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Port Economics, Management and Policy

Theo Notteboom, Athanasios Pallis and Jean-Paul Rodrigue

Port Economics, Management and Policy

Port Economics, Management and Policy provides a comprehensive analysis of the contemporary port industry, showing how ports are organized to serve the global economy and support regional and local development.

Structured in eight sections plus an introduction and epilog, this textbook examines a wide range of seaport topics, covering maritime shipping and international trade, port terminals, port governance, port competition, port policy and much more.

Key features of the book include:

- Multidisciplinary perspective, drawing on economics, geography, management science and engineering
- Multisector analysis including containers, bulk, break-bulk and the cruise industry
- Focus on the latest industry trends, such as supply chain management, automation, digitalization and sustainability

Benefitting from the authors' extensive involvement in shaping the port sector across five continents, this text provides students and scholars with a valuable resource on ports and maritime transport systems. Practitioners and policymakers can also use this as an essential guide towards better port management and governance.

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PREFACE

Port Economics, Management and Policy analyzes the contemporary port industry and how ports are organized to serve the global economy and regional and local development needs.

The economic importance of the port industry would lead to the assumption that an abundance of books already examines the port industry. However, this number is limited and usually consists of compilations or endeavors discussing a limited number of issues.

Having collaborated in port research for more than two decades, we decided to fill the gap by presenting a book that would navigate the reader across the dimensions of port economics, management, and policy. Over these two decades, we investigated ports, blending academic research with practical experience. We did so with a global reach, working with scholars, port authorities, terminal operators, international and regional port associations, and international organizations. We embarked on this project affiliated with Universities on three different continents: the Americas, Asia, and Europe. The insights gained throughout this exciting journey of knowledge are worth sharing.

Globalization, containerization, and technological advancements continue to transform seaports. Throughout centuries ports have been the critical infrastructure that allowed civilizations to advance themselves. In the twenty-first century, this is a multifaceted industry serving the global economy via its integration to supply chains. Specialized terminals, port authorities with a different but equally important role, and the involvement of private actors have evolved in the midst of the core pillars of the modern port industry. Thus, investigating economics, management, and policies related to contemporary ports have captured the interest of an expanding community of scholars. The study of ports demands a multifaceted approach covering macro, meso, and micro levels, and including themes such as the features of world ports, terminals, port markets, and related distribution networks; the economic, logistics, technological, and environmental factors affecting port development and strategy; port governance strategies; port policies; and port competition and performance. All these are equally important for stakeholders who strive to identify ways to secure competitive port development in an economically, environmentally, and socially sustainable manner.

Port Economics, Management and Policy uses a conceptual background supported by extensive fieldwork and empirical observations, such as analyzing flows, ports, and the strategies and policies articulating their dynamics.

The port industry is comprehensively investigated in this unique compilation with:

- **Multidisciplinary perspective** on the port industry relying on economics, geography, management science, and engineering.
- **Abundance of graphic elements** such as maps, figures, photos, and tables.
- **Focus on the latest trends** impacting the industry, such as supply chain management, automation, digitalization, and sustainability.
- **Multisector analysis** including containers, bulk, break-bulk, and the cruise industry.

***

The **Introduction** sets out the considerations that underlay the writing of this book. *Port Economics, Management and Policy* is a multifaceted approach to seaports, with the economic, social, and environmental value of seaports providing the foundations for defining modern ports and analyzing them.

Part I analyzes the aspects of modern maritime shipping that shape contemporary seaports. The dynamics of maritime shipping and international trade, and those of two growing shipping markets, namely containers and cruises, are investigated. This is followed by the analysis of port-related distribution networks and the importance of port hinterlands, the development of hinterland corridors, and the regionalization of port activities. The crucial role of interoceanic passages for maritime trade networks is also underlined.

Ports in the twenty-first century are facing a series of new dynamics, which are investigated in **Part II**. They are part of a geography with their location and operation subject to economic and technological changes. Port hinterlands have particularly been an emerging landscape for port-related activities, leading to their regionalization, the setting of corridors, and logistical platforms such as dry ports. The digital transformation of the industry and green supply chain management are also trends that have significantly impacted ports in recent years.

Part III focuses on port terminals. Terminals and terminal operators maintain a complex portfolio that is usually acquired through concessions and land leases. Forms of terminal funding and the financialization of terminal operations are also a fundamental part of terminal development. The analysis of terminal design and equipment looks at containers, bulk and break-bulk, and cruise port terminals. Attention then turns to dock labor and the ongoing automation of port terminals, particularly container terminals. The concluding part provides insights on port terminal construction.

Port governance is the theme of **Part IV**. Starting with an analysis of the links between governance and performance, this section presents reforms and models that shape global ports. Attention then shifts to port authorities, highlighting how their changing role takes place with the reinforcement of their centrality in contemporary port management. Their evolving role is evident through trends such as the coordination of actors along supply chains, port cooperation, port clusters, and green port management. Port management, governance, and leadership have evolved to reflect a new reality.

Part IV concludes with an invited contribution from Dr. Geraldine Knatz, who has served as CEO of one of the world's biggest ports, the Port of Los Angeles in the United States, providing an insightful contribution to port management, governance, and leadership.

Part V focuses on ports evolving within a complex competitive environment with various forms of port competition, such as inter-port and intra-port completion. Two parameters are crucial for competition, marketing and pricing. While marketing underlines the relationships that a port establishes with its customers, pricing remains a determining factor. Conditions for enhancing port competition are of strategic importance, including the potential of lowering entry barriers in port operations.

Part VI underlines that since ports are in a competitive environment, their performance is subject to careful consideration and monitored through a series of indicators. Port performance is composed of efficiency, performing tasks to minimize their costs and externalities, and effectiveness, performing

tasks that meet the expectations of users. Performance tends to be an operational criterion, while effectiveness is a market criterion. Ports can be subject to disruptions impairing their operations, testing their resilience to maintain operations.

Part VII analyzes port policies and development. Ports are political and economic tools. A wide array of principles and themes for national and international port and port-related policies exist, including international initiatives, such as emissions control, port security, and port labor, and there is also the controversial role of geopolitics in port development. The role of ports in economic development and strategic port planning is a relevant theme. The relationships between ports and their localities remain a challenge involving various facets of port–city interactions. To mitigate the political climate, associations are formed at different levels and with different priorities to represent port interests.

Part VIII focuses on ports, like transportation, serving a derived demand that can be segmented into specific markets. The most salient markets include cruise ports and terminals, the break-bulk market, ports as complexes supplying and distributing energy, the provision and management of containers, and how cold chain technology has allowed ports to play an active role within these supply chains, particularly with refrigerated containers (reefers).

The **Epilog** of this book discusses our perspectives on the emerging issues that will shape the economics, management, and policies of ports.

We hope that this book will support the expanding community of scholars involved in the study of this maturing research field to identify foundations of knowledge and stimuli for future research. Students will gain an all-inclusive approach to the port sector and its dynamics. Port professionals and stakeholders along the maritime supply chains will gain further insights on the dynamic port environment in which they want to expand their presence and competitiveness.

* * *

Conducting research forms a big part of our academic life. We consider this book as a milestone in our endeavors to share meaningful research with port enthusiasts from around the world. These endeavors were shaped by countless interactions with multiple port professionals, fellow scholars, and students. All three of us would like to thank them for enriching our perspectives of port economics, management, and policy. Special thanks go to our fellows in the Port Economics initiative and all those who worked with us in joint research efforts. We also extend special thanks to our colleagues at the International Association of Maritime Economists (IAME) and the Port Performance Research Network (PPRN). Theo Notteboom would particularly like to thank his current and former colleagues at the maritime and port-related centers of the University of Antwerp, Ghent University, Dalian Maritime University, and Shanghai Maritime University, many of whom have become friends. Special thanks to Emeritus Professor Willy Winkelmans from the University of Antwerp, who not only introduced him to the world of ports, but also opened many windows of opportunities to grow as a person and port economist. Thanos Pallis would like to thank his colleagues at the University of the Aegean for providing the environment for developing research in shipping and ports.

