing broader socio-economic and political environments. Thus, this study specifically examines performance factors in a developing country context, with Libya as the illustrative case.
3.3 The use of DEA to measure container port efficiency

There is a strong relationship between efficiency and productivity, where efficiency is measured by productivity. Increased productivity implies either fewer inputs are needed to produce more output, or that more output is produced by the same amount of input per time unit. Changes in productivity, known as ‘efficiency’, are usually estimated by parametric and non-parametric methods. Non-parametric estimation envelopment DEA has been widely applied in research on many industries, such as education (Lim and Zhu, 2013, Salleh, 2012), supply chain management (Manzoni and M.N.Islam, 2009), electricity distribution (Pérez-Reyes and Tovar, 2009), post-hurricane electric power restoration activities (Reilly, 2008), health insurance (Vela, 2000) and business intelligence (Vercellis, 2009). It has also been applied to the wider transport sector (Cullinane et al., 2006) and specifically the port industry (Cheon, 2009, Cullinane et al., 2005, Cullinane and Wang, 2006, Estache et al., 2004, Roll and Hayuth, 1993, Wang et al., 2003).

DEA is an appropriate non-parametric method for evaluating the relative efficiency of a set of (homogeneous) peer entities. These entities are known as DMUs, whose performance is characterised by a set of multiple performance measures (Jose, 2001, Jie et al., 2009, Cullinane et al., 2005, Cullinane et al., 2006, Lim and Zhu, 2013). DEA analysis can help suggest efficiency improvements for DMUs and/or policy makers (Kiatpathomchai, 2008).

Regarding container port efficiency, DEA has been applied in many studies and has been shown to be an appropriate technique for port efficiency evaluation. In many of these studies, DEA was employed as the operations research technique, as it allows the efficiency of selected entities to be measured and analysed comparatively, without the need for absolute ideal performance standards (Manzoni and M.N.Islam, 2009). Moreover, it measures the efficiency of a DMU with multiple inputs and/or outputs by constructing a single ‘virtual’ output to a single ‘virtual’ input without predefining a production function (Cullinane et al., 2006). It is also a technique that gives a minimal set of constraints on the input and output weights (Doyle and Green, 1994). It does not impose any functional forms on technology, or any restrictive assumptions on the reward of production factors (Cullinane, 2011).
Many research projects have been conducted to evaluate container port efficiency from different perspectives using different approaches and techniques. An example of that is the study of Wang et al. (2003), who used two alternative techniques—DEA and fee disposal hull (FDH)—to evaluate the production efficiency of the world’s most important container ports and terminals. The evaluation criteria considered as inputs were the optimal berth length, the number of QCs, storage yard area, the number of yard gantry cranes and SCs. Container throughput was used as an output variable. The results also showed that the two mathematical programming techniques led to different conclusions. Further, Roll and Hayuth (1993) used DEA to compare the performance of 20 ports. The study used four outputs and two inputs. The outputs were cargo throughput (container, general cargo and bulk), level of service, users’ satisfaction and ship calls. The input variables were human labour and capital. They concluded that DEA is a promising and easily adoptable technique for ranking.

DEA has been used by many authors for ranking ports in terms of efficiency. One such study was conducted by Cullinane et al. (2005) to determine the relationship between container port efficiency and privatisation. The study used terminal length, area and the number of QCs, YCs and SCs as inputs. Output was represented by container throughput. The study showed no clear-cut theoretical relationship between efficiency and ownership of port land or privatisation.

In evaluating the operational performance of major container ports in the Asia-Pacific region, Lin and Tseng (2007b) provided five models of DEA to establish competitive strategies that helped to improve container ports’ resource use and productivity. The output measures in this study were the number of container ships arriving at port and the loading/unloading volume of containers. Conversely, the input variables included length of container terminals, area of container base, the number of deep-water piers and the number of QCs. The results showed that the overall technical inefficiencies of these ports were mainly due to pure technical inefficiencies, rather than inefficiencies of scale. The low pure technical efficiency compared to the efficiency of scale suggested that inefficiencies were mostly because of inefficient management practices.
In gaining insights into port operations in emerging markets, Wu and Goh (2010) used DEA to evaluate 23 international container ports related to advanced markets and emerging markets. The inputs used were terminal area, quay length and the amount of cargo-handling equipment. The output variable was the TEUs’ throughput. The results showed that none of the ports in advanced markets was a role model for the field.

DEA was also used by Wu (2009b) to evaluate the performance of 28 container ports located in 12 different Asian countries. Land and equipment factors were incorporated into the model as input. These factors included the capacity of cargo-handling machines, number of berths, terminal area and storage yard capacity. The output was represented by container throughput. Despite the homogeneity of container terminals, the findings showed that, in terms of efficiency evaluation, each group of container ports located in one country could be very different from another group of container ports located in a different country. Additionally, the efficiency score of container ports reflected the overall status of the country’s economy. In China specifically, Li et al. (2013) used DEA to estimate the change dynamic efficiency of 42 Chinese coastal container terminals. The inputs used were terminal length, handling equipment and staff numbers. It was found that the overall efficiency of these terminals was relatively low due to scale inefficiency. Secondly, there was a vast regional difference in terminal efficiency among different port groups. For instance, the efficiency of the Yangtze River Delta region was higher than that of three other areas, and the south-east coast had lower than average efficiency.

In measuring the efficiency of a number of Australian ports, Jose (2001) provided an efficiency measurement for 12 international container ports, including four Australian container ports. The study used two output measures: container throughput and ship working rate, which are represented by the number of containers moved per working hour. In contrast, the input measures included the number of cranes, berths, port authority employees and tugs. They also included the area of the terminals and delay time. The results showed that port size was not the determinant of port efficiency.
Wanke et al. (2011) used DEA and stochastic frontier analysis (SFA) to measure the efficiency of major Brazilian terminals. The sample included 25 terminals. The inputs used were the number of berths, terminal area and size of parking lot for incoming trucks. The output variables were aggregate throughput (tons per year) and loaded shipments per year. As an extension of the contribution, conjuncture and structural variables were also included. The structural variables included the type of cargo handled (solid bulk, liquid bulk or container) and the connectivity of the terminal to railroad lines. In contrast, conjuncture variables encompassed the perceptions of interviewees on labour force qualifications, the control of the terminal (state or private) and the scheduling of incoming trucks to the terminal. The study found that the majority of Brazilian terminals ran short on capacity, due to the export boom that had occurred over the last few years, and due to the lack of investment in capacity expansion.

Schoyen and Odeck (2013) used DEA to evaluate the technical efficiency of 24 container ports, including Norwegian container ports and other Nordic and UK ports. The study used berth length, terminal areas, QCs, the number of YCs, reach stackers and SCs as input variables. Throughput was used as the output variable. The study found that all ports in the sample seemed to have improved their overall efficiency over the period studied, and much of this improvement was due to improvements in the scale of operations. The major reason for the observed scale inefficiency was due to ports that operated with increasing returns.

DEA was also used by Wanke (2013) to assess the physical infrastructure and shipment consolidation efficiency drivers in Brazilian ports. Warehousing area, berth numbers and the yard area were used as inputs, whereas the throughput (tons & TEUs) was used as an output variable. The result indicated that private administration had a positive impact on physical infrastructure efficiency levels, while the size of hinterland and the operation of the bulk and containerised cargoes had an opposite effect on the efficiency of shipment consolidation levels.

Cullinane and Wang (2006) investigated the relative efficiency of 69 European container terminals. Their study used container throughput as an output variable. Terminal length, terminal area and the amount of handling equipment were used as input variables. It was found that terminals could dramatically improve the level of
their output while using the same inputs, by up to 2.4 times of current levels. It was also found that the efficiency of container terminals located in different regions differed, to either a small or large extent. Another perspective regarding European ports was provided by Carlos Pestana and Athanassiou (2004). The study was conducted to increase the competitiveness of the seaports of Greece and Portugal against other European ports. The labour force and capital were used as inputs. Movement of freight, total cargo handled (dry and liquid cargo, containers, cars, trucks, motorcycles) and the number of passengers were used as outputs. The findings showed that the majority of seaports were efficient in managing their resources when they were evaluated on a VRS.

Wilmsmeier et al. (2013) investigated port efficiency under changing market dynamics. The study concentrated on two aspects. The first was geographic, focusing on Latin America, and the Caribbean as an emergent region. The second was temporal, looking at the pre-financial crisis, crisis and post-crisis periods. The study used terminal area, crane capacity and labour force as inputs. Terminal throughput was used as output variable. The results clearly illustrated changes in productivity when comparing these three periods, revealing that the significant loss in productivity was provoked by the economic crisis. Another perspective was provided by Bichou (2013), who examined the relationship between port efficiency and the operating environment. The study focused on the market and operating conditions of container ports and terminals, with a sample of 420 container terminals. The input variables in this study were terminal area, maximum draft, berth length, yard stacking and QC index, and the number of gate lanes and railway tracks at the gate. The results showed that terminal efficiency was highly affected by variations in operating conditions.

As with any analytical method, DEA has advantages and disadvantages. These are summarised in the following sections.

### 3.3.1 Strengths and Advantages of Data Envelopment Analysis

DEA is a powerful non-parametric tool for studying the efficiencies of DMUs in the same group or cohort by allowing direct peer, and peer-to-grouped-peers comparisons, on the basis of a multitude of input and output factors, through a new
diverse range of models (Manzoni and M.N.Islam, 2009). The following shows some advantages of DEA:

1. DEA can handle large numbers of variables and relations ‘constraints’ (Cooper et al., 2007).

2. Productivity changes can be measured by both parametric and non-parametric methods. The advantage of DEA as a parametric frontier estimation is that it imposes no functional form on technology, nor any restrictions on the reward of factors on production. Additionally, the frontier nature of DEA allows the capturing of productive inefficiencies (Cullinane, 2011).

3. DEA has the advantage of minimal specification error (Cullinane et al., 2006). Therefore, it often emerges as the preferred technique in container terminal performance evaluation (Cullinane, 2011, Jie et al., 2009).

4. DEA calculations are non-parametric and do not require an explicit prior determination of relationship between inputs and outputs (Jose, 2001).

5. This technique gives a minimal set of constrains on the input and output weights (Doyle and Green, 1994).

6. The characteristics of DEA, such as the ability to analyse simultaneously a number of inputs and outputs, and the ability to derive efficiency ratings within a set of analysed units, are particularly suitable for measuring port efficiency (Jose, 2001).

7. DEA does not require the development of standards against which efficiency is measured (Jose, 2001).

8. It enables the inclusion of environmental and other qualitative factors that are important in assessing performance (Roll and Hayuth, 1993).

9. It recognises the possibility of different but equally efficient combinations of outputs and inputs (in different proportions) (Manzoni and M.N.Islam, 2009).
10. It does not require the setting of rigid importance weights for the various factors (Roll and Hayuth, 1993, Cooper et al., 2007).

11. The DEA approach locates an ‘efficient frontier’ within the group analysed, and the salient units comprising it; thus, efficiency is measured relative to the highest performance, rather than against some average (Roll and Hayuth, 1993).

12. The approach points to specific sub-groups of the efficient units, which are appropriate as a reference level for each of the non-efficient units (Cooper et al., 2007).

All of these characteristics make DEA a most suitable tool for measuring port efficiency. However, DEA has some limitations.

3.3.2 Weaknesses and Limitations of Data Envelopment Analysis

The limitations include:

1. Attempting to move from partial to total factor productivity measures encounters some difficulties, such as selecting the outputs and inputs to be considered in a study and the weights to be used for obtaining a single-output to single-input ratio (Cooper et al., 2007, Wöber, 2007).

2. The accuracy of the outcomes of the efficiency analysis depends on the accuracy of the data used.

3. DEA is good at estimating relative efficiencies, but poor at absolute values (Manzoni and M.N.Islam, 2009).

The above literature review illustrates that DEA is the dominant method for port efficiency estimation. Due to its advantage, DEA is an appropriate non-parametric technique used in evaluating container port efficiency.
Chapter 4: Methodology

4.1 Introduction

The previous chapter presented a review of the literature related to port performance. Variables influencing port performance, as seen from an operations perspective, were identified. Drawing on this foundation, the theoretical framework was described, research questions were developed. In this chapter data collection and analysis techniques will be described. The purpose of this chapter is to introduce and discuss the research methodology used in this research.

This study takes an objective positivist perspective, with a predominately quantitative methodology. It is divided into two parts. The first part used a quantitative survey to target 200 Libyan stakeholders. The data were collected and analysed by two statistical techniques: descriptive analysis and one-way ANOVA. This second part used secondary data of 25 container port and terminals, and these were analysed by the DEA mathematical technique.

The choice of an appropriate research design depends on the objectives and nature of the research to be undertaken (Wu, 2009a). Working within a positivist framework, this study examines the logical causal relationships between the relevant independent variables derived from the literature and the performance of four Libyan ports. It then examines the relationships between the efficiency of seven Libyan ports and the independent variables that emerged as the most influential factors on port performance (see Figure 4.1).

The reason for choosing this methodological design is that the positivist paradigm suggests that events and things are logical, linked and can be predicted, and that much of human behaviour can be usefully understood in this way as well (Dasgupta, 2011, Wu, 2009b). Generally, empirical or positivist studies attempt to test theory in an empirical and logical way, to maximise the predictive understanding of phenomena (IAPH, 2012, Emmerson, 2010a). In many fields, the principle purpose
of a scientific approach is to establish robust causal laws that allow the anticipation and explanation of the phenomena (Trochim, 2006a). To achieve that, a causal relationship, where a change in any independent variable leads to a change in dependent variables, has to be well defined (Emmerson, 2010a). This study attempts to establish causal relationships between port performance and the independent
variables derived from the literature. Research design is broadly divided into two types: exploratory and conclusive (Martin and Bridgmon, 2012). An exploratory research design is used to provide insights into the nature of the phenomena under investigation, when little is known about the problem area (Malhotra, 2007). In contrast, a conclusive research design, which includes descriptive and causal designs, needs detailed input information and is used to test specific hypotheses and examine relationships (Malhotra et al., 2006); this approach is adopted for this study.

The positivist approach emphasises the central importance of empiricism: the idea that observation and measurement is the core of scientific investigation (Trochim, 2006a). Empiricism has been used mainly to denote a general approach to the study of reality. This suggests that, ultimately, only knowledge gained through experience and the senses is reliable (IAPH, 2012). Therefore, this study provides an empirical model to investigate the influence of certain factors on port performance in a very logical way. Some realist thinking has found its way into positivism. Realism adopts the interpretive stance that there are fundamental differences between the natural and the social world. Realism considers there is only one reality, although different perceptions of it exist (Caldera-Noriega, 2005).

In many practical research projects, when causal relationships are assumed to exist, the cause, which is an independent variable, and the effect, which is a dependent variable, are often well defined through empirical observation. However, the relationship between the cause and effect may not be well known (Trochim, 2006a, Malhotra, 2007). As would be necessary if operating within a situation that can be explained using a positivist theory of knowledge, the phenomena of container port performance and efficiency can be shown to exist, are known from experience and can be measured. However, for specific research topics, the full causal chain or network between independent variables and dependent variables (outcomes) are often not known (Malhotra, 2007).

Based on deductive reasoning, which is consistent with a positivist approach (Trochim, 2006b), this chapter is divided into two phases (see Table 4.1).
<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Aims</th>
<th>How to achieve aims</th>
<th>Variables</th>
<th>Source of data</th>
<th>Type of analysis</th>
<th>Respondents</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>To identify the factors that influence the performance of Libyan ports</td>
<td>Incorporate the literature of port performance to identify the performance criteria</td>
<td>Cost, time, cargo safety, accessibility, port reliability, service flexibility, online services, seaside productivity, terminal productivity</td>
<td>Qualitics quantitative questionnaire using snowball technique</td>
<td>Descriptive and one-way ANOVA</td>
<td>LMTPA, shipping companies, freight forwarders, port authority, local carriers, local seafarers, cargo owners</td>
</tr>
<tr>
<td></td>
<td>To find out the extent of that influence</td>
<td>Get the perspective of local stakeholders regarding these factors</td>
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<td>Phase 2</td>
<td>To establish ranking relationship and examine the influence of the existing port infrastructure and superstructure on the efficiency of Libyan ports</td>
<td>Compare the efficiency of Libyan ports against the efficiency of Libya’s trading partners’ ports</td>
<td>Inputs: water depth, berth length, storage yard area, number of cranes, number of transport equipment, number of staking equipment</td>
<td>Secondary data</td>
<td>DEA</td>
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<td></td>
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<td>Output: TEU throughput</td>
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Table 4.1: Summary of Research Methods
The first phase investigates the factors that undermine container and general cargo port performance in Libya, against the background of global trade transport connectivity. This was investigated from the perspective of Libyan ports’ local stakeholders. Four main Libyan ports were used for this purpose: Tripoli, Benghazi, Qasr Ahmed and Khoms. The considered factors in this phase, derived from the literature, include cost, time, safety of cargo at port, port accessibility, port reliability, service flexibility, online services and seaside and terminal productivity. To address this aim, a descriptive analysis and one-way ANOVA were conducted. The IBM Predictive Analytics Software SPSS was used for this purpose. The second phase describes the methodology used to measure the efficiency of seven Libyan container ports compared to 18 international container ports and terminals related to Libya’s trading partners. To confirm and validate the findings of the first part of the analysis, the second phase includes a number of factors that emerged as being most influential on port performance from the descriptive and one-way ANOVA analysis. All of these factors are associated with port superstructure and infrastructure, and are under the control of port operators and the port authority.

Due to the overwhelming dominance of containerisation and the expected future growth in container-handling technology, driven by the anticipated dramatic increase in container ship size and capacity (Marineinsight, 2012, Maersk, 2012, Dasgupta, 2011, Acosta et al., 2007), the second part of this analysis focuses only on container ports. For this purpose, DEA is employed, using the software DEA-Solver-Pro version 8.0.

The research seeks to determine the nature of the relationship between causes and effects in relation to port performance and efficiency. Therefore, this study can be described as positivist, conclusive and causal (Malhotra et al., 2006).

4.2 Phase 1: Measuring Libyan Port Performance

The main objective of this phase is to identify the relevant variables that determine the performance of Libyan ports and to determine the extent of that influence. To address this objective and to increase the research’s validity, the study has employed a quantitative method approach. This involved an examination of the literature on port performance and efficiency, to identify relevant variables. A quantitative survey
was then undertaken to determine the causal relationship between the dependent and independent variables, as seen from the perspective of Libyan port stakeholders. Accordingly, a Qualtrics online quantitative survey was developed and emailed to eight groups of local Libyan port stakeholders. The snowball technique was used to increase the response rate. These eight groups were: the LMA, Libyan port operators, local carriers, shipping companies, local freight forwarders, Libyan seafarers, port authorities and other parties associated with Libyan ports.

It was expected that the findings of port performance analysis in this phase would have the capacity to be generalised, especially in regard to ports in developing economies, as this study investigates port performance broadly, using Libyan ports as an example of a developing economy. The following shows in detail who the targeted participants were, and provides justifications to prove they were the most appropriate participants and the most appropriate sample size.

### 4.2.1 The Research Participants

The first step in survey sampling is identifying the population to be studied, which should include all the elements that represent the unit of analysis in the study (Pike, 2012). Well-selected sampling may reflect fairly accurately the characteristics of the population (Krishnaswamy, 2010). For increased reliability of results, adequate and accurate data are required. This was obtained by targeting an adequate sample of professional experts from the area subject to research; that is, Libyan ports. Therefore, this study targeted all Libyan port stakeholders from different managerial levels through a quantitative survey. These included port operators, LMPA, the port authority, freight forwarders, shipping companies, national carriers, seafarers and cargo owners. These participant groups represent the entire population of Libyan ports’ local stakeholders. Capturing the professional experience of these stakeholders was very important for developing optimal strategies for performance improvement. Additionally, the aim of targeting these groups was to obtain their views and opinions, to allow the establishment of comprehensive causal relationships.

The port operator is one of the main stakeholders, and they are focal players in port performance. That is because the port operator is the service provider to all port users. Therefore, the port operators were included among the participants. The aim
of the port operator is to increase port productivity by achieving higher throughput with fewer berths and handling machinery, while also serving and attracting more users (Imai et al., 2008, Beškovnik, 2008). However, using fewer berths and handling machinery increases ship turnaround time, which may conflict with the interest of ocean carriers (Beškovnik, 2009). Port performance can be affected if an ocean carrier leaves the port because of a long ship turnaround time (Gaur et al., 2011). Carriers assess the performance of container ports, taking into account a number of different measurements. The most important parameters for gauging container port performance from the perspective of the carriers are berth productivity, ship turnaround time (Beškovnik, 2009), service reliability, water depth (Chang et al., 2008) and berth availability (Chang et al., 2008). Based on the above, local ocean carriers were included in this study.

Shipping companies were also considered among the port stakeholders, as they deal directly with and represent the carriers at Libyan ports, and they have their own perspectives on the performance of Libyan ports. Freight forwarders were also involved, due to their interest in the efficiency of cargo flow from and to the ports. Seafarer groups were also targeted, as they can assess performance factors properly and accurately owing to their visitation of different ports. Specifically, they can compare the level of services provided by Libyan ports against other visited ports. Additionally, LMA was included among the sample, as it is the official regulatory body overseeing the ports’ functionality with a view to increasing national revenue. The Ports Authority is also one of the main port stakeholders, as it is the authorised body for implementing local laws, regulations and rules. The targeted participants were thus an appropriate sample for this study.

Appannaiah et al. (2010) argued that the theory of sampling provides little assistance in achieving good estimations of a sample size. However, two considerations are needed when determining the appropriate size of the sample. The first is that the sample size should increase as the variation in individual items increases. The second is that, the greater the degree of accuracy desired, the larger should be the sample size. Due to the small population of stakeholders and the expected low survey response rate, the research randomly targeted 200 participants, who represented the entire stakeholder population. Included in this population were
Libya’s two port operators: MFZ Company and LPC. MFZ Company operates the port of Qasr Ahmed in Misurata, and the LPC operates the other commercial ports. Further, there are approximately 300 local shipping and freight-forwarding companies in Libya (CETMO, 2010, Libyan Maritime Administration, 2013). Most of these freight forwarders have their own customs clearance officers, or deal with specific customs clearance companies (CETMO, 2010). In addition, there are three Libyan ship-owning companies (Libyan Maritime Administration, 2013). This shows that the entire population is less than 350 businesses, including both private and public sectors. Therefore, the participants and sample size are appropriate for research validity and reliable results.

4.2.2 Definition of Variables and Instrument Development

The determination and selection of variables are elementary steps in any study (Liu, 2010b). Regarding port performance, the literature shows that it can be influenced by a range of factors (Huybrechts et al., 2002), such as location, general cost, safety of operations, quality of service, time, accessibility, reliability, flexibility, availability of information and availability of a variety of services (Kao et al., 1995, Coto-Millan et al., 2000, Kia et al., 2000, Jose, 2001, Gekara and Chhetri, 2013, Striegler, 2013, Carlo et al., 2014).

According to the positivist paradigm, all causal variables should be considered to determine the most logical relationships between cause and effect (Trochim, 2006a). However, this is not practical due to the complexity of factors that determine such relationships (David Xiaosong Peng et al., 2011). Additionally, it is difficult to consider explicitly the entire range of possible influences, due to the complexity of factors that determine port performance (David Xiaosong Peng et al., 2011). Accordingly, not all of the influential factors and components were considered in this study. The excluded factors and components include port location and port dues. The reason for this exclusion is that all Libyan ports are located at an approximately similar distance from the east-west international trade lane. Moreover, there is no difference in port dues payable by any Libyan ports. In total, this study included 25 variables related to the performance criteria.
The performance criteria included shipside productivity, terminal productivity, cargo safety, port accessibility, port reliability, service flexibility, cost and time. Terminal productivity was measured by the capacity of storage yards, transport equipment and stacking equipment. Shipside productivity was measured by the capacity of QCs and the efficiency of cargo-handling operations to and from the ship. Cargo safety was evaluated by cargo damage and loss. Online services were evaluated by the availability of online services, such as online tracking of cargo and ships’ movement, online customs services and online transactions. Port accessibility was measured by both seaside accessibility and landside accessibility. Seaside accessibility consisted of water depth and berth length. Landside accessibility consisted of the connectivity of the port to sufficient rail and road networks. Port reliability was evaluated by the accuracy of ships’ scheduling, the reliability of cargo-handling facilities used at Libyan ports and the reliability of cargo delivery times. Service flexibility was evaluated by the ability of the Libyan ports to provide berthing on arrival, and the ability to deal with different cargo types, sizes and weights. Cost in this study consisted of the fees for cargo handling and customs clearance, as well as the cost of land transport. Finally, time was evaluated by the free cargo dwell time at port, the total handling time and the ship’s turnaround time.

The literature showed that the individual effects of the extracted variables included in this study were reasonably well known (Clark et al., 2004, Sanchez and et al., 2003, Asteris et al., 2012, Zhou and Kang, 2008, Kim and Kim, 2002). Further, the effect of some of these variables, as a group and in a certain region highlighted by the studies, was also known (Yeo et al., 2008, Yuen et al., 2012, Acosta et al., 2007, Zhou and Kang, 2008). However, for the first time, this study investigated the effects of all of the above-mentioned factors when operating in combination. This was done by using the most appropriate method and involving stakeholder experts in the process, bringing the benefit of their opinions and beliefs (Phillips and Stawarski, 2008).

The variables were used to develop a quantitative questionnaire, consisting of 15 structured questions. The online Qualtrics questionnaire consisted of 15 main questions (see Appendix 1). The first four main questions were demographic questions. Another question was included to measure the importance of a number of
customer requirements. Another question ranked the four main Libyan ports in terms of performance. The last nine main questions included 34 sub-questions related to port performance. Two scales were used to obtain respondents’ perceptions. The first measured the importance of some performance elements to the local stakeholders, based on a scale of seven, where ‘1’ denoted not important at all and ‘7’ denoted extremely important. The second scale expressed the level of agreement and disagreement of the respondents in regard to some statements used to measure the performance of Libyan ports. It was based on a scale of five, where ‘1’ denoted absolutely disagree/unlikely and ‘5’ denoted absolutely agree/more likely.

4.2.3 The Data

The data used in this study were quantitative data obtained by two methods: the quantitative questionnaire and secondary quantitative data related to the sample ports. Quantitative data involves measuring and counting, which can be expressed and represented numerically (Elizabeth and Lambert, 1990). It can be collected by questionnaires, surveys, psychological tests, archival searches and experiments (Al-Mutawah 2009). From this perspective, some variables included in this study were described as numerical variables. Examples include container throughput, water depth, quay length, storage area and the amount of handling equipment. The data were collected in a quantitative form. Conversely, the type of container-handling equipment can be described qualitatively. For example, to differentiate between the types of QCs used in a certain container port, QCs can be described as Panamax cranes, Post-Panamax cranes or Ultra-Panamax cranes. However, in some cases, qualitative data can be converted into quantitative data (Trochim, 2006b). In the case of QC types, each type of QC has different specifications that can be expressed quantitatively; for example, handling rate, outreach, height and moves per hour. Therefore, the data required for this research are quantitative. These data were obtained from primary sources for the first phase and secondary sources for the second phase.

Regarding the first phase of this study, the involved organisations were the Libyan ports. Primary data were used for this phase, analysed using descriptive and one-way ANOVA analysis. Primary data are original in character and are collected by research institutions or individuals for the purposes of a specific study or enquiry.
(Appannaiah et al., 2010). The primary data of this study were collected by the researcher to investigate the performance of Libyan ports. These primary data were collected directly from the primary sources of local Libyan port stakeholders, using an online survey and the snowball technique.

The data collection method is crucial for the feasibility and accuracy of the survey and is influenced by the type of data required (Phillips and Stawarski, 2008). For this study, a ‘Qualtrics’ online quantitative survey was used, as it is an inexpensive, rapid and appropriate method to capture the attitudes and opinions of experts in this field (Hair et al., 2000). The questionnaire consisted of 15 structured questions. Each question discussed one issue. The questionnaire was reviewed and pilot tested by two academics and two practitioners before it was released on 5 October 2012. (Qualtrics is a private research-software company that provides online services for data collection and analysis, including market research.)

Due to the small size of the population, the online survey was distributed to around 200 stakeholders using the snowball technique. Survey sampling was developed to confirm that it included all the elements representing the unit of analysis in the study. Therefore, it included participants from port operators, LMPA, the port authority, freight forwarders, shipping companies, national carriers, seafarers and cargo owners. All of these participants were from different managerial levels. Moreover, surveying might save time and effort and achieve more accurate results, as it extracts the important data from those who can tacitly assess the variables (Lam and Yap, 2011).

