PORT OPERATIONS,
PLANNING AND LOGISTICS
LLOYD'S PRACTICAL SHIPPING GUIDES

*The Handbook of Maritime Economics and Business*
Costas Th. Grammenos
(2002)

*Maritime Law*
6th edition
Chris Hill
(2004)

*ISM Code: A Practical Guide to the Legal Insurance Implications*
2nd edition
Dr Phil Anderson
(2005)

*Risk Management in Port Operations, Logistics and Supply Chain Security*
Khalid Bichou, Michael G.H. Bell and Andrew Evans
(2007)

*Port Management and Operations*
3rd edition
Professor Patrick M. Alderton
(2008)

*Introduction to Marine Cargo Management*
J. Mark Rowbotham
(2008)

*Steel Carriage by Sea*
5th edition
A. Sparks and F. Coppers
(2009)
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>About the Author</td>
<td>ix</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xv</td>
</tr>
<tr>
<td>CHAPTER 1 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1. Ports and the maritime business</td>
<td>2</td>
</tr>
<tr>
<td>2. Multi-disciplinary approaches to port operations and management</td>
<td>11</td>
</tr>
<tr>
<td>3. Rationale of the book</td>
<td>28</td>
</tr>
<tr>
<td>CHAPTER 2 PORT ORGANISATION AND DEVELOPMENT</td>
<td>31</td>
</tr>
<tr>
<td>1. Port roles and functions</td>
<td>31</td>
</tr>
<tr>
<td>2. Port institutional and organisational structure</td>
<td>36</td>
</tr>
<tr>
<td>3. Port development</td>
<td>41</td>
</tr>
<tr>
<td>CHAPTER 3 PORT PLANNING</td>
<td>51</td>
</tr>
<tr>
<td>1. Capacity planning</td>
<td>53</td>
</tr>
<tr>
<td>2. Capacity management</td>
<td>67</td>
</tr>
<tr>
<td>CHAPTER 4 PORT INVESTMENT AND FINANCE</td>
<td>79</td>
</tr>
<tr>
<td>1. Financial statements and ratio measures</td>
<td>79</td>
</tr>
<tr>
<td>2. Port costs and costing</td>
<td>83</td>
</tr>
<tr>
<td>3. Economic versus commercial appraisal of port investments</td>
<td>97</td>
</tr>
<tr>
<td>4. Port financing and private sector participation</td>
<td>107</td>
</tr>
</tbody>
</table>
CHAPTER 5 PORT PRICING 121
1. Port pricing strategies 121
2. Port pricing in practice 125
Appendix 1. Salalah Container Terminal Tariffs 127

CHAPTER 6 PORT OPERATIONS 135
1. The quay site 136
2. Yard and gate systems 142
3. Modelling terminal operations 144
4. Integrating terminal operations 159

CHAPTER 7 PORT PERFORMANCE AND BENCHMARKING 161
1. Metrics and productivity index methods 161
2. Frontier approach 168
3. Process approaches 182
4. Conclusion—benchmarking methods 184

CHAPTER 8 INFORMATION AND COMMUNICATION TECHNOLOGIES IN PORTS 195
1. Software and communication platforms 196
2. Automatic identification and data capture 199

CHAPTER 9 PORT COMPETITION AND MARKETING 205
1. Features and elements of port competition 205
2. Port promotion and marketing 222

CHAPTER 10 PORT LOGISTICS 225
1. Ports and logistics systems 225
2. Ports and supply chain networks 239
## CHAPTER 11 PORT SAFETY

1. System's safety for risk assessment and management
2. Risks and safety indicators
3. Valuing port safety

## CHAPTER 12 PORT SECURITY

1. Scope and nature of security threats to ports
2. Overview of port security programmes
3. Risk approach to port security
4. Economic evaluation of port security measures

Appendix 1. ISPS Port Facility Security Equipment Checklist
Appendix 2. N-RAT Assessment Exercise Report

## CHAPTER 13 PORT ENVIRONMENTAL MANAGEMENT

1. Environmental principles of port operations
2. Principles and procedures of environmental management in ports

## CHAPTER 14 PORT LABOUR AND HUMAN RESOURCE MANAGEMENT

1. History and organisation of port labour
2. Port training and education
3. HR systems and job types in ports

References and Further Reading
Index
Dr Khalid Bichou is a transport logistics and port consultant and is the co-founder of the Port Operations Research and Technology Centre (PORTeC) at Imperial College London. He has over 17 years of international experience in the port, maritime, transport and logistics industries including periods in senior positions and as Consultant and Adviser to global operators, financial institutions, governments and international agencies. His expertise spans port and maritime operations, transport economics and infrastructure, freight and distribution logistics, trade facilitation and supply chain security.

Following a career which has included periods as Transport Economist in a global shipping company, Transport Investment Analyst in a European bank, Head of Strategy and Business Development in two Nordic ports, Head of Port Infrastructure and Investment in a governmental agency, Director of Ports and Maritime Administration, and Senior Port and Transport Logistics Specialist in two international agencies, he has operated for the last five years as an Independent Consultant. He has been involved in around 40 consultancy projects and advisory services in over 32 countries. He has also been active in professional training and capacity building and has designed and delivered over 25 training courses and seminars for the maritime, transport and logistics industries.

He is a chartered member of the Institute of Transport and Logistics, Director of Logistics-Ports and Maritime at AVCONET, International Advisor to the Supply Chain and Logistics Group, and member and adviser of several other professional and academic associations in the field. He was recently appointed Specialist Port Adviser to the UK House of Commons and Transport Logistics Adviser to the EU Parliament. He has published two books and over 30 papers and policy reports. He is visiting academic and lecturer at several universities and research institutions, both in the UK and abroad.
This page intentionally left blank
# List of Figures

## Chapter 1
- Figure 1.1: Selection of ports and terminals  
  Page 6
- Figure 1.2: Main agents and intermediaries in international shipping  
  Page 7
- Figure 1.3: Description of selected operational patterns of liner shipping  
  Page 9
- Figure 1.4: Scope of this book  
  Page 28

## Chapter 2
- Figure 2.1: Main operational and administrative functions of a port  
  Page 35
- Figure 2.2: Variations of functional roles and institutional models across different port services and facilities  
  Page 41
- Figure 2.3: The ports of Marseille and Antwerp in the years 1575 and 1650 respectively  
  Page 43
- Figure 2.4: UNCTAD’s port generations model  
  Page 44

## Chapter 3
- Figure 3.1: Illustration of different definitions of port capacity  
  Page 52
- Figure 3.2: The process of a general framework for port demand and traffic forecasting  
  Page 57
- Figure 3.3: Illustration of the trade-off between ship and port costs  
  Page 66
- Figure 3.4: Elements of a contractual review between ports and shipping lines  
  Page 67
- Figure 3.5: Process and elements of strategic port planning  
  Page 68
- Figure 3.6: A simplified approach for port planning and development  
  Page 69
- Figure 3.7: Container identification in the ship  
  Page 70
- Figure 3.8: The VTS operation room of the port of Dover  
  Page 72
- Figure 3.9: Container identification in the yard  
  Page 76
- Figure 3.10: A demand approach for estimating CY and terminal requirements  
  Page 77

## Chapter 4
- Figure 4.1: Illustration of fixed, variable, average, marginal and total costs  
  Page 84
- Figure 4.2: Example of an ABC application  
  Page 87
- Figure 4.3: A model for cost control and distribution across port supply chain components  
  Page 88
- Figure 4.4: Transport cost, shipment size, and mode choice  
  Page 90
- Figure 4.5: Modal shift assumptions in the MDS container demand study  
  Page 91
# List of Figures

| Figure 4.6: | Typical cost structure of container shipping | 92 |
| Figure 4.7: | Inclusion of handling and friction costs | 93 |
| Figure 4.8: | Operating cost of an 8000 TEU container-ship | 94 |
| Figure 4.9: | Illustration of waiting time (Adapted from Bell, 2007) | 95 |
| Figure 4.10: | Top 10 commodity groups ranked by value per ton | 96 |
| Figure 4.11: | Main components of a tender document | 118 |
| Figure 4.12: | General clauses in a typical tender document | 119 |

## Chapter 5

| Figure 5.1: | Illustration of short-term and long-term marginal costs | 122 |
| Figure 5.2: | Interplay between SRMC and variations in port demand | 123 |
| Figure 5.3: | Illustration of the congestion pricing | 124 |

## Chapter 6

| Figure 6.1: | Container terminal sites and main handling equipment | 137 |
| Figure 6.2: | Quay site operations for selected ports and terminals | 138 |
| Figure 6.3: | Illustration of lifting capabilities of modern STS cranes | 141 |
| Figure 6.4: | Main cranes and handling equipment used in the yard | 143 |
| Figure 6.5: | Selected yard layout and cargo handling configurations | 143 |
| Figure 6.6: | Sample layout of tractor-chassis (wheeled) system | 147 |
| Figure 6.7: | Sample layout of straddle carrier direct system | 148 |
| Figure 6.8: | Sample layout of straddle carrier relay system | 149 |
| Figure 6.9: | Sample layout of RTG system | 150 |
| Figure 6.10: | Sample layout of RMG system | 151 |
| Figure 6.11: | Illustration of NISAC port operations simulator diagram | 155 |
| Figure 6.12: | IDEF0 model for import container’s flow | 156 |
| Figure 6.13: | IDEF0 model for export container’s flow | 157 |
| Figure 6.14: | IDEF0 model for transhipment container’s flow | 157 |
| Figure 6.15: | Illustration of operational bottlenecks in container terminal operating systems | 160 |

## Chapter 7

| Figure 7.1: | Graphical illustration of frontier methodologies | 170 |
| Figure 7.2: | DEA production frontier under the single input and single output scenario | 175 |
| Figure 7.3a: | Illustration of DEA input orientation (excluding the effect of technological change). (b) Illustration of DEA output orientation (excluding the effect of technological change) | 176 |
| Figure 7.4: | Linear cause-and-effect BSC relationships | 184 |
| Figure 7.5: | Basic matrix of performance–ratio dimensions | 188 |
### List of Figures