Special gratitude goes to Costas Chlomoudis, George Vaggelas, Aimilia Papachristou, and Evie Kladaki, prominent members of the Greek port studies cluster, who have been long-term partners in many good and challenging moments of research, and great friends in life. He also extends special thanks to Thomas Vitsounis, Spiros Tsiotsis, and Stefania Kollia, for the opportunity to supervise their doctoral research that has expanded his conceptual horizons. He would also like to thank Mary Brooks and Gordon Wilmsmeier for hosting intellectually stimulating sabbaticals that expanded horizons and provided opportunities for most productive research collaborations. Jean-Paul Rodrigue would like to thank his Port Economics colleagues, many of whom became friends over the years. Gratitude to Claude Comtois and Brian Slack for their introduction to the world of transportation many decades ago.

This book is dedicated to our families. The writing of this book is an idea that was conceived during a dinner at the Chart House in New York, United States. Since then, the 'ChartHouse team' embarked on a number of research trips, and finally made the long and passionate journey to conclude this book during pandemic times. Hui, Jayden, Luca, Valia, Gordana, and Nikola supported us on all of these hard-working days and nights. This book is dedicated to them.

Theo Notteboom, Thanos Pallis, Jean-Paul Rodrigue
Antwerp–Athens–New York, January 2022

INTRODUCTION: A MULTIFACETED APPROACH TO SEAPORTS

A seaport is a node in global supply chains with a strong maritime character and a functional and spatial clustering of port-related activities.

1 A COMPREHENSIVE PORT DEFINITION

The seaport has a long history going back to the early days of human endeavors. As soon as civilizations emerged across the world, trade networks supported by ports emerged as well. Although maritime transport technology has evolved substantially, the role and function of ports remain relatively similar. Conventionally, a port is defined as a transit area, a gateway through which goods and people move from and to the sea. It is a place of contact between the land and maritime space, a node where ocean and inland transport systems interact, and a place of convergence for different transportation modes. Since maritime and inland transportation modes have different capacities, the port assumes the role of a point of **load break** where cargo is consolidated or deconsolidated.

Even if the term port appears generic, it expresses a substantial diversity of sizes and functions. Ports also have a geographical diversity in terms of the sites being used for port activities, which can range from rivers, bays, to offshore locations. They are complex and multifaceted and can be approached primarily from a supply chain perspective, which leads to the following definition:

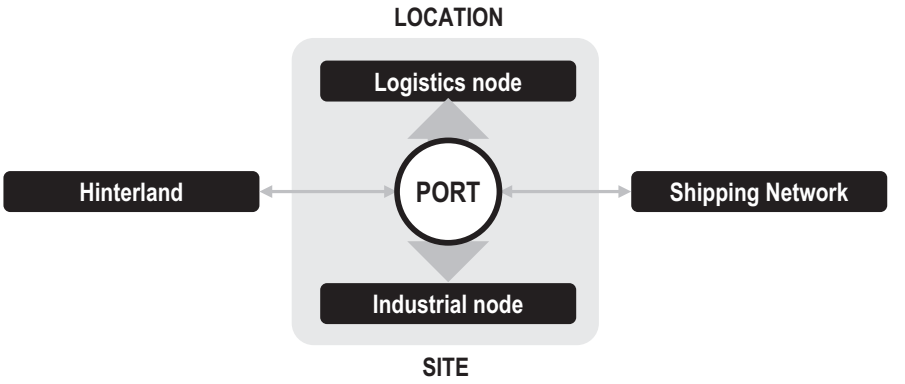
> *A seaport is a logistic and industrial node in global supply chains with a strong maritime character and a functional and spatial clustering of activities directly or indirectly linked to transportation, transformation, and information processes within global supply chains.*

A modern seaport is not regarded solely as a load breakpoint in various supply chains but should be considered a **value-adding transit point**. As nodes within transportation and logistics networks, ports have a location whose relative importance can fluctuate given economic, technical, and political changes. This location tries to capitalize on the advantages of a port site characterized by fundamental physical features influencing the nautical profile, such as water depth, access channels, and the available land.

The following geographical elements help define a seaport:

- **Location**. The relative position of the port in relation to other ports serviced through shipping networks and through its hinterland.
- **Site**. The physical characteristics of the port, such as its nautical profile (depth, access channel) and the land available for port activities, particularly for terminals.

FIGURE I.1 Defining the Seaport



The following functional elements help define a seaport (Figure I.1):

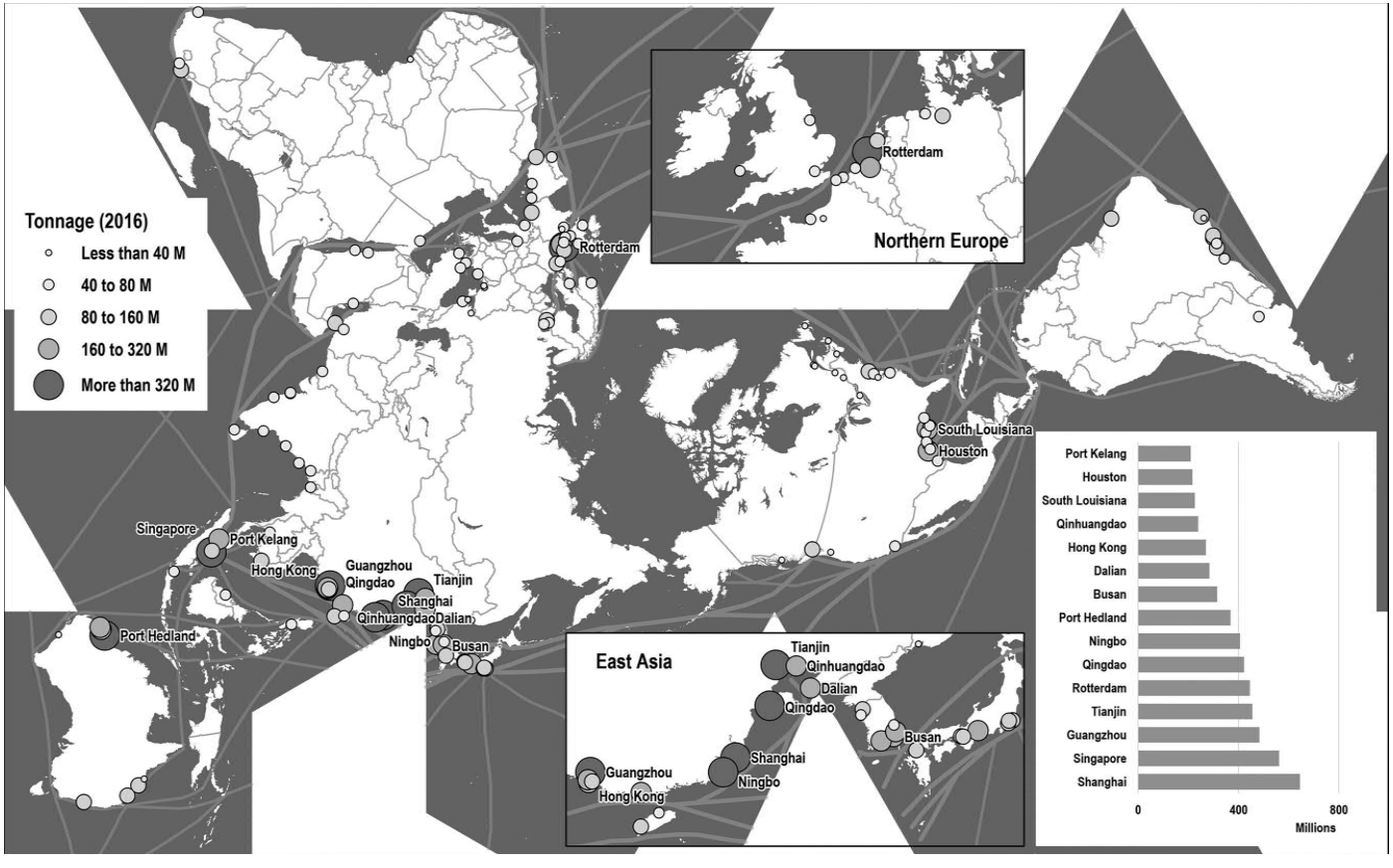
- **Logistics node**. The added value performed by the port's transportation function, including handling, consolidation, and deconsolidation.
- **Industrial node**. Activities depending on the port as a platform to supply inputs such as raw materials and distribute outputs such as parts and finished goods.