The snowball technique uses an initial set of members as informants for building up a sample or a list of a special population (Krishnaswamy, 2010). The snowball technique was used because it is ideal for data collection. It provides intensive results and spreads the questionnaire rapidly, economically, efficiently and effectively (Elizabeth and Lambert, 1990), diffusing information among professionals of various types (Krishnaswamy, 2010).

Emails and Facebook were used in the snowballing technique to increase the response rate efficiently. Due to the researcher’s professional background, the researcher was linked by Facebook with many potential participants in the Libyan
maritime industry. Some of those potential participants have their own private businesses and others work for the public sector. They also work in shipping, freight forwarding, maritime transport, the LMA, the Port Authority and port operators. The link to the Qualtrics questionnaire, with an introduction and request to complete the questionnaire, was posted on the researcher’s Facebook timeline. It was also emailed to many potential participants. Potential participants were asked to forward the questionnaire to their colleagues at different managerial levels and to ask those colleagues to help in forwarding the link to others.

The aim behind the strategy of targeting different managerial levels was firstly that managers are familiar with Libyan port problems and have good experience in the port industry. Therefore, they would not need a detailed explanation about the terminology used and the practical issues. Secondly, they are decision makers; they have the authority to release any relevant important information. Thirdly, they are familiar with the major factors influencing port performance and the relationships between them.

Five weeks after circulating the survey, a second reminder phase was conducted. Other emails were sent to relevant potential participants. Telephone calls were made to different stakeholders to encourage them to participate and distribute the questionnaire to their colleagues, to increase the response rate and minimise non-response bias. The survey was closed on 11 February 2013. From 200 targeted stakeholders, 186 participants responded to the questionnaire, as discussed in detail in the next chapter. However, only 84 respondents answered all questions, giving a response rate of 45 per cent. However, this was sufficient to run the analysis, as explained in Chapter 5.

4.2.4 Data Analysis

Many statistical techniques are available for use in data analysis. Each technique depends on the research subject, research question, the kind of information to be discovered and the final outcomes of the research (Wu, 2009a). Additionally, the selected statistical techniques depend on the variable types and number, the number of groups being compared and the purposes of the comparison (Martin and Bridgmon, 2012). Sometimes there may be one most appropriate empirical technique
for a specific research question; however, in most cases multiple techniques could be used (Malhotra et al., 2006).

Generally, basic or traditional statistical techniques use a limited number of variables (Kline, 2004, Schumacker and Lomax, 2004). According to Schumacker and Lomax (2004), some of these techniques deal with two variables and permit the prediction of dependent observed variable scores. This sort of technique uses linear regression models. Other techniques, such as confirmatory factor analysis (CFA), are used to test a set of items that form a construct. Some other techniques are used to model complex relationships among observed variables; for example, path analysis models use regression analysis and correlation coefficients for that purpose. This study used three quantitative techniques for data analysis. To measure the performance of Libyan ports from the perspective of local stakeholders, the study used descriptive analysis and one-way ANOVA, assessed using the IBM SPSS program. It used DEA to compare the efficiency of Libyan ports against the container ports of Libya’s trading partners.

Regarding the primary data of the factors determining port performance, only one sample of respondents’ views was drawn from the targeted population at one time point over a short period. Similarly, the secondary data were statistics related to the same year: 2010. Therefore, this study is considered a cross-sectional study (Balushi, 2010, Liu, 2010b, Malhotra et al., 2006). Moreover, research problems and causal variables are well identified and the focus of this study was on the causal quantitative relationship. Therefore, this study is considered causal quantitative research (Malhotra et al., 2006).

Descriptive analysis was used to analyse the primary data obtained through the questionnaire. It was used to test the frequencies of the primary data, summarise the raw data in a meaningful way and allow the researcher to make conclusions beyond the data analysed (Lund, 2013). The descriptive analysis was used to rank the selected variables of performance criteria, based on their importance to the local stakeholders in general, and then their importance to each stakeholder group. The descriptive analysis was also used to measure the effect of each independent variable on port performance as a dependent variable, according to the perspective of each stakeholder group.
Due to the different interests of the stakeholder groups, one-way ANOVA was used to determine the significant differences between two or more arithmetic means (Iversen, 2004, Martin and Bridgmon, 2012). In one-way ANOVA, there is one dependent variable that has to be continuously scaled at the level of interval or ratio, and one independent variable with two or more levels or conditions (Martin and Bridgmon, 2012). Similarly, in this study there was one final dependent variable, which is port performance. In contrast, there were a number of independent variables related to port superstructure and infrastructure. Their effect on Libyan port performance needed to be tested using a numerical scale. The influence of the observable independent variables was measured from the perspective of different local stakeholder groups and this statistical analysis was used to determine whether the arithmetic means of various stockholder groups were different.

4.2.5 Validity

Reliability and validity are two essential criteria for assessing the goodness of measurements (Balushi, 2010). Reliability refers to the accuracy of a measurement (Emmerson, 2010b). It is the degree of consistency among the items measuring a variable. A survey’s sample size should be sufficient to represent the population (Balushi, 2010). Validity, on the other hand, refers to the capability of a measurement to measure what it purports to measure (Emmerson, 2010b, Stawarski and Phillips 2008). Validity consists of internal and external validity (Emmerson, 2010b, Balushi, 2010, Stawarski and Phillips 2008).

To determine internal validity, whether the cause and effect relationship is indeed causal is assessed, based on the manipulations and measures of the variables used in a study (Martin and Bridgmon, 2012). The key issue in internal validity is whether the indicators that comprise the scale or index are consistent; that is, whether respondents’ scores on any indicator tend to be related to their scores on any other indicator (IAPH, 2012). Internal validity depends on the research design and its ability to show a causal relationship (Emmerson, 2010b) and face validity.

In terms of research design, this study used validated instruments used by previous researchers, as shown in Figure 3.1. The research incorporated the literature of port performance and efficiency to construct the related variables and identify the
relationships between the dependent and independent variables. Individual relationships between port performance and some independent variables have been illustrated in the literature. However, this research investigated the relationships between container port performance and a group of interacting independent variables from the perspective of different groups of stakeholders. Additionally, the questionnaire was designed to ensure that it measured the effect of any variable by more than one question. All of this achieved internal validity.

Face validity refers not to what the test actually measures, but to what it superficially appears to measure. It pertains to whether the test looks valid to the examinees who take it. Face validity is determined by a review of the items and not through formal procedures or through the use of statistical analyses (Trochim, 2006a). Accordingly, to ensure face validity, the survey was moderately sized and had a friendly design, to make it more pleasurable to complete, and to motivate respondents to answer all of the questions (see Appendix 1). It also used clear, written, formal and simple questions that were easy to understand and were designed to have a single meaning (Malhotra et al., 2006, Emmerson, 2010b). To confirm this, the questionnaire was presented to a group of academics and practitioners, including the researcher’s two supervisors and three other carefully selected experts on the port industry, two of whom held PhDs related to the port industry. Based on this, the questions can be considered clear and understandable.

External validity refers to the ability of sampling procedures to ensure that the research results can be generalised (Emmerson, 2010b), and to ensure reliability and construct validity as a positivist causal study. This study surveyed samples from all Libyan ports’ local stakeholder groups, to achieve consistency, as well as to remove potential bias (Malhotra et al., 2006). Moreover, commercial Libyan ports are operated by the same operators and they deal with the same types of goods. Additionally, container ports perform almost the same handling operations and deal with broadly the same types of cargo and kinds of ships. They also deal with the same sort of stakeholders. Moreover, English is mainly used by these organisations when they deal with international parties. All of these factors show homogeneity in the sample, which ensures the validity of the proposition or the conclusion (Trochim, 2006a). However, one of the weaknesses is that this study targeted only local
stakeholders, and not all the stakeholders of Libyan ports. Foreign stakeholders might have different opinions regarding the variables used in this study. Moreover, due to the small population of local carriers (only three companies own all Libyan flagships) their responses might undermine the study’s validity. In addition, all Libyan ports are operated by the public sector. Therefore, public port operators could have different opinions from private ones. Despite all of the above disadvantages, the findings of this study can still be generalised.

4.3 Phase 2: Evaluating the Efficiency of Libyan Ports

A quantitative analysis using DEA analysis was undertaken to measure and compare the efficiency of seven Libyan ports (Tripoli, Misurata, Benghazi, Khoms, Derna, Tubrouk and Brega) against 18 international container ports and terminals related to Libya’s trading partners. The purpose of this comparison was to establish ranking relationships and confirm the findings of the descriptive and one-way ANOVA analysis. For greater understanding about how the DEA has been applied in many studies to evaluate the efficiency of container ports in particular, and to identify the different variables that affect port efficiency, the literature of DEA analysis in the port industry was reviewed.

Firstly, efficiency refers to the performance of any organisation compared to the benchmark (Liu, 2010a). Technical efficiency is known as the capacity of obtaining the maximum amount of output from certain inputs, which is called ‘output orientation’. The ability of decision-making units (DMUs) to decrease input used to achieve the given levels of output is known as ‘input-orientation’ (Reilly, 2008). The DMU in this study is the container port or terminal.

It is important to gain a better understanding of factors attributed to container port efficiency (Yuen, Zhang & Cheung 2012). These factors can be used to evaluate port performance and determine the weaknesses that prevent a port from being efficient, and help in developing business strategies that contribute to business performance (Gonzalez and Trujillo, 2008).
4.3.1 Identifying the Variables

The output and input variables used for container port performance evaluation should reflect the process of container port production and the actual objectives as accurately as possible (Lin and Tseng, 2007a). Therefore, this section identifies the output variables used to measure efficiency. It also identifies the input variables that influence the efficiency of container ports, based on the literature. It can be seen from the literature of port performance that all port resources contribute to productivity. From the definition of productivity, increased productivity means increased port throughput using existing port resources as inputs to achieve this throughput. In this case, to be efficient, a port has to obtain maximum throughput using fewer resources.

Several factors affect container port efficiency. Such factors are related to port infrastructure, superstructure and human resources. In DEA evaluation, these influential factors are used as input variables. In contrast, the output variables are represented by performance criteria, such as cargo throughput, number of ship calls, ships’ turnaround time and other factors related to service quality and customer satisfaction. However, cargo throughput is the most common factor for measuring port efficiency and the most important indicator for port output, as it is closely related to cargo-handling facilities and services.

The literature review has also shown that the efficiency of container ports and terminals has been evaluated using a range of sets of inputs and outputs. However, the literature does not include any study investigating Libyan ports. Moreover, variables that have influence in one region do not necessarily have the same influence in another region. Therefore, this study used a set of input variables to evaluate the efficiency of Libyan container ports against 18 container ports and terminals related to Libya’s trading partners, as explained in detail in the following sections. This set of input variables has not been used in the previous literature. Therefore, this study contributes to the knowledge and the literature by providing an empirical model for evaluating container port efficiency using different sets of variables. This includes infrastructure variables, such as water depth to ensure safe passage for the container ships, berth length for safe docking and storage yard area to absorb the volume of container carried by these ships. The superstructure variables
include those related to the amount of container-handling equipment; that is, QCs, transport equipment and stacking equipment.

4.3.1.1 Output Variables

Container port productivity as an output can be measured by different criteria, such as revenue, throughput per time unit, QC throughput, yard throughput, human resource performance, dwell time, equipment idle time, number of ship calls and berth utilisation (Trevor, 2006, Ghashat et al., 2011, Sean D, 1997, Beškovnik, 2008, Ilmer, 2008, Imai et al., 2008, Carpenter and Macgill, 2001, Le-Griffin and Murphy, 2006, Coto-Millan et al., 2000, CSIL, 2012, Fried et al., 1993). However, container throughput, ship calls and ship turnaround times are considered the primary benchmark measures for comparing container port efficiency (Ashar, 1990, Beškovnik, 2008, Beškovnik, 2009, Chang et al., 2008, Duinkerken et al., 2006, Jose, 2001, Le-Griffin, 2008, Roll and Hayuth, 1993, Yuen et al., 2012, Zegordi and Nahavandi, 2002). The author had trouble in collecting data related to all of these primary benchmark measures, except container throughput. Therefore, only the container throughput variable is considered as an output variable for this research project to measure the efficiency of Libyan ports.

4.3.1.2 Input Variables

Port facilities require a variety of basic functions, traditionally considered under two broad categories: port infrastructure and port superstructure (Liu, 2010a). These facilities are considered input variables for the DEA analysis in this study. These input variables, which are derived from the descriptive and one-way ANOVA analysis, are expected to be closely associated with the recent growth in container ships’ size and capacity.

The historical evolution of container ships demonstrates a dramatic increase in the dimensions of container ships, to increase the volume of containers being transported (Marineinsight, 2012, Maersk, 2012). This increase includes ship’s length overall (LOA), width, freeboard and draft. However, most of the container ports, including Libyan ports, were built decades ago to serve the previous generation of container ships, which had smaller dimensions. The evidence for this is that the current crop of
ultra-large container vessels are only able to dock at a handful of the world’s ports (Kremer, 2013).

Given these increases, container ports need to accommodate ultra-large container vessels and increase productivity if they are to create or retain a competitive advantage. This could be done through having specific port infrastructure that suits the new generation of container ships. The essential port infrastructure includes water depth greater than the drafts of these ships to ensure safety of navigation and enable such ships to enter the port and moor. It also includes long berths to suit the overall length of the inbound container ships to provide safe docking. It also needs to include an optimal storage yard area that is able to absorb the volume of containers off-loaded from such ships. Basically, the carriers are saying to the ports:

If you do not expand, if you do not build new wharves and deepen the harbours and get high speed cranes, we’ll take our business someplace else (Kremer, 2013).

Therefore, port infrastructure, as represented by water depth, length of berths and storage yard area, is considered one of the most important input variables in this study.

Similarly, sufficient and efficient port superstructure is critical to facilitate this new generation of ships. Port superstructure includes all the equipment used for container transfer and transport within the port. These include QCs, SCs, AGVs, trucks, forklifts, trailers, reach stackers and yard cranes.

Each container port uses different types of these equipment categories, depending on many factors, such as container flow, storage yard dimensions and investment cost. For instance, within seaside operations and during the 1960s, container ships were loaded and discharged via normal shore cranes and wire slings. However, simultaneous with the changes in container ships, container ports changed to deploy more advanced and sophisticated handling equipment. On the seaside, when Panamax container ships entered into service, container ports deployed Panamax QCs. This type of crane, with 27 metres height and around 36 metres outreach (to reach about 14 rows), was appropriate to deal with Panamax container ships at that time. Once the dimensions of the container ships increased and post-Panamax
container ships were introduced, the QCs were upgraded again from Panamax QC to post-Panamax, with about 35 metres height and about 42.5 metres outreach (to cover 16 to 22 rows). Similarly, once the super post-Panamax container ships with bigger dimensions entered into service, super post-Panamax cranes were deployed to meet this increase in container ship size and capacity. The height of this kind of crane reached to around 42 metres with an outreach from 50.5 to 65.5 metres (to cover 18 to 24 container rows). In addition, these types of cranes have faster move rates to meet the increase in container volume carried by the new generation of container ships. The evolution of cranes was necessitated by the higher volume of containers and the increased size of container ships.

All of these changes determined how ports and terminals derived competitive advantage and kept pace with the changes in container ships. However, not all of the container ports use the same advanced QCs. Each container port uses different QCs with different move rates, height and outreach. Due to these differences in specifications, the throughput of these ports, and thus their performance, is different.

Between seaside and landside, containers are transported to storage yards and vice versa by horizontal transport vehicles, such as SCs, trucks, AGVs, trailers and tractors. Each container port uses different transport equipment, determined by factors such as the area of the port or terminal, the volume of containers being processed and capital investment (Lau and Zhao, 2008, Ioannou et al., 2000a).

Once a container has been transported to the storage yard, it has to be stacked in a specific spot. That can be done by forklift, reach stacker, RMG, RTG or SC. The choice of equipment depends on the stacking mode, the area of storage yard and the volume of containers at that port, as well as the investment (Kim and Kim, 2002, Lau and Zhao, 2008). Adopting a different container port superstructure leads to differentiation of performance among container ports. Therefore, the number of container-handling equipment is considered an input variable.

4.3.2 Secondary Data Collection for Measuring Port Efficiency

For the second phase of this study, secondary data were used to assess the efficiency of Libyan ports. The secondary data were collected and compiled for another purpose by other researchers (Krishnaswamy, 2010). Secondary data are used
because they are highly economical and time saving (Appannaiah et al., 2010), and cover a wider geographical area and longer reference period without much cost (Krishnaswamy, 2010). Yin (1994) argued that using evidence from multiple sources (triangulation) and establishing a chain of evidence could increase construct validity. Therefore, to increase validity, the research used a secondary data analysis to measure the effect of certain influential factors on the efficiency of Libyan container ports, in comparison to the container ports of Libya’s trading partners. The data were related to a number of variables that emerged as being most influential from the primary analysis. The secondary statistical data included data related to 25 international container ports and terminals, including Libyan ports. The primary analysis of the first phase of this study broadly investigated port performance. However, the DEA analysis of this study focused specifically on container ports and did not include any other type of port. This makes the findings of this study generalisable.

The secondary data were retrieved from reports and statistics issued by accredited bodies such as the International Association of Ports and Harbours and maritime authorities, UNCTAD, and the websites and annual reports of the sample container ports and terminals. These data consisted of port water draft, berth length, storage yard area, and the number and type of QC, transport equipment and stacking equipment; these were used as input variables. Data on port throughput in TEUs were also collected, and this was used as an output variable in this study.

The 25 container ports and terminals included in this sample were: Shanghai Pudong International Container Terminals, Shanghai Mingdong Container Terminals, La-Pezia, Gioia Tauro, Jebel Ali, Alexandria port, HHLA Container Terminal Altenwerder, Izmir, Mersin, Tripoli, Benghazi, Berga, Tobruk, Derna, Qasr Ahmed, Khoms, Antwerp gateway terminal, Marsaxlokk Terminals, Tanger Med port APM terminals, Terminal TCB SL in Barcelona, Terminal Catalunya SA in Barcelona, Pirraeus container terminal, Amsterdam container terminals, Patrick East Swanson Dock Melbourne and Brisbane Autostrad Terminal.

These ports and terminals have been chosen because they are belonging to Libya’s trading partners. Therefore, they handle the same cargo type and volume that are handled by Libyan ports. These ports and terminals are belonging to different
developed and developing countries and located in different regions. In addition, all of them use different cargo handling cargo equipment and have different features of infrastructure. They are also owned and operated under different systems of governing. All of these differences provide a comprehensive measurement environment for identifying the factors that make a certain port or terminal most efficient, which can be used to identify the inefficiency factors or weaknesses of Libyan ports. However, this study will not investigate the relationship between port efficiency and the type of port ownership and management, because it is already investigated by Cullinane et al. (2005) and Ghashat et al. (2011).

To increase the sample size, officials in some other ports and terminals were contacted individually and asked to provide some missing data. However, some of those officials could not disclose any further data and others did not reply at all. Therefore, they were excluded from the sample. These ports and terminals include Amsterdam container terminals, Piraeus container terminal, Trinity terminal in Port of Felixstowe, Antwerp Gateway terminal, Mersin container port in Turkey, Eurogate container terminal, Singapore port, Alexandria and Al-Dekhila in Egypt.

4.3.3 Data Analysis for Port Efficiency

In the first phase, descriptive and one-way ANOVA were used to analyse the data obtained from the local stakeholders of Libyan ports. Some of these variables emerged as the most influential variables on port performance. Further quantitative mathematical analysis was conducted to assess and compare the efficiency of seven Libyan ports against 18 container ports and terminals related to Libya’s trading partner countries, using secondary data related to the variables that emerged as influential on port performance. DEA was used for this purpose. DEA was chosen as it is an appropriate non-parametric method for measuring the efficiency of a DMU (Jose, 2001, Jie et al., 2009, Cullinane et al., 2005, Cullinane et al., 2006). DEA has been widely applied in many industries, including the wider transport sector (Cullinane et al., 2006). It is the dominant estimation method, because it does not impose any functional forms on technology, or any restrictive assumptions on the reward of production factors (Cullinane, 2011). It measures the efficiency of a DMU with multiple inputs and/or outputs by constructing a single virtual input and a single virtual output, without predefining a production function (Manzoni and M.N.Islam,
2009). It is also a technique that imposes minimal constraints on the input and output weights (Doyle and Green, 1994).

From the results of the DEA analysis, the study established relationships regarding ranking differentiation between Libyan and trading partner ports and terminals in terms of efficiency. These relationships determine the efficiency level of Libyan ports against the other container ports. They also determine the reason for Libyan port underperformance, as explained in detail in Chapter 6. Further, regarding measuring the efficiency of Libyan container ports against its trading partners’ container ports, the findings of this analysis can be generalised, as this study particularly investigated the efficiency of container ports and did not include any other types of ports.

4.4 Summary

This chapter has explained the research methodology used in this study. It was divided into two parts. The first part illustrated the methodology of measuring the performance of Libyan ports from the perspective of local stakeholders. The second part illustrated the methodology of evaluating the efficiency of Libyan container ports against 18 container ports and terminals related to Libya’s trading partners. In the first part, the participants were identified. They included participants from the port authority, port operators, shipping companies, freight forwarders, LMPA, carriers, seafarers and cargo owners. The relevant variables were well defended, based on a critical review of the port performance literature. Accordingly, the types of data were illustrated and the instrument was developed. For collecting the primary data, an online questionnaire was adopted using the snowball technique to increase the efficiency of the response rate. This chapter also illustrated the methods of data analysis, which included descriptive analysis and one-way ANOVA. A justification for using these two methods was provided. Finally, external and internal validity was discussed in detail. This methodology will be implemented in Chapter 5 to measure the performance of Libyan ports.

In the second part, the variables used to evaluate the efficiency of Libyan ports were well defined. They were divided into one output and six inputs. The output variable was port TEU throughput. The input variables used were closely associated with the
escalating increase in container ship size and capacity. Secondary data were used for the second phase of analysis. This phase also showed that DEA was the adopted technique for data analysis, as discussed in Chapter 6.
Chapter 5: Descriptive Analysis and One-Way ANOVA

5.1 Introduction

This chapter reports the analysis and findings of the survey questionnaire returned by the respondents, which was used to understand performance issues in relation to Libyan ports. It provides numerical results obtained by analysing the questionnaire responses. The descriptive analysis was conducted to investigate the frequencies of respondents’ perceptions obtained from this questionnaire, to obtain meaningful conclusions regarding Libyan ports’ performance.

Port performance is an important issue for all port stakeholders. The literature revealed that port performance could be measured by port productivity, efficiency and customer service quality. Recently, pressure has increased on transport operations due to logistics practices to minimise costs while enhancing service quality (Madeira Junior et al., 2012). This can be achieved by improving port performance and enhancing efficiency (Clark et al., 2004). However, due to the limitations of port capacities, the performance of Libyan ports seems to be poor. Therefore, this chapter quantitatively examines the performance of Libyan ports and attempts to understand—from the perspective of Libyan ports’ local stakeholders—the main issues that have undermined the performance of Libyan ports. This is done by analysing the data obtained through survey questionnaires using SPSS software.

The chapter includes discussions about the survey response rate, the non-response bias, and descriptive statistics of issues related to port performance from the perspective of Libyan ports’ local stakeholders. It also discusses the analysis of one-way ANOVA used to examine whether there are any significant differences in the perceptions of stakeholders regarding these issues.

5.2 Instrument Development

The questionnaire was designed based on a critical review of the literature of port performance. Port performance is influenced by shipside and terminal productivity,
cargo safety, port accessibility, port reliability, service flexibility, cost and time. However, the influence of each of these factors is a combination of a number of related variables. Therefore, the online questionnaire consisted of 15 main questions (see Appendix 1) that attempt to cover the influence of all these variables individually.

The first four main questions were considered demographic questions. To ensure that the right stakeholder groups and respondents were involved, the first question asked about the type of organisation in which the respondent was employed. This is because each stakeholder group has different interests, based on the nature of its business. To ensure that the respondents were familiar with Libyan ports and had good experience in the port industry, were familiar with the major factors influencing port performance, and had the authority to release any relevant important information, the second question identified the respondent’s position in the organisation. The third question identified the period for which this position had been held. Due to the differences in interests between the public and the private sectors, the fourth question asked about whether the respondent worked for the public or private sector.

Each group of port stakeholders measured port performance based on the type and quality of service required by this group. Therefore, the importance of these services was evaluated using a scale of seven, where ‘1’ denoted not important at all and ‘7’ denoted extremely important. Measuring the importance of these requirements determined the factors to be included in the further questions. This was also used to rank the four main Libyan ports, based on their performance in meeting these requirements. The requirements include:

1. seaside accessibility
2. berth availability
3. cargo loading and off-loading to and from the ship
4. ships’ scheduling
5. ships’ turnaround time
6. cargo-handling facilities
7. total cargo-handling time
8. port efficiency
9. free cargo dwell time
10. online services
11. the competency of port labourers
12. cargo damage
13. cargo loss
14. level of services for fresh water, bunkering and provisions
15. cargo-handling fees
16. customs clearance fees
17. customs clearance processes
18. landside accessibility (gate, road and rail transport)
19. inland transport cost
20. cargo delivery time.

The questionnaire was also developed to examine in detail the three key operational phases of terminal work. These include seaside operations, terminal operations and landside operations. For instance, seaside operations start from seaside accessibility, which includes sufficient water depth and suitable berth length (Acosta et al., 2007, Lin and Tseng, 2007a). Port accessibility is important to commence cargo-handling operations. Therefore, it is required by the stakeholders, especially by carriers, port operators and port authorities. Accordingly, the questionnaire included a number of questions used to evaluate the ability of Libyan ports to accommodate the inbound ships and to meet the demand of larger ships. It also examined the ability of these ports to provide berthing on arrival for the inbound ships. This was in the form of ‘agree’ or ‘disagree’ on statements using a scale of five, where ‘1’ denoted absolutely disagree and ‘5’ denoted absolutely agree. Examples of these statements are:

1. port’s water depth meets the demand of larger ships
2. berth length is suitable to accommodate larger ships

3. availability of berthing on arrival for the inbound ships.

The sea-accessibility-related questions were seen as important because a larger shipment carried by one larger ship reduces transport costs and increases port throughput and revenue.

Terminal operations link the operations of shipside and yard operations. To have an overall assessment on cargo-handling equipment used in the four main Libyan ports, a general question was developed in the form of ‘agree’ or ‘disagree’ on statements, using a scale of five to test the statement of: ‘Libyan ports use sufficient and effective cargo-handling equipment’. In this scale, ‘1’ denoted absolutely disagree and ‘5’ denoted absolutely agree. To confirm the stakeholders’ perspective and determine what type of handling equipment was insufficient and inefficient, the questionnaire examined the existing handling equipment in both shipside and landside in detail.

The performance of shipside operations is measured by the capacity of QCs and the efficiency of cargo-handling operations to and from the ship. To measure the performance of shipside, the questionnaire developed three questions in the form of ‘agree’ or ‘disagree’, with these statements using a scale of five, where ‘1’ denoted absolutely disagree and ‘5’ denoted absolutely agree. The statements are:

1. the available seaside cranes are sufficient to provide good quality service to the inbound ships in general

2. the quantity and quality of used cranes are optimal to deal with the inbound container ships

3. the quantity and quality of used cranes are optimal to deal with the potential demand for containerisation.

Port reliability and service flexibility at these ports have been considered among the port performance criteria. In terms of shipside operations, these two criteria depend on the performance of QCs. Therefore, the following statements were developed to test the potential effect of the existing cargo-handling equipment, particularly QCs using the same scale:
1. the port can provide some special handling services, such as handling heavy weight containers and different container sizes

2. the available cranes lead to reasonable ship turnaround times

3. ships’ schedules in port are accurate.

To measure the performance of sea-land operations, the questionnaire developed questions related to transport equipment, stacking equipment and storage yard area. A scale of five was again used for this part, where ‘0’ meant absolutely disagree and ‘5’ meant absolutely agree. The questionnaire provided a general approach to examine the effect of the existing transport and stacking equipment on port performance, and to see whether the stakeholders agreed or disagreed with the statement. The general statement is: ‘The quality and quantity of used transport and transfer equipment in the port are sufficient and efficient for good port performance’.

Two statements were then developed to examine the status of each type, to measure their capacity to deal with the current cargo volume and the potential demand for containerisation in Libyan ports.

In terms of transport equipment, the following two statements were used:

1. the quality and quantity of the transport vehicles used is sufficient to deal efficiently with the current volume of cargo handled by Libyan ports

2. the quality and quantity of used transport vehicles can meet the potential demand for containerisation in Libyan ports.