<table>
<thead>
<tr>
<th>Chapter 8</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 8.1</td>
<td>199</td>
</tr>
<tr>
<td>Figure 8.2</td>
<td>200</td>
</tr>
<tr>
<td>Figure 8.3</td>
<td>202</td>
</tr>
<tr>
<td>Figure 8.4</td>
<td>204</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 9</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 9.1</td>
<td>206</td>
</tr>
<tr>
<td>Figure 9.2</td>
<td>208</td>
</tr>
<tr>
<td>Figure 9.3</td>
<td>210</td>
</tr>
<tr>
<td>Figure 9.4</td>
<td>214</td>
</tr>
<tr>
<td>Figure 9.5</td>
<td>214</td>
</tr>
<tr>
<td>Figure 9.6</td>
<td>218</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 10</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 10.1</td>
<td>229</td>
</tr>
<tr>
<td>Figure 10.2</td>
<td>232</td>
</tr>
<tr>
<td>Figure 10.3</td>
<td>237</td>
</tr>
<tr>
<td>Figure 10.4</td>
<td>239</td>
</tr>
<tr>
<td>Figure 10.5</td>
<td>241</td>
</tr>
<tr>
<td>Figure 10.6</td>
<td>242</td>
</tr>
<tr>
<td>Figure 10.7</td>
<td>244</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 11</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 11.1</td>
<td>248</td>
</tr>
<tr>
<td>Figure 11.2</td>
<td>249</td>
</tr>
<tr>
<td>Figure 11.3</td>
<td>250</td>
</tr>
<tr>
<td>Figure 11.4</td>
<td>251</td>
</tr>
<tr>
<td>Figure 11.5</td>
<td>251</td>
</tr>
<tr>
<td>Figure 11.6</td>
<td>258</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 12</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 12.1</td>
<td>269</td>
</tr>
<tr>
<td>Figure 12.2</td>
<td>270</td>
</tr>
<tr>
<td>Figure 12.3</td>
<td>274</td>
</tr>
<tr>
<td>Figure 12.4</td>
<td>275</td>
</tr>
<tr>
<td>Figure 12.5</td>
<td>276</td>
</tr>
</tbody>
</table>
xiv  List of Figures

Figure 12.6:  Hierarchy of security measures by level of security and network coverage  281
Figure 12.7:  The Booz Allen Hamilton’s port security war game simulation  287

Chapter 14
Figure 14.1:  Examples of port jobs requiring NVQ qualifications  320
Figure 14.2:  Organisation of Tanjung Pelepas container terminal (with consent from APMT)  325
Figure 14.3:  APMT detailed description of the operations manager’s tasks  326
LIST OF TABLES

Chapter 1
Table 1.1: Growth of world seaborne trade in million tons 3
Table 1.2: Growth of world container seaborne trade and throughput in million EUs 3
Table 1.3: International classification of ships 4
Table 1.4: Different classifications of ports 11

Chapter 2
Table 2.1: Breakdown of port functions by type of assets and facilities 35
Table 2.2: Generic institutional port models 38
Table 2.3: Description, strengths and weaknesses of port institutional models 39
Table 2.4: The role of decisive factors in determining port approaches 46

Chapter 3
Table 3.1: Different types of port planning 53
Table 3.2: Determinants of the demand and supply of port capacity 54
Table 3.3: Summary of freight modelling approaches and techniques 55
Table 3.4: Output of the studies: main decision factors for port selection 60
Table 3.5: Characteristics of previous port choice studies 62
Table 3.6: Overall model structure 63
Table 3.7: Congestion factor in $M/E/n$ queue 74
Table 3.8: Congestion factor in $E/E/2$ queue 75
Table 3.9: Typical cargo stowage factors 76

Chapter 4
Table 4.1: Disaggregation of container-terminal capital and operating costs 85
Table 4.2: Comparison between different freight transportation systems 90
Table 4.3: Basis of economic valuation of project outputs and inputs 98
Table 4.4: Mass calculation methods to assess port impacts on the economy 101
Table 4.5: Price-to-equity ratio and investment trends in ports and terminals 108
Table 4.6: Pros and cons of PPPs 110
Table 4.7: Framework of PPP procedure and component 114

Chapter 5
Table 5.1: Ratio $K$ and proportion of port dues for Ro-Ro and container vessels in the port of Marseille 127
List of Tables

Chapter 6
Table 6.1: Different infrastructure and equipment of quay site systems 136
Table 6.2: Types and characteristics of modern STS cranes 139
Table 6.3: Relationship between container-ship size and requirements for STS cranes 140
Table 6.4: Relationship between STS crane (and below) speed and productivity — data based on average productivity of 25–30 moves per hour 141
Table 6.5: Relationship between STS crane productivity and vessel turnaround time 141
Table 6.6: Operational characteristics of major container yard handling systems 145
Table 6.7: Comparing the benefits of mathematical modelling versus simulation 153
Table 6.8: Selected industrial container terminal simulation tools 154
Table 6.9: Sample solutions for enhancing berth and yard productivity 155

Chapter 7
Table 7.1: Main benchmarking techniques 162
Table 7.2: Components and weighting of CTQI 185
Table 7.3: Characteristics of a good performance measure 187
Table 7.4: Sample of port metrics and their corresponding performance dimensions 189
Table 7.5: Controllable and uncontrollable factors in port operations and management 191
Table 7.6: Various approaches to ports and their corresponding performance models 192

Chapter 8
Table 8.1: Summary of information categories used in port operations and management 196
Table 8.2: Benefits of EDI 197
Table 8.3: EDIFACT messages used in planning berth and loading-unloading operations 198
Table 8.4: OCR uses and benefits 201
Table 8.5: Types of RFID tags 203
Table 8.6: Usage and benefits of RFID tags 203

Chapter 9
Table 9.1: Main components of PEST analysis 213
Table 9.2: Example of factors behind market power 215
Table 9.3: Top five container terminal operators in 2008 and 2007 217
Table 9.4: Advantages and disadvantages of shipping line participation in ports 219
Table 9.5: Tools of promotional mix 223
Chapter 10
Table 10.1: Major types of road freight vehicles and equipment 226
Table 10.2: Basic rail wagon types 228
Table 10.3: Main routing strategies for freight rail services 228
Table 10.4: Characteristics of dry cargo containers 230
Table 10.5: Main Europe-Asia railway routes 232
Table 10.6: Reasons for holding inventory 234
Table 10.7: Advantages of Freeport zones 235

Chapter 11
Table 11.1: Major hazard analysis tools 248
Table 11.2: Recent statistics of UK port accidents 253
Table 11.3: Fatal occupational injuries in US ports in 2007 254
Table 11.4: Casualties in cargo handling accidents in Hong Kong 2008 255
Table 11.5: Hazards associated with cargo types and operations 256

Chapter 12
Table 12.1: Outline of ISPS code and selected US-led port and maritime security measures 264
Table 12.2: Standard ship’s ISPS pre-arrival information pro-forma in UK ports 266
Table 12.3: Active participating ports in the US CSI as of 30/03/2007 267
Table 12.4: Data required for electronic reporting under the US 24-hour rule 268
Table 12.5: The CBP enrolment categories for C-TPAT participation 271
Table 12.6: Errors resulting from the interplay between threshold settings and event reporting 277
Table 12.7: Potential errors from implementing the 24-hour rule 279
Table 12.8: Summary of ISPS ex ante cost estimates as computed by various regulatory risk assessment impacts 283
Table 12.9: Sample of container ports’ security charges 288

Chapter 13
Table 13.1: Environmental factors and impacts in ports 308
Table 13.2: Category of pollution in ports 309
Table 13.3: Top ten environmental issues as identified by EU ports 309
Table 13.4: Tools and objectives of CAAP 312
Table 13.5: Regulations and procedures on ship’s emissions 312
Table 13.6: Regulations and procedures on ship’s waste and reception facilities in ports 314
Table 13.7: General framework for an EIA port project 315
xviii  List of Tables

Chapter 14

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1</td>
<td>Port job losses in the UK, the US and Australia</td>
<td>318</td>
</tr>
<tr>
<td>14.2</td>
<td>Redundancy compensation of port workers in selected countries</td>
<td>318</td>
</tr>
<tr>
<td>14.3</td>
<td>Comparison between the cost and productivity of French port workers between 1985 and 1997</td>
<td>318</td>
</tr>
<tr>
<td>14.4</td>
<td>List of PDP units</td>
<td>321</td>
</tr>
<tr>
<td>14.5</td>
<td>Example of postgraduate taught courses in port management in the UK</td>
<td>322</td>
</tr>
<tr>
<td>14.6</td>
<td>Outline of GTDP modules</td>
<td>323</td>
</tr>
<tr>
<td>14.7</td>
<td>Categories of port job employment in the UK</td>
<td>324</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Ports are critical infrastructure resources and serve a key role in the transportation of freight and people. With more than 80% of international trade by volume being carried by sea, ports are vital for seaborne trade and international commerce. Ports are the critical nodal interfaces where maritime transport connects with other modes of transport and where trading, distribution and logistics activities can take place. Efficient port operations significantly lower maritime and trade costs whereas delays in ports impose costs on logistics and supply chains through the cost of warehousing and inventory. Ports also serve as economic catalysts for the markets and regions they serve, where the aggregation of port services and activities generates socio-economic wealth and benefits.

There are no confirmed statistics on the number of ports in the world. Some sources estimate the total figure to vary between 2,000 and 30,000 ports and terminal facilities. In 2008, it was estimated that world ports handled over 8 billion tons of international seaborne trade of goods loaded (UNCTAD, 2008). Because of trade imbalances, transshipment practices and other operational considerations, the global port throughput and handling activity would have exceeded the volume of seaborne trade. For instance, 143 million twenty-foot equivalent units (TEUs) were handled by world ports and terminals for an estimated 1.24 billion tons of global container trade in 2007 (UNCTAD, 2008).