2 TYPOLOGIES OF SEAPORTS

An approach to understanding the diversity of ports is their classification into typologies to analyze their specific role and functions. Conventionally, ports can be categorized based on a large number of dimensions, such as:

- **Scale**. Refers to an assessment of port size in terms of its area, annual cargo throughput, the size of its hinterland, the number of shipping services it is connected to, or the number of customers. The scale of a port is commonly associated with its economic and commercial importance in the market it serves (Figure I.2).
- **Geographical attributes**. Refers to the main characteristics of the port site and situation. Coastal and inland geography conditions create variety in the locational setting of port sites such as in a bay, along a coastline, on a river, or in an estuary. Many sites have natural advantages, while for others, the site needs to be improved with dredging and landfills. Although a port site is fixed in space, its situation is relative to the main shipping lanes and hinterland, or its proximity to and interactions with cities or urban conurbations.
- **Governance and institutional settings**. Refers to the terms of land ownership and the roles of institutional arrangements between the public and private sectors. Many ports are publicly owned but have terminals operated by private organizations.
- **Port functions**. Refers to the range of services offered by the port such as cargo handling, logistics, and distribution, industry, and maritime services. They are subject to competitive pressures since the services offered by a port can be offered by another port.

FIGURE I.2 World's Largest Ports, 2016



- **Specialization**. Refers to the cargo handled, such as containers, conventional general cargo, liquid bulk, dry bulk, or roll-on/roll-off cargo. Some ports are specialized in handling passenger traffic, namely cruise ships and ferries. Another specialization concerns port-centric industries such as steel plants, energy plants, automotive, or chemical industries. Further, logistics activities are an important contributor to port specialization.

Through generations of port development, **port functions have changed and expanded**, responding to technical, economic, and social developments. From the traffic being generated, functions such as trade, distribution, and industry have emerged in seaports, broadening and deepening their functions. In recent decades, the main driving forces include containerization, diversification of cargo types and equipment, intermodal transport, and information technologies. Port functions are extended to trade, logistics, and production centers with an extensive portfolio of operations, including production, trade, and service industries. Some seaports have grown to become industrial complexes comprising a large number of industrial activities.

Successive stages in port development, in part coordinated by different economic opportunities, have favored the establishment of a hierarchy of ports, ranging from small ports servicing a niche market to large gateways servicing a vast area composed of an extensive range of economic activities. Like most hierarchies, there are a small number of very large ports accounting for a significant share of the total traffic and many small ports that account for limited traffic. For instance, in 2019, the 20 largest container ports accounted for 44% of the total traffic, reflecting a well-established hierarchy (Figure I.3). This does not imply that small ports are of limited importance for the economies they serve. Small islands and nation-states have a high dependence on their ports to access global markets.

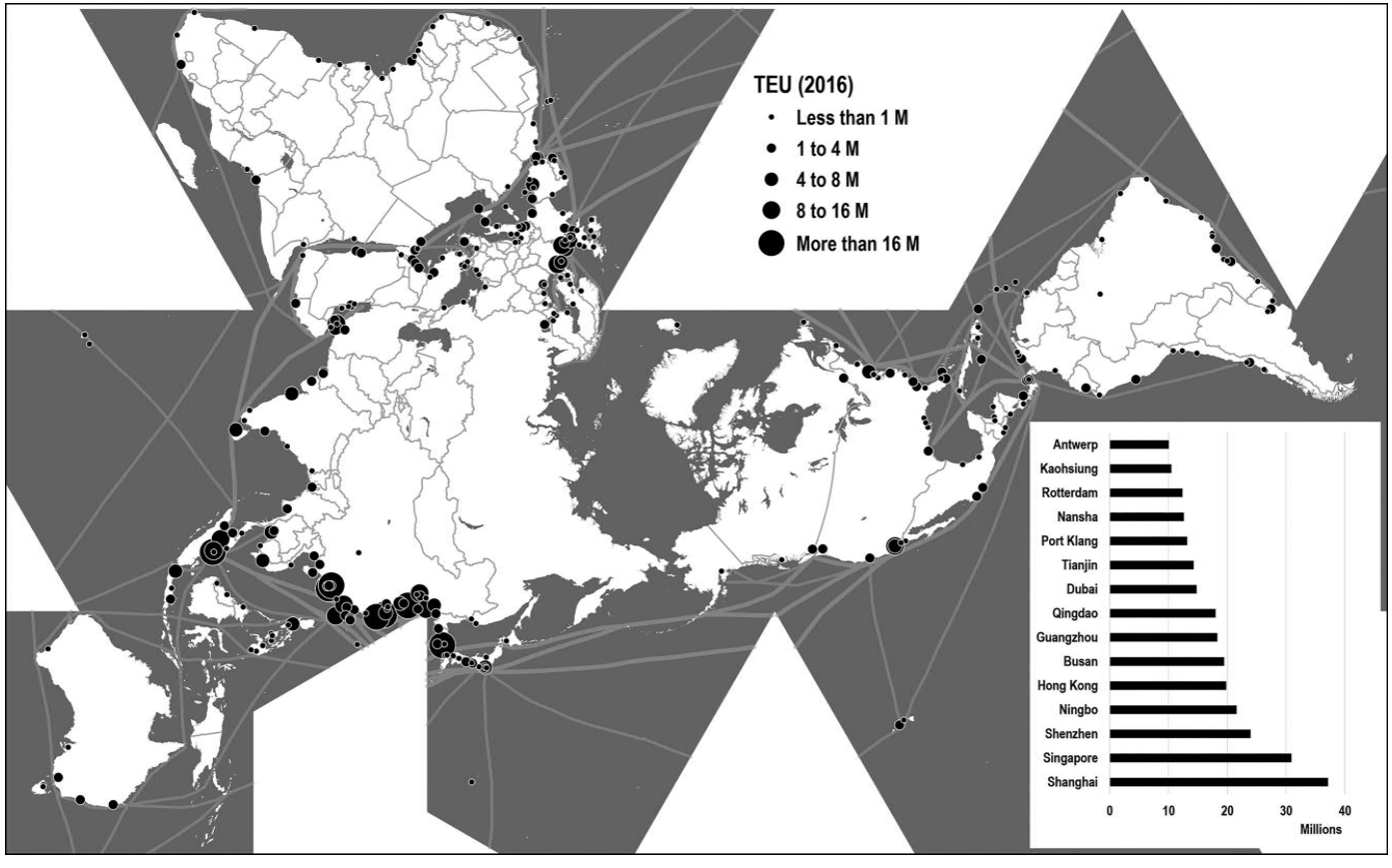
From a supply chain perspective, seaports are increasingly functioning not as individual places that handle ships but as turntables within global supply chains and global transportation networks. The contemporary port (labeled fourth-generation port) is characterized as a platform commanding freight flows and requiring knowledge-intensive coordination activities. A seaport is not self-contained as port activities contribute to the industrial and logistics development in the port areas and its hinterland. Thus, ports act as **service centers and logistics platforms** for international trade and transport.