Similarly, the following two statements were used to examine the stacking equipment:

1. the used stacking equipment provides an efficient cargo stacking and retrieving service

2. the used stacking equipment (reach stacker, forklift, SCs, gantry crane) can meet the potential demand for containerisation in Libyan ports.

Storage capacity at port is crucial to absorb the volume of cargo handled by that port. It also affects the free dwell time at port. Therefore, the capacity of Libyan ports’
storage yards was examined by the following statements, using the same scale of five:

1. the space of storage yards is enough for the volume of cargo/containers that is dedicated to the local market

2. the space of storage yards is able to absorb the cargo/container volume dedicated to international transhipment and local market.

Port performance is also influenced by other factors, such as land accessibility (Gekara and Fairbrother, 2013). Land accessibility starts from the port gate and includes rail and road networks (Parola and Sciomachen, 2005, Transystems, 2011). Proper road and rail networks enhance cargo flow between a port and its hinterland, and therefore port performance. To examine the effect of the existing rail and road networks on port performance, the study used the following statements to gain the perspective of Libyan ports’ stakeholders accordingly. The questionnaire used a scale of five for this purpose, where ‘0’ meant absolutely disagree and ‘5’ meant absolutely agree:

1. the number of lanes of port gates undermine the cargo flow to and from the port

2. the existing road networks are suitable for hinterland transport if the demand for Libyan ports increases

3. integrated rail networks are needed to reduce transport costs, increase cargo flow and increase port performance.

Cargo flow is also influenced by other factors, such as cargo clearance processes, port working hours and the optimal use of these working hours. It is also influenced by implementing ICT to facilitate the cargo flow process. A scale of five, where ‘0’ meant absolutely disagree and ‘5’ meant absolutely agree, was used to examine these aspects from the perspective of local stakeholders:

1. cargo clearance processes are efficient

2. customs services are complicated and corrupt

3. port working hours are sufficient
4. the actual working time is efficiently used, without any idle time.

All of these factors affect cargo delivery time, which is one of the most important factors used to measure port performance from a customer perspective. Therefore, the questionnaire included a statement to examine the influence of the above factors on cargo delivery time, using the same scale of five, where ‘0’ meant absolutely disagree and ‘5’ meant absolutely agree:

1. cargo delivery time is reasonable.

The lack of new ICT stifles port operations (Gekara and Chhetri, 2013). Therefore, four questions about online services were developed and included in the questionnaire, to evaluate whether such types of online services provided by Libyan ports met customer demand. This was done after measuring the importance of online services to the stakeholders. A scale of five was used, where ‘0’ meant absolutely does not meet the demand and ‘5’ meant absolutely meets the demand. The statements are:

1. online customs services
2. online information accessibility for port users for cargo tracking
3. online information accessibility for port users to track ships’ movements
4. online transactions.

Due to the high value of commodities handled by ports, cargo safety is another factor used to measure port performance. In this study, cargo safety consisted of cargo damage and cargo loss. Cargo safety is influenced by the level of safety awareness among port personnel. Cargo damage and cargo loss may occur at any port, but the concern is how likely it is to occur, and how complicated the settlement process of an accident claim is. Therefore, the complexity of accident claim settlements was included in the questionnaire. The questionnaire also included two statements to measure the likelihood of cargo loss and cargo damage. A scale of five was used for this purpose, where ‘0’ denoted less likely and ‘5’ denoted more likely:

1. frequency of cargo loss
2. frequency of cargo damage.
By including these questions, the questionnaire was designed to cover all port performance factors included in the empirical model. Thus, the questionnaire will answer the research questions of this study.

5.3 Data Collection

The primary data were collected from the local stakeholders of Libyan ports via an online questionnaire. The questionnaire was emailed to eight groups of stakeholders using the snowball technique. All the targeted stakeholders were Libyans, and included individuals from LMA, seafarers, freight forwarders, shippers, local ship owners, port operators, port authorities and other groups. The other group included people from the offshore oil industry, consultancy and training groups, marine construction and marine survey companies. The respondents of this group shared the same maritime background and they were working for maritime transport companies.

The entirety of the local Libyan port stakeholder groups is relatively small. It consists of two port operators, about 300 local shipping and freight-forwarding companies, three ship owners, seafarers, four port authorities, one LMPA, cargo owners and shippers. Due to the small population of Libyan port stakeholders, the targeted sample was 200 participants from different managerial levels. As the researcher came from the Libyan maritime industry, the researcher sent the questionnaire link to stakeholders whose contact details he could access. Additionally, some contact details were derived from the official websites of the stakeholders’ organisations. The questionnaire link was also posted on the researcher’s Facebook timeline, to increase the response rate. An introduction and request to complete the questionnaire were attached to the questionnaire. The introduction also asked the participants to forward the link to other stakeholders that they dealt with, to increase the response rate.

The first response was obtained on 6 October 2012, and the last response was obtained on 11 February 2013. In December 2012, the response rate slowed. Approaches such as developing a short questionnaire, persuasive communication to encourage participants and multiple rounds of follow-up contact were used as methods to increase the response rate (Pike, 2012). Therefore, apart from developing
a short questionnaire, five weeks after the initial emails, a second reminder phase was conducted. Other emails were sent to the relevant participants, and telephone calls were made to different stakeholders to encourage them to participate and to distribute the questionnaire to their colleagues, to increase the response rate and minimise non-response bias.

From about 200 targeted participants, 186 responses were obtained within four-and-a-half months. However, after cleaning the data, it was found that only 84 responses were valid and could be used in the analysis. This represented 45 per cent of the total respondents. The other 102 respondents answered only the first four demographic questions. Two respondents answered most of the questions, but not the entire questionnaire. These respondents represented 2.4 per cent of the total respondents. Fifty-six respondents were from the public sector, which represented 68.3 per cent. The remaining 26 respondents were from the private sector, which represented 31.7 per cent (see Table 5.1). The relatively high response rate from the public sector was due to all Libyan ports being owned and operated by the public sector. It is also due to targeting participants from the LMA, port authorities, public carriers, shipping and freight-forwarding companies, which are all from the public sector.

<table>
<thead>
<tr>
<th>Table 5.1: Classifying the Respondents by Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td>Private sector</td>
</tr>
<tr>
<td>Public sector</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>System</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

In terms of groups, the highest response rate was recorded by the seafarer group, which reached 17.1 per cent of the total respondents, followed by LMA with 14.6 per cent, and then the carrier group with 13.4 per cent. Other groups represented 12.2 per cent. Additionally, port operators, shipping companies and freight forwarder
groups had the same response rate of 11 per cent. The lowest response rate was 9.8 per cent, which was recorded by the port authority (see Table 5.2).

Table 5.2: Classifying the Respondents by Stakeholder Group

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
<th>Valid percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMA</td>
<td>12</td>
<td>14.3</td>
</tr>
<tr>
<td>Port authority</td>
<td>8</td>
<td>9.5</td>
</tr>
<tr>
<td>Port operator</td>
<td>9</td>
<td>10.7</td>
</tr>
<tr>
<td>Shipping company</td>
<td>9</td>
<td>10.7</td>
</tr>
<tr>
<td>Freight forwarder</td>
<td>9</td>
<td>10.7</td>
</tr>
<tr>
<td>Carrier</td>
<td>11</td>
<td>13.1</td>
</tr>
<tr>
<td>Sea farer</td>
<td>14</td>
<td>16.7</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>11.9</td>
</tr>
<tr>
<td>Total</td>
<td>82</td>
<td>97.6</td>
</tr>
<tr>
<td>Missing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The majority of respondents were from the management level (see Table 5.3). These included 17 department managers and nine chief executive officers/directors/chairpersons, representing 30.9 per cent in total. Nine respondents worked as superintendents, representing 10.7 per cent. Six coordinators responded to the questionnaire, which represented 7.1 per cent. Additionally, 10 supervisor respondents completed the questionnaire, which represented 10 per cent of the total respondents. The total seafarers who responded to the questionnaire were 12, which represented 17 per cent of the total respondents. The other group that completed the questionnaire included 15 respondents from different industries associated with port activities. This consisted of marine pilots, a harbour master, a stevedoring foreperson, respondents from the oil industry, respondents from offshore oil installations, a mooring master, retired captains, marine surveyors and employees of consultancy and training organisations.

Surveying different port stakeholders from different managerial levels and obtaining different perspectives is important to obtain a heuristic view. In addition, involving
other groups working in different areas and having good experience in maritime transport and the port industry provides essential information to this study. This is due to their ability to measure the impact of Libyan port performance on their organisations. Further, Libyan seafarers are a good information resource, because they can compare the performance of Libyan ports against the other international ports they visit.

Table 5.3: Classifying the Respondents by Position

<table>
<thead>
<tr>
<th>Position</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Valid percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head/CEO/director/chairman</td>
<td>9</td>
<td>10.7</td>
<td>10.8</td>
</tr>
<tr>
<td>Department manager</td>
<td>17</td>
<td>20.2</td>
<td>20.5</td>
</tr>
<tr>
<td>Superintendent</td>
<td>9</td>
<td>10.7</td>
<td>10.8</td>
</tr>
<tr>
<td>Coordinator</td>
<td>6</td>
<td>7.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Supervisor</td>
<td>10</td>
<td>11.9</td>
<td>12.0</td>
</tr>
<tr>
<td>Pilot</td>
<td>3</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Seafarer</td>
<td>12</td>
<td>14.3</td>
<td>14.5</td>
</tr>
<tr>
<td>Harbour master</td>
<td>1</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Stevedoring foreman</td>
<td>1</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
<td>17.9</td>
<td>18.1</td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>98.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Missing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System</td>
<td>1</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Work experience is another important factor that increases the reliability of the collected data and therefore the results. The statistics showed that the majority of the respondents had experience of 15 years or more. This group represented 44.2 per cent of the total respondents; a further 19.5 per cent of the respondents had experience of between 10 to 15 years. This also increased the reliability of the data. Five to 10 years’ experience was held by 10.4 per cent of the respondents, so they can also provide useful responses about Libyan ports’ performance; 16.9 per cent had experience of between one to five years, whereas the lowest percentage was 9.1 per cent, representing the respondents with experience of less than one year in their current positions.
Table 5.3 shows that the primary data were collected from a wide range of local stakeholder groups representing the entire targeted population. This provided the most comprehensive perspective, which increased the validity of the findings.

### 5.4 Non-Response Bias

Non-response errors occur when some prospective respondents are not included in the final sample (Kolb, 2008). The problem posed by survey non-responses is that the individuals who do not respond to a survey may differ from respondents in important ways on survey variables (Pike, 2012). Generally, there are many reasons that some respondents do not participate in the survey, such as a lack of interest in the topic under study, the respondents’ company policies of non-participation in external surveys, and the respondents being too busy (Tivesten et al., 2012).

The late respondents who responded after a considerable time and researcher effort are expected to be the most similar to non-respondents on the measures of interest (Maclennan et al., 2012). Therefore, a non-response bias can be analysed by comparing early and late responses (van der Vorst, 2000). Moreover, non-response bias tests examine whether there is any difference between those who choose to respond to the research, and those who choose not to respond (Wrenn et al., 2001).

The samples were drawn from Libyan port stakeholders. In total, 186 participated and responded within nearly four-and-a-half months. However, of these, only 82 were valid responses, which represented 45 per cent of the total responses. To test the non-response bias, the responses were divided into two groups to determine whether there was any difference between the means of the early wave and the late wave of responses. The earlier responses are those obtained within the first five weeks before the second reminder was sent. The rest of the responses are considered late responses.

Non-response bias was evaluated using ex-post-statistical techniques (Maclennan et al., 2012). T-tests were performed to test for significant differences between the means of early and later responses, at the significance level of 0.05 (Martin and Bridgmon, 2012). Survey non-response can produce biased estimators when respondents and non-respondents differ significantly on survey variables (Pike,
Therefore, random variables—such as the type of stakeholder group, water depth and the efficiency of transport vehicles at the four Libyan ports—were chosen for this purpose. The results suggest that non-response bias does not appear to be a problem when the means of the early and late responses are compared at the significance level of 0.05. For instance, there is no significant difference among the means of early responses \((t = 1.335; p = 0.186)\) and late responses \((t = 1.365; p = 0.178)\) regarding the variable of water depth in Tripoli port. Moreover, there is no significant difference between the early responses \((t = -1.187; p = 0.239)\) and late responses \((t = -1.205; p = 0.234)\) regarding the variable of water depth in Qasr Ahmed port. Further, the non-response bias test shows no significant difference between the means of early responses \((t = -0.909; p = 0.362)\) and late responses \((t = -0.888; p = 0.379)\) in terms of the efficiency of transport equipment used at Benghazi port. Regarding the efficiency of transport equipment used at Khoms port, the test also shows no significant difference between the means of early responses \((t = -0.594; p = 0.554)\) and late responses \((t = -0.566; p = 0.574)\).

The above tests illustrate there is no mean difference across respondents with respect to early or late response. This increases the validity of the study findings.

## 5.5 Performance Criteria

Every port works to achieve the goal of performing more efficiently at lower costs, and maintaining competitiveness by providing customers with a high quality of service (Ioannou et al., 2000b). This can be achieved by enhancing the performance of seaside operations, terminal operations and land operations.

Productivity is defined in different ways, based on the industry, as shown in Chapter 3.1. Generally, it is a ratio of output to input (Al-Darrab, 2000). Increased productivity implies either fewer inputs are needed to produce more output, or more output is produced by the same amount of input in a certain period (Chinda, 2010b). In addition, improving productivity is a key issue for survival and success in the long term (Chinda, 2010a).

Container-handling productivity is directly related to the transfer functions of a container terminal, including the number and movement rate of quayside container
cranes, the use of yard equipment and the productivity of workers employed in waterside, landside and gate operations (Le-Griffin and Murphy, 2006). Accordingly, cargo volume and container TEU throughput is commonly used as the key performance indicator of ports (Feng et al., 2013). Port throughput is determined by a number of elements. These include the total working hours and the efficiency of seaside operations, terminal operations and landside operations. It is also influenced by the extent to which advanced ICT is used to integrate and manage operations, and ultimately enhance operations visibility (Gekara and Fairbrother, 2013). Therefore, the following examines the performance criteria of these three areas from the local stakeholders’ perspectives. Prior to that, the total working time and its use were also examined from the local stakeholders’ perspectives. At the end, some other factors related to cargo safety and online services were investigated.

5.5.1 The Total Working Hours

Many ports in the region work 24 hours a day, seven days a week. However, the total working time at all Libyan ports is fixed and set by the LMA from 8am to 5pm. This time is insufficient to provide the required services to customers. This was illustrated by the perception of the local stakeholders when they were asked to express their agreement or disagreement with the statement that the port total working hours are sufficient to provide the required services (see Table 5.4).

<table>
<thead>
<tr>
<th>Port’s name</th>
<th>No.</th>
<th>Missing</th>
<th>Total mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>69</td>
<td>15</td>
<td>1.94</td>
</tr>
<tr>
<td>Benghazi</td>
<td>69</td>
<td>15</td>
<td>1.91</td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>70</td>
<td>14</td>
<td>2.11</td>
</tr>
<tr>
<td>Khoms</td>
<td>69</td>
<td>15</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Around 69 respondents out of 84 answered this question. The total means were around 2.00. These total means illustrated that the total working hours at Libyan ports are insufficient to provide the required services to their customers.
In more detail, due to the similarity of the working hours at all Libyan ports, the analysis showed similarity in the perceptions of the respondents. For instance, regarding Tripoli and Benghazi port, the analysis showed that 36.2 per cent of the respondents absolutely disagreed with the statement that the working hours at these ports were sufficient to provide the required services. It is also showed that 39.1 per cent of the respondents disagreed with the above statement regarding these two ports. These two percentages represent around two-thirds of the total respondents.

Qasr Ahmed and Khoms differ slightly in regard to the respondents who absolutely disagreed with the above statement: 31.4 per cent for Qasr Ahmed port, and 40.6 per cent for Khoms port. However, nearly 36 per cent of the respondents disagreed with the above statement regarding these two ports. This illustrates that around 67 per cent of the respondents were not satisfied with this operating time.

Generally, it can be concluded that the working hours at Libyan ports are not sufficient to provide the required services to customers, which influences the total cargo-handling time. Therefore, this time has to be extended (from the respondents’ perspective). However, it is also important to know whether these working hours are used efficiently and without any idle time.

5.5.2 Using Total Working Time

It seems that the total working hours have not been used efficiently and there is wasted or idle time. The stakeholders were asked whether they agreed or disagreed with the statement that the total working time at Libyan ports is efficiently used without any idle time. The analysis showed that the total mean of the respondents’ perceptions in terms of utilising the working time at all ports is around 1.9, with no significant difference. This illustrates no consensus on the above statement from all of the groups. The analysis showed that around 80 per cent of the respondents believed that the working hours at Libyan ports were not utilised efficiently and there was wasted time during the total working time.

From the above two analyses regarding the dedicated working time and the actual working time, it can be concluded that the total working hours at Libyan ports are insufficient to provide what customers need. In addition, this time is not used efficiently. This increases ships’ turnaround time and cargo delivery time. As a
result, it increases ships’ total operational costs and influences the choice to use the port. Further, it reduces the port throughput and increases the total operational cost of a port’s facilities, which all undermine port performance.

### 5.5.3 Seaside Operations

Seaside operations concern the operations of ship docking. Apart from the pilotage and tugging/towing services, ship docking requires sufficient water depth to ensure safe passage and suitable berths to secure a ship’s mooring, which is essential to commence cargo-handling operations. This section illustrates the influence of seaside accessibility on port performance, focusing on water depth and berth length.

Accessibility has generally been defined as the ease with which activities may be reached from a given location, using a particular transportation system (Economic research centre, 2000). Port accessibility refers to the infrastructure used to facilitate cargo flow, and allows the use of a port’s essential facilities. To reduce the cost of maritime transport, ship sizes and capacity have increased dramatically (Maersk, 2012, Clark et al., 2004). Consequently, ports have to meet these changes to accommodate these kinds of ships and deal with the increased volume of cargo being transported. To examine the role of seaside accessibility on Libyan ports’ performance through providing the required customer service, this study set up questions about accessibility to the four main Libyan commercial ports. Seaside accessibility is represented by water depth and the length of berths to accommodate such larger ships.

Seaside accessibility refers to the ability of a port to accommodate inbound ships. Libyan ports have a strategic location close to the routes of international trade, and between industrial and consuming countries. This provides a potential opportunity to increase the volume of trade handled by Libyan ports.

The demand for larger ships, particularly container ships, has dramatically increased due to the advantages of containerisation (Dasgupta, 2011). Consequently, the dimensions of such mega ships, including their drafts and overall length have also increased. Therefore, to be competitive in attracting larger ships and their cargoes, ports have to provide sufficient water depth to ensure safe passage for these ships, as well as suitable berths to accommodate them.
In general, seaside accessibility seems to be very important to the local stakeholders, with a total mean of 6.15. This was based on the perception of the 79 respondents who completed the relevant question. It was found that seaside accessibility was extremely important for freight forwarders, the port authority and carrier groups. Moreover, seaside accessibility was very important to shipping companies, LMA, seafarers and other groups. However, and surprisingly, the port operator group perceived that seaside accessibility was only somewhat important (see Appendix 2). This shows that port operators of the Libyan ports have not paid much attention to the dramatic increase in ships’ sizes and drafts.

Due to the importance of seaside accessibility to local stakeholders, further investigation was conducted to measure the impact of the existing water depth at Libyan ports on the ability of these ports to meet the escalating size of container ships. In this perspective, seaside accessibility was represented by water depth and berth length.

5.5.3.1 Water Depth

This section details the findings regarding the suitability of the Libyan ports’ water depth for deep draft container ships. Starting with Tripoli port, the water depth is between eight and 12 metres. On the scale of five, where ‘1’ denoted strongly disagree and ‘5’ denoted strongly agree, the analysis showed that the total mean of the perspective of 73 respondents was 2.13, with no significant difference. This indicates that the respondents disagreed with the statement that water depth at Tripoli port did not meet the demand of larger ships. The percentage of respondents who had this perception represents 69.8 per cent of the total respondents.

Similarly, the water depth of Benghazi port is between seven and 13 metres. This port had the highest total mean of 2.97. This showed no consensus about the ability of Qasr Ahmed port water depth to meet the demand of larger ships. Similarly, the water depth of Khoms port is about 13 metres. This port had the
second highest total mean after Qasr Ahmed port, at 2.85. This mean also indicated no consensus on the ability of Khoms port to attract deep draft container ships. The analysis also showed that around half of the respondents did not consider Khoms port to meet the recent demand of mega ships.

Concerning water depth, it can be concluded that Qasr Ahmed and Khoms ports can receive up to third generation container ships with a maximum draft of 12 metres. However, Tripoli and Benghazi ports can only receive the second generation container ships of 10 metres draft. Therefore, Libyan ports cannot provide the required seaside accessibility for larger ships. This is due to insufficient water depth, which has become an important requirement for carriers, shippers and traders.

5.5.3.2 Berth Length

As mentioned above, ship sizes have increased and can now exceed 400 metres in length (Maersk, 2012, Marineinsight, 2012). Therefore, to provide the required service to such ships, a port has to own berths that can dock these larger ships (Imai et al., 2008). Libyan ports have different berth designs and lengths. To see the ability of Libyan ports to meet this requirement from the perspective of Libyan port stakeholders, the study set up questions focusing on this aspect.

Starting with Tripoli port again, and on the scale of five, the participants were asked whether they agreed or disagreed with the statement that berth length at Tripoli port is suitable to accommodate larger ships. The descriptive analysis showed the total mean of 72 responses was 2.54, with no significance among the means. It also found that about 55.5 per cent of the respondents believed that the berth lengths at Tripoli port were not suitable to accommodate the larger ships, compared to about 29 per cent of the respondents with different perspectives.

On the same scale, Benghazi port had a total mean of 2.33, with no significant difference among the respondents’ perceptions. This illustrates that the respondents similarly disagreed with the statement that the berth lengths in Benghazi port were suitable to accommodate larger ships. For instance, 66.6 per cent of the respondents believed this port could not dock the larger ships.
Regarding Qasr Ahmed port, the total mean of the perception of 72 respondents was 3.33, with no significant difference. Despite the fact that Qasr Ahmed port is a comparatively new port with long berths, only about 51.5 per cent of the participants agreed with the statement that berth length at Qasr Ahmed port was suitable to accommodate larger ships. The lowest percentage was 12.5 per cent, representing the respondents who did not agree or disagree with the statement. In general, we can say that Qasr Ahmed port can accommodate larger ships.

Regarding Khoms port, which is also a comparatively new port, the total mean of 71 respondents’ perceptions was 3.13, with no significant difference. The analysis showed that about 55 per cent of the respondents agreed with the above statement regarding Khoms port. About 39.5 per cent of the respondents had a different perception. In general, it was considered that the port of Khoms could provide the required berths to the larger ships.

From the above, it can be concluded that the berth lengths of Khoms and Qasr Ahmed port, which are comparatively new, can meet the demand of the larger ships, in terms of berth length. However, about half of the respondents believed that berth lengths at Tripoli and Benghazi port were not suitable to accommodate new generation container ships, due to the large ships’ length overall, compared to the existing length of berths. Moreover, despite the fact that berth lengths at Khoms and Qasr Ahmed allowed them to accommodate larger ships, the limited water depth undermined the ability of these two ports, and the other Libyan ports, to attract deep draft ships.

5.5.4 Terminal Operations

Terminal operations include the entire operations of container handling from the ship’s hold to the storage yard. Terminal operations depend on port superstructure. Port superstructure includes all cargo-handling equipment used within the port for cargo-handling operations. The number and type of cargo-handling equipment play a vital role in the efficiency of cargo handling, which is a determinant of port performance. This influences the speed of cargo movement within the port, storage mode and capacity, as well as the total operational time, including ship turnaround time. No Libyan ports employ specialised and sophisticated cargo-handling
equipment, with the exception of Qasr Ahmed port, which is the only Libyan port that operates two QCs and two RTGs.

5.5.4.1 General Port Superstructure

Based on 79 responses, the analysis showed that the importance of cargo-handling facilities in general is very high to local stakeholders, with a total mean of 6.18. It is extremely important to the freight forwarder group, carriers, LMA and port authorities (see Appendix 2). Port operators mainly rely on cargo-handling facilities in serving ships calling at the port. In the same manner, a shipping company depends on cargo-handling facilities to accelerate cargo flow and minimise ship turnaround times at port. Therefore, both of these groups believe that cargo-handling facilities are very important.

In examining the sufficiency and efficiency of the cargo-handling facilities used at Libyan ports, the analysis showed that 85 per cent of 70 respondents absolutely disagreed with the statement that Tripoli, Benghazi and Khoms ports use sufficient and efficient cargo-handling facilities. The total means of the responses regarding these ports were around 1.5. In addition, 40 per cent of the respondents absolutely disagreed with the statement regarding Qasr Ahmed port, and 38 per cent of the respondents just disagreed with it. The total mean of this group was 1.94 (see Figure 5.1). The analysis also showed no significant difference among the means of the groups in terms of the sufficiency and efficiency of the cargo-handling facilities, except for Benghazi port.

From the above, it can be concluded that the performance of the four main Libyan commercial ports is low, due to a lack of sufficient and efficient cargo-handling equipment. This low performance affects port users, whether by providing unsatisfying service quality, increasing ships’ turnaround time or increasing total operating costs for inbound ships and port facilities. The lack of efficient cargo-handling equipment also affects cargo-handling times, which are very important to the local stakeholders (see Appendix 2). It would also affect the cargo-handling fees in some ports; however, cargo-handling fees are fixed at all Libyan ports and are regulated by the LMA. Therefore, they are somewhat important to the local stakeholders, with a total mean of 5.30.
Figure 5.1: The Sufficiency and Efficiency of Cargo-Handling Equipment used at Libyan Ports

Apart from the influence of the number and the type of cargo-handling equipment used at each port, the total cargo-handling time is influenced by the total working hours at port, and how efficiently this time is used, as discussed earlier.

The terminology of cargo-handling facilities, which consist of cargo transfer and cargo-transport equipment, is a general term. Therefore, to be more specific, the study has classified cargo-handling equipment into three types of equipment. The first type is seaside cranes. The second type is transport equipment, and the third is stacking equipment. The strategy behind this classification is to confirm the above findings and to determine specifically which type of equipment has more influence on the capacity of Libyan ports and their performance.

Cargo loading and off-loading to and from the ship is considered a crucial factor for port performance. It depends on the productivity of seaside cranes (Imai et al., 2008). It influences berth allocation plans, ship turnaround times, berth availability, port reliability and flexibility. In terms of the importance of cargo loading and off-loading operations to and from the ship, the analysis showed that the total mean of 81 responses was 6.30, which confirms that cargo loading and off-loading to and from the ship is very important to local stakeholders in general. In addition, four groups believe that this element is extremely important: freight forwarders, port operators,
shipping companies and LMA. The other stakeholder groups who believe that this element is very important are carriers, port authorities, seafarers and other groups.

The efficiency of terminal operations in general, and cargo loading and off-loading to and from the ship specifically, depends mainly on seaside cranes (SCI, 2010). Due to the importance of QCs on port performance, the following section examines the status of the cranes used at Libyan ports.

5.5.4.2 Quay Container Cranes

Crane productivity is measured by the throughput in TEUs per year, or by moves per hour. Each port uses a different type and number of seaside crane. This depends on many factors, including port type, cargo type and volume, port capital and some other factors. Therefore, some ports employ just mobile cranes, others use fixed shore cranes with comparatively high handling rates, other ports depend on ships’ cranes for cargo-handling operations and others employ specialised and more sophisticated QCs.

Due to the high demand for containerisation, container ports have employed specialised QCs with high move rates. The QCs are developed according to the changes in container ship size and capacity. However, Libyan ports still do not employ an optimal quality and quantity of cranes to deal with the inbound container ships that call at Libyan ports (see Table 5.5). This is illustrated by the total means of the perception of respondents, which was 1.50 regarding Tripoli, Benghazi and Khoms and 2.24 regarding Qasr Ahmed port. The descriptive analysis showed no significant difference among the means.

<table>
<thead>
<tr>
<th>Crane type</th>
<th>Tripoli</th>
<th>Benghazi</th>
<th>Qasr Ahmed</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quay container cranes</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Boosting telescopic mast cranes</td>
<td>9</td>
<td>3</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Fixed mast cranes</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: (Misurata Free Zone, 2013, Libyan Maritime Administration, 2013).