A port can range from a small quay for berthing a ship to a very large-scale centre with many terminals and a cluster of industries and services. Ports are dissimilar in their assets, operations, roles and functions, and even within a single port the activities and services performed are, or could be, broad in scope and nature. This situation has led to a variety of operational, management, organisational and institutional approaches to ports, and it is almost impossible to find a worldwide uniform definition for them. There is indeed a variety of terms describing ports such as interfaces between sea and land, nodes in the multimodal and inter-modal transport network, distribution and logistics centres, maritime gateways and corridors, distriparks and maritime clusters, and free zones and trading hubs.
2 Introduction

Ports are not just seaports. In some countries such as the USA, the term port usually includes airports and sometimes inter-modal facilities such as railway and road connections. Today, ports are not only a transfer point between sea and land but also serve as distribution, logistics and production centres. Ports can also serve leisure, fishing and/or military ships, thus deviating from traditional commercial cargo-ship activities. In some ports, non-sea-related activities can also fall under the wider definition of ports. For instance, dry ports are inland logistics centres not directly linked to sea or waterway connections. For the purposes of this book, we will restrict most of our discussion to the seaport, hereafter simply called the port, and defined as:

“The interface between land and a sea or a waterway connection providing facilities and services to commercial ships and their cargo, as well as the associated multimodal, distribution and logistics activities.”

1 PORTS AND THE MARITIME BUSINESS

Traditionally, ports have been regarded as a sub-system of the shipping and maritime industry, with their main roles being restricted to the provision of services to ships and their cargoes. Shipping or maritime business is mainly concerned with the transport of goods by sea and/or waterway connections. The economic approach treats maritime transport as a derived demand from international trade. The term shipping is a generic term often used interchangeably, and may be reduced to the sole provision of sea transportation or expanded to the provision of other logistics and trading services. Shipping markets may be divided into four main segments:

- the freight market: trades sea transport,
- the new building market: trades new ships,
- the sales and purchase market: trades second hand ships, and
- the demolition or scrap market: trades old and obsolete ships.

Shipping services are usually determined by the nature of trade, or traffic, and more specifically by the type of cargo or commodity transported. The term commodity is frequently used in international shipping and port management, and denotes situations where there is little qualitative difference between the products of different suppliers. Unlike branded products, the markets of commodity products have little or no differentiation between them and are considered equivalent regardless of their supply base. Examples of commodity products include basic bulk products such as oil, grain, coal and iron ore. In shipping and ports, many segments run the risk of commoditisation, for instance, in the case of container shipping and transhipment terminals. This has several implications on the competitive, pricing and marketing strategies of shipping and port services.
Typically, seaborne trade is categorised into bulk, break-bulk and general cargo trades, and this categorisation has also been used to classify different types of ships (see Table 1.3). Other criteria for ship classification include type of packaging (e.g., containers: containerships; trailers: roll-on roll-off or Ro-Ro ships); ship’s size (e.g., Panamax versus post-Panamax vessels, very large crude carriers (VLCC) versus ultra-large crude carriers (ULCC)); technological specifications (e.g., conventional versus cellular containerships, single-deck...
4 Introduction

versus double-deck ships); and safety and security records (eg safety class for vessels, ISPS ship security levels).

As with a ship’s specialisation, modern port layout and operating systems are increasingly designed to serve a particular trade, ship or cargo type, although many ports around the world still operate multipurpose facilities. For instance,

Table 1.3: International classification of ships

<table>
<thead>
<tr>
<th>Merchant ships</th>
<th>Non-ship structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naval and military crafts</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Oil tanker</td>
</tr>
<tr>
<td></td>
<td>Crude oil</td>
</tr>
<tr>
<td></td>
<td>Crude products</td>
</tr>
<tr>
<td></td>
<td>Oil products</td>
</tr>
<tr>
<td></td>
<td>Oil/chemical</td>
</tr>
<tr>
<td>2</td>
<td>Chemical tanker</td>
</tr>
<tr>
<td>3</td>
<td>Liquefied gas carrier</td>
</tr>
<tr>
<td></td>
<td>LNG</td>
</tr>
<tr>
<td></td>
<td>LPG</td>
</tr>
<tr>
<td></td>
<td>Other liquefied</td>
</tr>
<tr>
<td>4</td>
<td>Tank barge</td>
</tr>
<tr>
<td></td>
<td>Single hull</td>
</tr>
<tr>
<td></td>
<td>Double hull</td>
</tr>
<tr>
<td></td>
<td>Double-side</td>
</tr>
<tr>
<td></td>
<td>Double-bottom</td>
</tr>
<tr>
<td></td>
<td>Other tank barge</td>
</tr>
<tr>
<td>5</td>
<td>Other tanker</td>
</tr>
<tr>
<td></td>
<td>Asphalt, bitumen</td>
</tr>
<tr>
<td></td>
<td>Molasses</td>
</tr>
<tr>
<td></td>
<td>Vegetable oil</td>
</tr>
<tr>
<td></td>
<td>Other tankers</td>
</tr>
<tr>
<td>6</td>
<td>Bulk/oil carrier</td>
</tr>
<tr>
<td></td>
<td>Ore/bulk/oil</td>
</tr>
<tr>
<td></td>
<td>Ore/oil</td>
</tr>
<tr>
<td></td>
<td>Bulk/oil</td>
</tr>
<tr>
<td>7</td>
<td>Bulk carrier</td>
</tr>
<tr>
<td></td>
<td>Ore</td>
</tr>
<tr>
<td></td>
<td>Bulk/container</td>
</tr>
<tr>
<td></td>
<td>Other bulk</td>
</tr>
<tr>
<td>8</td>
<td>Specialised carrier</td>
</tr>
<tr>
<td></td>
<td>Barge carrier</td>
</tr>
<tr>
<td></td>
<td>Chemical carrier</td>
</tr>
<tr>
<td></td>
<td>Irradiated fuel carrier</td>
</tr>
<tr>
<td></td>
<td>Livestock carrier</td>
</tr>
<tr>
<td></td>
<td>Other specialised carrier</td>
</tr>
</tbody>
</table>

(Continued)
Table 1.3: International classification of ships (Continued)

<table>
<thead>
<tr>
<th>Marine structures</th>
<th>Non-ship structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merchant ships</td>
<td>Naval and military crafts</td>
</tr>
<tr>
<td>9</td>
<td>Container ships</td>
</tr>
<tr>
<td>10</td>
<td>Ro-Ro passenger</td>
</tr>
<tr>
<td>11</td>
<td>Ro-Ro containers</td>
</tr>
<tr>
<td>12</td>
<td>Other Ro-Ro cargo</td>
</tr>
<tr>
<td>13</td>
<td>General cargo ships</td>
</tr>
<tr>
<td>14</td>
<td>Reefer</td>
</tr>
<tr>
<td>15</td>
<td>General cargo/passenger</td>
</tr>
<tr>
<td>16</td>
<td>General cargo/single deck</td>
</tr>
<tr>
<td>17</td>
<td>General cargo/containers</td>
</tr>
<tr>
<td>18</td>
<td>General cargo multi-deck</td>
</tr>
<tr>
<td>19</td>
<td>Dry cargo barge</td>
</tr>
<tr>
<td>20</td>
<td>Deck barge</td>
</tr>
<tr>
<td>21</td>
<td>Hopper barge</td>
</tr>
<tr>
<td>22</td>
<td>Lash/sea-bee barge</td>
</tr>
<tr>
<td>23</td>
<td>Open dry cargo barge</td>
</tr>
<tr>
<td>24</td>
<td>Covered dry cargo barge</td>
</tr>
<tr>
<td>25</td>
<td>Other dry cargo barge</td>
</tr>
<tr>
<td>19</td>
<td>Passenger ship</td>
</tr>
<tr>
<td>20</td>
<td>Cruise</td>
</tr>
<tr>
<td>21</td>
<td>Other passenger</td>
</tr>
<tr>
<td>22</td>
<td>Fish catching and processing</td>
</tr>
<tr>
<td>23</td>
<td>Fish processing</td>
</tr>
<tr>
<td>24</td>
<td>Fish catching</td>
</tr>
<tr>
<td>25</td>
<td>Off-shore production and support</td>
</tr>
<tr>
<td>26</td>
<td>Off-shore drilling</td>
</tr>
<tr>
<td>27</td>
<td>Off-shore support</td>
</tr>
<tr>
<td>28</td>
<td>Tow-boats and tugs</td>
</tr>
<tr>
<td>29</td>
<td>Tug</td>
</tr>
<tr>
<td>30</td>
<td>Push-boat</td>
</tr>
<tr>
<td>31</td>
<td>Research/survey</td>
</tr>
<tr>
<td>32</td>
<td>Other ship types</td>
</tr>
<tr>
<td>33</td>
<td>Dredger</td>
</tr>
<tr>
<td>34</td>
<td>Other</td>
</tr>
</tbody>
</table>

Source: International Association of Classification Societies (IACS).
LNG: liquefied natural gas; LPG: liquefied petroleum gas; Ro-Ro: roll-on roll-off.

a bulk port provides berthing, cargo handling and processing facilities for ships carrying bulk (liquid or dry) cargo, while a container port consists of a set of berths, yards, gates and, sometimes, extended landside connections solely designed to accommodate containerships and their cargoes. Seaports must not be confused with terminals; the latter are specialised units within ports (see Figure 1.1).
6 Introduction

Fig. 1.1: Selection of ports and terminals
When shippers (cargo owners, senders or receivers) outsource the transport of their cargo by sea or water, shipping services are usually divided into *liner shipping* and *tramp shipping*. While liner shipping plies regular routes and ports according to published sailing schedules, tramp shipping is irregular in both time and space. Sometimes, shipping services are performed directly by the shipper (*industrial shipping*), for instance, in the case of vertically integrated global oil firms and car manufacturing companies. Industrial operators may use their own fleet and/or charter in vessels, usually on a *voyage charter*, a *time charter* or a *bareboat (demise) charter*. Generally, industrial shipping is treated as a separate market although it can account for as much as 35% of the world’s seaborne trade.