In recent decades ports have been subject to a wave of reforms that reflects the increasing business and market-oriented approach to port management. From governance and institutional perspectives, many ports have become independent commercial organizations aiming at profitability, cost recovery, and customer service.

3 STAGES IN PORT DEVELOPMENT

The widely cited port-type generations of United Nations Conference on Trade and Development (UNCTAD) and later port generation models look at port roles and functions, but also at institutional structuring and operational and management practices. In 1994, UNCTAD coined the term

FIGURE I.3 World's Major Container Ports, 2016



'**third-generation port**', to describe a port which has functions dealing with cargo handling plus other value-added services such as warehousing, packaging, and distribution, providing additional employment and revenue to the port community. In 1999, UNCTAD defined port-type generations from the first to the fourth-generation port based on interfaces of ship and shore with the operation of cargo types, a higher dependency on capital rather than labor, the development of containerization and logistics, and changes in port operators and administration with vertical and horizontal integration strategies (Figure I.4).

Therefore, ports develop both functionally, in terms of the cargo they handle, and spatially, in terms of the extent of their infrastructure and position in shipping networks. Four major generations (or stages) can be identified, each corresponding to a specific era in the commercial geography of ports. Three main typological factors can articulate the temporal sequence of port development:

- **External environment**. A series of external political, economic, and technological developments impact the role and function of ports. The most recent driving forces concern globalization, sustainability, and digitalization.
- **Spatial organization**. The scale and scope of port activity have substantially expanded with the setting of port networks.
- **Organization and strategy**. Port authorities have become complex entities managing the port network communities with the goal of developing integrated transportation and logistics services for their hinterland.

Some scholars have proposed a '**fifth-generation port**' (5GP) with the introduction of a 'port ladder' towards customer-centric community-focused ports. The 5GP involves customer-centric community ports that increasingly look at market opportunities through the eyes of their customers and adapt to meet the ever-higher expectations of their host communities.

4 PORT DIMENSIONS

Four main dimensions help define the role and function of a port (Figure I.5):

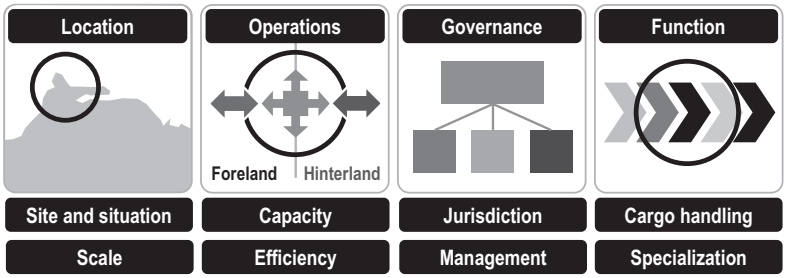
- **Location**. A port is a location that has convenient physical characteristics (such as a protected bay) and thus supports a more effective interface between the maritime and land domains than other locations. Although the location of a port does not change, the site can be improved through dredging and land reclamation, which requires substantial capital investments. This allows the port to expand its scale in terms of its surface and the amount of traffic it can handle. The situation of a port can also change as it is dependent on large zones of production and consumption.
- **Operations**. A port has operational characteristics in terms of the type of traffic it can handle and related volumes. This is contingent upon the infrastructure (berths) and the superstructure (cranes and yard equipment) linking the port foreland (the ports it is connected to) and the port hinterland (inland market area). With capital investments and

FIGURE I.4 Functional and Spatial Development of a Seaport

	First Generation (Before 1960s)	Second Generation (1960s to 1980s)	Third Generation (1980s to 2000s)	Fourth Generation (Since 2000s)
External Environment				
Development factors	▪ Steamships; Rise of nations; Rise of trade	▪ Petrochemistry; Trucks and pipelines; Structural prosperity; Industrialization	▪ Multinational corporations; Containerization; Environmentalism; Globalization.	▪ Global economy; Information systems; Sustainability; Digitalization
Port functions	▪ Transshipment (1); Storage (2); Trade (3)	▪ (1) to (3) + Industry (4)	▪ (1) to (4) + Distribution (5)	▪ (1) to (5) + Logistics (6)
Nature of production	▪ Cargo flow; Simple services; Low added-value.	▪ Cargo flow; Cargo transformation; Combined services; Improved value-added	▪ Cargo/information flow; Cargo distribution; Multiple service package; High value-added	▪ Cargo/information flow; Cargo/information distribution; Multiple service package; High value-added; Chain management
Type of cargo	▪ General cargo and bulk	▪ General cargo, bulk and liquid bulk	▪ Bulk and unitized/containerized cargo	▪ General/containerized cargo; information
Spatial Organization				
Port spatial scale	▪ Port city	▪ Port area	▪ Port region	▪ Port network
Port spatial expansion	▪ Quay and waterfront area	▪ Enlarged port area	▪ Terminals and inland corridors	▪ Network-related functional expansion
Location factors	▪ Labor and market access	▪ Access to raw materials; Access to sales market; Availability of capital	▪ Availability of transshipment facilities; Access to sales market; Space; Flexibility; and labor costs	▪ Availability of transshipment facilities; Access to sales market; Space; Flexibility; and labor costs
Strategy				
Organization	▪ Independent activities within port; Informal relationship between port and port users	▪ Close port / users relationship; Loose port / activities relationship; Causal port / city relationship	▪ Port community; Port / transport chain integration; Close relation between port and municipality; Enlarged port organization	▪ Port network community; Close relation between port network and public authorities on different levels
Role of port authority	▪ Nautical services (1)	▪ 1 + land and infrastructure development (2)	▪ (1), (2) + Port marketing (3)	▪ (1) to (3) + Network management (4)
Port strategy	▪ Port as changing point of transport	▪ Transport, industrial and commercial center	▪ Integrated transport and logistic center	▪ Integrated transport, logistic and information complex and network

Source: Adapted from Van Klink (2003).

FIGURE I.5 Port Dimensions



management, the operational efficiency of a port can be improved with changes to land, equipment, and management.

- **Governance**. A port is a well-defined administrative unit that involves land ownership and a jurisdiction (what a port can legally do). The port authority is a common administrative framework for a port, and in many cases, terminal management and operations are leased to private companies. Port authorities usually have the right to spearhead port development projects and secure funding.
- **Function**. A port adds value to transport and supply chains through its cargo handling. Historically, heavy industrial activities such as steel mills and petrochemical plants had a propensity to locate within or nearby ports. This process is still going on and being complemented by a large array of freight distribution activities. There is a diversity of port functions associated with specialization forms, such as ports involved in minerals, energy, and containers. Large ports tend to be polyfunctional, while smaller ports tend to be monofunctional.

Port sites have been the subject of geographical considerations, with a preference for sites combining a good maritime profile with inland accessibility. There is a vast array of port sites linked to specific nautical profiles, which are articulated around seaports and mainland ports (Figure I.6):

- **Seaports**. These ports have direct access to the sea and try to take advantage of a local geographical feature. This can involve (A) bays or direct coastline, and (B) natural harbors, or protected locations. These sites are often associated with a lateral expansion of the port facilities, often towards locations with a deeper nautical profile.
- **Mainland ports**. These ports are linked to a major river, which often serves a vast hinterland. There are ports in (C) an estuary, (D) a delta, and (E) along a river, often at the furthest point of inland navigation. These sites are associated with an upstream expansion of port facilities.