More specifically, around 92 per cent of the respondents believed there was a severe lack of efficient seaside cranes at Tripoli and Khoms ports. This group represents
87.5 per cent of the total respondents regarding Benghazi port. However, this percentage was slightly smaller regarding Qasr Ahmed port, at 69.4 per cent of the total respondents. This difference was due to employing two specialised QCs at Qasr Ahmed port. The severe deficiency of efficient QCs had a negative impact on port performance (Zhou and Kang, 2008, Zhang and Jiang, 2008) and the perceived future demand for such ports. Consequently, this lack enforced the operators of Libyan ports’ to use ships’ cranes for loading and off-loading operations.

Figure 5.2: Seaside Cranes at Libyan Ports v. the Demand for Containerisation

The severe lack of efficient QCs at Libyan ports has undermined the ability of all Libyan ports to meet the potential demand for containerisation. This was confirmed by the perception of 72 respondents. On the scale of five, the descriptive analysis showed that more than 90 per cent of the respondents had the same perception regarding Tripoli, Benghazi and Khoms ports, with total means of around 1.30, and with no significant difference. Qasr Ahmed port had the highest total mean (1.63), with no significant difference. This shows that, despite Qasr Ahmed port being the only Libyan port operating two QCs, it has still been unable to meet the potential demand for containerisation, similar to the other Libyan ports. This is the perception of more than 85 per cent of the total respondents (see Figure 5.2).

From the above analysis, it can be concluded that the seaside cranes used at Libyan ports do not have the capacity to deal efficiently with the ships that call at Libyan
ports, as they are unable to meet the potential demand for containerisation if this increases. This is due to the absence of efficient and specialised QCs at these ports, which is considered a bottleneck that ensures underperformance. Therefore, it is crucial to include seaside cranes in the DEA analysis as an input variable to evaluate the efficiency of Libyan ports in the next chapter.

The impact of the severe deficiency of QCs extends to port reliability, which concerns ship turnaround times and scheduling. This also affects port service flexibility, which concerns berth availability and the provision of some special handling services. Therefore, the following sections investigate these aspects from the perspective of local stakeholders in more detail.

5.5.4.3 Ship Turnaround Times

A ship’s turnaround time is the time spent by the ship being loaded and off-loaded at port. To assess the importance of ship turnaround times, a scale of seven has been used. The descriptive analysis showed that ship turnaround time had a total mean of 6.05, indicating it is very important to the local stakeholders of Libyan ports. From 79 responses, a ship’s turnaround time was extremely important to port authorities and freight forwarders. The groups of LMA, carriers, shipping group and port operators believed that a ship’s turnaround time was very important. In contrast, the seafarers and the other group believed that a ship’s turnaround time was somewhat important. It can be concluded that most of the stakeholders are interested in shorter ship turnaround times, which is closely associated with the efficiency of port operations, especially seaside operations. However, the analysis shows that ship turnaround times are still lengthy at all Libya ports, due to the lack of efficient QCs. This affects the reliability of Libyan ports, as it affects ships’ scheduling negatively.

5.5.4.4 Ships’ Scheduling

Ships’ scheduling refers to the timetable of ships’ movements from one port to another. Any interruption in a ship’s scheduling influences the entire ship sailing timetable, as well as berth allocation plans at the next port of call. Ships’ scheduling is associated mainly with the efficiency of seaside operations, which strongly depends on seaside cranes, as well as the handling equipment in general.
Based on 78 responses, a ship’s scheduling seems to be very important to local stakeholders in general. It had a total mean of 6.00 (see Appendix 2). The analysis showed that a ship’s scheduling was extremely important to the port authority and port operator groups. Despite freight-forwarding group concerns about landside distribution, the respondents of this group believed that the accuracy of ships’ scheduling is extremely important. Further, LMA, carrier, shipping group, seafarer and the other group believe that a ship’s scheduling is very important.

![Figure 5.3: Accuracy of Ships’ Scheduling at Libyan Ports](image)

Despite the importance of ships’ scheduling to Libyan port stakeholders, it is inaccurate at all Libyan ports. Therefore, the Libyan ports are not reliable in terms of ships’ scheduling. This can be seen through the total means of the respondents’ perceptions concerning these four ports, which was around 1.50, with no significant differences. Moreover, the analysis showed that around 90 per cent of the respondents believed that ships’ scheduling was inaccurate at Tripoli and Khoms ports, and about 80 per cent had the same perspective of Qasr Ahmed and Benghazi (see Figure 5.3).

This inaccuracy in ships’ scheduling is due to the inefficiency of seaside operations, caused by the lack of efficient cranes to load and off-load such ships. This could be one of the reasons that shipping lines avoid Libyan ports.
5.5.4.5 Berth Availability

In some cases, an inbound ship can wait at an anchorage area for extra hours or days due to the unavailability of berths. This waiting period increases a ship’s operational costs and prevents the ship from maintaining a sailing timetable. Therefore, the ship’s owners or charterers tend to avoid ports with low berth availability to minimise operational costs and to allow for many more trips per time unit. This prevents such ports from attaining high throughput.

Accordingly, this study found that the service of berthing on arrival seems to be very important to local stakeholders in general. This was confirmed by the total mean of respondents’ perception, which is 6.09 (see Appendix 2). More specifically, the descriptive analysis showed that berth availability is not only very important to the ships’ owners, but it is also very important to the local carriers, freight forwarders, LMA, port authority, shipping companies and the port operator group. In contrast, it is somewhat important to the seafarers and the other group. However, the availability of berthing on arrival is unavailable at all Libyan ports.

In more detail, from 71 responses and on the scale of five, the analysis showed that the total means of the respondents’ perceptions were 2.00 for all Libyan ports, with no significant difference among these means. This illustrates that the respondents disagreed with the statement that berthing on arrival is available at Libyan ports. Also noted is the similarity between Tripoli, Benghazi and Khoms ports. Around 80 per cent of the total respondents disagreed with the statement regarding these three ports. However, this group represents 71.8 per cent of the total respondents regarding Qasr Ahmed port. This could be due to that port operating two specialised QCUs.

From the above, it can be concluded that berthing on arrival is very important, not only to the carrier group, but also to the majority of local Libyan port stakeholders. The service of berthing on arrival at these four commercial Libyan ports is insufficient, due to the unavailability of berths to accommodate the inbound ships. This might be because the number of ships is greater than the capacity of the port, or that inefficient terminal operations exist, caused by a lack of efficient seaside cranes.
5.5.4.6 Service Flexibility

The lack of efficient QCs has also affected port service flexibility. Service flexibility refers to the ability of a port to provide a variety of services needed by the customer, where the time and quality of services are crucial (David Xiaosong Peng et al., 2011). This includes the ability of a port to provide a berth for inbound ships at short notice, as discussed earlier. It also includes the ability to deal with non-standardised cargo, such as handling heavy weights and different sizes of containers.

From this perspective, it seems there is no consensus on the ability of Libyan ports to provide some special handling services, such as handling heavy weight containers and different sizes of containers. From around 73 responses, and on a scale of five, the total means of these responses regarding Tripoli and Benghazi port was 2.1, with no significant difference. This illustrates that these ports cannot provide such special services. In more detail, around 65 per cent of the respondents believed that these two ports could not provide some special services. Similarly, the port of Khoms has no capability to provide such services, where the total mean of the responses regarding Khoms port was only 1.72. Around 80 per cent of the respondents disagreed with the statement that Khoms port could provide some special services. However, the highest total mean was recorded for Qasr Ahmed port. This mean was 2.88, which illustrated there is no consensus among the respondents about the ability of Qasr Ahmed port to provide some special services. It was also found that 37.8 per cent of the respondents agreed with the statement regarding the capability of providing some special services, compared to 43.3 per cent who disagreed with this statement.

In general, due to the severe lack of efficient QCs at the four main Libyan commercial ports, these ports have no flexibility to provide any irregular service related to the volume and weight of containers. This also emphasises the negative effect of employing traditional mobile cranes at Libyan ports, which consequently undermines the performance of these ports.

5.5.4.7 Transport Equipment

Transport equipment includes all the equipment used to transport the cargo and containers from one side of a port to another. In addition to the role of QCs, the type
and the number of cargo-transport vehicles at ports plays an essential role in port performance. In other words, the performance of a container port that uses conventional transport equipment, such as trucks or trailers, to transport containers between the ship’s side and yard is lower than the performance of a port that uses more sophisticated equipment, such as AGVs or SCs (Ioannou et al., 2000a). Libyan ports still use conventional transport equipment. Therefore, it is expected that the performance of Libyan ports is low and they would be unable to meet recent and potential increased demand.

Regarding recent demand, the descriptive analysis showed that around two-thirds of the respondents believed these Libyan ports did not have a sufficient amount of efficient transport equipment to deal with the volume of containers processed. The total means of about 66 responses regarding the four Libyan ports were around 2.00, with no significant difference.

Similarly, the analysis shows that the quality and quantity of transport vehicles used at Libyan ports cannot meet the potential demand for containerisation if it increased at Libyan port. On the scale of five, the analysis found that the total means of the responses regarding Tripoli, Khoms Benghazi ports were around 1.50, with no significant differences. Despite the fact that Qasr Ahmed port is the most developed Libyan port in terms of container-handling equipment, it had a total mean of 1.77. All of these means indicated that the quality and quantity of the transport vehicles used at these four Libyan ports could not meet the potential demand for containerisation if it is increased. This was the perspective of more than two-thirds of the total respondents.

The above illustrates that these four main Libyan commercial ports suffer from the lack of efficient technology used to transport cargo and containers within the ports. This is also considered a bottleneck that undermines Libyan port performance. Therefore, transport equipment is included as an input variable to evaluate the efficiency of Libyan ports, as detailed in the next chapter.

### 5.5.4.8 Storage Yard Capacity

Storage yard capacity refers to the ability of storage areas to absorb the current and the potential volumes of cargoes if demand increases. Storage yard capacity is
another influential port performance factor. In the case of Libyan ports, regarding the two relatively old ports, Tripoli and Benghazi, there was no consensus on the ability of these ports’ storage yards to absorb the volume of containers dedicated to the local market. However, more than 60 per cent of the respondents believed that these ports did not have the capacity to absorb both the local and international transhipment cargoes in the same time. However, regarding the two relatively new ports, Qasr Ahmed and Khoms, nearly 60 per cent of the respondents agreed that these two ports had enough space for the local market cargo. In contrast, there was no consensus on their ability to absorb the cargo dedicated to both the local market and international transhipment (see Table 5.6). This illustrates that under the current conditions of the storage yards, Libyan ports can only deal with the cargo dedicated to the local market. The above also indicated that storage yard capacity is a crucial factor for port performance. Therefore, it is considered as an input variable in the efficiency analysis using DEA.

<table>
<thead>
<tr>
<th>Port</th>
<th>Storage capacity</th>
<th>No.</th>
<th>Missing</th>
<th>Total mean</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>Local market</td>
<td>67</td>
<td>17</td>
<td>2.94</td>
<td>0.082</td>
</tr>
<tr>
<td></td>
<td>Local and international transhipment</td>
<td>66</td>
<td>18</td>
<td>2.08</td>
<td>0.824</td>
</tr>
<tr>
<td>Benghazi</td>
<td>Local market</td>
<td>65</td>
<td>19</td>
<td>3.08</td>
<td>0.329</td>
</tr>
<tr>
<td></td>
<td>Local and international transhipment</td>
<td>65</td>
<td>19</td>
<td>2.34</td>
<td>0.967</td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>Local market</td>
<td>66</td>
<td>18</td>
<td>3.76</td>
<td>0.128</td>
</tr>
<tr>
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<td>Local and international transhipment</td>
<td>66</td>
<td>18</td>
<td>3.29</td>
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<tr>
<td>Khoms</td>
<td>Local market</td>
<td>65</td>
<td>19</td>
<td>3.48</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>Local and international transhipment</td>
<td>65</td>
<td>19</td>
<td>3.08</td>
<td>0.533</td>
</tr>
</tbody>
</table>

Port performance in general and the capacity of storage yards in particular are also influenced by the type and the number of stacking equipment used. The type and the number of stacking equipment form the stacking mode as ‘vertical or horizontal’,
and influence the efficiency of stacking and retrieving operations. Therefore, examining their impact on Libyan ports’ performance is important.

5.5.4.9 Stacking Equipment

Stacking equipment is complementary to transport equipment. This equipment plays a vital role in the optimal utilisation of storage yard (Lau and Zhao, 2008). Most high performing ports use sophisticated stacking equipment, such as RMGs or RTGs or SCs, to maximise the capacity of storage yards and enhance the efficiency of container stacking and retrieving operations (Kim and Kim, 2002). However, Libyan containers still use forklifts and reach stackers for stacking and retrieving containers. Employing such conventional equipment undermines the performance of yard operations, which is the case with Libyan ports.

This was confirmed by the answers of 71 respondents, when they were asked whether they agreed or disagreed with the statement that the stacking equipment used provided efficient cargo stacking and retrieving services. On the scale of five, the total mean of the responses was about 1.70, with no significant difference among the perceptions of the respondents; 83.1 per cent of the respondents believed that the stacking equipment used at Tripoli port was inefficient. Similarly, 81.7 per cent and 85 per cent of the respondents had the same perception regarding Benghazi and Khoms ports, respectively. Qasr Ahmed port was the only Libyan port with two RTGs used to stack containers in its storage yard. However, two-thirds of the respondents believed that the stacking equipment used at Qasr Ahmed port did not provide efficient cargo stacking and retrieving services.

The deficiency of efficient stacking equipment has a negative impact on the ability of these ports to meet potential demand. The local stakeholders of Libyan ports confirmed this. The descriptive analysis showed that the total mean of the responses was about 1.70, with no significant difference. The analysis also showed that more than 90 per cent of the respondents believed that Tripoli and Benghazi port could not meet the potential increased demand in terms of stacking equipment. This percentage decreased to 88.7 per cent of the respondents regarding Khoms port and 76.7 per cent regarding Qasr Ahmed port.
From the above, it can be concluded that the majority of the respondents believed there was a severe lack of efficient stacking equipment at all Libyan ports. Therefore, the performance of these ports was low due to inefficient cargo-stacking operations. The shortage of stacking equipment requires special measures to increase the capacity of the storage yards of the four main Libyan ports. This may include redesigning storage yard layout and deploying new technology, such as RTGs or RMGs, or extending the storage areas if land is available. Due to the effect of stacking equipment on the performance of Libyan ports, stacking equipment, in parallel with the storage yard area, has been included to evaluate the efficiency of Libyan ports, using DEA analysis in the next chapter.

5.5.4.10 Free Cargo Dwell Time

Free cargo dwell time is one of the performance components used to attract port customers. It refers to the time that allows keeping the cargo and containers at port for free. Normally, the crowded ports allow a shorter free dwell time because of land scarcity. Due to the limited capacity of Libyan ports’ storage yards, the following examines the importance of free cargo dwell time to the stakeholders. Regarding this particular component, 80 responses were obtained.

The analysis showed that free cargo dwell time had a total mean of 5.24, indicating it is considered somewhat important from the stakeholders’ perceptions. Freight forwarders, the other group, port operators and the carrier group believed it was somewhat important. However, it was very important to port authorities, LMA and shipping companies. Only the seafarer group believed that cargo dwell time was neither important nor unimportant.

5.5.5 Landside Operations

Landside operations concern landside accessibility to enhance the efficiency of container flow between a port and its hinterland. Landside accessibility to sea ports has become one of the major concerns of port authorities and public policy makers, as it is an important factor for port performance and for enhancing economic development, for both land-locked and coastal regions (Economic research centre, 2000).
Landside accessibility is also one of the most influential factors affecting cargo flow through a port (Gekara and Chhetri, 2013, Chang et al., 2008). Port landside accessibility starts from the port gate, which is the first interface point between a port and the hinterland. It is also associated with the capacity of the existing road and rail networks. To illustrate the importance of landside accessibility from the perspective of local Libyan port stakeholders, the study employed a seven-point scale. The question of the importance of landside accessibility was answered by 79 respondents out of 84. The analysis found that landside accessibility, which includes ports’ gate performance, road transport and rail transport, is very important to local stakeholders in general; with a total mean of 5.82 (see Appendix 2). In more detail, landside accessibility is extremely important to the freight forwarder group, due to the nature of the service provided by this group. It is also very important to LMA, shipping companies, port operators, port authority and carrier groups. In contrast, the other group and seafarer group believed that landside accessibility is only somewhat important.

Due to the importance of landside accessibility to the majority of stakeholders, the following section examines the influence of the existing number of gate lanes and road networks on the performance of Libyan ports. It also investigates the necessity of the potential rail network to enhance cargo flow.

5.5.5.1 Number of Gate Lanes

The number of gate lanes influences the flow of cargo through the port, which has an influence on the capacity of the storage yard and the quality of the cargo delivery service. All of the four Libyan ports have two gate lanes, an entrance and exit. When the respondents were asked about whether the existing number of lanes of Tripoli port gate undermined cargo flow, the total mean of 72 responses was 3.57, with no significant difference ($F = .2.154; p = .050$). This illustrates that the number of lanes at Tripoli port's gate undermines cargo flow through the port.

The total means of the respondents regarding Benghazi, Qasr Ahmed and Khoms ports were less than 3.00, which showed no consensus on the statement that the number of lanes undermined cargo flow through these ports. In more detail, regarding Benghazi port, half of the respondents disagreed with the above statement.
Concerning Qasr Ahmed port of Misurata city, the analysis also showed that 43.1 per cent of the respondents believed that the number of gate lanes at Qasr Ahmed port did not undermine cargo flow, compared to 34.8 per cent of the respondents who had different perceptions. Similarly, around 45 per cent of the respondents disagreed with the statement regarding Khoms port, compared to 36.6 per cent of the respondents who agreed with the statement, with significant difference among the means ($F = 2.654; p = .018$). This might be because Tripoli has a larger population than the other cities, which means that these cities have less traffic.

The above shows no consensus among stakeholders regarding the influence of the number of gate lanes at Libyan ports on the cargo flow. However, the procedure of cargo clearance has a strong effect on the cargo flow and delivery time. This is well investigated in the following two sections.

5.5.5.2 Customs Clearance Process

Customs clearance processes play an important role in port performance. They influence the flow of cargo through the port. Therefore, their effect extends to influencing the capacity of the storage spaces if clearing the imported cargo is complicated or slow. Moreover, they affect a ship’s turnaround time in the case of exported cargo. Therefore, the customs clearance process seems to be important from the perspective of Libyan port stakeholders, with a total mean of 5.5 (see Appendix 2).

The customs clearance process is very important to the freight forwarding and shipping company groups, due to the nature of their work. It is also very important to LMA and port operators, as the efficiency of cargo clearance increases the volume of cargo being handled, and therefore a port’s income. However, it is only somewhat important to the other group, the port authorities, the carrier group and the seafarer group. In contrast, customs clearance fees do not have any influence on the process. Therefore, they are considered somewhat important to local stakeholders (see Appendix 2). This could be because the fee for cargo customs clearance is regulated by the customs authority, which is fixed at all Libyan ports.

The performance of ports can also be affected by the cargo clearance process, as it influences the cargo flow through the port. However, according to 72 responses, the
local stakeholders believed that cargo clearance processes at Libyan ports were inefficient. The analysis showed that the total mean of responses regarding all Libyan ports was around 1.80, with no significant difference ($F = .160; p = .992$).

![Figure 5.4: The Quality of Customs Services at Libyan Ports](image)

In more detail, 44.4 per cent of the respondents absolutely disagreed with the statement that the cargo clearance processes in Qasr Ahmed and Khoms ports were efficient, and 30.6 per cent of the respondents only disagreed with the statement. This represents 75 per cent of the total respondents. Moreover, 80.3 per cent of the respondents declared that the cargo clearance process was inefficient at Tripoli port, and 83.3 per cent shared the same perception in regard to Benghazi port. Therefore, from the above, the cargo clearance processes at all Libyan ports were inefficient, which affects the performance of these ports.

The cargo clearance process is inefficient as it is corrupt and complicated. This was derived from the responses of 71 participants. The analysis showed no significant difference among the perceptions of the respondents regarding the quality of the customs service. Despite the fact that about a quarter of the respondents did not agree nor disagree with the statement that customs services at the Libyan ports were complicated and corrupt, around 63 per cent of the respondents agreed with this statement (see Figure 5.4). Therefore, this shows that the cargo clearance process is
inefficient. The complexity of the cargo clearance process is also influenced by the lack of ITC, as discussed in detail in Section 5.5.6.

5.5.5.3 Cargo Delivery

Cargo delivery in this research refers to the time taken to off-load the cargo from a ship, clear it and deliver it out of the port gate in good condition. The efficiency of cargo delivery depends on a number of factors. These include the efficiency of the operations within the seaside, terminal and landside operations, including the efficiency of the cargo clearance processes.

From 81 responses, cargo delivery seems to be very important to local stakeholders in general, with a total mean of 6.06. It is considered extremely important to freight forwarders, due to the main interest of this group, and the nature of its business. It is also extremely important to the port operator and shipping company groups. Moreover, the groups declaring cargo delivery to be very important included the LMA, port authority, the other group and carriers. The seafarer group was the only group who believed it was only somewhat important. This could be because seafarers are concerned with seaside operations, rather than landside operations.

Cargo delivery is an important factor in terms of port reliability. However, cargo delivery times at Libyan ports are unreasonable, according to the perspective of 72 respondents. The total means of the responses related to all Libyan ports were around 2.00, with no significant difference among the respondents. About two-thirds of the respondents believed that cargo delivery times at Libyan ports were unreasonable. These times are due to a number of factors, such as the total cargo-handling time at ports, and the cargo clearance processes and efficiency. It also could be affected by not implementing online services. All of these factors make Libyan ports unreliable and low performing.

5.5.5.4 Road Networks

The total length of Libya’s paved road network is around 43,000 kilometres, including about 15,000 kilometres of main roads (RABA, 2012). However, the analysis showed that the existing road networks are not considered suitable for
hinterland transport if the demand for Libyan ports increases. It also showed there is no significant difference among the respondents’ perceptions.

By comparing the answer of 72 respondents regarding both Tripoli and Benghazi ports, which are located in the biggest cities, similarity is revealed in the perception of the respondents about these two ports. The total means for Tripoli and Benghazi ports were 1.85 and 1.88, respectively. Moreover, the analysis showed about two-thirds of the respondents believed that the existing road networks were not suitable for hinterland transport if the demand for Tripoli and Benghazi port increased. Regarding Qasr Ahmed port of Misurata, the result was slightly different, with 63.9 per cent of the respondents not supporting the statement that the existing road networks were suitable for hinterland transport if the demand for these ports increased, compared to 11.1 per cent of the respondents who supported the statement. The total mean of the respondents’ perceptions regarding Qasr Ahmed port was 2.15, which is the highest mean compared to the other ports, with no significant difference ($F = .614; p = .743$). Khoms port had a total mean of 2.03, with no significant difference ($F = .525; p = .812$). This illustrates that, in general, the respondents disagreed with the statement that the existing road networks were suitable for hinterland transport if the demand for Khoms port increased. This was represented by 71.9 per cent of the total respondents.

The above indicates that the existing road networks linked to Libyan ports are working over their capacity. In addition, they may not be able to handle the potential demand for these ports if it increases. This not only affects cargo flow, but also increases the cost of inland transport, which is very important to the freight forwarders group, LMA and the port authority and shipping company groups (see Appendix 2). The lack of proper road networks also disconnects Libyan ports from land-locked countries, which undermines the potential regional role of these ports. Therefore, to enhance the performance of Libyan ports though improving cargo flow, the existing road networks need to be developed. Alternatively, finding another way, such as establishing rail networks to reduce the load on the existing road networks, is essential.
5.5.5.5 Rail Networks

Libya still does not have functional rail networks. Therefore, the necessity of efficient rail networks is very important, according to the perceptions of all respondents (see Appendix 2). This is reflected in the total means of the respondents’ perceptions, which were between 4.04 and 4.13, with no significant differences. In addition, around 72 per cent of the respondents absolutely agreed with the statement that integrated rail networks were needed to increase cargo flow and reduce transport costs.

The above shows that the number of gate lanes at Libyan ports is a bottleneck neither for cargo flow nor for processing the recent volume of cargo dedicated to the local market. Conversely, the lack of rail networks puts more pressure on the existing road networks, which affects the ports’ performance throughput, undermining cargo flow. However, these three variables are excluded from port efficiency evaluation in the following chapter, as they are not under the control of the ports.

5.5.6 Online Services

In addition to efficient container-handling equipment, ICT is considered an important determinant of port performance to manage seaside, sea-land and land operations (Beškovnik, 2008). Contemporary port operations are unthinkable without effective and efficient use of ICT (Steenken et al., 2004b). Therefore, better information flow is one of the keys to port success (Bonney, 2014).

ICT has become a crucial part of the accurate and rapid transfer and processing of a huge volume of data processed in international transport firms and port organisations (Kia et al., 2000). Rapid and accurate information exchange between ports and their users is crucial for efficient cargo transport. Therefore, many ports have introduced ICT to enhance the efficiency of their performance. This has led to less bureaucracy and reduced transaction times and costs.

This has been confirmed by this study, which shows that online services are very important to the local stakeholders, with a total mean of 5.58 (see Appendix 2). It is also very important to freight forwarders, LMA, shipping companies and port authorities. However, the groups who believe that online services are only somewhat
important are carriers, port operators, the other group and the seafarer group. Despite the high demand for e-commerce, no Libyan ports have implemented e-commerce or any kind of online transactions as yet. Online services in this study consist of online customs services, online cargo tracking, online tracking for ships’ movements and online transactions.

Around 70 respondents out of 84 answered questions regarding the above types of online services. The analysis showed that the total means of the respondents’ perceptions regarding these services were around 1.10, with no significant difference. Further, around 90 per cent of the total respondents absolutely disagreed with the statement that online services in these ports met customer requirements. Due to the absence of online customs services, Libyan port users have to complete customs paper work manually. Moreover, due to the absence of online information accessibility about ships’ movement tracking, the local stakeholders face planning difficulties in terms of knowing a ship’s arrival time, departure time, cargo delivery and customs clearance. Consequently, the absence of an online service undermines the performance of Libyan ports. However, this factor was not included in the analysis in the next chapter, as it could not be quantified.

5.5.7 Cargo Safety

Efficient and safe cargo-handling operations require competent staff, according to the respondents’ perceptions. The importance of port labour competency had a total mean of 5.74, which indicates it is very important to the stakeholders in general (see Appendix 2). Port labour competency includes the level of awareness of port personnel about safety measures and responsibilities at port. Safety awareness reduces the unproductive time that might cause accidents or incidents, thereby increasing performance. It may also prevent any liabilities with loss of life, injuries, cargo loss, cargo damage and pollution caused by port personnel. In the meantime, it contributes to the quality of port services provided to the customer. From the analysis of about 70 responses, about 85 per cent of the respondents believed that the staff of Libyan ports were not aware of the safety measures at these four main ports (see Figure 5.5). The total means of these respondents was around 1.58, with no significant differences among the means. This low level of safety knowledge and
awareness could be due to a lack of training and/or a lack of implementing strict regulations and rules.

Safety awareness may influence cargo safety, such as cargo damage and loss. Cargo damage could happen during cargo-handling operations, such as loading or off-loading cargo to or from a ship, train or truck. It could also occur during storing or retrieving the cargo. The consequences of cargo damage may affect many stakeholders, such as insurance companies and port operators, due to the liability of cargo handling. The port authority may also be affected by pollution. Shipping companies are also subject to this impact, according to the bill of lading agreement. Therefore, cargo damage is one concern of local stakeholders. The descriptive analysis confirms that cargo damage is very important to the stakeholders in general (see Appendix 2). The total mean of the stakeholders’ perceptions regarding cargo damage was 5.56. This shows that it is very important to all Libyan ports stakeholders, except the port authority group, who believed that it was neither important nor unimportant.

![Figure 5.5: The Level of Port Personnel Safety Awareness](image)

Despite the lack of safety awareness among the staff of Libyan ports, the analysis illustrates that the frequency of cargo damage at these ports is unlikely to be high, based on 80 responses. The total means of the responses regarding the likelihood of cargo damage were around 2.20, with no significant difference. There was similarity
in the perceptions of the respondents regarding Tripoli and Benghazi ports in terms of cargo damage (see Figure 5.6).

For instance, the total means of the respondents’ perceptions for Tripoli and Benghazi ports were around 2.37. This indicated that the frequency of cargo damage in these two ports was unlikely to be high. Moreover, the percentage of the respondents who believed that cargo damage was most unlikely totalled about 15 per cent of the total respondents. The respondents who believed that cargo damage was unlikely represented around 50 per cent of the total respondents. Further, the respondents who believed that cargo damage was between more likely and unlikely represented 20 per cent of the total respondents.