Both tramp and liner operators may be regarded as third-party transport operators. Traditional third-party operators have focused their services on a single logistics operation (eg transport, warehousing, information management, audit and payment, and so on). Modern transport operators offer more than just transport services and can therefore be considered as *third-party logistics (3PL)* providers. Core activities of 3PL, also called *logistics outsourcing* or *contract logistics*, include transport, warehousing, inventory management, information systems, consolidation and distribution, freight management and consulting services. Other functions include value-added

---

**Fig. 1.2:** Main agents and intermediaries in international shipping

MTOs, multimodal transport operators; NVOCCs, non-vessel operating common carriers.
8 Introduction
capabilities such as labelling, packaging and telemarketing. A distinction should be made between asset-based logistics (3PL) and non-asset-based logistics (fourth-party logistics (4PL)). The latter is performed by providers who do not have tangible assets or equipment. Instead, they offer management skills to the shipper, for example, by facilitating shipping documentation and coordinating inter-modal services. Finally, integrators are those 3PL providers who provide integrated services such as in the courier and express market.

A key feature in shipping and port markets is the use of intermediaries either between carriers or between carriers and shippers. The use of intermediaries may add unnecessary costs to cargo transport and logistics, but is often justified by the advantages of specialisation and efficiency. Depending on the services they provide, intermediaries may be called ship brokers, ship agents, freight forwarders, multimodal transport operators (MTOs), non-vessel operating common carriers (NVOCCs), export management houses, etc. In the context of logistics management, shipping and port intermediaries may be assimilated to 4PL providers.

Unlike tramp ships, the voyages of which can link two or more ports at any time, liner ships operate between designated trade routes or lanes. Typically, trade lanes follow cargo, commodity and/or geographical classifications, for instance, containerised versus non-containerised routes, inter-continental versus intra-regional routes, deep-sea versus short-sea routes, etc. Within the same route, ships are deployed to perform multiple consecutive trips between a series of ports, sometimes called shipping string which includes both loading and unloading ports. Because of significant economies of scale of ships (increasing ship size), their physical constraints (draft, length, width, etc), cost structure (operating costs, time in port, space utilisation, etc), trade imbalance and other factors, different logistical patterns of liner routing have evolved through the years. These include double-dipping, pendulum and hub-and-spoke services, among others.

Another way to look at the maritime business in general, and at ports in particular, is to consider freight transport (or the transport of goods) as an integral part of the logistics system. Unlike the economic and trade approach where maritime transport and ports are perceived as a derived demand from trade, the logistics and supply chain approach integrates the transport function with other business components of the firm such as purchasing, production, storage and inventory management. In this approach, ports are categorised according to their logistical and locational status within international shipping and trade patterns, to their positioning and alignments within supply chain systems and configurations, and/or to the nature and extent of logistics and value-added services they provide (see Section 2.3). A thorough discussion on logistics and supply chain issues in port operations and management is provided in Chapter 10 of this book.
As far as shipping services and trading routes are concerned, ports may be classified as network ports, transhipment ports, direct-call ports and/or feeder ports. However, this taxonomy is neither exhaustive nor comprehensive for modern port logistics.

- **Network ports** provide high value-added services to both ships and cargo and generate traffic from/to the port and its hinterland and foreland. Given their extensive channels of distribution, network ports are commercially attractive and offer low unit cost per ship.

- **Transhipment ports** provide high value-added services to ships but low value-added services to cargo. They are mainly dedicated to ship–shore operations and provide fast turnaround times for ships. They are also suitable for cargo concentration and distribution.

- **Direct-call ports** provide low value-added services to ships but high value-added services to cargo. They are particularly attractive to tramp shipping and some forms of liner shipping.

- **Feeder ports** provide low value-added services to ships but not necessarily to cargo. They are not physically, or possibly, economically suitable for direct call and need to be linked to network or transhipment ports.

An alternative way to classify ports is to look at their geographical and spatial markets, specifically the extent of the land area a port can serve, commonly

**Fig. 1.3:** Description of selected operational patterns of liner shipping

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-to-end services</td>
<td>Traditional liner services between two markets.</td>
</tr>
<tr>
<td>Hub-spoke services</td>
<td>A combination of two End-to-End services, calling at three markets instead of two. The market (port) in the middle serves as a fulcrum.</td>
</tr>
<tr>
<td>Triangular services</td>
<td>A combination of three End-to-End services linking three imbalanced trades in an effort to optimise a ship’s utilisation.</td>
</tr>
<tr>
<td>Pendulum services</td>
<td>A combination of two End-to-End services, calling at three markets instead of two. The market (port) in the middle serves as a fulcrum.</td>
</tr>
<tr>
<td>Double-dipping services</td>
<td>This pattern combines longer inter-continental routes with shorter inter-regional ones, in an effort to replace feeder vessels with big mainline ships. It requires mainline ships to call at a hub port in the middle of a round-trip voyage on both ways.</td>
</tr>
</tbody>
</table>
Introduction

called the *hinterland*. Here ports can be classified as local, regional, national or international. The size of the hinterland may vary considerably from one port to another due to several factors such as the scope of shipping services and port traffic, the quality of port facilities and services, the size and efficiency of the inland transport network, and the number of competing ports for the same hinterland. A good example of port competition for the same hinterland can be found in the US Midwest region, the seaborne trade of which is the subject of intense competition between East, West and the Great Lakes US ports. In Europe, the main ports in the Le Havre–Hamburg range (also called the Banana range)—Le Havre, Antwerp, Rotterdam, Bremen/Bremerhaven and Hamburg—compete for the same hinterland. Ports can serve a wider spatial region beyond their immediate hinterland. This is often called the *foreland* and denotes the geographical area a hub or a network port serves through networking with other feeder ports or through an extended inland transport system. Here again, several ports can compete for the same foreland.

From a spatial and geographical perspective, the relationship between freight flows and port development is better understood through the concepts of gateways, articulation points, freight corridors and distribution centres:

- **Gateways** are locations that bring together different modes of transportation along with warehousing, freight forwarding, customs broking and other logistics services. Many textbooks differentiate between transport gateways as hubs for major regions and freight gateways which serve cities and regional areas. An illustration of this categorisation may be found in the port of New York/New Jersey as an industrial and logistics hub (freight gateway) which is joined by the inland port of Albany (transportation gateway) designated to receive freight containers barged from the main hub port.

- **Articulation points** are nodal locations interfacing several spatial systems and serving as gateways between spheres of production and consumption, and may include terminal facilities, distribution, warehousing and trading centres. The difference between gateways and articulation points is that the latter are viewed from an urban perspective, whereas gateways do not necessarily need to be located at city interfaces. From this perspective, seaports are seen as hard terminals since they are immovable, whereas inland terminals dispose of a great degree of locational flexibility.

- **Freight corridors** represent transport links of freight transportation supported by an accumulation of transport infrastructures and activities servicing these flows. Traditionally, flows in freight corridors tended to be fragmented and segmented since each mode tried to exploit its own advantages in terms of cost, service, reliability and safety. Hence, maritime corridors may be assimilated to geographical trade routes. However, evolving routing patterns, such as hub-and-spoke and transhipment networks, currently reduce the capacity of maritime corridors to accommodate operational and logistics patterns of maritime transport.
Multi-Disciplinary Approaches

Freight distribution centres serve as locations for cargo transfer and distribution to regional or extended markets, depending on corridor capacity and articulation point links. Traditionally, many distribution centres were located close to central areas mainly as a factor of market proximity, but are currently relocating to peripheral areas. Functionally, a freight distribution is the combination of a freight corridor and an articulation point or a gateway.

Another popular way to categorise ports is to classify them in terms of ownership and institutional structure. Here ports can be classified by type of ownership (private port, public port, etc), institutional structure (landlord port, tool port, service port, etc) and/or a combination of these and other criteria. A detailed review of these models and others is provided in Chapter 2.

2 MULTI-DISCIPLINARY APPROACHES TO PORT OPERATIONS AND MANAGEMENT

The literature on approaches to port operations and management is quite extensive as it cuts across various subjects and disciplines. It is noticeable in the current body of port literature that the conceptualisation of the port...
business has taken place at different disciplinary levels without producing a comprehensive and structured port management discipline. Much of the current literature on ports has been developed by international organisations and institutions in the field (UNCTAD, IAPH, the World Bank, etc), and a resulting terminology has evolved depicting specific concepts hardly understood by professionals and academics outside the field (see Chapter 2). On the other hand, many areas of port operations and management still remain unexplored, and there are few references outlining the different features of operational, logistics and strategic management in ports. Generally, the activities and operations of ports have been studied from three main perspectives: an economic approach, an engineering/operations approach, and an evolving logistics and supply chain management (SCM) approach.

2.1 The Economic Approach

Standard economic approaches and theories on international trade and development, production output and capacity, geography and spatial organisation, market structures and industrial organisation, and policy and regulation have been applied to the economic activity of ports and terminals along with other transport infrastructures. A central tenant in the economic approach to ports is that freight and maritime transport is a derived demand from trade, essentially international trade. In other words, there will be no need for transport if no trade takes place. Key economic characteristics of the port industry include, but are not limited, to the following: multi-product/multi-output system, multi-agent system, externalities, spillovers and wider effects, natural monopoly and economies of scale and scope, location and network structure, requirements for market, safety and environmental regulation, and long-life assets and long lead times for planning and project completion.

2.1.1 Multi-product/multi-output system

Port production, in economic terms, is highly heterogeneous with many attributes. This is because most ports handle different cargo and ship categories, hence providing different types of port services. Even within specialised ports or terminals, different port services may be provided such as in terms of services to ships and services to cargo, or in terms of nautical services, cargo handling services and value added services. Traditionally, port services have been categorised into services to ships (pilotage, towage, mooring, bunkering, ship repair, etc) and services to cargo (eg loading and unloading, stacking and storage), but other complimentary and value-added services, such as consolidation and break bulk, packaging and labelling, repositioning and distribution, may also be carried out in ports or around their vicinity. Chapter 2 reviews the organisational structure of ports and lists the different functions and roles of modern ports and terminals.
Because of the multi-output nature of port operations, the application of the single-productive theory to ports is clearly unsatisfactory; but it was not until the last decade or so that the port literature started recognising the multi-productive nature of port processes. Despite this, little consensus seems to have been reached among port researchers on the factors of production that should be considered in a production function, or on the related costs and factor prices that should be considered in a cost function. There is also little consensus on the extent to which non-controllable or exogenous variables should be included in the analysis. A detailed review of cost and production functions in ports and of the techniques for analysing port productive efficiency is provided in Chapter 9.