The most common sites are those in bays or by the coastline (50%), followed by natural harbors (20%). This underlines the importance of maritime accessibility for the world's largest ports. The remaining 30% involve ports located along river systems.

FIGURE I.6 Port Sites

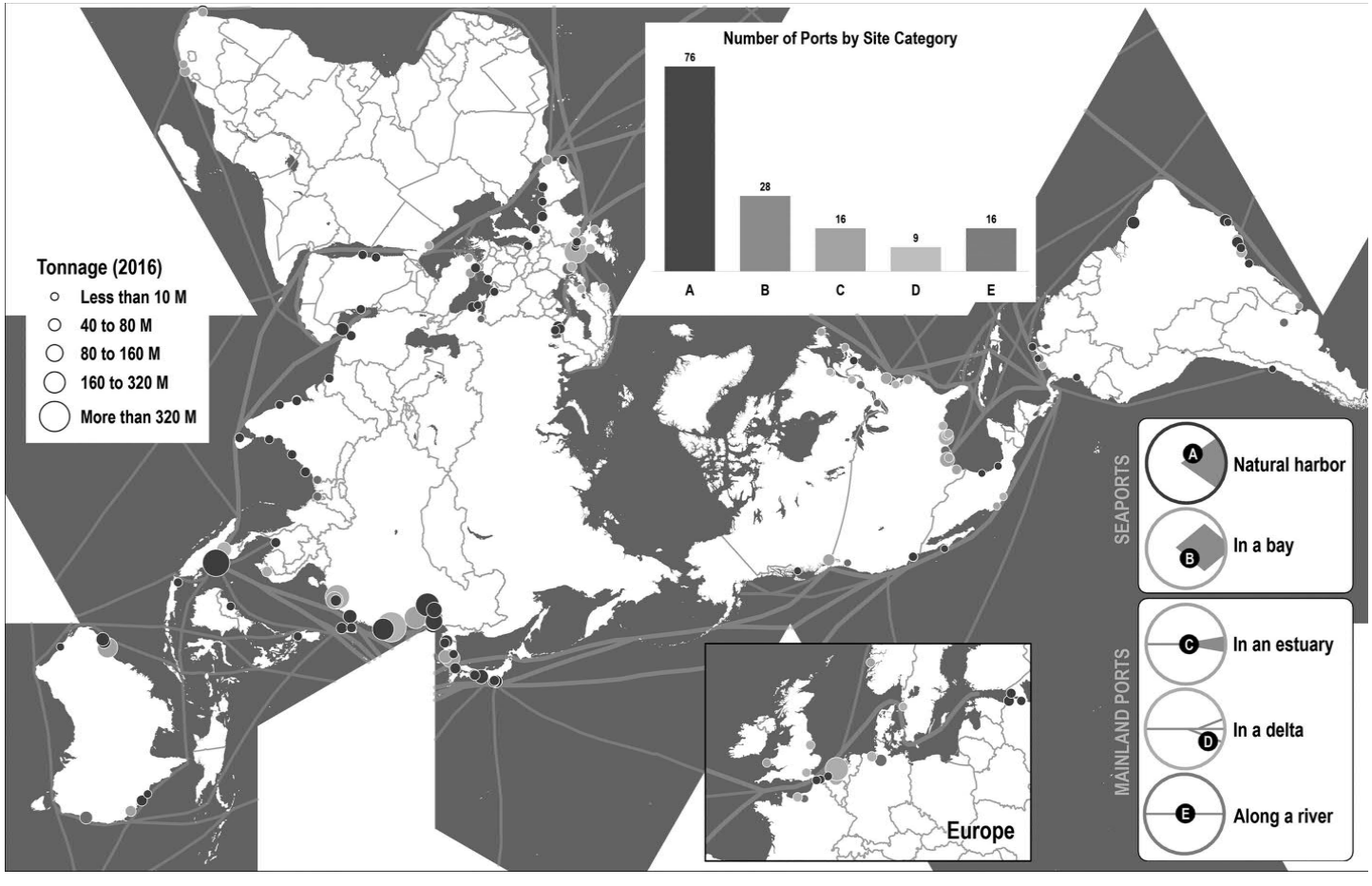
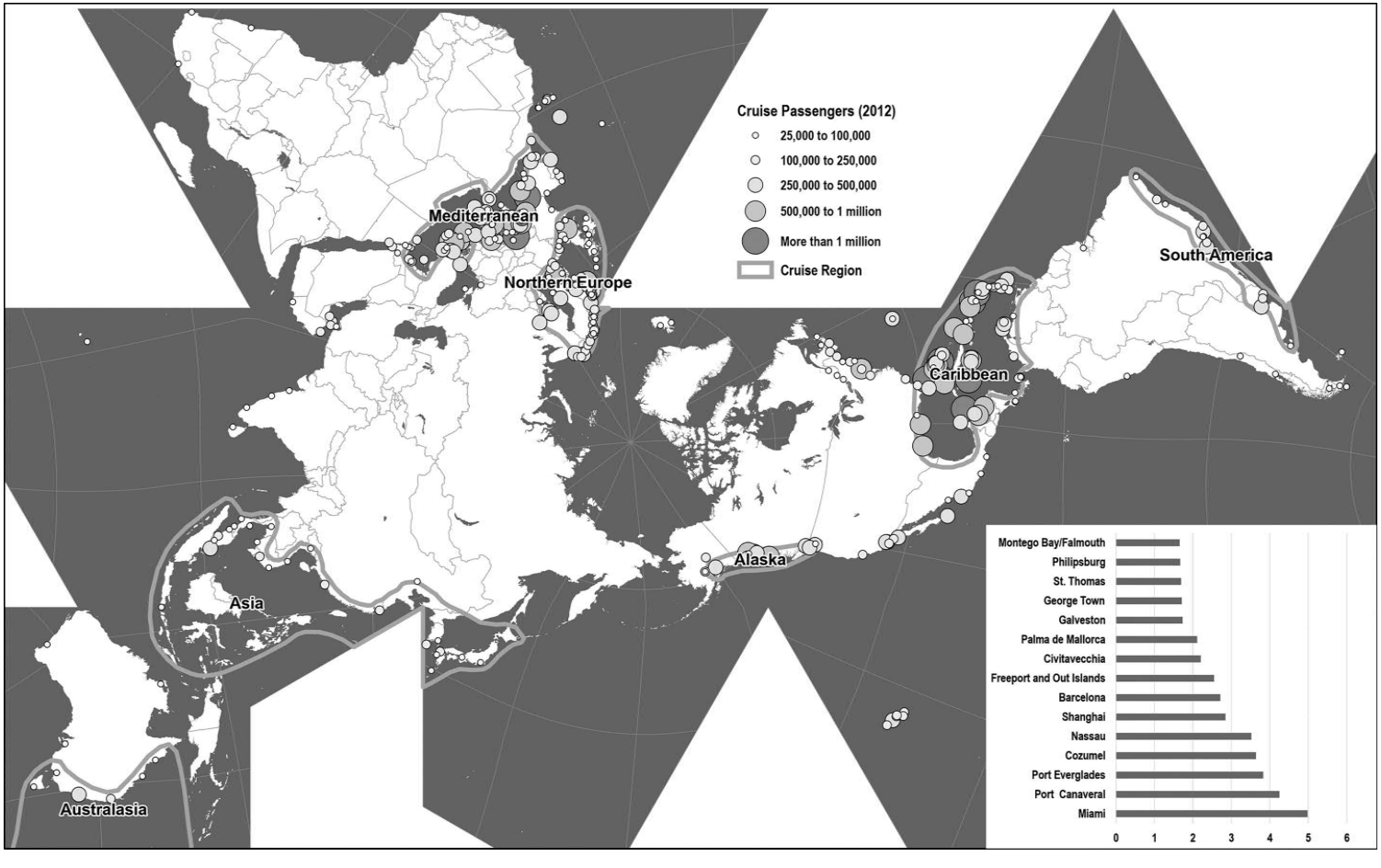


FIGURE I.7 Global Cruise Port Activity, 2012



Source: Data adapted from Cruise Market Watch (www.cruisemarketwatch.com). Cruise port visits based upon the published itineraries of about 90% of the global cruise shipping capacity.