Figure 5.6: The Likelihood of Cargo Damage in Libyan Ports

Qasr Ahmed port in Misurata was slightly different from Tripoli and Benghazi on this item. Thirteen respondents out of 84 did not answer the question regarding cargo damage in Qasr Ahmed port. Of those who did answer, the total mean of their perceptions was 2.17. The analysis showed that more than two-thirds of the respondents believed that cargo damage in Qasr Ahmed port was between most unlikely and unlikely (see Figure 5.6).

Regarding the likelihood of cargo damage at Khoms ports, the total mean of the respondents’ perceptions was 2.23, with no significant difference ($F = 1.829; p = .097$). The respondents who believed that cargo damage was between most unlikely
and unlikely represented 68.5 per cent of the total respondents. Therefore, it can be concluded that cargo damage does not affect the performance of Libyan ports, as a high frequency of cargo damage is unlikely.

Similarly, cargo loss is very important to the stakeholders in general. It has a total mean of 5.65 (see Appendix 2). The question of the importance of cargo loss was completed by 79 respondents out of 84. The analysis showed that it was extremely important to the shipping company group only. Four groups claimed that cargo loss was very important; that is, LMA, port operators, freight forwarders and the other group. In contrast, carriers, seafarers and the port authority believed that cargo loss was only somewhat important.

By investigating the likelihood of cargo loss at Libyan ports, it was deemed unlikely to happen, with the total means of the respondents’ perceptions around 2.00. More specifically, regarding Tripoli port, 70 respondents out of 84 answered this question. With no significant differences among the means of the respondents’ perceptions ($F = 1.175; p = .330$), the descriptive analysis showed that the total mean was 2.16. This indicated that the frequency of cargo loss at Tripoli port was considered unlikely on average. About two-thirds of the respondents believed that cargo loss in Tripoli port was unlikely (see Figure 5.7).

![Figure 5.7: The Likelihood of Cargo Loss in Libyan Ports](image)

Similarly, cargo loss seems to be unlikely at Benghazi port. Seventy-one respondents out of 84 responded to the question of cargo loss at Benghazi port. The analysis
showed that the total mean of these responses was 2.08, with no significant difference \((F = 1.238; \ p = .296)\). The analysis also showed that 76.1 per cent of the respondents believed that cargo loss at Benghazi port was unlikely.

Similarly, Qasr Ahmed port has no significant difference among the perception of the respondents \((F = 1.693; \ p = .127)\), and the total mean was 2.00. This also indicates that cargo loss at Qasr Ahmed port was considered unlikely. The analysis illustrates that 78.8 per cent of the respondents were satisfied with Qasr Ahmed port in terms of cargo loss. Khoms port is almost similar to Tripoli port. The total mean of the respondents’ perceptions was 2.11, with no significant difference \((F = .751; \ p = .630)\). Around two-thirds of the respondents believed that cargo loss at Khoms port was unlikely (see Figure 5.7).

Generally, it can be concluded that cargo loss was considered unlikely at Libyan ports, which means that it is not a bottleneck affecting the performance of Libyan ports. Therefore, cargo safety has been excluded from the efficiency analysis in the next chapter.

**5.6 Analysis of Variance**

ANOVA is the generalisation of a t-test to more than two groups (Iversen, 2004). ANOVA was used to detect any discriminant effects of independent groups (i.e., local stakeholders) on dependent variables (Martin and Bridgmon, 2012).

There are many Libyan local stakeholders, including LMA, port authorities, port operators, shipping companies, freight forwarders, carriers, seafarer and other groups that use Libyan ports for their business. These stakeholders have different activities and interests. For instance, port operators aim at loading and off-loading the ships safely and efficiently. However, this is not the interest of freight forwarders. The main concern of freight forwarders is to clear and receive cargo from the port and deliver it to the end user in the minimum time and at the minimum cost. Moreover, carriers or shipping lines have no interest in the tasks of port authorities. The carriers or shipping lines’ concern is to minimise the ship’s turnaround time, whereas the port authority’s priority is to implement the local laws and regulations, and then the efficiency of the port. Due to these differences in interests, a significant difference
among these groups was expected in terms of their perspectives about the selected performance variables.

As the dependent groups numbered more than two, a one-way ANOVA test was used to determine whether there was a significant difference in the perception means of these groups regarding the selected variables. Moreover, a post-hoc Tukey HSD test was used to identify the pairs that had significant differences. Post-hoc Tukey HSD tests are a more conservative way to detect the difference between group means, which hold the entire experiment’s error rate to a specific $\alpha$ level (Zhou and Kang, 2008). However, the analysis showed that there was consensus among the stakeholder groups about most of the variables selected to measure the performance of Libyan ports. Therefore, only the values of variables with differences are listed under the following headings.

5.6.1 The Total Working Hours

Despite the total working hours being fixed at all Libyan ports, one-way ANOVA showed a significant difference among the total means of the respondents regarding Khoms port ($F = 2.909; p = .011$).

Table 5.7: One-Way ANOVA Analysis Regarding the Working Time at Libyan Ports

<table>
<thead>
<tr>
<th>Port</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tripoli</td>
<td>.925</td>
<td>1.193</td>
<td>.321</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>.775</td>
<td></td>
</tr>
<tr>
<td>Benghazi</td>
<td>1.093</td>
<td>1.674</td>
<td>.132</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>.653</td>
<td></td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>1.358</td>
<td>1.462</td>
<td>.197</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>.929</td>
<td></td>
</tr>
<tr>
<td>Khoms</td>
<td>1.736</td>
<td>2.909</td>
<td>.011</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>.597</td>
<td></td>
</tr>
</tbody>
</table>
Further post-hoc Tukey HSD tests, at the significance level of 0.05, were conducted to determine the pairs with significant difference. Only one pair has the lowest significant difference, which is the other and the carrier group \((p = .050)\). However, there was no significant difference among the respondents regarding the utilisation of total working time in the rest of the ports (see Table 5.7).

### 5.6.2 Seaside Operations

Seaside accessibility is associated with the water depth of the fairway channel and port basin, as well as the berth length. In terms of water depth, one-way ANOVA showed no significant difference among the means of the respondents’ perceptions regarding Tripoli, Qasr Ahmed and Khoms ports \((p > .05)\). However, there is a significant difference among the perceptions of respondents regarding Benghazi port \((p = .016)\) (see Table 5.8).

#### Table 5.8: One-Way ANOVA Analysis Regarding Water Depth

<table>
<thead>
<tr>
<th>Port</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>Between groups 2.876</td>
<td>.996</td>
<td>.443</td>
</tr>
<tr>
<td></td>
<td>Within groups 2.888</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benghazi</td>
<td>Between groups 3.899</td>
<td>2.715</td>
<td>.016</td>
</tr>
<tr>
<td></td>
<td>Within groups 1.436</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>Between groups 2.076</td>
<td>.966</td>
<td>.464</td>
</tr>
<tr>
<td></td>
<td>Within groups 2.149</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khoms</td>
<td>Between groups 1.370</td>
<td>.652</td>
<td>.711</td>
</tr>
<tr>
<td></td>
<td>Within groups 2.101</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A post-hoc Tukey HSD analysis was run and showed significant differences between the pairs of port authority and seafarer group \((p = .032)\) and between seafarer and carrier group \((p = .010)\). The significant difference of seafarers might be because seafarers used to visit different international ports with different water depths, and may have compared these international ports with the Benghazi port. However, a one-way ANOVA test showed that there was no significant difference among the respondents’ perceptions regarding berth length and the ability of the Libyan ports to provide a berthing on arrival service for inbound ships.
5.6.3 Terminal Operations

Regarding the respondents’ perceptions about the type and quantity of cargo-handling equipment employed by Libyan ports, and their efficiency and capacity, one-way ANOVA showed no significant differences among the means of the respondents’ perceptions, except as related to the capacity of seaside cranes at Benghazi port \( (F = 2.373; p = .032) \) (see Table 5.9). A post-hoc Tukey HSD test showed that the smallest \( p \) value was 0.055. A significant difference was only between one pair, which is the seafarer and freight forwarder group, as the means of these groups were 2.23 and 1.00, respectively. The low mean of the freight-forwarding group could be due to the unsatisfactory way they dealt with the Libyan ports during delivering or shipping their cargo. However, the comparatively higher mean of the seafarer group was because seafarers are not greatly concerned about the general efficiency of cargo-handling equipment, other than the efficiency and capacity of QCs.

Table 5.9: One-Way ANOVA Analysis Regarding the Capacity of Seaside Cranes

<table>
<thead>
<tr>
<th>Port</th>
<th>Sum of squares</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>8.319</td>
<td>1.655</td>
<td>.137</td>
</tr>
<tr>
<td>Within groups</td>
<td>45.230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>53.549</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benghazi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>13.965</td>
<td>2.373</td>
<td>.032</td>
</tr>
<tr>
<td>Within groups</td>
<td>53.813</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>67.778</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>6.739</td>
<td>.615</td>
<td>.742</td>
</tr>
<tr>
<td>Within groups</td>
<td>100.247</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>106.986</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khoms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>7.362</td>
<td>1.447</td>
<td>.203</td>
</tr>
<tr>
<td>Within groups</td>
<td>45.793</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>53.155</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Additionally, in terms of providing special services, such as dealing with irregular cargo weights and sizes, Benghazi port was the only port with a significant difference among the means of the respondents’ perceptions \((F = 2.434; p = .028)\) (see Table 5.10). This difference was between the port authority group and seafarer group \((p = .026)\). However, one-way ANOVA showed no significant difference among the respondents’ perceptions regarding ports’ reliability, including ships’ scheduling and ship’s turnaround times.

**Table 5.10: One-Way ANOVA Analysis Regarding the Ability of Libyan Ports to Provide Special Cargo-Handling Services**

<table>
<thead>
<tr>
<th>Port</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>Between groups 1.107</td>
<td>.686</td>
<td>.684</td>
</tr>
<tr>
<td></td>
<td>Within groups 1.615</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benghazi</td>
<td>Between groups 3.164</td>
<td>2.434</td>
<td>.028</td>
</tr>
<tr>
<td></td>
<td>Within groups 1.300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>Between groups 2.417</td>
<td>1.358</td>
<td>.238</td>
</tr>
<tr>
<td></td>
<td>Within groups 1.780</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khoms</td>
<td>Between groups .922</td>
<td>.719</td>
<td>.656</td>
</tr>
<tr>
<td></td>
<td>Within groups 1.281</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In terms of the ability of the storage yards to absorb the cargo/containers dedicated to the local market and international transhipment, the analysis did not show any significant difference among the means of the groups. However, regarding the ability of the storage yards to absorb the cargo/containers dedicated to the local market, one-way ANOVA test showed no significant difference among the means of the groups regarding Tripoli, Benghazi and Qasr Ahmed port. However, Khoms was the only port that had a \(p\) value less than .05 (see Table 5.11). A post-hoc Tukey HDS test was employed and found that the pair with a significant difference was the freight-forwarding group and the other group \((p = .018)\). Similarly, there was a significant difference among the means of the port authority and seafarer group regarding the importance of free dwell time \((F = 2.281; p = .037)\).
Table 5.11: One-Way ANOVA Analysis Regarding the Capacity of Storage Space to Absorb Cargo Dedicated to the Local Market

<table>
<thead>
<tr>
<th>Port</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>Between groups</td>
<td>4.769</td>
<td>1.922</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td></td>
<td>2.481</td>
</tr>
<tr>
<td>Benghazi</td>
<td>Between groups</td>
<td>2.831</td>
<td>1.179</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td></td>
<td>2.400</td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>Between groups</td>
<td>3.109</td>
<td>1.696</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td></td>
<td>1.834</td>
</tr>
<tr>
<td>Khoms</td>
<td>Between groups</td>
<td>5.701</td>
<td>2.894</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td></td>
<td>1.970</td>
</tr>
</tbody>
</table>

5.6.4 Landside Operations

Landside connectivity is also crucial for port performance. The port gate is the first interaction point between the port and its hinterland. Regarding the number of gate lanes, the analysis showed significant difference among the perceptions of the respondents regarding the number of gate lanes at Benghazi, Qasr Ahmed and Khoms ports. For instance, regarding Benghazi port, it was found that the $p$ value was .016 (see Table 5.12). A post-hoc Tukey HDS test showed that this significant difference was only between the LMT and seafarer group ($p = .027$).

In addition, a significant difference was found among the respondents’ perceptions regarding Qasr Ahmed port ($F = 2.436; p = .028$). A post-hoc Tukey HDS test showed that the smallest $p$ value was 0.054, which was between the freight forwarder group and the other group. Further, a Games-Howell test was conducted and found that the mean significant difference at the level of .050 was between the same pair, where $p$ was .036. Yet another significant difference among the means was in relation to Khoms port ($F = 2.654; p = .018$). This significant difference was between the freight forwarder group and seafarer group ($p = .024$).
Similarly, there was a significant difference among the respondents’ perceptions regarding the importance of the customs clearance process. The pair that had the smallest $p$ value was the LMA and seafarer group, with a significant difference ($p = .068$). However, there was no significant difference regarding the corruption of customs clearance processes and cargo delivery times.

**Table 5.12: ANOVA Test Regarding the Number of Gate Lanes**

<table>
<thead>
<tr>
<th>Port</th>
<th>Mean square</th>
<th>$F$</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli</td>
<td>Between groups</td>
<td>77.556</td>
<td>2.154</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>36.012</td>
<td></td>
</tr>
<tr>
<td>Benghazi</td>
<td>Between groups</td>
<td>5.51</td>
<td>2.718</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>2.027</td>
<td></td>
</tr>
<tr>
<td>Qasr Ahmed</td>
<td>Between groups</td>
<td>4.408</td>
<td>2.436</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>1.809</td>
<td></td>
</tr>
<tr>
<td>Khoms</td>
<td>Between groups</td>
<td>5.138</td>
<td>2.654</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>1.936</td>
<td></td>
</tr>
</tbody>
</table>

Regarding the suitability of the existing road networks for hinterland transport and the necessity of rail networks to enhance the efficiency cargo flow, no significant difference among the means of the respondents’ perceptions was found. However, the analysis showed that there are significant difference between the perceptions of the LMA and carrier group in terms of the importance of inland transport cost ($F = 2.278; p = .038$).

**5.6.5 Online Services and Cargo Safety**

One-way ANOVA showed no significant difference among the means of the respondents’ perceptions regarding online services (e.g., online services for customs services, cargo tracking, tracking of ships’ movements and online transactions). Similarly, one-way ANOVA showed no significant difference among the total means of the stakeholders’ perceptions regarding cargo safety (e.g., the level of labour competence, safety awareness, cargo damage and cargo loss).
5.7 Summary

The study used primary data obtained from an online survey questionnaire to examine the performance of the four main Libyan ports. The response rate was 45 per cent of the total participants. The participants were from local Libyan port stakeholders and from different managerial levels. A non-response bias test was conducted using a t-test. The t-test illustrated no mean difference across the respondents with respect to the early and late responses.

The performance criteria consisted of port productivity, port efficiency and customer service quality related to seaside operations, terminal operations and landside operations. The poor performance of Libyan ports was due to a lack of capacity of the seaside, sea-land and landside resources. Improving productivity by expanding the capacity of port facilities appeared to be the only viable solution for meeting growing customer demand. This includes the capacity of port infrastructure and superstructure.

Concerning seaside, the lack of deep water has prevented Libyan ports from attracting larger ships. Moreover, the berth length of Tripoli and Benghazi ports has had the same effect in relation to attracting larger ships. This has forced Libyan ports to deal only with smaller ships, which has a negative effect on performance. Apart from the larger shipments reducing transport costs, serving smaller ships leads to wasting the time used to dock and undock the ships.

Regarding terminal operations, the analysis showed that all Libyan ports suffer from a severe deficiency in cargo-handling equipment. The lack of efficient QCs has forced the Libyan ports to use ships’ cranes for loading and off-loading containers. This has resulted in longer ship turnaround times, unavailability of berths for inbound vessels, and disturbances in ships’ scheduling and consequent port performance. It has also prevented the ports from meeting customer requirements, such as port reliability and service flexibility.

Additionally, the lack of efficient transport equipment has slowed down container movements between the ship’s side and storage yard. This has resulted in idle crane time and a consequent low crane throughput. Similarly, the severe lack of
sophisticated stacking equipment has undermined the optimal utilisation of Libyan ports’ storage yards. Consequently, the storage yards of Libyan ports can only absorb containers dedicated to the local market. However, apart from other influential factors, Libyan ports cannot be used as hubs for international distribution unless the capacity of stacking equipment is increased by replacing the currently used conventional stacking equipment with more sophisticated ones.

In terms of landside operations, the number of gate lanes of Libyan ports is not considered a bottleneck that undermines container flow between the ports and the hinterland. However, the corrupt and complicated customs clearance process is the main obstacle of container flow and delivery time. Further, the study has showed that improving the existing road networks is required to enhance cargo flow. Additionally, establishing rail networks is essential to reduce pressure on the existing road networks.

Other factors also undermine the performance of Libyan ports. These include the total working hours and the absence of online services. Regarding the total working hours at Libyan ports, the existing working time is not sufficient to provide the required services to customers. Moreover, this time is used inefficiently. Therefore, to increase performance, this time has to be increased to 24 hours a day, seven days a week and idle time has to be eliminated.

The second factor is the non-adoptability of online services. This includes online customs services, online cargo tracking, online tracking for ships’ movement and online transactions. Implementing all of these online services enhances port performance as it minimises bureaucracy and processing time and effort.

The above illustrates that there are some factors related to port infrastructure and superstructure that have substantial influence on the performance of Libyan ports. Some of these factors are under the control of the port authority and can be quantified. Such factors are water depth, berth length, the number and the type of QCs, transport equipment, stacking equipment and the storage yard area. These factors are used again in Chapter 6 to evaluate and compare the efficiency of seven Libyan ports against 18 container ports related to Libya’s trading partner countries.
Chapter 6: Data Envelopment Analysis

6.1 Introduction

The previous chapter contained the descriptive and one-way ANOVA analysis. The performance of Libyan ports is low. The performance of Libyan ports is influenced by the limitation of the ports’ capacity, which is caused by the lack of key port resources. These resources are closely associated with port infrastructure and superstructure. This chapter uses the same variables associated with port infrastructure and superstructure to evaluate the efficiency of Libyan ports using DEA.

DEA relies on productivity indicators that provide a measure of efficiency, which characterises the operating activities of the units being compared (Vercellis, 2009). Efficiency can be measured totally or partially. However, due to the quantity and availability of the data required, it is difficult to measure the total factor productivity (Manzoni, 2007). The total factor productivity attempts to obtain the output-to-input ratio value, which considers all outputs and all inputs (Cooper et al., 2007). The partial productivity ratio has become the most widely used as it is easy to understand, calculate and obtain data for. However, one of the disadvantages of the partial productivity measurement is that it may mislead and fail to give a true and complete picture of the situation (Manzoni and M.N.Islam, 2009).

Cooper, Seiford and Tone (2007) have divided the efficiency measures in DEA into two types: radial and non-radial. The differences between these two measures lie in the characteristics of the items of inputs or outputs. Most DEA models can be categorised into four categories: 1) radial and oriented, 2) non-radial and oriented, 3) radial and non-oriented, and 4) non-radial and non-oriented (Cooper et al., 2007). Radial means that a proportional reduction or enlargement of inputs/outputs is the major concern in efficiency measurement, while oriented indicates input-oriented or output-oriented. The radial approach is represented by the CCR and BBC models. The non-radial approach, or slacks-based measure (SBM), utilises input and output slacks directly. The outcomes of DEA analysis are efficiency scores, which represent performance indicators: ‘1’ is the best performance and ‘0’ is the worst performance.
Two choices of formulation are required by a basic DEA analysis: choice of envelopment surface and choice of orientation. The choice of envelopment surface is possible as constant return-to-scale (CRS) or VRS. The choice of orientation used in this research, or focus of analysis, is possible as a maximisation of outputs or minimisation of inputs or no orientation (Cooper et al., 2007).

An assumption of the CRS model refers to the situation where the changes in output are in the same proportion as the changes in inputs, while assumptions of the VRS model reflect increasing changes; for example, changes of 25 per cent in inputs correspond to changes of 50 per cent in outputs (Samoilenko and Osei-Bryson, 2013).

The two most basic DEA models are the CCR model and the BCC. The CCR model was initially proposed by Charnes, Cooper and Rhodes in 1978 (Wöber, 2007). It is based on the assumption that CRS prevails at the efficient frontiers. Computationally, it is likely to be more efficient, as it involves fewer constraints (Vercellis, 2009). Therefore, the use of the CCR model might be preferred to the BCC model for returns-to-scale analyses.

Efficiency frontier is a line that envelops all the efficient MDUs (1 score) in the sample, which is very precisely defined and allows the calculation of potential improvements for the inefficient MDUs (Manzoni and M.N.Islam, 2009) (see Figure 6.1).

The BCC is the CCR model modified by Banker, Charnes and Cooper in 1984 (Reilly, 2008). BCC and additive models assume VRS frontiers; that is, increasing, constant and decreasing returns-to-scale (Cooper et al., 2007). The BCC model separates the analysis in a twofold manner by: (1) evaluating technical efficiency in its envelopment model and (2) evaluating returns-to-scale efficiency in its dual (multiplier) model. The CCR model simultaneously evaluates both types of efficiency (Manzoni and M.N.Islam, 2009, Cooper et al., 2007).
This chapter uses the two most basic DEA models, which are the DEA-CCR model and the DEA-BCC under input-oriented approach. CCR was used to measure the global technical efficiency and BCC was used to measure the local pure technical efficiency. The multiple performance measures are classified into inputs and outputs (Lim and Zhu, 2013). In this study, an input-oriented measure was applied. In the input-oriented analysis, the production frontier explains the minimum amount of inputs required to achieve the given levels of output. In other words, technical efficiency (TE) refers to the ability of DMUs to decrease the input used to achieve the given levels of output, or evaluate by how much input quantities can be proportionally decreased without changing the quantities produced (Reilly, 2008). This implies that the improvement of container port efficiency by reducing inputs used can automatically increase the port container throughput.

### 6.2 Variables Identification

The TE analysis is the ratio form of actual productivity (output per unit of input) and frontier (best practice) productivity (Kiatpathomchai, 2008). Accordingly, it requires technical data or input and output quantity data for analysis. Handling all of the
factors that influence port efficiency could complicate the study (Wöber, 2007). Further, obtaining quantitative data for all of these factors is impractical (Lim and Zhu, 2013). Despite the author searching on the official websites of a number of container ports and port operators to obtain as much data as possible, as well as contacting some officials related to these ports, he could not access all of the required data to increase the sample size and the number of variables. Therefore, the study partially measured the efficiency of seven Libyan ports compared with 18 container ports and terminals in Libya’s trading partner countries. Moreover, it focused on the factors determined out of the descriptive analysis (in Chapter 5), as the most influential factors on Libyan port performance.

The output and input variables used for performance evaluation should reflect the process of container port production and the actual objectives as accurately as possible (Lin and Tseng, 2007a, Cullinane and Wang, 2006). Therefore, the study relied on secondary data derived from the official websites, reports and media releases of the sample ports. Some other data were obtained directly from the port authorities through email or phone communication.

As the focus here is on container ports, the total throughput in terms of TEUs is a good measurement for output (Tongzon and Heng, 2005). Therefore, TEU throughput was considered as an output variable in the DEA analysis of this study. To produce this output and facilitate port operations, certain types of inputs were needed (Tongzon and Heng, 2005).

The descriptive analysis in Chapter 5 showed that Libyan ports do not perform well because of a deficiency in port superstructure and infrastructure. Similarly, the efficiency of container ports is associated with some resources related to ports’ infrastructure and superstructure, which were used as inputs in DEA analysis. For instance, carriers require deep water and berths suitable for the size of their ships and an optimal storage yard area (Kremer, 2013). Therefore, port infrastructure resources including port water depth and the total length of berths to provide seaside accessibility were included as input variables. Further, such resources consist of the storage yard area to accommodate the volume of containers handled at the port. In contrast, port superstructure resources consist of all the equipment used to handle containers within the port.
Container-handling equipment includes transport equipment, stacking equipment and gantry container cranes. Therefore, these three types of superstructure resources were used as input variables in the DEA analysis (see Figure 6.2).

![Diagram of Port Superstructure]

**Figure 6.2: Port Superstructure**

For more explanation in terms of seaside cranes, some ports included in the sample use mobile cranes such as boosting telescopic mast cranes and fixed mast cranes. Others employ more specialised and sophisticated cranes, such as Panamax or post-Panamax or Super-post-Panamax gantry container cranes. Employing different types of cranes leads to different port performances, due to the different capacities of each type.

Similarly, the data showed that each port in the sample use different numbers and types of stacking equipment. For instance, some less developed ports use forklifts
and reach stackers for container stacking. Others ports, which adopt a vertical stacking mode, use more sophisticated equipment, such as RMGs or RTGs to optimise storage capacity.

In the same manner regarding transport equipment, some ports employ trucks or trailers and tractors to transport containers between the seaside and storage yards. Others use remotely controlled vehicles called AGVs to enhance the efficiency of container transport within the port. Other ports use SCs for both transporting and stacking the containers. The differences in using this equipment are expected to lead to different port performance.

Apart from the type of handling equipment used, the amount of this equipment also has an influence on container port efficiency. Moreover, port infrastructure, combined with port superstructure, influences efficiency. The statistics also show that the amount of equipment and the dimensions of the infrastructure differ from one port to another. Table 6.1 shows the differences in container-handling equipment and port infrastructure of the selected container ports and terminals around the world belonging to Libya’s trading partner countries.