2.1.2 Multi-agent system

From a microeconomic perspective, ports are seen as entities producing private goods for which the levels of supply and demand and relative prices are determined by agents’ behaviour, market mechanisms and regulatory requirements. From a macroeconomic approach, ports are critical infrastructure producing public goods that are hardly captured in market transactions but which create direct benefits to port operators as well as indirect effects, be they positive or negative.

Traditional microeconomic port models limit port agents to two main actors: ports and port operators, representing the supply side, versus ocean carriers and shipping lines, representing the demand side. On the supply side, port services facilities may be provided by a single entity or by a myriad of firms and organisations. A key agent in port operations and management is the port authority whose role may be limited to the provision of basic nautical and operational infrastructure (landlord port) or extended to the provision, operation and management of all port facilities and services (public service port). However, with the growing scope and intervention of private sector participation in ports, some or all of port activities and services are increasingly being performed by the private sector. A detailed review and analysis of port ownership and institutional models is provided in Chapter 2. On the demand side, port economics has traditionally focused on the study of the economic behaviour of shipping lines and ocean carriers. This is usually conducted in terms of a cost-minimising exercise for shipping lines as opposed to a revenue-maximising exercise for ports, but sometimes a game simulation between the two objectives is undertaken.

Nonetheless, in a typical port setting several agents and stakeholders may influence decisions on port choice and on the selection of freight transport and shipping services. By way of illustration, a typical international movement of a container box is estimated to involve 25 parties on average. While not all these parties have a direct impact on ports, some actors such as shippers (cargo owners), 3PL providers, freight forwarders and NVOCCs certainly influence
Introduction

port demand, choice and selection. The extent to which those actors are involved in port management is described in the chapters on port operations (Chapter 6) and marketing and competition (Chapter 9).

As for modelling the economic behaviour of port agents, much emphasis has been placed on the analysis of port demand and on the study of the competitive dynamics of port markets. For the former, the bulk of the literature on the subject has focused on the modelling of the behaviour of shipping lines, and more recently on the modelling of port choice and selection from the perspectives of shippers and other port agents. For the latter, the contemporary literature has focused on the growing intensity of competition and contestability within and between different port markets. The interactions between port demand and supply are at the core of the study of port planning, pricing and competition, and these aspects will be thoroughly discussed in Chapters 3, 5 and 9, respectively.

2.1.3 Requirements for market, safety and environmental regulation

Since ports are public goods, port policy becomes an integral part of the country’s general economic, trade and social policy. Generally, port policy is formulated based on two understandings: (i) the role of ports in the development of the country and (ii) the set of policy measures that are needed in order to support and further promote this role. It is these measures that constitute the components of a port policy. Key to port economics is the extent to which governments and public regulators are involved in the process of port planning and development, and in the aspects of safety, economic and market regulation. Governments and public authorities can use a range of policy instruments to either promote or hinder the development of port and shipping services, for instance, in terms of a protection-oriented, market-oriented or market-regulated port policy. Even in situations where public agents adopt a neutral view of port planning and development, the market mechanisms through which the port sector is functioning may not be completely free or independent from the influence of the process of public decision making. For instance, in their quest to reduce congestion and promote environmental sustainability, governments may favour one transport mode over another or simply one port over another. Sometimes, port development and policy decisions are usually beyond the remit of a single public agent especially where local, national and supra-national decisions interact, and sometimes conflict, in the shaping of port policy and development. The recent trend of globalisation of port operations and services suggest that many aspects of port policy will now be dealt with at international level.

A central tenet of modern port policy is to ensure effective competition between and within ports so as to provide users with real choice. While modern port management in which commercial investment, whether private or public, drives port development is becoming the norm across many ports and
terminals in the world, the regulatory intervention from governments and other public authorities should aim at remedying potential or demonstrable market failures and other hindrances to the wider economic, social, safety and environmental objectives. Port market regulation may also include such aspects as port prices and user’s charging, market access, mergers and acquisitions, concessions and private sector participation, incentives and subsidy programmes, and efficiency and yard-stick benchmarking. Another important element of policy intervention is the assessment of port capacity and whether or not industry and market mechanisms alone should plan and finance current and future capacity of the port system.

Other issues of policy and regulatory intervention in ports are safety, security and environmental sustainability. Examples of regulated activities in ports include port state control, harbour and traffic management, hazardous materials (HAZMAT) the handling of storage, port safety and security, environmental protection and impact assessment, health and occupational safety, etc. Several regulatory standards have been developed to ensure the safety, security and environmental sustainability of ports and port operations. Many of these regulations are set at international or regional levels such as through the International Maritime Organization (IMO), the European Union’s (EU) Maritime Safety Agency, the World Customs Organization (WCO), the World Trade Organization (WTO), International Labour Organization (ILO), etc. International and regional professional associations in the field (eg the International Association of Ports and Harbours (IAPH), the American Association of Port Authorities (AAPA), the European Sea-Port Organisation (ESPO) and the International Association of Ports and Cities (IAPC/AIPC) also set professional standards for safety, security and environmental sustainability. These will be discussed in Chapters 11, 12 and 13, respectively.

2.1.4 Externalities, spillovers and wider effects

Externalities are indirect effects that can be passed on to third parties, other interests and the wider economy beyond port firms and investors. External microeconomic benefits of ports include the improvement of the efficiency of the productive and trade-logistic system and the reduction of congestion and generalised port costs, which can then be transferred to port users (eg shipping lines) and their clients (eg shippers). External macroeconomic benefits include spatial spillover effects (eg higher accessibility, agglomeration economies, regeneration and redistribution), socio-economic and multiplier effects (eg increases in employment, earnings and consumption), and innovation and technological progress. Port externalities may also be negative, arising from the costs of congestion, safety hazards, environmental degradation and pollution, as well as negative location effects on certain industries such as tourism and real estate development.
16 Introduction

An important aspect in the study of the wider effects on port infrastructure is the direction of causation between economic growth and the port activity. Most studies assume that growth is caused by port infrastructure, but as economies spend more on port infrastructure, the latter may follow growth as well. Another key point is the level of excludability from indirect effects where, for instance, some third parties cannot be prevented from enjoying the effects of direct investments made by port firms and operators. Equally important are the market, regulatory and pricing mechanisms that determine how much port users (and non-users) should pay for using port facilities and enjoying their wider benefits, but also for recovering the costs imposed by negative effects.

2.1.5 Natural monopoly and economies of scale and scope

Ports have large sunk assets and therefore tend to exhibit increasing returns to scale (cost per unit traffic tends to fall as a port expands) and increasing returns to scope or density (cost per unit traffic usually falls when more vessels and cargo are handled by existing facilities). Sometimes, economies of scale are defined as being associated with the efficiencies associated with supply-side changes of a single product type such as increasing or decreasing scale of production; for instance, when a port achieves higher container throughput. On the other hand, economies of scope are often defined as being associated with demand-side changes of multiple products such as increasing or decreasing scope of distribution and marketing; for instance, when port facilities are used to handle more than one type of cargo or when ports offer various port services (eg handling, storage, cargo consolidation and so on). While in the single-output case economies of scale are a sufficient condition for the verification of a natural monopoly, in the multi-output case, they are neither necessary nor sufficient. Economies of scope are, however, a necessary condition.

Traditionally, ports have been viewed as natural monopolies, justifying public involvement in both the provision (to ensure adequate investment) and the operation (to prevent monopoly exploitation) of port services and facilities. Nevertheless, not all port assets entail a long-lived and largely sunk cost structure. Several port facilities, such as port equipment and superstructure, can be easily assigned to specific port users and may therefore attract private investors and bring about competitive market features. Kessides (2004) refers to the example of towing and related port services where most of the capital costs relate to tugs. As there is an active international market for tugs, these may be bought, sold or leased quite easily. Thus, towing is a contestable activity as the cost of acquiring a tug is not a significant barrier to entry. Furthermore, the multi-product character of modern ports creates greater scope for unbundling and competition. Even when some ports have natural monopoly characteristics, several port segments and services may be perfectly competitive.
2.1.6 Location and network structure

Ports are immovable assets and their exclusive location attribute has been used to explain the monopolistic nature of ports, although this is no longer the case in modern port systems where the traditional captive hinterland is now being contested by different ports as well as other transport infrastructure systems.

An equally important aspect in port economics is the network structure of the port system. Here ports may be viewed as infrastructure facilities which are part of a wider transportation economic network for moving goods and people. From a network economics approach, the port network is comprised of network users (port users), service providers (ports and port operators) and the rest of the economy. This should not be confused with the engineering approach of network systems where transport networks are defined as flow (eg traffic) networks of links (mode and path) and nodes. In a simple presentation of a marine transport system, the mode represents maritime transport, the path corresponds to the maritime route and the node represents the port or terminal. A third definition of network systems is given by the SCM theory whereby a supply chain network is comprised of a series of firms and organisations that pass goods and materials forward from upstream suppliers to downstream customers, but also sometimes backward (reverse logistics) such as in the case of full export containers returning as empties. From this perspective, the port and marine transportation network is an integral part of the total supply chain network (see Section 2.3).

A central feature of network economics is the creation of network effects (i.e. the effect that one user) of certain goods or services has on the value of those goods to other users). This is particularly the case in network industries (telecommunication, electricity, transport, etc) where the more people that use a product or a service, the more valuable that product or service becomes to each user. In this sense, network effects correspond to positive network externalities but network effects may sometimes lead to negative externalities such as congestion. The study of congestion effects and increased queuing in ports is particularly important since it directly affects decisions and strategies of port planning, operations and competition. Network effects are sometimes confused for economies of scale and economies of scope, but the latter refer to the efficiencies associated with the supply-side and demand-side changes, respectively.