Container ports are reflective of the world's **commercial geography**, particularly since they predominantly handle finished and intermediate goods. Commodities are becoming more prevalent but remain a niche market. Prior to the 1990s, the world's most important ports were North American (e.g. New York) and Western European (e.g. Rotterdam). Globalization, supported by containerization, completely changed the world's commercial geography with the emergence of new port locations reflecting changes in the global geography of production, distribution, and consumption. This geography indicates a high level of traffic concentration around large port facilities, notably Pacific Asian ports along the Tokyo-Singapore corridor. As export-oriented economic development strategies took shape, the number of containers handled in Pacific Asian ports, notably Chinese ports, surged.

The comparative size of ports requires caution as several ports can be considered more as **statistical agglomerations** than functional entities. For instance, the port of Shenzhen in the Pearl River Delta is composed of several large port facilities (e.g. Yantian, Chiwan, Shekou) that act as distinct entities within their operations and even service different hinterlands. The same observation applies to Guangzhou and Shanghai that are multiport (and multi-terminal) entities.

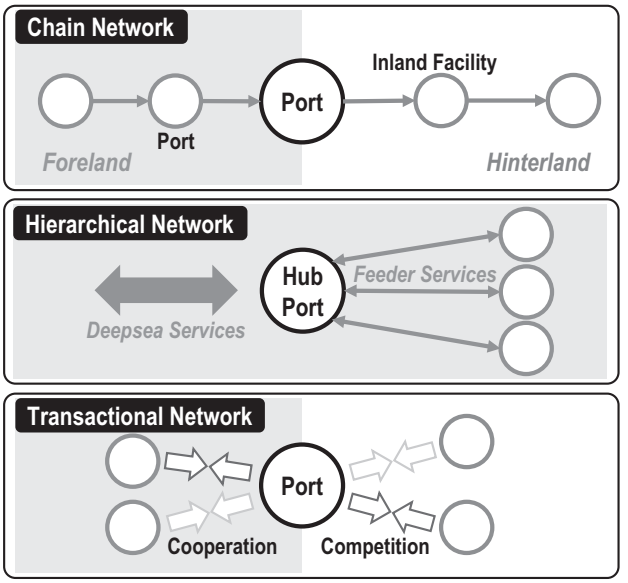
The **global cruise port system** is characterized by a high level of regional concentration as well as a clustering of port visits (Figure I.7). The observed destination patterns clearly underline the prominence of port visits around the Caribbean and the Mediterranean, in line with the operational characteristics of seven day cruises calling at three to five ports. Other clusters of significant activity concern the US Northeast and Atlantic Canada, Alaska, Hawaii, Hanseatic ports, and the coast of Norway. In the 2010s, Asia has been the most significant growth market for the industry. New cruising clusters are emerging to serve a latent demand from a growing middle and upper class in Asia, the Middle East, and South America. With a number of cruise vessels deployed in the Australian market offering their services in the region, cruise ports are developing in all parts of the world.

5 PORT SYSTEMS: BEYOND INDIVIDUAL SEAPORTS

Seaports are part of a system with specific spatial and functional characteristics, supporting global logistics and transport networks. They interact with other nodes such as overseas and neighboring seaports, intermodal terminals, and inland logistics platforms. Seaports are subject to three types of functional interdependences with other nodes (Figure I.8):

- **Chain networks**. Ports are nodes, part of a sequence of flows where the output of one node in the network is the input for another. An example is a relation between container ports and inland load centers. Rotterdam services of a chain of inland terminals along with the Rhine river, a role similarly assumed by Shanghai for inland terminals along the Yangtze River. Chain networks also apply for trans-ocean relations, including deep sea liner services such as the Rotterdam–Singapore chain supporting the Europe–Far East trade.

FIGURE I.8 Functional Interdependencies of a Seaport



- **Hierarchical networks**. Ports are nodes, part of different connectivity levels, implying that some locations can be reached indirectly as opposed to directly. An example is the hub-feeder port relation in container shipping linking the South Korean container port Busan to smaller feeder ports in Northeast Asia.
- **Transactional networks**. Ports are nodes in a system of commercial relations where they can be competitive or complementary. They use advantages such as location, cost, and productivity to attract or retain shipping services and traffic.

6 INTERDEPENDENCIES WITH OTHER NODES

Ports rarely operate in isolation from other ports but are part of complex networks of interactions. A **port system** can be defined as a system of two or more ports located in proximity within a given area. They can relate to a complete coastline such as the West coast of North America. The port range is one of the largest consistent port systems.

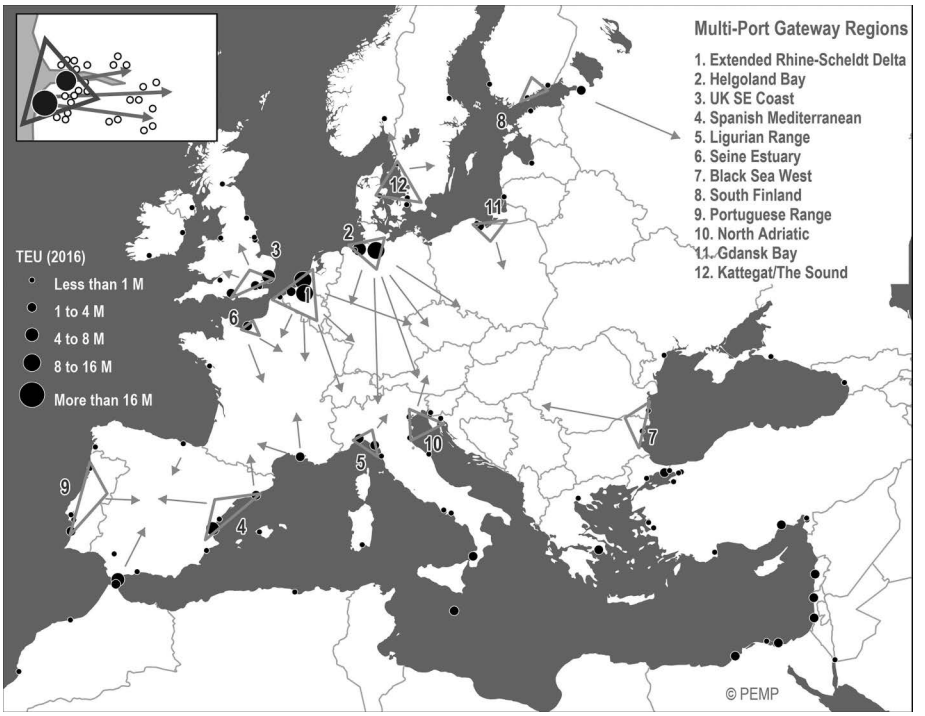
> *A **port range** can be defined as a group of ports situated along the same seashore and potentially sharing access to a hinterland.*

There are many maritime ranges worldwide, each with its inherent geographical, economic, and functional characteristics. The Hamburg–Le Havre range in Europe is a typical example, which can be expanded to include the Gdansk–Le Havre range. An acute intra-range competition can be observed at the multiport gateway level.