The port equipment included in Table 6.1 were consolidated and classified based on their functionality into three input variables, for two reasons. The first is to have homogenous variables and the second is to minimise the number of variables that suit the sample size. Moreover, using the data in Table 6.1 increases the number of efficient ports dramatically, because of the zero value in most variables. Therefore, the total input variables considered in this analysis are six related to port infrastructure and superstructure. The variables related to port infrastructure were port water depth, berth length and storage yard area. The port superstructure variables were seaside cranes, transport and transfer equipment (see Figure 6.2), whereas the output variable used was TEU throughput.
Table 6.1: Facts Related to the Resources of Selected Container Ports

<table>
<thead>
<tr>
<th>Name</th>
<th>Mobile crane</th>
<th>Mobile trailer</th>
<th>Mobile truck/trailer</th>
<th>AGV</th>
<th>ISC Reach</th>
<th>Forklift/Reachstacker</th>
<th>Quay length/m</th>
<th>Storage area/km²</th>
<th>Water depth/m</th>
<th>Tput 2010 (M. TEUs)</th>
<th>CO2 Emissions 2010 (M. TEUS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal 1. Shanghai Pudong Int. Cont.Terminals Ltd</td>
<td>10</td>
<td>0</td>
<td>73</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>36</td>
<td>900</td>
<td>500</td>
<td>13</td>
<td>2.450176</td>
</tr>
<tr>
<td>Terminal 5. Shanghai Mingdong Cont.r Terminals Ltd</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>48</td>
<td>0</td>
<td>25</td>
<td>48</td>
<td>1300</td>
<td>781</td>
<td>12.8</td>
<td>9.061</td>
</tr>
<tr>
<td>La-Pezia</td>
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<td>2</td>
<td>0</td>
<td>66</td>
<td>16</td>
<td>18</td>
<td>1232</td>
<td>372</td>
<td>14</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>Gioia Tauro</td>
<td>22</td>
<td>2</td>
<td>0</td>
<td>110</td>
<td>13</td>
<td>0</td>
<td>3391</td>
<td>1600</td>
<td>18</td>
<td>2.857438</td>
<td></td>
</tr>
<tr>
<td>Jebel Ali Terminal 1&amp;2</td>
<td>79</td>
<td>0</td>
<td>1301</td>
<td>0</td>
<td>0</td>
<td>78</td>
<td>206</td>
<td>7475</td>
<td>20563.9</td>
<td>17</td>
<td>11.6</td>
</tr>
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<td>Alexandria</td>
<td>5</td>
<td>0</td>
<td>44</td>
<td>0</td>
<td>0</td>
<td>35</td>
<td>6</td>
<td>732</td>
<td>120</td>
<td>14</td>
<td>0.543</td>
</tr>
<tr>
<td>HHLA container terminal Altenwerder</td>
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<td>0</td>
<td>0</td>
<td>84</td>
<td>0</td>
<td>52</td>
<td>1400</td>
<td>1000</td>
<td>16.7</td>
<td>5.844</td>
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</tr>
<tr>
<td>Mersin</td>
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<td>5</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>19</td>
<td>3255</td>
<td>0.25132</td>
<td>14</td>
<td>1.015567</td>
</tr>
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<td>Izmir</td>
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<td>0</td>
<td>60</td>
<td>19</td>
<td>1050</td>
<td>0.21594</td>
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<td>63</td>
<td>4929</td>
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<td>12</td>
<td>0.131833</td>
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</tr>
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<td>Benghazi</td>
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<td>38</td>
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<td>0</td>
<td>50</td>
<td>4400</td>
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<td>12.5</td>
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<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
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<td>380</td>
<td>64</td>
<td>11</td>
<td>0.002241</td>
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<td>5</td>
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</tr>
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<td>6</td>
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<td>9</td>
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<td>0</td>
<td>50</td>
<td>4150</td>
<td>46</td>
<td>13</td>
<td>0.25587</td>
<td></td>
</tr>
<tr>
<td>Khoms</td>
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<td>4</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>1680</td>
<td>120</td>
<td>13</td>
<td>0.081381</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>(I)QC crane</td>
<td>(I)Mobile trailer</td>
<td>(I)Truck/ (I)AGV</td>
<td>(I)SC</td>
<td>Reach</td>
<td>(I)ForHIt/</td>
<td>G</td>
<td>(I)Quay length/m</td>
<td>(I)RMG/RT</td>
<td>(I)Water depth/m</td>
<td>(I)Storage area/km2</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>------------------</td>
<td>------</td>
<td>-------</td>
<td>------------</td>
<td>---</td>
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<td>-----------</td>
<td>-----------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Antwerp gateway terminal</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>47</td>
<td>1</td>
<td>14</td>
<td>1700</td>
<td>1260</td>
<td>16</td>
<td>0.795534</td>
</tr>
<tr>
<td>Marsaxlokk terminals</td>
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<td>346</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>62</td>
<td>2000</td>
<td>615</td>
<td>15.5</td>
<td>2.37</td>
</tr>
<tr>
<td>Tanger Med port APM terminals</td>
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<td>0</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>800</td>
<td>40</td>
<td>16</td>
<td>1.35</td>
</tr>
<tr>
<td>Terminal TCB SL Barcelona</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>64</td>
<td>11</td>
<td>0</td>
<td>1380</td>
<td>13.8</td>
<td>16</td>
<td>1.017733</td>
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<tr>
<td>Terminal Catalunya SA Spain</td>
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<td>56</td>
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<td>0</td>
<td>33</td>
<td>11</td>
<td>1085</td>
<td>3.607</td>
<td>14</td>
<td>0.928</td>
</tr>
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<td>Piraeus container terminal</td>
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<td>Amsterdam container terminals</td>
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<td>38</td>
<td>2</td>
<td>0</td>
<td>1415</td>
<td>542</td>
<td>15</td>
<td>9.215</td>
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<tr>
<td>Patrick east Swanson dock &quot;Melbourne&quot;</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>42</td>
<td>1</td>
<td>0</td>
<td>885</td>
<td>96.746</td>
<td>14</td>
<td>0.088883</td>
</tr>
<tr>
<td>Brisbane Autostrad terminal</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>3</td>
<td>0</td>
<td>930</td>
<td>85.821</td>
<td>14</td>
<td>0.918999</td>
</tr>
</tbody>
</table>
6.3 Sample Size

Sample size is crucial for reliable results. If the number of DMUs is less than the combined number of inputs and outputs, a large portion of the DMUs will be identified as efficient; additionally, efficiency discrimination among DMUs is questionable due to an inadequate number of degrees of freedom (Cooper et al., 2007).

Some rules of thumb are used to suggest the optimal number of DMU ‘sample size’, inputs and outputs in the envelopment model. The first says that the number of DMUs should be equal to or greater than the sum of inputs and outputs (Cooper et al., 2007). Another rule of thumb says that the sample size should be equal to or greater than three times the sum of outputs and inputs. Finally, the third rule states that the sample size is acceptable if the number of fully efficient DMUs is no greater than one-third of the total number of DMUs in the sample (Manzoni and M.N.Islam, 2009).

In this study, six variables were used as input variables. These include the number of cranes, transport equipment, stacking equipment, berths length, storage yard and water depth. The single output variable is the TEU throughput. Taking the most restricted rule, which is that the sample size should be equal to or greater than three times the sum of outputs and inputs, the required DMUs are:

\[
\text{DMUs} = 3(\text{inputs} + \text{outputs})
\]

\[
\text{DMUs} = 3(6+1) = 21 \text{ port}
\]

Accordingly, the total DMUs included in this study are 25 container port and terminals, which are more than the required DMUs. Seven are Libyan ports and 18 are related to 13 countries of Libya’s trading partners (see Table 6.2).
Table 6.2: The Selected DMUs and Input and Output Variables

<table>
<thead>
<tr>
<th>Country</th>
<th>Name</th>
<th>No. Of cranes</th>
<th>(I)No. ofort</th>
<th>(I)Transport equipment</th>
<th>(I)Stacking length/m</th>
<th>(I)Storage area/km²</th>
<th>(I)Water depth/m</th>
<th>(O)Tput 2010 (ML TEUs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China Terminal 1. Shanghai Pudong International Container Terminals Ltd</td>
<td>10</td>
<td>73</td>
<td>47</td>
<td>900</td>
<td>500</td>
<td>13</td>
<td>2.450176</td>
</tr>
<tr>
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<td>Terminal 5. Shanghai Mingdong Container Terminals Limited</td>
<td>16</td>
<td>48</td>
<td>73</td>
<td>1300</td>
<td>781</td>
<td>12.8</td>
<td>9.061</td>
</tr>
<tr>
<td>3</td>
<td>Italy La-Pezia</td>
<td>11</td>
<td>66</td>
<td>34</td>
<td>1232</td>
<td>372</td>
<td>14</td>
<td>0.85</td>
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<td>4</td>
<td>Gioia Tauro</td>
<td>24</td>
<td>110</td>
<td>13</td>
<td>3391</td>
<td>1600</td>
<td>18</td>
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<tr>
<td>5</td>
<td>UAE Jebel Ali Terminal 1&amp;2</td>
<td>79</td>
<td>1301</td>
<td>293</td>
<td>7475</td>
<td>20563.9</td>
<td>17</td>
<td>11.6</td>
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<tr>
<td>6</td>
<td>Egypt Alexandria</td>
<td>5</td>
<td>44</td>
<td>35</td>
<td>732</td>
<td>120</td>
<td>14</td>
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<td>52</td>
<td>1400</td>
<td>1000</td>
<td>16.7</td>
<td>5.844</td>
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<td>10</td>
<td>50</td>
<td>43</td>
<td>3255</td>
<td>251.32</td>
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<td>9</td>
<td>Izmir</td>
<td>5</td>
<td>70</td>
<td>79</td>
<td>1050</td>
<td>215.94</td>
<td>13</td>
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<td>10</td>
<td>Libya Tripoli</td>
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<td>46</td>
<td>63</td>
<td>4929</td>
<td>75</td>
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<td>52</td>
<td>4150</td>
<td>46</td>
<td>13</td>
<td>0.25587</td>
</tr>
<tr>
<td>Country</td>
<td>Name</td>
<td>Cranes</td>
<td>(I)No. Of</td>
<td>(I)Transport equipment</td>
<td>(I)Stacking equipment</td>
<td>(I)Quay length/m</td>
<td>(I)Storage area/km²</td>
<td>(I)Water depth/m</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------</td>
<td>--------</td>
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<tr>
<td>16</td>
<td>Khoms</td>
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<td>32</td>
<td>33</td>
<td>1680</td>
<td>125</td>
<td>13</td>
<td>0.081381</td>
</tr>
<tr>
<td>17</td>
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<td>74</td>
<td>15</td>
<td>1700</td>
<td>1260</td>
<td>16</td>
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</tr>
<tr>
<td>18</td>
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<td>346</td>
<td>75</td>
<td>2000</td>
<td>615</td>
<td>15.5</td>
<td>2.37</td>
</tr>
<tr>
<td>19</td>
<td>Morocco Tanger Med port APM terminals</td>
<td>8</td>
<td>90</td>
<td>23</td>
<td>800</td>
<td>40</td>
<td>16</td>
<td>1.35</td>
</tr>
<tr>
<td>20</td>
<td>Spain Terminal TCB SL (Barcelona)</td>
<td>12</td>
<td>64</td>
<td>11</td>
<td>1380</td>
<td>13.8</td>
<td>16</td>
<td>1.017733</td>
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<td>21</td>
<td>Terminal Catalunya SA</td>
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<td>44</td>
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<td>360.7</td>
<td>14</td>
<td>0.928</td>
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<td>22</td>
<td>Greece Pireaus container terminal</td>
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<td>8</td>
<td>1487</td>
<td>764</td>
<td>16.5</td>
<td>0.684881</td>
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<td>Netherland Amsterdam container terminals</td>
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<td>51</td>
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<td>1415</td>
<td>542</td>
<td>15</td>
<td>9.215</td>
</tr>
<tr>
<td>24</td>
<td>Australia Patrick East Swanson Dock &quot;Melbourne&quot;</td>
<td>7</td>
<td>42</td>
<td>1</td>
<td>885</td>
<td>96.746</td>
<td>14</td>
<td>0.088883</td>
</tr>
<tr>
<td>25</td>
<td>Brisbane Autostrad Terminal</td>
<td>4</td>
<td>27</td>
<td>3</td>
<td>930</td>
<td>85.821</td>
<td>14</td>
<td>0.918999</td>
</tr>
</tbody>
</table>
6.4 Empirical Findings of the BCC and CCR Analyses

The software DEA-Solver-Pro 9.0 was employed to solve the DEA-BCC-I and CCR-I returns-to-scale model. To deal with multiple inputs and outputs, a ratio like the following may be used:

\[
\frac{\sum_{r=1}^{p} u_r y_r}{\sum_{i=1}^{m} v_i x_i} = \frac{u_1y_1 + u_2y_2 + \cdots + u_p y_p}{v_1x_1 + v_2x_2 + \cdots + v_m x_m}
\]

Where:

\( y_r = \text{amount of output } r \)
\( U_r = \text{weight assigned to output } r \)
\( X_i = \text{amount of input } i \)
\( V_i = \text{weight assigned to input } i \).

The BCC model assumes that convex combinations of the observed DMUs form the production possibility set. The BCC score is known as local pure TE (Lim and Zhu, 2013). However, the CCR model assumes that the radial expansion and reduction of all observed DMUs and their non-negative combinations are possible (Manzoni and M.N.Islam, 2009). The CCR score is called global TE. This means that the CCR model assumes the constant returns-to-scale production possibility set (Cooper et al., 2007).

The input-oriented efficiency is defined as the ratio between the ideal input quantity that should be used by DMU if it were efficient, and the actually used quantity (Vercellis, 2009). Similarly, the output-oriented efficiency is defined as the ratio between the quantity of the actual output produced by the unit and the ideal quantity that should be produced in conditions of efficiency (Manzoni, 2007).

The CCR model, which is an input-oriented model, aims at minimising inputs while producing at least the given output levels (Vercellis, 2009). However, the output-oriented model attempts to maximise outputs, while using no more than the observed amount on any inputs (Cooper et al., 2007).
One important reason for undertaking a DEA study is to identify inefficient DMUs, so that they can be projected onto the efficient frontier (Manzoni and M.N.Islam, 2009). The efficient frontier provides some indications for improving the performance of inefficient DMUs. It identifies, for each output level, the minimum level of input used to produce that output (Vercellis, 2009). If a DMU’s actual productivity is equal to frontier productivity or lies on the frontier, it means it is perfectly technically efficient. Conversely, if a DMU’s actual productivity is less than frontier productivity, or lies below the frontier, this illustrates that it is technically inefficient (Manzoni, 2007). In other words, the outcomes of DEA analysis are efficiency scores, which are represented as performance indicators: (1) is best performance and (0) is worst performance (Reilly, 2008).

### 6.5 Efficiency and Return-to-Scale

Table 6.2 shows data from 25 container ports and terminals. Seven of these container ports and terminals are Libyan ports. The other 18 belong to 13 of Libya’s trading partner countries. The data include variables related to port infrastructure and superstructure. To evaluate the relative efficiency of these container ports, the study employed six inputs and one output. These inputs are seaside cranes, transport equipment, stacking equipment, storage yard area, berths’ length and water depth. The single output is container throughput TEUs. From the correlation table (see Table 6.3), there is a generally high positive correlation between all the variables, except water depth. The value of the correlation coefficient between the water depth variable and the other variables is between 0.2065 and 0.4567. This shows that the variables are highly associated with each other in a positive linear sense, except that the water depth variable is relatively high in relation to the number of cranes, transport equipment and total throughput.

The study used input-oriented models to measure port efficiency. If a DMU has a low CCR score and full BCC efficiency, then it is operating efficiently locally, but not globally due to the scale size of the DMU. As a result, it is reasonable to characterise the scale efficiency of a DMU by the ratio of the two scores (Cooper et al., 2007). If a DMU is fully efficient (100%) or scores (1) in both the BCC and CCR scores, this means that it is operating at the most productive scale size (Cooper et al.,
The CCR, BCC and scale efficiency and returns-to-scale characteristics of each port/terminal are listed in Table 6.4.

### Table 6.3: Variable Correlations

<table>
<thead>
<tr>
<th></th>
<th>No. of cranes</th>
<th>0.942166</th>
<th>0.886753</th>
<th>0.784923</th>
<th>0.933412</th>
<th>0.456677</th>
<th>0.657598</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport equipment</td>
<td>0.942166</td>
<td>1</td>
<td>0.913891</td>
<td>0.6708</td>
<td>0.971258</td>
<td>0.392489</td>
<td>0.618799</td>
</tr>
<tr>
<td>Stacking equipment</td>
<td>0.886753</td>
<td>0.913891</td>
<td>1</td>
<td>0.71694</td>
<td>0.905878</td>
<td>0.207453</td>
<td>0.602849</td>
</tr>
<tr>
<td>Quay length/m</td>
<td>0.784923</td>
<td>0.6708</td>
<td>0.716942</td>
<td>1</td>
<td>0.685635</td>
<td>0.206503</td>
<td>0.342201</td>
</tr>
<tr>
<td>Storage area/km²</td>
<td>0.933412</td>
<td>0.971258</td>
<td>0.905878</td>
<td>0.685635</td>
<td>1</td>
<td>0.334151</td>
<td>0.644314</td>
</tr>
<tr>
<td>Water depth/m</td>
<td>0.456677</td>
<td>0.392489</td>
<td>0.207453</td>
<td>0.206503</td>
<td>0.334151</td>
<td>1</td>
<td>0.393606</td>
</tr>
<tr>
<td>Tput 2010 (M. TEUs)</td>
<td>0.657598</td>
<td>0.618799</td>
<td>0.602849</td>
<td>0.342201</td>
<td>0.644314</td>
<td>0.393606</td>
<td>1</td>
</tr>
</tbody>
</table>

The results of CCR input-orientation, listed in column three of Table 6.4, show that four of the container ports and terminals performed efficiently when they were evaluated on the constant returns-to-scale assumption. These ports and terminals are: 
1) Terminal 5 of Shanghai port, operated by Shanghai Mingdong C/T LTD; 
2) Tanger Med port APM terminals in Morocco; 
3) Terminal TCB SL in Barcelona Spain; and 4) Amsterdam container terminals in the Netherlands. No Libyan ports were included.

Terminal 5 of Shanghai port was one of best performers, and therefore it is the most frequent referent (the largest λ value). It is considered as the most frequent referent in ten instances, followed by Terminal TCB SL (Barcelona), with seven and finally Tanger Med port APM terminals with six instances. This confirms that these container ports and terminals use unique and efficient cargo-handling equipment, in contrast to the Libyan ports (see Table 6.1). This issue is discussed in Section 6.8.
Table 6.4: Efficiencies and Return-to-Scale

<table>
<thead>
<tr>
<th>No.</th>
<th>DMU</th>
<th>CCR-I Score</th>
<th>Reference set (lambda)</th>
<th>BCC-I Score</th>
<th>RTS</th>
<th>Scale efficiency score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Terminal 1. Shanghai Pudong C/T Ltd</td>
<td>0.39599</td>
<td>Terminal 5. Shanghai Mingdong C/T Ltd</td>
<td>0.847329</td>
<td>Increasing</td>
<td>0.467339</td>
</tr>
<tr>
<td>2</td>
<td>Terminal 5. Shanghai Mingdong C/T Ltd</td>
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<td>Terminal 5. Shanghai Mingdong C/T Ltd</td>
<td>1</td>
<td>Constant</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>La-Peizia</td>
<td>0.130712</td>
<td>Tanger Med port APM terminals</td>
<td>0.698646</td>
<td>Increasing</td>
<td>0.187093</td>
</tr>
<tr>
<td>4</td>
<td>Gioia Tauro</td>
<td>0.25431</td>
<td>Terminal 5. Shanghai Mingdong C/T Ltd</td>
<td>0.622271</td>
<td>Increasing</td>
<td>0.40868</td>
</tr>
<tr>
<td>5</td>
<td>Jebel Ali Terminal 1&amp;2</td>
<td>0.963924</td>
<td>Terminal 5. Shanghai Mingdong C/T Ltd</td>
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<td>Decreasing</td>
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<tr>
<td>6</td>
<td>Alexandria</td>
<td>0.235609</td>
<td>Tanger Med port APM terminals</td>
<td>0.765082</td>
<td>Increasing</td>
<td>0.307953</td>
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<tr>
<td>7</td>
<td>HHLA Container Terminal Altenwerder</td>
<td>0.612868</td>
<td>Terminal 5. Shanghai Mingdong C/T Ltd</td>
<td>0.743745</td>
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<td>0.82403</td>
</tr>
<tr>
<td>8</td>
<td>Mersin</td>
<td>0.220678</td>
<td>Terminal TCB SL (Barcelona)</td>
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<td>0.343981</td>
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<td>Izmir</td>
<td>0.188416</td>
<td>Tanger Med port APM terminals</td>
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<td>Tripoli</td>
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<td>CCR-I</td>
<td>BCC-I</td>
<td>Rate</td>
<td>Change</td>
<td>Average</td>
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<tr>
<td>14</td>
<td>Derna</td>
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<td>Qasr Ahmed</td>
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<td>Terminal TCB SL (Barcelona)</td>
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<td>16</td>
<td>Khoms</td>
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<td>Antwerp gateway terminal</td>
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<td>Amsterdam container terminals</td>
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<td>0.130047</td>
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<td>Marsaxlokk Terminals</td>
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<td>19</td>
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<td>Patrick East Swanson Dock &quot;Melbourne&quot;</td>
<td>5.26E-02</td>
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<td>Tanger Med port APM terminals</td>
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<td>0.562528</td>
</tr>
<tr>
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<td><strong>Average</strong></td>
<td><strong>0.341251</strong></td>
<td><strong>0.824154</strong></td>
<td><strong>0.388298</strong></td>
<td></td>
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The BCC scores provide an efficiency assessment using a local measure of scale under variable returns-to-scale. In this model, six container ports and terminals were accorded efficient status, in addition to the four CCR efficient container ports and terminals. Three of these additional ports were Libyan ports: Brega, Tobruk and Derna (see Table 6.4). The full efficiency of these Libyan ports is due to their use of the smallest amount of inputs compared to the other most efficient ports.

According the BCC scores, the Libyan ports exhibited scores in which four out of seven were below average (0.824154), while the trading partner container ports and terminals achieved ten out of 18. This means that both the inefficient Libyan and trading partner ports are positioned on average at nearly the same relative distance from the efficient BCC frontiers, although there are differences in efficiency among these ports and terminals.

DEA provides a way to investigate the sources of inefficiency that a DMU might have and determine whether they are caused by the DMU inefficient operation itself, or by the disadvantageous conditions under which the DMU is operating. This can be achieved by comparing the CCR-I and BCC-I scores, as mentioned earlier (Cooper et al., 2007).

The scale of efficiency (SE) is defined by the ratio of CCR to BCC as follows:

\[
SE = \frac{\theta^* \text{CCR}}{\theta^* \text{BCC}}
\]

The CCR is known as the global TE, whereas BCC expresses the local pure technical efficiency (PTE) under returns-to-scale circumstances. Therefore, using these concepts illustrates a decomposition of efficiency as:

\[
\theta^* \text{CCR} = \theta^* \text{BCC} \times SE
\]
Where:

\( \Omega \) CCR is the score of the global TE, and  
\( \Omega \) BCC is the score of the local PTE.

This means that:

The \( \mathrm{TE} = \mathrm{PTE} \times \mathrm{SE} \) (Wöber, 2007).

Referring to Table 6.4, comparing the trading partner ports and terminals in terms of SE score reveals that nine out of 18 ports and terminals are below the average (0.388298). However, all the Libyan ports’ scores are below the average, with remarkable differences. This may mean that the Libya’s trading partner ports experience advantageous conditions compared with the Libyan ports. Moreover, the global inefficiency of Libyan ports (CCR) was mainly attributed to the inefficient operations associated with port infrastructure and superstructure.

For instance, Qasr Ahmed port has a low BCC score (0.66699) and a relatively high SE compared to the other Libyan ports. This means that the overall inefficiency (0.18918) in the CCR column is caused by inefficiency operations, rather than SE (0.28364). The inefficient operations are closely associated with the equipment that are used for cargo handling. This is similar to Tripoli, Benghazi and Khoms ports. However, Berga port has a fully efficient BCC score (1.0) and a low SE (0.00297). This can be interpreted as meaning that the global inefficiency of this port as given by its CCR score is mainly attributable to its disadvantageous port infrastructure and superstructure conditions. These results are similarly applied to Derna and Tobruk ports.

Referring to Table 6.4 again, the returns-to-scale, as identified by the input-oriented BCC model is under the sixth column ‘RTS’. Any DMU with full efficiency in the CCR score is also efficient in the BCC model, and is positioned in the most productive scale size (MPSS), in the region where constant returns-to-scale prevails. Therefore, Terminal 5 in Shanghai port, operated by Shanghai Mingdong C/T LTD, Tanger Med port APM terminals in Morocco, Terminal TCB SL in Barcelona and Amsterdam container terminals in the Netherlands are considered in the MPSS.
region. In contrast, 20 out of the 25 container ports and terminals could possibly improve their efficiency by scaling up their activities. This includes all Libyan ports.

### 6.6 The Effects of Port Superstructure and Infrastructure

Based on the BCC model, which provided an efficiency assessment using a local measure of scale under VRS, three Libyan ports are fully efficient. These are Brega, Tobruk and Derna ports. The full efficiency of these Libyan ports was due to their use of the smallest amount of inputs compared to the other efficient ports, which is associated with the types of inputs.

In terms of superstructure, it is noted that all the CCR efficient ports and terminals use more sophisticated and specialised container-handling equipment (see Table 6.5). This is not the case with Libyan ports. For instance, all these ports use different types of quay container cranes for ship cargo operations. These include Panamax or Post-Panama or Super post-Panamax quay container cranes, with high container move rates. However, all the Libyan ports operate mobile cranes for the same purpose. Qasr Ahmed is the only Libyan port with two Panamax quay container cranes. Moreover, at all the Libyan ports, including Qasr Ahmed in some berths, the port operator uses ships’ cranes for ship cargo operations. That is due firstly to the lack of efficient cranes at port, and secondly to the efficiency of ships’ cranes compared to the ports’ mobile cranes. Thirdly, it is because the ships’ cranes are located above the cargo holds; therefore, they are more convenient than the ports’ mobile cranes. Fourthly, ships’ cranes have less blind sectors, enabling the crane operator to control the container-handling operations more efficiently and safely.

These findings match the findings of the descriptive and one-way ANOVA analysis, which illustrate that the performance of seaside operations in Libyan ports is low because of the lack of efficient and specialised cranes at these ports.

Similarly, Libyan ports use external trucks for container transport, with some port tractors and trailers. However, the most efficient ports and terminals use more sophisticated transport equipment, such as AGVs, straddle carriers and tractors and trailers. For instance, the most efficient terminal, Terminal 5 in Shanghai port, employs 48 AGVs. In addition, Terminal TCB SL in Barcelona operates 64 SCs to
<table>
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<tr>
<th>Name</th>
<th>QC</th>
<th>QC Type of</th>
<th>Truck</th>
<th>AGV/T</th>
<th>Forklift/T</th>
<th>Tractor</th>
<th>SC</th>
<th>RTG</th>
<th>Quay length/m</th>
<th>Storage area/km²</th>
<th>Water depth/m</th>
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transport and stack containers in the same time. Similarly, Amsterdam container terminals use a combination of SC and trailers, depending mainly on the straddle carriers. A Tangier Med port APM terminal in Morocco uses 45 tractors and 45 trailers, which is the same type of transport equipment used by the Libyan ports. However, the amount of this equipment at the Libyan ports is not enough to ensure the efficiency of Libyan ports. This illustrates that the used transport equipment is both insufficient and inefficient, which is an outcome similar to that indicated by data derived from the descriptive and one-way ANOVA analysis in Chapter 5. According to the perspective of Libyan port stakeholders, the transport equipment used at Libyan ports undermines the performance of ports’ performance.

Similarly, regarding stacking equipment, some of the most efficient ports use SCs for transport and stacking operations. The most efficient Terminal 5 in Shanghai port uses 48 RTGs for container stacking and retrieving. However, Libyan ports still use conventional forklifts and reach stackers for container stacking and retrieving. As a result, both the descriptive and DEA analysis show that Libyan ports are not efficient due to their use of inefficient stacking equipment. Using such conventional stacking equipment increases the stacking and retrieving time, which is closely associated with the total operations time.

All of this shows that the existing superstructure at Libyan ports has a negative impact on their efficiency. It is also validates the findings derived from the local stakeholders of Libyan ports. Therefore, Libyan port superstructure needs to be developed to enhance efficiency.

In terms of infrastructure, specifically water depth, the analysis shows that the correlation coefficient value of the water depth and other variables is between 0.2065 and 0.4567, which is comparatively low. However, the highest correlation value of water depth was with the number of cranes (0.457), followed by transport equipment and container throughput (0.39). Therefore, this variable is considered in the DEA analysis.

A port with deep water can attract the mega ships with deep draft to use its facilities (Maersk, 2012). Serving mega ships with a large volume of containers increases the throughput per time unit. This increase in throughput is achieved by saving the time
used for ships’ docking/undocking. In other words, the time required to handle 7,000 TEUs from a single ship, using a certain amount of handling equipment, is shorter than the time required to handle the same number of TEUs from two or three ships using the same handling equipment. This time difference is the time used for undocking the first ship and docking the next ship. Further, part of this time is considered idle time for cranes, transport and stacking equipment, which is spent in docking operations. However, the water depth of Qasr Ahmed and Khoms ports, compared to Terminal 5 in Shanghai port (which is the most efficient terminal) are nearly the same. This implies that the Libyan ports’ water depth does not undermine the performance of these ports. Therefore, some Libyan ports can enhance their efficiency through better use of other port resources, rather than dredging their seabed. This also validates the findings of the descriptive analysis regarding water depth. However, this cannot be applied to the Tripoli and Benghazi ports.

Similarly, the length of berths, as part of the infrastructure, does not seem to disrupt the efficiency of Qasr Ahmed and Khoms ports. This is because some of the most efficient ports and terminals have shorter total berth lengths than these ports. However, berth design, which is not included in this study, may influence both berth allocation and crane allocation plans (Imai et al., 2008, Kim and Park, 2004, Zhou and Kang, 2008), which are associated with port efficiency. This could be the case with Tripoli and Benghazi ports: they have a corrugated berth design, which makes the length of each individual berth short, whereas the new ports of Qasr Ahmed and Khoms have straight and long berths.

Storage yard use depends mainly on cargo-handling equipment, particularly stacking equipment (Chen, 1999). It also depends on storage mode and block design (Kim and Kim, 2002). The storage yard area of the most efficient ports and terminals, and Libyan ports, is nearly similar. For instance, the storage yard area of the first most efficient terminal is 781 square kilometres, compared to 444.5 square kilometres for Benghazi port. In contrast, the storage yard area of Terminal TCB SL in Barcelona is only 13.8 square kilometres, as compared to the 15 square kilometres of Derna port. Therefore, the influence of storage yard area on the efficiency of Libyan ports could be due to a severe lack of efficient stacking equipment at Libyan ports. This is also confirmed by the perspective of the local stakeholders in Chapter 5, which illustrated
that the existing area of the storage yards can deal with the existing volume of cargo dedicated to local market, but not the cargo dedicated to both local and international markets.