2.1.7 Long-life assets and long lead times for planning and project completion

The long-term strategy for port planning and project completion also affects the determinants of economic decision making in ports. The long lead time for port construction, including a lengthy planning and design period, and for superstructure and equipment procurement has always meant that short-term
18 Introduction

matching of the supply of port facilities to the expected demand is difficult to achieve, particularly in times of uncertainty and for unstable port markets. Port assets, in terms of both infrastructure and superstructure, have a long economic life and therefore entail a long pay-back period for investment and project appraisal.

2.2 The Operations Approach

From the engineering and operations approach, ports are seen as fixed assets and operations systems. Engineering applications in ports are mainly associated with the aspects of port design, construction, modelling, planning, operations, maintenance, optimisation and performance measurement. The sub-branches of engineering that are mostly concerned with port operations, planning and logistics include transportation engineering, environmental engineering and industrial engineering. The last sub-branch is often used to study ports using a systems and process approach, and is therefore closely related to the fields of logistics and SCM. The conceptualisation of ports as logistics and supply chain systems forms the basis of a new approach to ports, which is introduced in the next section and discussed extensively in Chapter 10.

A system is often defined as a set of components standing in inter-relations among themselves and with the environment. A port’s internal system is composed of at least four components: physical assets (infrastructure and superstructure), labour and human resources, technology and information systems, and management and workflow processes. Because of the complex nature of port operations, relevant research on the subject is usually undertaken at disaggregated operational levels (eg terminal, site, equipment, technology and so on). A further distinction is also made between the types of engineering and operations decisions. The latter can be categorised into strategic, tactical or operational decisions according to their scope and time horizon.

Outside the nautical infrastructure, key port operations that have been mostly examined in the literature include ship and berth scheduling, stowage plans and quay-crane efficiency, vehicle-flow dispatching and scheduling, staking and storage in the yard, empty container management, automated operating systems, and inter-modal transport operations. A good review of these and other operations problems in terminal operations is provided in Chapter 6. Despite this, many operational features of port systems remain under-researched including aspects such as network structure, reliability and interoperability.

2.2.1 Network structure

Most transport and freight distribution systems follow a node-link network structure, although the nature and properties of the network differ greatly between and within systems. For instance, unlike rail and road systems,
maritime links may be established between any two or more seaport locations subject to a number of infrastructural (ports, canals, locks, etc), operational (volume, capacity, price, etc) and organisational (liner shipping versus tramp shipping) constraints.

From an engineering and operations perspective, ports are a central node of the maritime and inter-modal transport networks. Mathematically, a transport network can be represented by a graph consisting of a set of links (edges) and a set of nodes (vertices). The links represent the transport movements between the nodes, which in turn represent points (eg ports) in space and sometimes in time as well. A path is a collection of links and nodes specifying both the route and the mode(s) of transport. In the graph theory, a network is pure when only topology and connectivity properties are considered. When flow properties are considered as well, a network is then referred to as a flow network, in which case capacity constraints and other related factors become key features of network analysis. Random graphs are one of the earliest and most extensively studied network models. They are defined as networks where nodes and links are assigned at random. On the opposite side of the network model spectrum, one encounters regular networks where link creation adheres to strict rules. Most of the models and concepts developed in the graph and network theory can be applied to ports, at least in two separate areas of interest depending on how ports are perceived as network structures. When ports are viewed as nodes of the shipping and inter-modal transport network, the graph theory can be used to study certain shipping and related port aspects such as path flow estimation (freight flow modelling and traffic forecasting), network equilibrium (deterministic or stochastic user equilibrium), port and depot location, and route and mode choice (traffic assignment). When ports are analysed as individual spatial networks, the graph theory can be used to study several issues of port operations and short-term (operational) planning such as the routing, deployment and scheduling of port equipment and vehicles as well as labour and manpower. The network structure can also be applied to port planning, design and construction through the study of project networks and industrial scheduling.

The study of a port’s network topology is also relevant to port operations and logistics, but the literature on the subject is relatively scarce. This may be due to the conventional thinking that the location of ports in spatial networks is exogenous (ie ships follow ports). On the other hand, the more specific study of the topology of port and shipping networks (eg scale-free networks, complex networks and small world networks) has received little attention from academics and professionals. Traditionally, port planning and capacity expansion schemes have relied on their volume/capacity ratio to identify highly congested links resulting in localised solutions. In a similar vein, international shipping networks have followed a trade-led pattern where new routes are opened and operated to link two or multiple markets, but traffic and operational constraints have forced shipping lines to develop new operational
patterns in an effort to optimise ship utilisation and efficiency. As a result, the issue of liner network routing has been reduced to a ship’s scheduling problem. The key point is that port and maritime network patterns have evolved from micro-level and fragmented decisions that do not always consider global network performance and system-wide impacts. With the evolving complex shipping networks (transhipment routes, hub-and-spoke systems, increasing use of hierarchical networks and multiple line bundling arrangements, etc) and the recent trends in port choice and logistics (shifts in global distribution patterns, changes in supply chain segmentation and planning processes, the general trends in outsourcing and the emergence of global terminal operators, etc), network design and capacity in shipping and ports require a new approach and systemisation.

2.2.2 Reliability

Another area of interest in network analysis is network reliability, which studies the vulnerability and robustness of a transportation network including topics of connectivity, link failure, disruption and redundancy, vulnerability and security. However, reliability in ports include aspects that go beyond the field of transport network reliability, for instance, terminal reliability, capacity reliability, operational reliability, transit (travel time) reliability and encounter reliability.

A widely accepted definition of reliability is the one provided by Wakabayashi and Iida (1992) who define reliability as “the probability of a device performing its purpose adequately for the period of time under the operating conditions encountered”. Obviously, the extent to which a system or device is reliable depends on the interests and perceptions of different users, for instance, between those who focus on cost reliability versus those who favour time reliability, or simply between high risk averse users versus less risk averse users.

The potential sources of disruption to port systems and networks are numerous, ranging from routine events such as congestion and equipment failure to exceptional disasters such as earthquakes, terrorist attacks, ship collisions and other major accidents. The cause, scale, impact and frequency of such events will vary extensively, but it is possible to design and manage port systems and operations in ways that enhance the predictability of such events, minimise the disruptions they may cause, and improve the robustness and redundancy of the port system against such disruptions. Here, the concept of risk assessment and management becomes a key element in the study of a system’s reliability. Risk assessment and evaluation is a well-established engineering process for identifying hazards, their probabilities and consequences, assessing the acceptability of risks and taking remedial action to address unacceptable risks. Vulnerability is another concept closely related to risk in that it encompasses both probability and consequences. Generally, vulnerability is defined as the
likelihood of severe adverse consequences. Therefore, vulnerability may be interpreted as being the opposite of reliability.

Superior port design and redundancy improves a system’s reliability. For instance, enhancing the methods and execution of port planning, operations and maintenance would improve the quality of services provided with a view to satisfying users’ expectations. In a similar vein, developing systems and processes with quick recovery and resilience in the event of failure reduces the adverse consequences of disruption. Therefore, both the design and redundancy components of port equipment, operational procedures and management systems must be taken into account when assessing port safety and security. However, while port safety is based on the assumption of unintentional human and system behaviour to cause harm, port security involves a high degree of malevolence. Current maritime transport and port networks have been designed to respond to an extensive set of market and operational requirements, but their robustness and reliability vis-à-vis random or targeted failures have long been taken for granted. In the post-9/11 era, the robustness and survivability of the maritime network against node or port failures is a high priority. Despite this, the topic of network reliability in ports is surprisingly under-researched and only a few relevant works on the subject exist. The topics of port safety and security will be discussed in more detail in Chapters 11 and 12, respectively.

2.2.3 Interoperability

Interoperability refers to the capability of diverse systems and organisations to operate and work together. In seaports, interoperability must be achieved at operational, communication and technology levels. Operational interoperability refers to the ability of port operators to handle various types and sizes of ships and their cargoes. While some ports have a higher interoperable capability, many ports have lesser interoperability for conforming to operating requirements and working standards, for instance, in terms of equipment and labour capability. The ability to integrate various inter-modal systems is also a key to achieving a high degree of operational interoperability in ports. Communication and business process interoperability between various members of the port community is a key to successful port operations. The use of standard communication systems, such as vessel traffic services (VTS), electronic data interchange (EDI), EDI for Administration, Commerce and Transport (EDIFACT) and enterprise resource planning (ERP) systems, ensures the exchange of documentation, data and information in interoperable semantics, communication protocols and file formats. In the areas of port safety, security and environmental protection, interoperability communication between various port stakeholders and public agencies is the key to a successful management response during wide-scale emergencies. From an economic perspective, a lack of interoperability creates conditions for negative network externalities such as monopolistic behaviour, market failure and congestion effects.
22 Introduction

2.3 The Logistics and Supply Chain Management Approach

Logistics had long been exclusively used by the military and was only integrated into operations and business management in the mid-1960s. There are almost as many definitions of logistics as the number of books and articles written on the subject. This, to some extent, reflects the underlying characteristics of logistics, which has been undergoing a constant evolution during the last three decades or so. The basis of logistics management is the integration and optimisation of a firm’s functions and processes for the dual purpose of overall cost reduction and customer satisfaction. Logistics seeks to deliver the right product or service, in the right quantity and condition, at the right price, to the right place and for the right customer. Typically, the logistics process encompasses inbound, in-house and outbound logistics and spans the flows of goods, services, people and information from point of origin until point of consumption (forward logistics) and vice versa (reverse logistics). Logistics functions are usually categorised into two main components: materials management and physical distribution, and may include a range of activities such as purchasing, planning, production control, inventory management, materials handling, storage and warehousing, transport and distribution and sales and marketing. Most concepts of logistics and SCM also apply to ports. They include the following.

2.3.1 Customer service

Much of the emphasis of business logistics is placed on effective customer service which, combined with the objective of cost reduction, opposes business logistics to military logistics. The concept of customer service associates many aspects of logistics closely with marketing. It can be broadly described as the measure of how well the logistics system satisfies its customers and their expected levels of service. Customer service must be viewed as an integral part of the design and operation of any logistics system. In ports, much of the debate to date has been on how to perform efficient operations while still satisfying a wide range of port users and customers.