> *A **multiport gateway region** refers to a group of ports in proximity competing for the same port calls and hinterland. It has a smaller geographical scale than a container port range. The locational relationship*

to nearby identical traffic hinterlands is one of the criteria for grouping adjacent container ports into the same multiport gateway region. The port-calling patterns in the maritime service networks and hinterland connectivity profile can also help group ports to a multiport gateway region.

FIGURE I.9 The European Container Port System and its Multi-port Gateway Regions



Source: Rodrigue and Notteboom (2010).

Typical examples include the Rhine–Scheldt Delta (Belgium and the Netherlands) and the Yangtze River Delta and Pearl River Delta in China. A port range can be home to several multiport gateway regions (Figure I.9). For example, the Gdansk–Le Havre range includes the multiport gateway regions of the Gdansk Bay in Poland, North-Germany, the Rhine–Scheldt Delta, and the Seine Estuary in France.

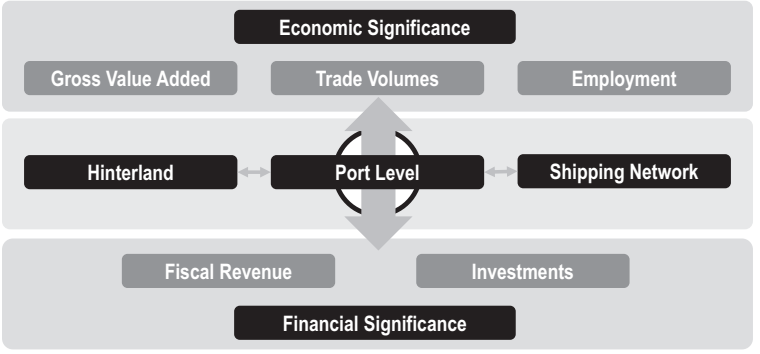
Inland nodes and feeder ports are also considered as part of the port system. They are competing to attract economic activities associated with seaports, which leads to functional changes in the port system. These nodes can also co-operate and coordinate their development by bundling transport flows and offering land for development. This gives economic activities such as manufacturing and logistics a range of locational options for nodes that are the most suitable to their operational and market access needs.

7 PORTS AS ECONOMIC CATALYSTS

The core value of ports is economic since they support trade flows and the ecosystem of related activities. As they can represent a substantial economic investment, ports are expected to provide enough value to justify these investments. From an economic and public policy perspective, ports are viewed as economic catalysts for the regions they serve. Two distinct approaches can be followed when evaluating the strategic and economic significance of ports (Figure I.10). The first is to measure the economic significance of ports via distinct parameters. There exists a large range of potential indicators. Some are expressed in absolute figures, while others are expressed in relative terms. A non-exhaustive list includes:

- **Gross value-added**, which provides an insight into the contribution of port activity to the GDP (Gross Domestic Product) or GRP (Gross Regional Product) in a given time period (often annually). This added-value can be complex to evaluate since ports directly impact those activities directly connected to them and without which the port could not effectively function. There is also a range of indirect impacts on the whole ecosystem of economic activities that may interact with the activities directly related to the port. As international trade grew, the indirect impacts of ports on national or regional economies became even more important.
- **Employment**, which is mainly expressed in full-time equivalents (FTEs) and provides an insight into how port activities contribute to employment creation. In most cases, a snapshot is taken once a year to provide the total employment or port activities. Similar to added-value, there is a whole range of employment that is indirectly related to port activities.
- **Trade volumes and values**, which provide an insight into the importance of ports for international trade. Traffic direction can also be considered since several ports are dominantly export platforms while others are focused on imports. In these cases, the same volume and trade composition can support different economic structures.
- **Fiscal revenue**, which indicates how port activities contribute to the taxation income within their jurisdictions, ranging from national to municipal governments. This is particularly relevant to justify the public expenses supporting port activities, particularly infrastructure.

FIGURE I.10 The Economic Significance of Ports



- **Investments** by the public and private sector in port activities over a given period. Port superstructure and infrastructure are capital intensive and require constant maintenance.

The second approach is of a more qualitative nature and tries to evaluate the significance and value of seaports for the economic development and performance of their market. These strategic aspects are difficult to quantify but deserve attention.

7.1 Ports as generators of added value and employment

The first approach asserts that ports contribute to the **generation of socio-economic benefits and wealth**, particularly direct and indirect added-value and employment. The external spill-over effects of ports can be substantial. Simultaneously, the economic effects of seaport activities are no longer limited to the local environment. They are increasingly spread over a much wider geographical area and among a large number of international players. In other words, the economic benefits of port activities are expanding from the local port system towards a much larger economic system. The geographical dispersion of economic effects is apparent when a port does not develop local added value activities linked to transit cargo or establish a strong local industrial and logistics cluster. In that case, cargo flows are transiting the port, thereby generating employment and value-added effects for the local community, mainly in cargo handling, ship services, and inland transport operations.

The changing distribution of benefits is also illustrated by the **development of logistics zones** in the vicinity of seaports or inland locations along the main corridors towards the hinterland. This trend has been supported by growing containerization and intermodal transport systems. In many cases, these logistics sites and zones generate considerable economic benefits by providing low-end, high-end value-added logistics services (VALS) to the cargo and only using ports as a transit point. However, it is unlikely that these sites and zones would have developed if it were not for seaports.

Policymakers and public authorities typically approach the macro-economic impacts of ports from a **national or regional competitiveness perspective**. Most available reports and figures on the economic impact of seaports portray the national or regional economic effects. Ports impact the wider economic space and international trade, with logistics receiving less attention. While leakages of port-related benefits to regions in the more distant hinterland can be substantial, policymakers focus on maximizing the port's input payback for the local or regional communities under their jurisdiction. The main port development objective is to provide infrastructures for the local, regional, or national interest at the lowest combined cost to the port and its users.

From a macro-economic perspective, seaports typically are important **generators of employment**. The employment effects of a port activity usually extend beyond the initial round of employment generated by that activity. The extent of the employment effects of ports is affected by the boundaries of the economy that is being analyzed. The increasingly international nature of port and shipping activities and the characteristics of global supply chains make the employment effects of port activities typically extend beyond the local

level to a regional or even supranational level. For instance, shipping lines are operating on a global scale with related employment effects such as for ship crews. On a local scale, they might generate employment via their liner shipping agencies in the ports of call.

Employment related to ship management, container fleet management, and investment and commercial strategies is usually concentrated in global or regional headquarters. The same applies to global container terminal operators such as PSA (headquartered in Singapore), Hutchison Ports (Hong Kong), DP World (Dubai), or APM Terminals (The Hague). While these companies generate many operational jobs at the local port level, they keep some activities centralized in global or regional headquarters, such as equipment purchases and research and development. Terminal operators might purchase terminal equipment from foreign suppliers such as Kalmar, Konecranes, or Shanghai-based ZPMC. For a particular port activity, the flow-on employment effects to the national or international economy will generally be larger than the flow-on effects to the regional economy.

7.2 The strategic value of ports

By providing cost-efficient, reliable, and frequent connections to overseas and inland markets, seaports play an essential role in **facilitating trade** and **increasing the competitiveness** of a nation or region. This strategic value manifests itself in different ways:

- First, the **proximity of efficient seaports** can be an important factor in the location decisions of firms.
- Second, the **availability of a competitive seaport system** can reduce reliance on foreign ports for trade and can reduce the total logistics costs for firms located in the region.
- Third, **seaports can substantially contribute to the international competitiveness of firms** in a region or country, mainly through existing innovation and advanced business networks and management.