6.7 Conclusion

This chapter has assessed the efficiency of seven Libyan ports compared to 18 container ports and terminals related to Libya’s trading partners. Six variables have been used as inputs and one variable has been used as an output. The software DEA-Solver-Pro 9.0 was employed to solve the input-orientation BCC and CCR returns-to-scale model. The local measure of the BCC input-oriented showed that only three ports are locally efficient, due to using the smallest amount of inputs. These ports are Brega, Derna and Tobruk. However, the CCR input-oriented showed that no Libyan ports were globally efficient. The overall inefficiency of Qasr Ahmed, Tripoli, Benghazi and Khoms was due to inefficient operations, which are associated with port capacity. Port capacity is more closely associated with port infrastructure and superstructure, rather than with SE.

The fully efficient BCC Libyan ports of Brega, Derna and Tobruk have low SE. This means that the global inefficiency of these ports as given by their CCR scores can be attributed to their disadvantageous port infrastructure and superstructure conditions. These findings increase the finding validity of the descriptive and one-way ANOVA analysis, which illustrated that the number and type of cranes, transport and stacking equipment used by Libyan ports are the main influential factors undermining their performance. Neither are they able to meet any potential increased demand.

In addition, in terms of port infrastructure, the water depth and berth length of the two comparatively new ports—Qasr Ahmed and Khoms—do not have a significant influence on performance. However, these factors do affect the performance of Tripoli and Khoms ports. This is due to both the shallow water depth compared to the new generation of container ships and the berth design of these ports.
Chapter 7: Discussion

7.1 Introduction and Summary of Findings

The purpose of this chapter is to provide a critical discussion about the research findings regarding port performance and efficiency, within the Libyan context. This thesis was developed to provide a comprehensive explanation as to why Libyan ports continue to struggle with basic performance problems. It also investigates the direct factors that influence port performance, based on the primary data collected for this study. It then links these factors to the external influential factors derived from the literature. Although much is known from the literature on port performance, most of the evidence relates to ports in developed economies. Little analysis has been conducted on port performance issues in developing economies, particularly in Africa.

This study was conducted in two phases to achieve the objectives. The first phase measured the performance of the four main Libyan ports from the perspective of local stakeholders, using quantitative survey data. The second phase evaluated the performance of seven Libyan ports against 18 container ports and terminals belonging to Libya’s trading partners. The study findings highlight a number of issues leading to poor performance at the ports. Port users identified a number of factors they considered most important in an efficient world-class port. These include: port reliability, flexibility, cargo safety, port accessibility, port throughput and operational cost and time. Port reliability is expressed in terms of ships’ scheduling, cargo-handling facilities, cargo delivery time and the reliability of customs clearance processes. Similarly, the ability of Libyan ports to deliver flexible services to the customer was considered very important. Such services include providing berthing on arrival for inbound ships at short notice and dealing with irregular cargo sizes and weights. Cargo safety was presented in terms of cargo damage and loss and was considered a critical factor that undermined user confidence. The analysis also found that seaside accessibility, which includes water depth and length of berths, constituted a major factor for port users, as these determine the size of ships that can be served by Libyan ports.
Another major factor affecting Libyan ports’ performance relates to landside accessibility: this determines cargo flow and overall dwell time. By extension, these factors affect overall port throughput and productivity. Ultimately, the combined outcome of these factors is escalating operating costs for all users, including cargo owners and ship owners. These expenses incorporate cargo-handling fees, customs clearance fees and inland transport costs. The cost component was also expressed in terms of time lost in inland cargo transit for cargo owners, and ships’ turnaround times for ship owners. Another important factor that influences the performance of Libyan ports is the lack of up-to-date technological capability. The literature shows that the world’s best-performing ports use advanced managerial technologies when organising their work processes (Gekara & Fairbrother 2013; Kia et al. 2004). Such technologies could improve customs clearances, cargo tracking, ships’ scheduling and cargo delivery scheduling. The streamlining of the cargo-operation process and reduction in paperwork through process automation would greatly reduce operation time and costs for all stakeholders. In the present situation, in which the operations are apparently characterised by heavy bureaucracy, corruption and workforce ineptitude, stakeholders see such automations as a way of improving operations.

Most importantly, the data shows that the real problem lies in a failure to invest in port infrastructure, superstructure and hinterland transport infrastructure. This includes maritime and land port accessibility, as well as cargo-handling equipment, cargo holding yards and workplace technologies. This issue of investment in ports seems to underpin the overall situation of underperformance. The DEA analysis in the second phase of the study also confirmed that the lack of seaside cranes, transport and stacking equipment, as well as maritime accessibility, are the key impediments to the efficient performance of Libyan ports.

The discussion in this chapter seeks to theorise the situation in the Libyan port industry and examine the salient reason behind the factors identified in the data. The key question is: what do these findings mean? This discussion is developed in the following sections.
7.2 Assessment

The data have revealed that port performance in Libya is undermined by a number of resource-related factors. It is important to understand the root cause of the resource problem. The general literature on port performance shows that this issue is multi-dimensional. In the literature, port performance is assessed by the extent to which it meets the expectations of customers and/or by its productivity or efficiency (Liu, 2009, Haezendonck et al., 2011, Yan et al., 2009, Le-Griffin, 2008, Acosta et al., 2011, Myung-Shin, 2003, Yap and Lam, 2006, Perez-Labajos and Blanco, 2004, David Xiaosong Peng et al., 2011, Wu and Goh, 2010). These aspects of performance include port reliability, flexibility, cargo safety, port accessibility, port throughput and cargo-handling cost and time.

Studies also reveal a number of factors that influence port performance and highlight some of the key challenges in achieving and maintaining efficient performance. Further, they indicate that only a few of these can be controlled directly by port operators through their internal management systems (Le-Griffin, 2008). These include port infrastructure, the technology used for handling operations, port workforce recruitment training and skills development, and internal management. However, most of the factors that may enhance or hinder performance lie outside the control of individual port authorities and terminal operators. As such, Gekara and Chhetri (2013), in their analysis of Mombasa port, conclude that a port is only as efficient as the environment within which it operates. Factors such as trade volumes and the hinterland trade capacity, shipping patterns, hinterland connectivity and access, and the performance of hinterland transportation modes are very influential, yet are beyond the control of port operators and port authorities (Le-Griffin, 2008). Other political, economic and social factors are also highly influential and also beyond the control of port operators; for example, the nature of economic governance, regional security and the availability and efficiency of supporting industries. Therefore, this analysis takes an internal–external sphere of influence approach to determine the most influential factors, which explain the Libyan port industry’s continued poor performance.

Figure 7.1 illustrates the relationships between port performance and its internal and external environment. This figure is based on the analysis findings and the literature
concerning Libya. It is adopted as a framework for grounding the study findings in context and developing an understanding of the underlying causes for the poor performance of Libyan ports.

Figure 7.1: Framework for Understanding Port Performance in a Developing Country Context

Most ports perform differently, as they operate under different environments. In most developing economies, a particular political, economic and social environment is created, which influences the performance of economic institutions. Figure 7.1 illustrates the pressures that bear on ports and suggests that the effectiveness of any one port will be determined by whether these pressures are positive or negative. At the centre of the framework are the structures and systems directly under the control of the terminal/port operator. This is the internal environment. The assumption is that the terminal operator is able to control and regulate the internal environment to optimise operations and achieve efficiency. This operator should be able to develop an efficient cargo-operation process, using an effective system of process
management and resource allocation. Another assumption is that the terminal operator is able to acquire up-to-date equipment and technologies, and employ the most skilled workers. They should also be able to ensure that the port is able to dock appropriately sized ships.

These assumptions are embedded in the various pressures that validate or invalidate them. These form the external environment that is often beyond the control of the port/terminal operator. The performance of a port terminal will be influenced by a number of external pressures, including the region’s trade capacity and the accessibility of the port’s economic catchment area, the prevailing political environment, the prevailing social and economic environment, and the existing system of governance. If the regional trade volumes are low, then the viability of the port is undermined. If the hinterland is inaccessible because of poor connectivity, this may mean that cargo does not reach or leave the port as scheduled, causing delays and port congestion, a situation characterised by long dwell times and lengthy ship turnarounds. Poor systems of economic governance combined with political instability could undermine the operations of different economic institutions, such as ports. For example, the ability of the port operator to invest in appropriate equipment, technologies and skills depends on the capacity to attract capital. The ability of the port to access private sector capital is important, and is therefore related to the level of economic liberalisation in the country.

With Libyan ports, the findings indicate a situation of continuing underperformance. Using the above framework of internal structures and processes versus external performance enablers, the next section examines the specific situation in Libya, in an attempt to ground the findings contextually. The question is: why have ports failed to implement efficient operating environments? The factors identified as hindering efficient performance mostly relate to a lack of investment in port infrastructure, superstructure, ICT and labour skills. However, improving these internal factors without addressing the external factors is a key problem facing Libyan ports. Therefore, to understand what these findings mean, we need to look at a broader environment and understand the reality concerning how ports perform in a developing country with a particular type of economic, social and political environment. To develop this understanding with reference to Libyan ports, the
following sections will examine the influence of Libya’s local and regional politics, and the system of economic regulation and governance, on the performance of essential economic institutions; in this case, ports.

### 7.2.1 Bad Politics, Poor Economic Governance and the Implications for Port Performance

Libya presents a particular type of environment, shaped by the nature of its politics and economic governance. The Libyan economy is influenced by a troubled history of internal systems of poor governance and a volatile political environment. In terms of internal systems, when Gaddafi began ruling the country in 1969, his regime managed to promote some vital sectors such as health, education, agriculture, manufacturing, infrastructure and transportation (RABA, 2012, RABA, 2013, Otman and Karlberg, 2007). All of these sectors contributed to the Libyan economy. During this period, the country was almost self-sufficient, mostly relying on its own production. However, all of these sectors, except the oil sector, experienced a decline at the end of the 1970s and 1980s, when the Libyan regime became much more socialist and introduced the Green Book (Pack, 2013).

The Green Book was written by Gaddafi to illustrate his philosophy in three parts and named it the third universal theory. The first part discussed the problem of democracy, which gives authority to the people. This chapter argued that all people are equal and have the same political authority (al-Qaddafi, 1975). However, this affected the organisational hierarchy in Libya. It was understood that there was no difference between the leader or the manager and the low ranks of labourers. This led to inefficient performance within organisations due to the lack of adherence to organisational procedures. The second part discussed the solutions to economic problems. In this part, Gaddafi presented his belief that socialism was the optimal solution for economic problems. This part discussed the economic basis of the so-called ‘third universal theory’: need, ownership of housing, land, means of transport, income and domestic servants. However, 42 years of bad politics based on the Green Book have undermined economic performance (Obaidi, 2014). The Green Book determined economic liberalisation and consequently introduced corruption, mismanagement and problems with governance (Obaidi, 2014). These have undermined the performance of all economic aspects, not just ports, as an ‘illness’ in
local politics cannot be isolated from the economy (as discussed later in detail). The third part discussed the social basis of the Green Book. This includes the family, the tribe, the nation, women, minorities, education, music, arts and sports.

The deterioration of these vital sectors was due to the central management, mismanagement and the regime focusing more on external involvement rather than internal issues. For example, road networks were not paved to prevent increased congestion, existing roads were not maintained (RABA, 2012, RABA, 2013) and the country is still without any rail network to minimise the pressure on roads (CETMO, 2010, Gazette, 2010, Gazette, 2008, RPEMB, 2013). Moreover, foreign specialists at local hospitals, schools and factories were not paid and so left the country. Many staff had already left the country during the conflicts with Egypt and Tunisia. Together, these losses of staff reduced the level of health and education services. As the quality of health services provided by the local hospitals and local staff was now insufficient (WHO, 2012), Libyans were forced to travel to neighbouring countries such as Tunisia and Egypt for medical treatment, which is very costly due to the modified exchange rate.

The socialist transformation adopted by the former regime affected the Libyans’ welfare and national economy (Obaidi, 2014). The following illustrates the impact of local politics on welfare and economic performance. Based on the Green Book published by Gaddafi, owning more than one house and car was prohibited. Therefore, if a person had two houses and one of them was rented, the tenant had the right to own this house. Similarly, no person or authority had the right to own a means of transportation for the purpose of renting it. In the same manner, as per the Green Book (p. 57), no one could own a piece of land, even if he or she had bought it:

Land is the private property of none. Rather, everyone has the right to beneficially utilise it by working, farming or pasturing as long as he and his heirs live on it—to satisfy their needs, but without employing others with or without a wage (al-Qaddafi, 1975).

The Green Book dictated that savings in excess of one’s needs would be the person’s share of society’s wealth (al-Qaddafi, 1975). Therefore, everyone had the right to save from his or her wealth the amount that he or she needed, no matter the source of
this income. However, this did not apply to the president’s family and loyalists. Therefore, Gaddafi was strangling the economy at the same time as he was enriching his people, which meant he was activating and sustaining injustice, corruption and mismanagement (Pack, 2013). These factors translated into economic mismanagement on a large scale (Elbsaikri, 2005). Further, all of these philosophies resulted in animosities and led to chronic problems within the Libyan community. Many people resorted to the judiciary to regain their property, in a corrupt way.

Meanwhile, implementing the Green Book philosophy forced the majority of Libyans to work for the public sector at low wages. This sector was full of corruption and was unproductive. However, if anyone criticised the beliefs enshrined in the Green Book, they faced severe punishment from ‘the revolutionary committee members’. The regime successfully stifled voices demanding freedom, justice and development, not by negotiation, but by execution, arrest or exile. Examples of this are that Gaddafi had killed his companions who were involved in the overthrow, and had the opposition hanged in town squares and universities. The most horrible example was when 1,200 prisoners in Abu Salim prison were killed over the course of a few hours in June 1996 (HRW, 2006).

Regarding the economy, it established a system of economic management, which led to many problems, such as weak and inconsistent regulations, centralisation of economic power in the hands of the regime, a high number of inefficiencies, a lack of diversification and extensive patronage. Political patronage, corruption, nepotism and economic mismanagement were major features of the governance system (Combaz, 2014). All these problems undermined the performance of all aspects of the economy, including ports.

It is long acknowledged that the model of port administration adopted greatly determines ports’ competitiveness and performance. Following extensive port reforms around the world in the 1990s, many countries adopted the ‘landlord’ model, whereby private operators manage most of the functions of the port. The state, in this model, retains only the landowner and regulatory function (Baird A, 1999). The idea behind the reforms was to inject private capital and private sector management systems into the hitherto publicly owned ports. The wave of economic privatisation happening at the time recognised the management issues often associated with public
sector bureaucracies (Xiao et al., 2012), as well as the fact that most governments could not afford the large amounts of capital required to establish and maintain well-performing modern ports without the private sector, including multinational terminal operators (Xiao et al., 2012). By continuing to implement Gaddafi’s Green Book, Libya has done the opposite, seeking to strengthen the state’s hold on economic management (Alam et al., 2009).

Part two of the Green Book dictates the model of business ownership and management, including the transference of private ownership to the state. From the introduction of this model, the government increased the state’s role in national economic management, expropriating all private factories, transportation companies, oil companies and other enterprises. One of Gaddafi’s supposed objectives was to ‘free the wage earners from slavery’ and to make them partners in the productive process, by taking over the public and private means of production. However, the takeover was mostly done by Gaddafi’s loyalists, who were assigned roles by the regime. Additionally, Gaddafi abolished the wage system. Rather than contributing to the productive process for the owner’s benefit or profit, the actual producer was to be a partner in the process, sharing equally in what was produced, or in the income derived from what was produced. However, even where the state owned the enterprise and the income derived from it and reverted to the community, the plight of the wage earner remained unchanged (Metz, 1987).

Obviously, ports were not excluded from the Green Book’s philosophy. Laws were established to organise the relationship between workers and port management. For instance, according to article five of law number 21 of 1985, regarding the SPC’s establishment, port workers are considered partners in the port business. Therefore, they have the right to share port revenue with the company. The implication for ports and their performance is dire and underpins the conclusions in this study. First, having taken over the ports, the government has been unable to afford the huge amount of capital required to establish and maintain well-performing, world-class ports. This leaves the ports struggling with a lack of capital, inadequate port equipment and a dilapidated infrastructure. The ports are unable to acquire new technologies, which in many ports around the world are the main drivers of efficiency. Second, the government is unable to recruit, train and pay workers
appropriately to ensure the best management and operation skills are available. Poor pay rates also lead to a lack of motivation and people resorting to corruption. Third, port management is characterised by political patronage (as most of the top management comprises loyalists appointed by the regime), and all the drawbacks often associated with public sector bureaucracy, including mismanagement of public funds, ineptitude and inefficiency, nepotism and corruption.

Another important aspect of the Libyan political and economic system, which has implications for port performance, concerns trade volumes. Policies regarding public ownership and control of all aspects of the economy have led to a decline in Libya’s trade output (Metz, 1987). The nationalisation of manufacturing activities has reduced Libyan exports. In addition, to protect local products, Libya has placed restrictions on a wide range of imports (Combaz, 2014). The problem with cargo volumes is also caused by political instability in the region that forms the ports’ potential wider hinterland. This includes the surrounding countries such as Egypt, Tunisia, Chad and Sudan.

In more details, in 1977, Libya engaged with Egypt in a short war, which affected the political relationship between the two countries. The poor political relations with Egypt directly affected regional trade and some other aspects, such as education, health care, manufacturing and agriculture (Zaki, 2014). This was because most Egyptians were evacuated from Libya for their safety.

In the case of Tunisia, these conflicts stemmed from Gaddafi’s interference in the internal affairs of that country, sometimes using Libya’s wealth and at other times, the military. Political ties between these two countries were broken off in 1974, when Tunisia rejected Gaddafi’s proposal for unification. Gaddafi reacted by expelling 14,000 Tunisians from Libya, which negatively affected Libya’s labour force (Noonpost, 2015). The continuing interference of Gaddafi ended with an attack on Tunisia in 1979, and the severance of diplomatic relations between the countries on 26 September 1985, until 1988 (Noonpost, 2015).

Another example of the political conflicts with its neighbours, is in 1973, Libya attacked the north of Chad and occupied the Aouzou strip. In early September 1987, 2,000 troops (with the support of French troops) crossed the disputed strip and drove
into Libya itself. The Chadians claimed they had killed some 1,700 Libyans, taken hundreds of others prisoner, and destroyed 26 planes and 70 tanks (Pukrop, 1997). In 1990, the two countries finally agreed to take their dispute to the International Court of Justice, which ruled in early 1994 that the Aozou strip belonged to Chad. By doing this, Libya destroyed a significant part of its army and wealth, instead of building political and economic bridges with this land-locked country. In addition, Libya supported the rebels of west and south Sudan against the Sudanese regime.

The above shows that Libya is a state of constant conflict with its neighbours. This means that neighbouring countries avoid Libyan ports as gateways to international trade. Despite Libya restoring its diplomatic relationships with Chad and Sudan, the war between Libya and Chad, and the conflict between Libya and Sudan, were obstacles to establishing strategic economic bridges between these countries. This ensured that trade between Libya and these countries was virtually non-existent. Moreover, the troubled relationships with these countries prevented any potential investment, and consequently the potential trade that might be handled by Libyan ports. Additionally, the reaction of Gaddafi, when he expelled all Tunisian and Egyptian workers, meant that Libya struggled from a lack of labour for several years. The consequence of this irresponsible reaction was a decline in Libya’s trade productivity and exports other than oil, and an increase in Libya’s imports. Similarly, the small volume of trade and the country’s unproductivity caused by external political conflicts disconnected Libyan ports from their hinterlands and reduced the potential volume of goods that could be handled by them. The cumulative effect for ports is that there is not enough cargo volume to attract big ships. Further, and perhaps more importantly, the lack of cargo volume has been used to justify not investing more in ports, based on the argument that cargo volumes do not justify such investment.

Similarly, the conflicts between Libya and the western country have severely affected the overall Libyan economy and therefore, its ports. For more explanation, the main drivers of the Libyan economy are oil and gas. Both contribute around 95 per cent of export earnings (Emporiki Bank, 2012, CIA, 2012), 80 per cent of government revenue and 65 per cent of gross domestic product (GDP) (Indexmundi, 2012). Western countries are the main importers of Libyan oil; Libya imports most
of its needs from western countries. Owing to the conflicts between the Gaddafi regime and the west, Libya has been considered by much of the western media as a source of international terrorism (Davis, 1987). The political relationship between Libya and the west worsened at the beginning of the 1980s. Due to nationalising oil companies, including those operated by American companies, as well as the hostile attitude of Libya towards Israel, the USA banned imports of Libyan oil and some exports to Libya in 1982, following deteriorating relations (Indexmundi, 2012). Therefore, Libya turned to western European countries for trade. However, hostility from these countries started when a London policewoman was shot from the Libyan Embassy in 1984 in London, as well as in reaction to Libya’s arming of the Irish Republican Army (IRA) and involvement in the Lockerbie airline bombing (Oakes, 2011). This hostile relationship increased after a bombing at a Berlin night club (Schmidt, 1991), after which international sanctions were widened to include a total ban on direct export and import trade, commercial contact and travel-related activities with Libya (Oakes, 2011). Consequently, all types of investment, and international trade with, Libya declined, which negatively affected all port activities in Libya.

Further, investment in Libya is not secure (UNCTAD, 2012). The FDI inflow and outflow was increased after political volatility subsided, and some procedures were established to secure and ensure the rights of local and foreigner investors. However, Libya’s unclear legal structure, arbitrary government decision-making processes and over-staffed public sector, alongside various other structural rigidities, have posed impediments to foreign investment and economic growth (Mateos, 2005). Moreover, the weak banking sector and poor regulatory framework are just two of the problems facing foreign investors in Libya (Monitor, 2008). Therefore, since 2008, the FDI has experienced a decline, reaching zero in 2011, due to the war (UNCTAD, 2012) (see Section 2.4). Despite Libya managing to attract greater foreign investment after it reintegrated globally, most of this investment was in the oil sector (Fraenzel, 2009). Libya failed to promote growth in the non-oil sector and diversify its economy (Mateos, 2005), reducing the volume of international trade and thus port activities.
After restoring diplomatic ties with Chad and granting exemptions of taxes and tariffs on Arabic products, Libya was rated the fourth most attractive country in the world with which to do business between 2012 and 2014, according to a UK trade and investment study (Fraenzel, 2009). However, this did not last long. Due to heightened insecurity after the revolution of 17 February 2011 that overthrew Gaddafi’s regime, most foreign investors have again tended to avoid Libya. Due to the large volume of weapons in the streets, only a few brave foreign investors, such as some from Turkey, South Korea and China, established businesses in Libya. However, even these have now left Libya, due to the political and tribal wars that began in July 2014 (Economist, 2013).

Another important factor that affects Libyan port performance is the lack of proper hinterland connectivity. It is well established that the trade volume between a port and its hinterland is largely associated with the capacity of its hinterland connectivity. Additionally, successful and efficient ports are often those that are well connected to their hinterland by adequate and effective transport corridors (Gekara and Chhetri, 2013, Chang et al., 2008). This study has found that the lack of efficient roads and the absence of rail networks have undermined the efficiency of cargo flow between Libyan ports and their hinterland, and therefore port performance (see Sections 5.5.5.4 and 5.5.5.5). These findings support the argument that rail connectivity is essential for efficient cargo flow between ports and their hinterland (Woodburn, 2013, Transystems, 2011, SCI, 2010, Kozan, 1997, Kozan, 2000, Dinwoodie, 2006, Ashar, 1990, Economic research centre, 2000, Reis et al., 2013, Gekara and Chhetri, 2013, Niérat, 1997), particularly to transport large volumes of goods over long distances (Hansen, 2004, Kia et al., 2003). However, the existing road networks in Libya are working beyond their capacity. Congestion on these roads is common, which increases the cost of land transport and cargo delivery times and reduces the reliability of Libyan ports. In addition, an inefficient cargo flow caused by the lack of proper land transport corridors causes constant congestion at the ports, which has major implications for ship turnaround times. This study has determined this is due to cost, time, reliability and port throughput being important performance criteria for all local stakeholders of Libyan ports. These problems have enhanced the perception and experience of inefficiency. An important question is: what causes the poor hinterland connectivity?
The absence of rail networks and inadequate roads is associated with the poor governance system and the political environment. Local politics (which created a central decision-making process, corruption, mismanagement, the absence of private sector investment and some issues related to external politics) have ensured that Libya has not invested in developing a road transport sector since 1986 (see Section 5.5.5.4). Libya’s troubled relations with the international community, particularly lending countries and institutions, have also meant that no development aid is forthcoming. For these reasons, no rail network exists, the road network is limited, and road capacity is mostly inadequate and in a state of disrepair.

The troubled Libyan governance system has affected decision making, leading to economic mismanagement. In 1975, the Libyan government designed railway lines and sent 1,026 students overseas for training to assist in the design’s implementation. In 2003, 28 years later, the authority commissioned the establishment and management of the rail networks. However, the work is yet to begin, and the project seems to have stalled completely. Apart from poor management, this situation is also a culmination of the nationalisation system, which has starved the economy of investment capital for essential infrastructure.

This section has illustrated how poor economic governance and unstable political situations adversely affect the performance of essential economic sectors. The case of Libyan ports is characterised by a lack of capital investment in essential infrastructure and equipment, mismanagement, poor hinterland connectivity and a lack of trade volume. Ultimately, the ports are unable to perform their role effectively in the national and regional economy. The issue of nationalisation has been highlighted as a key part of the problem. In the next section, this problem is examined further in a discussion of the effects of a centralised and state-controlled management system.

7.2.2 Implications of Management Centralisation and State Control on Port Performance

As discussed in Section 7.2.1, introducing part two of the Green Book led to drastic changes in business ownership, including the transference of private ownership to the state and implementing the social partnership philosophy. Libya had adopted a
centralised administration model in most of the public sector, and considering that many businesses were state owned or controlled, this centralisation extended to a large part of the economy, including the ports industry. Most of Libya’s industry was state controlled, largely excluding the private sector and foreign investment. Existing firms acquired strong market influence as a result of little or no competition. Nonetheless, failure in these industries was clear in the resulting low productivity and the reduced quality of products and services. This failure badly affected the overall volumes of Libya’s international trade handled by Libyan ports.

All of Libya’s ports remain state owned and/or controlled, and therefore fall under the public service port model above. This arrangement is the major cause of sustained poor performance. It is also a direct result of the actions and decisions of the former regime’s socialist ideals, which, through instruments such as the Green Book, saw the systematic nationalisation of all sectors. In spite, the transport ministry and the LMA put in place some measures to involve the private sector in port industry after the revolution of February 2011, the loopy of the SPC management managed to persuade the company’s employees to strike against the involvement of the private sector in port operations (TV, 2013). This strike in six vital ports forced the LMA and transport ministry to freeze this decision till further notice (Ammar, 2012).

Ports typically function under a dual administration structure comprising a regulatory arm and a management arm. These functions may be shared across private and public sectors, depending on the model adopted for ownership and management. As such, invariably there will be a port authority (regulatory) and a management arm. The port authority is usually formed by the state to provide regulatory oversight and secure the operational and technical integrity of the port facilities by implementing maritime rules to ensure that navigational safety, security and maritime environmental protection are maintained. In contrast, port or terminal operators, whether public or private, provide management expertise; in that they administer all aspects of port operations (Burns, 2015). However, in the context of Libya’s ports, the structure and layers of control and management are highly complex, involving a multiplicity of ministries, government departments and agencies. In fact, all Libyan
ports are operated by two public companies (see Section 2.6.4). The port of Qasr Ahmed in Misurata can be classified as both a state owned and a public service port.

Qasr Ahmed is the only port operated by MFZ Company, based on resolution number 32 of 2006. Despite the fact that ports usually fall under the Ministry of Transport, the MFZ belongs to the Ministry of Economy—an arrangement with no rational explanation. Figure 7.2 represents the organisational structure within which ports are owned and managed.

In this arrangement, the Ministry of Economy is not directly involved in the management and operations at Qasr Ahmed port. Figure 7.2 shows that Qasr Ahmed port enjoys a certain amount of autonomy, largely because it is owned separately from the mainstream public ownership structure that applies to the other ports, although it is still owned by a state ministry. The dotted square suggests a level of insulation from the general operating environment. The only connection with the main ownership structure is the shared regulatory services offered by the Maritime Administration. Decisions regarding investment and other management strategies are therefore likely to be quicker. Further, MFZ has its own budget underwritten through the revenue it generates and credits allocated in the general Libyan budget and any facility loans obtained. This also suggests that Qasr Ahmed port enjoys discretion in how it manages its revenues and develops its strategies. Therefore, it is to a lesser extent affected by prevailing public service bureaucratic hurdles, including issues of political interference, corruption and inefficiency.