In SCM, the concept of customer service takes on another dimension since it assumes that the network of organisations in a port supply chain should work collaboratively in order to ensure superior customer service and competitive advantage vis-à-vis other supply chains. This means that port competition is moving to a further level: ports are not only competing against other ports on the basis of operational efficiency, price and location, but also, and more importantly, on the basis that they are embedded in quality supply chains that offer shippers, shipping lines and other customers a greater value than alternative ports, routes and supply chains. Today competitive advantage depends less on a port’s internal capabilities but rather on its supply chain competitive potential whereas long-term success depends upon the competitiveness of the entire port supply network.
2.3.2 Value added

In logistics, the term value added is closely related to customer satisfaction. The most appropriate customer service level is the one that gives the customer the maximum value added. The performance of a logistics system is assessed based on how well it performs in creating value-added benefits to the customer in a cost-effective way. While the value of port services to shipping lines may be reduced to the aspects of operational efficiency and turnaround time, the value of port services to shippers may be extended to the aspects of product conversion, process decoupling, inventory management, market customisation, postponed manufacturing, modal shift and regional distribution.

Value added also means the value newly created or added to traditional services. Logistics activities are key elements in the value chain, and thus contribute greatly in the creation of value added. Apart from their traditional function as a sea–land interface, ports are a good location for value-added logistics activities such as consolidation and break bulk, sequencing and order processing, packing and packaging, postponement and customisation, promotion and market intelligence, facilitation of contacts and procedures, and so on. From a logistics approach, ports should be conceived of as logistics and distribution centres that not only optimise the movement of goods and services within the maritime and multimodal transport system, but also provide complementary services and add value to members of the larger logistics and supply chain network. The role of ports as logistics centres has been fully recognised in recent years with many ports worldwide expanding their activities into a wide range of logistics and value-added services. Thus, the port system not only serves as an integral component of the transport system, but is also a major sub-system of the broader logistics and supply chain systems.

2.3.3 Process and integrated approach

Much of the logistics philosophy is based on a process approach to business. This means that logistics is not an isolated activity, but rather a series of continuous and inter-related activities whereby planning, organisation, operation and management apply. One of the main benefits of logistics is that it offers an integrated approach to a range of activities and functions (eg purchasing, production, transport, warehousing and so on), and enables manufacturers and other organisations to identify the total cost of the system, and balances (or trades off) one aspect against another.

Over the past two decades or so, the integration of the international logistics chain has become a focal issue in developing strategic plans and long-term objectives for 3PL, shipping lines and even port operators. Today, 3PL providers offer packages that include full coverage of logistics services from origin to destination. In a similar vein, advances in containerisation, inter-modal integration and information technology have allowed shipping lines to extend the
Introduction

The scope of their activities from traditional sea transport services to integrated door-to-door transport and logistics services including such activities as inland transportation, consolidation, freight forwarding and even cargo handling and port services. Yet, total logistics integration is achieved by few mega-carriers, while most shipping lines limit their services to sea transport and related shore-based operations. In ports, the process of port privatisation and deregulation being widely implemented during the last two decades or so has gradually lifted the barriers against logistics integration in the port industry. Nowadays, many port operators are capable of offering a range of logistics services beyond the traditional package of services to ships and cargo. There is also a growing trend on the part of ocean carriers, logistics service providers and even shippers towards port ownership and management. Recent strategies of vertical and horizontal integration evolving around port ownership and operations have produced new institutional port structures capable of offering integrated port and logistics services.

2.3.4 Total costs and cost trade-off analysis

A key element of integrated logistics is total cost analysis. The essence of logistics is to minimise the total cost rather than the cost of individual activities. Any change made in one aspect of an organisation is likely to affect other aspects as well as the total cost of the entire logistics system. Cost trade-off analysis is a key feature of total logistics costs and consists of comparing different combinations of cost elements so as to achieve an overall optimal solution. Examples of cost trade-off analysis include transport costs against inventory costs, warehousing costs against transport costs and production costs against inventory costs. It is obvious that these costs are inherently inter-related with each other. Cost trade-off analysis is also a useful tool for strategic decisions. A typical illustration is when a firm decides to move production to a cheaper place in order to reduce the cost per unit of the product at the factory, but the new production site would imply an increase in transport and other related costs.

While the objective of shipping lines is to minimise total door-to-door transport costs, including cargo handling and port costs, shippers seek to minimise total logistics costs, which include transportation costs, warehousing costs, order processing and information costs, lot quantity costs and inventory costs. Despite this, the literature on port planning, choice and freight flow modelling often overlooks the costs of shippers and limits the analysis to a trade-off exercise between a cost-minimisation for shipping lines versus a revenue-maximising objective for ports.

2.3.5 Ports as logistics systems

Despite the widespread recognition of the logistics and supply chain dimension of ports, the bulk of the practical and theoretical literature on ports has
Multi-Disciplinary Approaches

studied port systems from either an economic approach or an operations approach. However, these approaches neither fully justify the evolution of port systems nor integrate various functional port units into the wider freight logistics and supply chain network:

- On the one hand, the economic approach treats freight and maritime transport as a derived demand from trade. Here, maritime transport and port activities are perceived as an afterthought; that is, something which is considered only after the main activities of the firm such as purchasing, production and inventory have been undertaken. We believe that the economic and trade approach justifies only part of the evolution of freight distribution systems. The focus on the nature, origins and destinations of freight movements disintegrates port management from logistics and supply chain structures.

- On the other hand, the operations approach disaggregates the port system into individual units and components and seeks to optimise their individual operations rather than that of an overall port system. Here, operational fragmentation may result in conflicting objectives and disintegrated port operations. An integrative approach is therefore required.

- The logistics approach integrates both transport and cargo handling functions with other logistics components such as purchasing, production, storage and inventory management, promotion and marketing. In this approach, ports should be conceived as logistics and distribution centres that not only optimise the movement of goods and services within the entire transport and logistics chain, but also provide and add value to ultimate customers and users. Chapter 10 introduces a new conceptualisation of seaports as logistics and supply chain systems and discusses its implications on various port decisions such as planning, operations, marketing, competition, choice and selection.

2.3.6 Ports and international logistics

Most of the logistics concepts discussed above are also relevant in the international sphere. However, there is a great degree of complexity and uncertainty in international logistics compared with domestic logistics. The areas of complexity listed below also apply to international port and terminal management:

- **International trade complexities**: Different terms of sale and documentation, terms of payment, problems with the use of different currencies and the fluctuations of the exchange rate, etc.

- **The international and changing nature of markets**: involvement of supranational trading blocs (EU, North American Free Trade Agreement (NAFTA), Association of Southeast Asian Nations (ASEAN), etc), different national/regional tastes, languages, traditions, regulations, etc.
Introduction

- The nature of international supply chains, procurement and sourcing: multiple choice of production, inventory location and management; difficulty of control over deliveries and inventories; different expectations for customer service.
- The involvement of multinational and global corporations: aspects of channel control and power, footloose strategies and risk of mobility, the growth of intra-firm trading, etc.
- The general trend of outsourcing transport and logistics activities: through contracting out with 3PL/4PL providers.
- The frequent use of transport agents and intermediaries: including brokers, agents, NVOCCs, freight forwarders and other intermediaries.

As the world economy becomes more integrated through an accelerated process of globalisation of production, consumption and services, the market place for an increasing number of port users and customers is now simply the globe. In international logistics, the relentless striving for greater economies of scale, global coverage, higher efficiency and improved service quality have leveraged port competition for cargo and shipping services to a global market level. Logistics integration and network orientation in the port and maritime industry have redefined the functional role of ports in value chains and have generated new patterns of freight distribution and new approaches to port hierarchy. Successful ports have realised that in order to survive and prosper in today’s business environment, they have to adopt a global view. Today, many port operators have reached a global status by extending their activities to international port markets. The international consolidation of the port industry will be discussed in detail in Chapter 10.

2.3.7 Ports and supply chain management

Supply chain management extends the logistics concept of integration to a network of organisations by advocating trust, closer collaboration and partnership arrangements. SCM corresponds to external integration where a systems approach is used for managing the entire flow of information, materials and services from raw materials’ suppliers through factories, warehouses, distribution centres and retailers to the final customer or end user. Key SCM decisions include supply chain configuration, planning and forecasting, suppliers’ selection, process and product design, plant and warehouse location, demand management, supply chain risk and security, IT integration and enterprise systems, ecommerce and electronic markets, etc. Partnership arrangements in SCM require an abatement of conflictual attitudes in favour of long-term trust and cooperative relationships. Nevertheless, traditional relationships in the international logistics and shipping industry, including ports, have been more adversative than collaborative and where arm’s length arrangements seem to prevail over integration.
2.4 Marketing Channels and Port Management

In marketing management, a channel is defined as the network of organisational contacts a firm operates to achieve its distribution objectives. In other words, it is the physical route taken by goods from producer to consumer or the route of the transfer of ownership (or title) of the goods. Sometimes, the two routes are the same, but often they are not, particularly in international trade where payment, information and sometimes ownership may be associated with entities other than the exporter and the importer. A marketing channel can be identified by the types of institutions associated with the ownership and transaction of goods. For instance, merchants (buyers and sellers) have the ownership of the goods and agents act on behalf of merchants, but sometimes negotiate the ownership. On the other hand, transport and logistics providers do not take ownership of the goods but only facilitate their efficient passage through the channel. As such, logistics operators/providers are not members of the marketing channel.

The literature on channel management has its roots in marketing management, and of late in logistics and SCM. A channel can be loosely defined as a set of organisations that have banded together for trade, distribution and/or marketing purposes. In logistics management, channels are often reduced to the physical routes taken by goods as they move from producers to customers. In marketing management, a channel may be defined as the network of organisational contacts a firm operates to achieve its distribution objectives. Members of the marketing channel are entities that take part in the various marketing flows including title, information, promotion and payment, while members of the supply chain include all the organisations involved in the sourcing, production, transport, storage, delivery, sales and even return of the product or the service. Two distinctive features of the marketing channel approach are worth underlining: (i) its focus on channel control and (ii) the appreciation of conflict between organisations. Such features differentiate the marketing channel approach from the supply chain approach, the latter requiring cooperative relationships and integration of organisations.

Another distinction between the two approaches stem from the way each of them focuses on inter-organisational relationships. The marketing channel approach deals with the control of the channel and focuses mainly on external organisational arrangements. The SCM approach, on the other hand, seeks optimal efficiency by focusing on organisational integration including internal arrangements within a single company. In either case, it is crucially important not to confuse between institutions and functions. Institutions refer to channel members (shippers, ocean carriers, ports, freight forwarders, regulators, etc) while functions describe what channel members do (production, transport, cargo handling, storage, regulation, etc). Often, this distinction is blurred given that many functions of port management are operated by channel members other than ports, for instance, when a shipper or a shipping line owns or
Introduction operates ports and terminals. A thorough discussion of channel structure and design in ports from marketing and supply chain perspectives is provided in Chapters 9 and 10 respectively.

3 RATIONALE OF THE BOOK

From the above discussion, it is clear that ports are complex and dynamic entities, often dissimilar from each other, and where various services and activities are carried out by and for the account of different actors and organisations. Such a multi-faceted situation has led to a variety of operational, organisational and strategic management approaches to port systems.

It is noticeable in the current body of port literature that the conceptualisation of the port business has taken place at different disciplinary levels without producing a comprehensive and structured port operations and management discipline. Furthermore, many areas of port operations and management still remain unexplored, and there are few theoretical and practical references outlining the different features of operational, strategic and logistics management in ports.

Port Operations, Planning and Logistics is designed to offer a comprehensive, integrated, and detailed analysis of the complex and multi-faceted port system. As shown in Figure 1.4, the port system is portrayed in terms of four core

Fig. 1.4: Scope of this book
components: agents, operations, markets and services and impact. The focus of the book is on the interplay between those components and on the types of decisions they generate, namely planning and operations decisions, marketing and logistics decisions, and economic and policy decisions. The book provides a unique and multi-disciplinary reference that cuts across different research fields: economics, engineering, operations, technology, management, logistics, strategy and policy.

3.1 Contents of the Book

This book reviews theoretical and practical applications in port operations, planning and logistics and addresses the various needs, challenges and risks in port operations and management. The book explores various port topics: planning, operations, logistics, institutional organisation, investment and financing, pricing and asset management, efficiency and performance benchmarking, marketing and competition, information and communication technology, human resource management, safety and security, and environmental management, each supported with case studies, practical examples and illustrations of the latest developments in the field.

Chapter 1 points out the link between ports and the maritime business and presents alternative ways of port definitions and classifications. In particular, it outlines the different approaches to modern port systems and highlights the current and future trends in port operations and management. Chapter 2 reviews various port roles and functions and examines the traditional and evolving forms of port organisation, institutional structure and development. Chapter 3 reviews the various topics and elements of port planning—operational, strategic and long-term planning—while analysing the issue of port capacity in terms of both capacity planning and capacity management. It goes on to describe in detail the different models of port demand modelling, network design and traffic forecasting. Chapter 4 deals with port investment and finance with particular emphasis on port costs and costing, economic and financial appraisal of port investment, and the nature and modes of private sector participation in ports.

Chapter 5 introduces the subject of port pricing, lists the different port dues and charges, and reviews the different approaches to port pricing and user charging. Chapter 6 discusses various aspects of port operations: queuing and congestion, terminal configurations, terminal processes and procedures, equipment and handling systems, and maintenance and repair, with particular emphasis on containerised operations. Chapter 7 is dedicated to the subject of port productivity, performance and benchmarking. The various approaches and methods for measuring and benchmarking port performance and efficiency are described in detail supported by theoretical applications and practical case studies. Chapter 8 investigates the use of information and communication technology applications in ports from EDI and port community systems to
Introduction

radio frequency identification (RFID) and automation. Chapter 9 addresses the issues of port competition and marketing, focusing on the topics of market structure and analysis, competition and cooperation strategies in ports, port choice and selection, tools for port marketing and promotion, and instances of channel conflict and power in ports.

Chapter 10 investigates the logistics and supply chain dimensions of ports and discusses their applications and wider implications on inland systems and supply chain strategies. Chapters 11, 12 and 13 review the subjects of port safety, security and environmental management, respectively. Throughout these three chapters, the operational, economic and policy frameworks technical regulation in ports are discussed and their contemporary impacts on port operations and planning are assessed and analysed. The final chapter, Chapter 14, reviews the historical and contemporary organisation of a port’s labour and workforce and assesses its impact on port productivity. In addition, the chapter outlines modern HR management approaches and their applications in port operations and management, and highlights the need for global standards of port education and training.
REFERENCES AND FURTHER READING


References and Further Readings


References and Further Readings


Bichou, K, Lai, KH, Venus Lun, YH and Cheng, TCE, 2007b, A quality management framework for liner shipping companies to implement the 24-hour advance vessel manifest rule, Transportation Journal, 46(1), 5–21

Bier, VM, 1993, Statistical methods for the use of accident precursor data in estimating the frequency of rare events, Reliability Engineering and System Safety, 42, 267–280


Bird, J, 1980, Seaports and Seaport Terminals, Hutchinson University Library: London


Bosk, LB, 2006, Port and Supply-Chain Security Initiatives in the United States and Abroad, Policy Research Project Reports Series 150, Lyndon B Johnson School of Public Affairs, University of Texas at Austin, 1–238

Bostel, N and Dejax, P, 1998, Models and algorithms for container allocation problems on trains in a rapid transhipment shunting yard, Transportation Science, 32(4), 370–379

Bowersox, DJ and Closs, DJ, 2002, Supply chain sustainability and cost in the new war economy, Traffic World, April 1, 2002


Bureau of Transportation Statistics (BTS), 2002, Project 6 overview: Develop better data on accident precursors or leading indicators, in: *Safety Numbers Conference Compendium*, BTS: Washington, DC


References and Further Readings


Cullen, WD, 2000, The Ladbroke Grove Rail Inquiry, Her Majesty’s Stationary Office: Norwich


Cullinane, K and Toy, N, 2000, Identifying influential attributes in freight route/mode choice decisions: a content analysis, Transportation Research E, 36, 41–53


D’Este, G, 1992, Frameworks for understanding the behaviour of purchasers of general cargo shipping services, in: *World Conference on Transport Research*, Lyons, France


References and Further Readings


Ertay, T, Ruan, D and Tuzkaya, UR, 2006, Integrating data envelopment analysis and analytical hierarchy for facility layout design in manufacturing systems, *Information Systems*, 176, 237–262


Frankel, EG, 1991, Port performance and productivity measurement, *Ports and Harbours*, 36(8), 11–13


Hayuth, Y, 198, Containerization and the load centre concept, *Economic Geography*, 57(2), 160–176


Hummels, D, 2001, *Time as a Trade Barrier*, Mimeo, Purdue University, 1–40


ISEMAR (Institut Supérieur d’Economie Maritime), 1999


Kim, KH and Moon, KC, 2003, Berth scheduling by simulated annealing, *Transportation Research Part B*, 37, 541–560
References and Further Readings


Lawrance, D and Richards, A, 2004, Distributing the gains from waterfront productivity improvements, *Economic Record*, 80, 43–52


Malchow, MB, 2001, *An Analysis of Port Selection*, Dissertation submitted to the Department of Civil Engineering, Institute of Transportation Studies, University of California at Berkeley


Murphy, P, Dalenberg, D and Daley, J, 1988, A contemporary perspective of international port operations, *Transportation Journal*, 28(2), 23–32

References and Further Readings


Page, T, 1978, A generic view of toxic chemicals and similar risks, Ecology Law Quarterly, 7, 204–244


Pritchard, J, 2002, Firms, consumers tally losses now that West Coast ports see peace, Associated Press State and Local Wire, 26 November

Rios, LR and Gastaud Mecada, AC, 2006, Analysing the relative efficiency of container terminals of Mercosur using DEA, Maritime Economics and Logistics, 8, 331–346

Robinson, R, 1976, Modelling the port as an operational system: a perspective for research, Economic Geography, 52(1), 71–86


Rothengatter, W, 2003, Marginal cost and other pricing principles for user charging in transport, Transport Policy, 10(2), 121–130


Steenken, D, Voss, S and Stahlbock, R, 2004, Container terminal operation and operations research - a classification and literature review, OR Spectrum, 26(1), 3–49


Tuna, O and Silan, M, 2002, Freight transportation selection criteria, an empirical investigation of Turkish liner shipping, IAME Panama 2002 Proceedings

UNCTAD, 1976, Port Performance Indicators, UNCTAD: Geneva

UNCTAD, 1985, Port Development Handbook, UNACTAD: Geneva

UNCTAD, 1999, The fourth generation port, UNCTAD Ports Newsletter, 19: 9–12


US Federal Register, 2003, N-RAT assessment exercise, Federal Register, 68(204)

References and Further Readings


Van der Linden, JA, 1998, Interdependence and Specialisation in the European Union: Inter-country Input-Output Analysis and European Integration, Labyrint: Capelle IJssel

Van der Linden, JA, 2001, The economic impact study of maritime policy issues: application to the German case, Maritime Policy and Management, 28(1), 33–54


Vis, IFA and De Koster, R, 2003, Transshipment of containers at a container terminal: an overview, European Journal of Operational Research, 147(1), 1–16

Vis, IFA and Harika, I, 2004, Comparison of vehicle types at an automated container terminal, OR Spectrum, 26, 117–143

Vitale, MR and Mavrinac, SC, 1995, How effective is your performance measurement system? Management Accounting, 77(2), 43–73


Wang, TF, Cullinane, KBP and Song, DW, 2005, Container Port Production and Economic Efficiency, Palgrave: New York


White, CC, 2002, *Transportation Security and Efficiency*, Presentation at the Sloan Annual Industry Centers Meeting, Boston, 6 December


Zuckerman, S, 2002, Shutdown not so bad after all, *San Francisco Chronicle*, 18 October
This page intentionally left blank