In contrast, and based on law number 21 of 1985, all other ports are operated by the central management of the SPC, which belongs to the Ministry of Transport. Following the revolution of February 2011 against Gaddafi’s regime, SPC was renamed the LPC. Similarly, the port authorities of these ports, including Qasr Ahmed, are under the authority of LMA, which is a Ministry of Transport entity (see Figure 7.2). The role of the port authority is only statutory and regulatory; it includes implementing local laws and legislation, investigating maritime and marine pollution
Figure 7.2: Decision-Making Processes in MFZ and LPC.
incidents, registering ships, and conducting crew sign on and sign off procedures. Berthing allocation and planning, tugging and pilotage are conducted by the port operator.

Due to the central management system, no Libyan ports operated by LPC have a free hand to invest and develop individual strategies. Therefore, they have to raise any relevant strategic issues related to port development and investment with the Ministry of Transport, following a long bureaucratic chain through the LPC headquarters, maritime authority and finally the Ministry. In many cases, the Ministry of Transport needs to discuss these strategies and issues with the General Ministry (which oversees all the functions of the ministries) for approval. Matters relating to funding new investments at the port—for example, buying new equipment, expanding infrastructure and superstructure—must be approved at the top level. Due to this state-controlled central command model, management at these ports is characterised by corruption, miscommunication and mismanagement, and a lack of investment in new equipment, infrastructure and technologies. By extension, the situation has hindered any progress in making greater operational efficiencies. All these problems are highlighted by stakeholders as the key obstacles to better performance. The literature also confirms that monopoly, centralisation of decision making and corruption wield the most influence on the development of Libya’s vital port sector (outlook, 2012).

The central management of a firm revolves around where the high-level decision-making processes and strategic decisions are made. Such decisions include, but are not limited to, major agreements, financial monitoring and reporting the firm’s overall corporate performance. In central management, all high-level decisions, documentation approval and contract signing are executed by a board of directors at board meetings (GPG, 2011). Centralised management has some advantages, such as clear communication, easy coordination and budget control (Marzec, 2014). Centralisation, which is also called ‘command-and-control’, was originally the dominant structure for almost all businesses, but has declined in recent years among large businesses (Marzec, 2014). Conversely, in decentralised management systems, decision-making powers are delegated further down the hierarchy (Marzec, 2014).
Decentralised corporate and management structures have become increasingly more popular in the global port sectors of many countries (Cheon et al., 2010).

The advantages and disadvantages of these systems are well illustrated in the ports of Libya. Although generally the study has found that Libyan ports are poor performers, those ports operated by LPC and managed through the large and unwieldy bureaucracy were identified by stakeholders as being the most inefficient. In contrast, Qasr Ahmed, which enjoys a level of autonomy, was identified as the best performer. This port is also leading the rest in terms of throughput, according to cargo data (CETMO, 2010, Maritime-database, 2012, SPC, 2011, Misurata Free Zone, 2013, Libyan Maritime Administration, 2013, Libyan ports company, 2013). The findings of the study regarding performance must therefore be understood against the prevailing context. In the current highly competitive operating environment, Libya’s ports must have access to sufficient capital and this can only come from the private sector.

The Libyan social, economic and political environment presents great obstacles to economic performance. As discussed in the first part of this chapter, the political situation deters development and institutional performance due to insecurity, the inability to consolidate regional trade, the inability to focus on hinterland access infrastructure and poor national economic output generally. When coupled with poor economic management and governance structures, the overall situation is one in which both the internal and external operating environments undermine performance.
Chapter 8: Conclusion

8.1 Overview of the Research

This research was designed to highlight the challenges and key lost opportunities regarding port performance and efficiency in Libya, by examining the performance of the country’s ports from the perspective of local stakeholders. It has also evaluated Libyan ports’ efficiency compared to 18 container ports and terminals belonging to Libya’s trading partners. The main contribution of this study has been to develop a conceptual framework for measuring port performance using multiple criteria. This framework can be used to measure port performance in developing economies that are influenced by specific external factors. An important aim of this study was to contribute to a greater understanding of the impediments to port performance in the context of developing countries, especially in Africa where such studies are scarce.

Libya has 20 ports. Seven of these are purely commercial entities used to handle containers and general cargo rather than oil, petrochemicals or ore. The four main ports are Tripoli, Khoms and Qasr Ahmed in the west of Libya and Benghazi in the east. Benghazi and Tripoli are the oldest ports, while Qasr Ahmed and Khoms are relatively new. The other ports are Derna, Berga, Tobruk and Zwara.

Libyan ports were chosen for this study because they have so far failed to play a significant role as efficient gateways to regional trade, despite their strategic location on the Asia-Europe international trade route that passes through the Mediterranean Sea. They are also located on the north coast of Africa between the European and African continents. They can be the main facilitators for the imports and exports of the neighbouring land locked countries: Chad and Niger. Another reason for the choice is pragmatic. As a Libyan national with many years of maritime experience, including in shipping and ports, I have travelled to many ports and experienced how varied port performance can be. I was always troubled by the fact that Libyan ports were unable to break through the efficiency barrier compared to others around the world. For instance, to off-load and load a general cargo ship of 7,000 GT, a ship
spends between one and two days at a typical western European port, such as Hamburg, Antwerp or Rotterdam. However, to off-load the same volume of cargo, a ship can spend around a week or more at a Libyan port. This seriously compromises a ship’s turnaround time, its scheduling and therefore the ship’s operational costs and the shipping line’s reliability. Additionally, it undermines port throughput and the potential role of Libyan ports in the region. In all cases, this has a significant impact on doing business in Libya, affecting the national and regional economy. These observations led to a desire to understand the main obstacles preventing improved port performance in the Libyan context.

The study was conducted in two phases. The first phase measured the performance of Libyan ports from the perspective of local stakeholders. The second phase compared the efficiency of Libyan ports against other ports related to Libya’s trading partners. Firstly, measuring the performance of the four main Libyan ports was conducted to determine the most influential factors on performance using a quantitative questionnaire survey. The criteria for measuring performance were identified from the literature and classified into port productivity, port efficiency and customer service quality. Port productivity consisted of seaside productivity and terminal productivity. The criteria of port efficiency focused on time and cost. The quality of customer service consisted of port accessibility, port reliability, online services, service flexibility and cargo safety.

All of these factors and their components were used to develop an online quantitative questionnaire. The questionnaire was distributed online to 200 local stakeholders of Libyan ports. It used the snowball technique, which is assumed to increase the response rate, especially when total populations are quite small, as with this study. The local stakeholders included LMA, seafarers, freight forwarders, shippers, local ship owners, port operators, port authorities and other groups associated with Libyan ports. After about four-and-a-half months, 84 valid responses out of 186 responses had been received, which represented 45 per cent of the total respondents. These data were analysed using SPSS descriptive analysis and one-way ANOVA.

In the second phase, the evaluation of port efficiency was used to compare the efficiency of the Libyan ports against the ports of Libya’s trading partners, using factors that emerged as influential from the perception of local stakeholders. For this
purpose, seven Libyan ports were compared against 18 container ports related to 13 of Libya’s trading partner countries. DEA was employed for this comparison of efficiency.

The descriptive analysis and one-way ANOVA revealed a set of variables that emerged as influential factors on port performance. These variables were closely associated with port superstructure and infrastructure. On the port side, these variables included water depth, berth length, storage area, number and type of cranes, transport equipment and stacking equipment. In addition, most of the extremely important service quality variables, which represented some of the performance measurement criteria, were associated with the seaside and terminal operations. The bottleneck in Libyan port performance began with the issue of seaside accessibility. Despite the escalating demand for larger container ships to increase throughput and reduce their operational and transport costs, Libyan ports can only accommodate container ships smaller than the third generation class. In addition, specialised container QCs were absent, except at Qasr Ahmed port, which has two. This absence of QCs forced the port operators to use ships’ cranes or other mobile cranes for loading and off-loading operations. This led to longer ship turnaround times. This has resulted in low throughput and the abandonment of Libyan ports due to the increased operational times and cost for ships. Additionally, a deficiency in transport and stacking equipment has led to container transport and stacking inefficiency. This deficiency has prevented Libyan ports from meeting the potential demand and becoming important hub ports.

On the hinterland side, railway connectivity is essential to enhance cargo flow efficiency and connect Libyan ports with their hinterland, including neighbouring land-locked countries. The absence of a functional railway system in Libya has placed more pressure on road networks. Consequently, the efficiency of cargo flow has been low, and the cost of cargo land transport quite high.

All of the above-mentioned variables under the control of Libyan ports were used as inputs in the second phase of the efficiency assessment analysis. Port throughput was used as the output variable, as it is the most common measurement for port performance. The two most basic DEA models, the DEA-CCR model and the DEA-BCC under input-oriented approach, were used in this study. CCR was used to
measure the global TE, while the BCC was used to measure the local PTE. The DEA analysis illustrated that all Libyan ports were globally inefficient when assessed on the CCR input-oriented CRS. The overall underperformance of Qasr Ahmed, Tripoli, Benghazi and Khoms ports was caused by inefficiency in operations, associated with port capacity. The global inefficiency of Libyan ports (CCR) was mainly attributed to the inefficient operations associated with port infrastructure and superstructure. To confirm this, it was noted that the most efficient trading partner ports used unique, advanced and efficient cargo-handling equipment different from that used in Libyan ports.

The DEA-BCC illustrated that three of the Libyan ports were locally efficient when they were assessed under VRS. These ports were Brega, Tobruk and Derna. This was because these ports used the smallest amount of inputs compared to the other most efficient ports. The evidence supporting this is that these ports used ships’ cranes for cargo loading and off-loading operations and external trucks to transport containers from the ship’s side to the final destination, and vice versa. However, despite these ports being locally fully efficient, they had a low SE. This may mean that the global inefficiency of these ports as given by their CCR score is mainly attributable to disadvantageous port infrastructure and superstructure conditions. However, the Libyan ports exhibited increasing returns-to-scale. Therefore, these ports could expand their output using the same inputs if they establish some efficiency enhancing measures. These could include increasing the total working hours and using these hours efficiently, and introducing online services to accelerate paper work and cargo clearance procedures. It may also include minimising bureaucracy and preventing corruption.

All of the above influential factors might affect the performance of any port. However, as Libya is unique in its politics and economy, these two factors contribute heavily to ports underperforming. Politics and economy are two different sides of the same coin. Politically, Libya has been unstable globally and locally due to the aggressive political behaviour of the former leader Gaddafi (See chapter 2). This discouraged the creation of corridors between Libyan ports and neighbouring countries and prevented them from playing the potential role in the global supply chain.
Locally, as port activities rely mainly on the volume of trade handled by that port, Libyan ports are predominately used to handle import needs. Incorporating socialist ideals has led to a low trade capacity and reduction in the volume of cargo handled by Libyan ports as discussed in details in Chapter 2. The Libyan government has not had much impetus to invest in Libya’s ports, nor to deploy costly equipment and develop infrastructure, as not much trade has moved through the ports. However, despite the chronic problems with neighbouring countries, Libya can benefit from its strategic location and use its ports as hubs for container re-transhipment. Mismanagement, over-centralisation in decision making and monopoly practices have been the main obstacles.

In terms of management, most Libyan port managers and the heads of LMA were marine engineers or captains. The belief is that these people can operate ports efficiently, due to their seafaring experience. However, some of these managers are not from the maritime industry at all, and are in their position because they were loyalists supporting Gaddafi’s regime. In terms of decision making, most of the strategic decisions regarding port development have not been taken by the port authority or LMA, or in some cases by the Ministry of Transport. These strategic decisions have to be taken, or approved, by the highest authority in the country, which was the former president himself.

In terms of monopoly, the study found it had a negative impact on port performance; it also detected similarities between the Libyan ports in terms of performance indicators, except that Qasr Ahmed port differed slightly. This is because all Libyan ports are state owned, and they are operated by two public companies. In contrast, Qasr Ahmed port in Misurata is operated by MFZ Company, which has a level of autonomy. This port is relatively new and has some flexibility to purchase required equipment and improve its performance. The rest of Libya’s ports are operated by LPC. This has undermined competition, as these ports are operated by a centralised management with full bureaucracy among which miscommunication is rife. The LPC does not have a free hand to invest its capital and improve its ports’ capacities. This makes Qasr Ahmed port the top Libyan port in terms of service quality and throughput. This study has also confirmed that the existence of a monopoly is a major factor that has undermined the ability of Libyan ports to function efficiently.
8.2 Recommendations

One of the aims of this research was to provide recommendations to assist the key decision makers in Libya’s port industry to improve port performance. These recommendations have only focused on the port side, rather than on economic issues, land connectivity and trade productivity. Therefore, the following recommendations are:

1. Due to the growing demand for efficient ports, ports need to enhance their capacity to attract more users and increase throughput. From an economic perspective, efficient container handling at terminals is important in reducing transportation costs and maintaining shipping schedules, as well as maximising profits. Therefore, Libyan ports have to employ sophisticated and specialised handling equipment to enhance their performance and compete against neighbouring ports.

2. Despite the escalating demand for containerisation, Libyan ports are still operating as general cargo ports. Additionally, there is a severe lack of specialised container-handling equipment. Therefore, these ports need to assign some terminals as specialised container terminals, considering the water draft to attract ‘mother’ or mega container ships, storage yard areas and specialised and efficient container-handling equipment.

3. It was proved that centralised management is a vital factor preventing Libyan ports from acquiring efficiency. Therefore, giving Libyan ports autonomy minimises bureaucracy and gives the ports a free hand to invest, enhancing their capacity.

4. All of Libya’s ports are state owned and operated by the public sector. In addition, most Libyan ports are monopolised and operated by one company, LPC. The study showed that this public company is not able to operate all of these ports. Therefore, liberating these ports is crucial to increase competitiveness and performance.

5. The study has also determined that the domination of the public sector and its bureaucracy has created many problems that have undermined port
performance. These include corruption, nepotism and mismanagement. Without allowing private sector participation, the ports cannot afford adequate capital investment, sophisticated technologies and efficient private sector management systems. Therefore, the study highly recommends the involvement of the private sector to overcome all existing performance problems.

6. The study has also illustrated that the total working hours at Libyan ports are not enough to provide the required services to customers. Additionally, this time is not used efficiently. Therefore, applying a 24/7 working week schedule may improve port performance by minimising ship turnaround times and maximising throughput.

7. Most of the efficient and advanced ports use e-commerce and provide online services. However, Libyan ports do not provide such services. This increases bureaucracy and complicates business planning related to cargo clearing and ship arrivals and departures. Therefore, implementing online services is essential for performance optimisation.

8. This study recommends reviewing all port-related laws and regulations to rectify conflicts in the authorities and responsibilities of port authorities. Examples of these conflicts include the law number 21 of 1985, regarding the establishment of LPC.

8.3 Study Limitations and Further Research on Port Performance

It is worth pointing out that data collection generally was rather difficult for this study because of the political and civil instability in Libya at the time – a situation which continues to date. Although this does not necessarily undermine the findings in a significant way, more information could have been generated to make the analysis much richer.

This PhD research was a vertical study and discussed certain independent variables of Libyan port performance. However, this research did not cover all aspects of port performance, which will require separate analyses. This quantitative study relied on the general literature of port performance to extract relevant influential factors. It
also relied on the literature on Libya’s politics and economy to interpret the findings of this study. However, conducting a qualitative investigation may provide more insights and in-depth explanations of these findings. Nevertheless the analysis has made use of available general knowledge, in the literature and the author’s personal understanding of the prevailing political and socio-economic context to enrich the findings and conclusions. Other limitations are of note mainly relate to the analysis of the second phase of this study. Most of these limitations are related to data availability and accessibility. As such, these limitations are:

1. The study used secondary data to measure and compare the efficiency of Libyan ports using DEA. Despite the fact that these data were collected from credible organisations, the secondary data may not always be as accurate as desired. Therefore, the accuracy of efficiency analysis outcomes depends on the accuracy of the data used.

   The study used secondary data related to 2010, due to the unavailability of current data at the time of the study. This was because of the civil war in the country which broke out in 2011. However, including this latter data would have led to false conclusions since port performance at this time was greatly affected by the abnormal circumstances of the time. Therefore the absence of this data does not necessarily undermine the validity of the quality or findings. Despite the fact that many emails were sent to the targeted port authorities and operators, we had trouble in gathering information regarding the output variables, such as the number of ship calls, ship turnaround times, the capacity of cargo-handling equipment and cargo loading and off-loading rates. Due to these difficulties, only container throughput was considered as an output variable to measure the efficiency of Libyan ports. Therefore, this study is considered a partial evaluation, due to the unavailability of some required data.

2. Each port uses a different type of handling equipment with different specifications. Therefore, the performance of each type of equipment could vary compared to others. However, to obtain homogenous data, the handling equipment was categorised into three groups. These groups are: seaside cranes, transport equipment and stacking equipment.
3. The DEA analysis was used to establish ranking relationships and measure the efficiency scores of the sample ports, using a number of variables derived from the descriptive analysis. These variables were used as one set to evaluate efficiency. However, they were not monopolised to determine the effect of each individual variable on Libyan port efficiency.

4. Most Libyan ports use ships’ cranes for cargo-handling operations, which contributes to the total throughput. However, the number of ships’ cranes has not been included in the DEA analysis, as these cranes do not belong to the ports. This may influence the accuracy of the results.

To enrich the literature on Libyan port performance, the following points can be made with reference to further research:

1. The stakeholders of Libyan ports vary and include local and international stakeholders. This study involved only local stakeholders and excluded international ones. The latter may have different perceptions of the variables included in this study. Therefore, conducting a study involving international stakeholders may either support this study or lead to quite different results.

2. This study included specific variables related to port infrastructure and superstructure to measure Libyan port performance and efficiency. This is because the new generations of mega container ships are served by a very small number of container ports, due to some infrastructure and superstructure constraints. However, Libyan port performance is influenced by some other factors, such as existing local laws and regulations, human resources, congestion, the national economy, external politics and the volume of international trade. The effects of all these factors on Libyan ports are not well investigated. Therefore, studying all of these factors in the future will contribute to the literature.
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Appendices

Appendix 1: Research Questionnaire

Dear respondent. This survey is an aid of a study which seeks to examine the competitiveness of Libyan ports. The ports industry is critical to efficient trade and regional economic development, hence it is important to identify the barriers that undermine the competitiveness of Libyan ports from the perspective of local users, in order to provide recommendations for LMA and both Libyan ports’ operators and authority to enhance ports’ competitiveness. The study consists of two sections which are: general information about your experience and your organisation as well as your perspective about the determinants of ports’ performance, which are closely associated with ports’ competitiveness. The survey should take less than 15 minutes to complete. Your assistance in this regard is of great importance and is highly appreciated by the researchers. Thank you.

Q 1. In what type of organisations are you employed?

- Libyan Maritime Administration (1)
- Port Authority (2)
- Port operator (3)
- Shipping company (4)
- Freight Forwarder (5)
- Carrier (6)
- Sea farer (7)
- Trade Union (8)
- Other (Please specify) (9) ____________________

Q 2. What is your position in this organisation?

- Head/ CEO/ Director/ Chairman (1)
- Department Manager (2)
- Superintendent (3)
- Coordinator (4)
Q 3. How long have you worked in this position?

- Less than a year (1)
- 1 to 5 years (2)
- 5–10 years (3)
- 10–15 years (4)
- 15 years or above (5)

Q 4. Please specify which sector your organisation falls in?

- Private sector (1)
- Public sector (2)

Q 5. Does the public sector monopoly in Libyan ports undermine service quality? Please rank your opinion?

- Strongly undermine (1)
- Undermine (2)
- No influence (3)
- Strengthen (4)
- Strongly strengthen (5)

Ports have to offer a variety of activities aimed at generating value for customers and making the customers satisfied in order to win their loyalty. Therefore, meeting customer requirements, which are different from one user to another, is an important determinant for attracting more users. These requirements could be related to the cost, time or/and the level of services provided.
Q 6. Please indicate the importance of the following determinants of ports’ customer requirements based on the scale provided.

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Not at all Important</th>
<th>Very Unimportant</th>
<th>Somewhat Unimportant</th>
<th>Neither Important nor Unimportant</th>
<th>Somewhat Important</th>
<th>Very Important</th>
<th>Extremely Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cargo loading and off-loading to and from the ship</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Cargo delivery</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Ships’ scheduling</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. The competency of port labours</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>5. Online service</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>6. Cargo damage</td>
<td>○</td>
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<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. Cargo loss</td>
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<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>8. Sea side accessibility</td>
<td>○</td>
<td>○</td>
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<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>9. Land side accessibility (Gate, road &amp; rail transport)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>10. Cargo-handling facilities</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>11. Port efficiency</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>12. Berth availability</td>
<td>○</td>
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<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>13. Total cargo-handling time</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>14. Ship’s turnaround time</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>15. Level of services for fresh water, bunkering and provisions</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>16. Cargo-handling fee</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>17. Free cargo dwell time</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>18. Customs clearance fee</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>19. Customs clearance process</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>20. Inland transport cost</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>21. Other (Please specify)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Q 7. Would you rank the following Libyan ports based on the level of their services? Where 1 illustrates the top port in terms of meeting customer requirements. Choose from the list below.

<table>
<thead>
<tr>
<th></th>
<th>The first port</th>
<th>The second port</th>
<th>The third port</th>
<th>The fourth port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripoli port</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Benghazi port</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Qasr Ahmed port</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Khoms port</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

Service port service consists of a number of elements which reflect the level of service provided to its users. These include port accessibility from seaside and landside, reliability, information and flexibility, all of which influence customer preference for a port. Please answer the following questions related to port service criteria.

Q 8. Port accessibility. Port accessibility refers to the ability of a port to be reached for efficient cargo movement to and from it. This includes the ability of a port to provide sufficient water depth and berths to ensure safe access and docking for the inbound and outbound ships. It is also related to port gates, roads and rail networks in the landside. To what extent do you agree or disagree with the following statements? Where 0 means absolutely disagree and 5 means absolutely agree.

<table>
<thead>
<tr>
<th></th>
<th>Tripoli</th>
<th>Benghazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Port’s water depth meets the demand of larger ships.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>2. Berth length is suitable to accommodate larger ships.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>3. The number of lanes of port’s gate undermines the cargo flow to and from the port.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>4. The existing road networks are suitable for hinterland transport if the demand for Libyan ports increased.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>5. Integrated rail networks are needed to increase cargo flow and reduce transport cost.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>
Q 9. Port reliability. Briefly, reliability refers to how stable, dependable, trustworthy, and consistent the port is. To what extent do you agree or disagree with the following statements? Where 0 means absolutely disagree and 5 means absolutely agree.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Tripoli</th>
<th>Benghazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The port can provide some special handling services, such as handling heavy weight containers, different container sizes etc.?</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. The quality and quantity of used transport vehicles can meet the potential demand for containerisation in Libyan ports.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. The used stacking equipment (reach stacker, forklift, SCs, gantry crane etc) can meet the potential demand for containerisation in Libyan ports.</td>
<td>○</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>4. Cargo clearance process is efficient.</td>
<td>○</td>
<td>○</td>
<td>○</td>
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</tr>
<tr>
<td>5. Cargo delivery time is reasonable.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. Ships’ schedules in port are accurate.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. The quantity and quality of used cranes are optimal to deal with the inbound container ships.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>8. The quantity and quality of used cranes are optimal to deal with the potential demand for containerisation.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Q 10. Service quality. Briefly, it shows how well a delivered service conforms to the client’s expectations. To what extent do you agree or disagree with the following statements? Where 0 means absolutely disagree and 5 means absolutely agree.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Tripoli</th>
<th>Benghazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Customs service is complicated and corrupted.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Settlement of accident claims in port is easy.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The quality and quantity of used transport and transfer equipment in the port are sufficient and efficient for good port performance. (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. The used stacking equipment provide efficient cargo stacking and retrieving service. (4)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Q 11. Information system. Please indicate the level of meeting between the following online services and customer demand. Where 0 means absolutely does not meet the demand and 5 means absolutely meets the demand.

<table>
<thead>
<tr>
<th></th>
<th>Tripoli</th>
<th>Benghazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Online customs service.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Online information accessibility for port users for cargo tracking.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Online information accessibility for port users to track ships’ movement.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Online transactions.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Q 12. Safety. Please estimate the likelihood of the following safety issues, where 0 denotes less likely and 5 denotes more likely.

<table>
<thead>
<tr>
<th></th>
<th>Tripoli</th>
<th>Benghazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Frequency of cargo loss.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Frequency of cargo damage.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. The level of safety awareness for port's personnel.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Flexibility of port operations. A port has to have flexibility to provide a range of service ‘products’ for different customers in a reasonable window of time using a variety of resources.

Q 13. Availability. To what extent do you agree or disagree with the following statements related to availability. Where 0 means absolutely disagree and 5 means absolutely agree.

<table>
<thead>
<tr>
<th></th>
<th>Tripoli</th>
<th>Benghazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Availability of berthing on arrival for the inbound ships.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Sufficient and effective cargo-handling equipment.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Q 14. Time. To what extent do you agree or disagree with the following statements related to time. Where 0 means absolutely disagree and 5 means absolutely agree.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Tripoli</th>
<th>Bengazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The available cranes lead to reasonable ship turnaround time.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2. Port working hours are sufficient.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. The actual working time is efficiently used without any idle time.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Q 15. Product. To what extent do you agree or disagree with the following statements related to the product. Where 0 means absolutely disagree and 5 means absolutely agree.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Tripoli</th>
<th>Bengazi</th>
<th>Misurata</th>
<th>Khoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The space of storage yards is enough for the volume of cargo/containers that is dedicated to the local market.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2. The space of storage yards is able to absorb the cargo/container volume dedicated to international transshipment and local market.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. The quality and quantity of the transport vehicles used is sufficient to deal efficiently with the volume of cargo handled by Libyan ports.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4. The quality and quantity of transport vehicles used can meet the potential demand for containerisation in the Libyan ports.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5. The available seaside cranes are efficient to provide good quality service to the inbound ships.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Appendix 2: The Importance of Performance Measurements to Local Stakeholders.

<table>
<thead>
<tr>
<th>Competitive component</th>
<th>LMA</th>
<th>Port authority</th>
<th>Port operator</th>
<th>Shipping company</th>
<th>Freight forwarder</th>
<th>Carrier</th>
<th>Sea farer</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Description</td>
<td>6.25</td>
<td>0.754</td>
<td>5.88</td>
<td>1.12</td>
<td>5.33</td>
<td>0.707</td>
<td>5.67</td>
<td>1.225</td>
<td>6.38</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>Berth availability</td>
<td>6.42</td>
<td>0.515</td>
<td>6.38</td>
<td>1.40</td>
<td>6.00</td>
<td>1.80</td>
<td>6.33</td>
<td>1.118</td>
<td>6.44</td>
</tr>
<tr>
<td>Total cargo-handling time</td>
<td>6.67</td>
<td>0.492</td>
<td>6.88</td>
<td>0.354</td>
<td>5.78</td>
<td>1.64</td>
<td>6.22</td>
<td>1.093</td>
<td>6.89</td>
</tr>
<tr>
<td>Ship’s turnaround time</td>
<td>6.33</td>
<td>0.778</td>
<td>6.75</td>
<td>0.463</td>
<td>5.63</td>
<td>1.99</td>
<td>6.22</td>
<td>0.972</td>
<td>6.67</td>
</tr>
<tr>
<td>Level of services for fresh water,</td>
<td>5.67</td>
<td>0.778</td>
<td>5.00</td>
<td>2.26</td>
<td>4.63</td>
<td>1.68</td>
<td>5.33</td>
<td>1.732</td>
<td>5.22</td>
</tr>
<tr>
<td>bunkering and provisions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cargo-handling fee</td>
<td>6.00</td>
<td>0.739</td>
<td>5.25</td>
<td>2.05</td>
<td>5.33</td>
<td>0.707</td>
<td>5.78</td>
<td>1.202</td>
<td>5.22</td>
</tr>
<tr>
<td>Free cargo dwell time</td>
<td>5.83</td>
<td>0.718</td>
<td>6.13</td>
<td>0.835</td>
<td>5.00</td>
<td>1.30</td>
<td>5.67</td>
<td>1.414</td>
<td>5.44</td>
</tr>
<tr>
<td>Customs clearance fee</td>
<td>5.83</td>
<td>0.718</td>
<td>4.63</td>
<td>2.38</td>
<td>5.44</td>
<td>0.726</td>
<td>5.22</td>
<td>1.856</td>
<td>5.78</td>
</tr>
<tr>
<td>Customs clearance process</td>
<td>6.33</td>
<td>0.778</td>
<td>4.86</td>
<td>2.03</td>
<td>5.56</td>
<td>1.33</td>
<td>6.13</td>
<td>0.641</td>
<td>6.33</td>
</tr>
<tr>
<td>Inland transport cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>