Good infrastructure and **high accessibility or connectivity** are increasingly becoming basic requirements for competitiveness. For high-income economies, innovation and advanced production factors become essential to remain competitive. This also alters the strategic role of seaports. Instead of just ensuring connectivity to overseas and inland markets, seaports also play a role as innovation centers. A port is no longer a quayside area where cargo is simply shifted from land to sea. It becomes a vital link in global supply chains and international transport networks. By striving for competitiveness and efficiency improvements, seaports can become drivers of innovation. This sense of innovation is strengthened by port cluster management that enhances knowledge exchanges among organizations within and outside the cluster. Through clustering, a knowledge spill-over is created, increasing innovation and added value.

Ports can be sources for **innovation, productivity enhancements**, and **strategic cooperation** through the presence of large multinational firms, leading firms, and clusters of related and supporting industries. Ports can also enhance specialization, innovation, and productivity improvements through cooperation with ports and other logistics hubs in the region. Finally, ports can help support the diffusion of competencies and the further gathering of knowledge in port management and logistics. Next to pure economic arguments,

these more strategic aspects should be considered when evaluating port development plans.

The importance of a port to a regional, national, or supranational economy is greater than is shown by measures of direct and indirect value-added and employment. For example, a 2015 study estimated the strategic value of the seaport system in Belgium at €45 billion, or 60% more than reported in the annual port economic impact studies of the National Bank of Belgium.

8 FROM CARGO HANDLING TO NODES IN GLOBAL SUPPLY CHAINS

Next to the macro-economic perspective, seaports can also be analyzed using a microeconomic approach. Port operations are usually oriented towards the two traditional components of ships and cargo (Figure I.11).

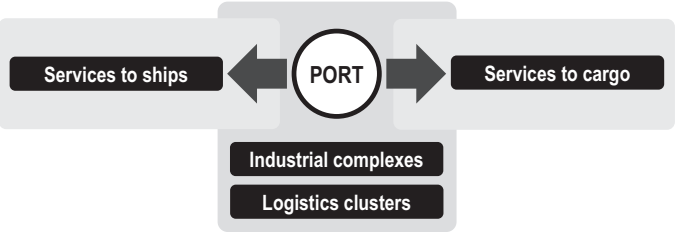
- **Services to ships** include those performed at the sea or waterways side (dredging, pilotage, mooring/unmooring) and the ship/shore interface (berthing, repair and maintenance, supply, and bunkering).
- **Services to cargo** can be divided into those performed at the ship/shore interface (stowing, loading, discharging) and those entirely performed in landside areas such as consolidation, storage, and distribution.

Key in the micro-perspective approach are the concepts of **efficiency, performance**, and **sustainability** at the operational level (i.e. a company or a terminal). This approach to ports advocates that corporations and their terminals are the relevant units of analysis when analyzing or assessing port competition, not seaports.

While the transit, transport, and handling of cargo is the rationale for ports, seaport functions have become diverse in scope and nature and evolve over time. The complexity of seaports goes beyond the loading and discharging of vessels along the quay. Fundamental processes of economic and technological change have broadened and deepened the functions of seaports. Seaports added new functions to their traditional role of transshipping and storing goods. After the Second World War, the industrial function grew rapidly. Some seaports have grown out to become **industrial complexes** comprising a large number of related industrial activities, the so-called maritime industrial development areas (MIDA).

In more recent years, the **logistical function of seaports** received attention. The increasing importance of integrating ports and terminals in value-driven supply chains has increased the focus on creating added value linked

FIGURE I.11 Transport and Cargo Handling Functions of a Port



to cargo passing through the port. The gateway position of major seaports offers opportunities to enhance value-added logistics services (VALS) by integrating the production and distribution chain. By offering VALS, ports aim to attract a large portion of the value-added creation within product chains. Modern seaports have evolved from pure cargo handling centers to a function in a logistics system.

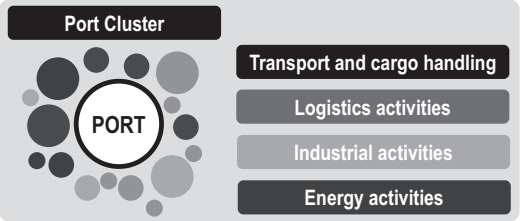
The competitiveness of ports can be better understood by following a supply chain approach. Ports compete not as individual places that handle ships but as crucial links within global supply chains. Port and route selection criteria are related to the entire network in which the port is just one node. The selected ports are those that will help to minimize the sum of sea, port, and inland costs, including inventory and quality considerations of shippers. Port choice becomes more a function of the overall network cost and performance. A well-coordinated logistics and distribution function of seaports with the cooperation of various service providers facilitates the integration of ports in advanced logistical and distributional networks through a new range of high-quality value-adding services.

9 PORTS AS CLUSTERS OF ECONOMIC ACTIVITY

At the intermediate level, ports are often approached as **clusters of companies and economic activities** (Figure I.12). Ports typically consist of geographically concentrated and mutually related business units centered around transport, trade, and industrial production. Port clusters exhibit strong scale and scope advantages linked to physical cargo flows. The concentration of activities opens more opportunities to the bundling of cargo flows via intermodal transport (shortsea, barge, or rail) and to achieve higher connectivity to the rest of the world via frequent transport services. Port clusters can be home to a wide range of activities.

While industrial activities in ports are often associated with negative effects in terms of emissions and noise pollution, port clusters can exert strong environmental advantages. For example, '**ecologies of scale**' are achieved in the petrochemical industry through which companies utilize waste material or by-products such as heat. It would be far more difficult to achieve this if the concerned plants would be spatially scattered. Ecologies of scale advantages are increasingly being acknowledged in environmental policy. Successful port clusters might also face some challenges, mainly in terms of accessibility (congestion) and higher land costs.

FIGURE I.12 Ports as Clusters of Economic Activity



Seaports interact with other nodes such as overseas and neighboring seaports, intermodal terminals, and inland logistics platforms. They rarely operate in isolation from other ports.

10 THE PUBLIC IMAGE OF PORTS

The general public often considers port areas as desolate, dangerous, dirty, and unattractive, characterized by buildings with low aesthetics and large machinery emitting noise and air pollutants. People might feel **disconnected** from ports, particularly in those areas where the port has moved away from the city. In short, ports cannot take broad public support for granted. This aspect of port competitiveness will undoubtedly become more important in the future as resources such as land are becoming increasingly scarce and as broader social and environmental functions are challenging the economic function of seaports.

As such, port managers and government bodies nowadays are trying to make sure that new port developments are socially broadly based. **Conflicts of interest among different stakeholders** may overshadow the community of interests. Major socio-economic confrontations related to port development and operations can occur when community groups perceive a clear imbalance between the benefits and costs for the local community of having larger ports. Public support for ports becomes particularly bleak when a large part of the population is unaware of how the port is organized and operated and to what extent the port contributes to the local economy. The concerns solely focus on potential negative effects for the local community, such as road congestion, intrusions on the landscape, noise and air pollution, and the use of scarce land. The potential erosion of public support for seaports is a real concern to port managers.

Next to pure economic effects, ports increasingly need to be guided by **social and environmental considerations**. Public policymakers and port managing bodies are challenged to design effective port-related policies in urban planning and expansion, safety, security, and sustainability. The economic value of a port now tends to be taken as a given by some stakeholders, so the argument concentrates on environmental issues and social issues.

Ports must demonstrate a high level of environmental value to ensure community support. However, environmental aspects also play an increasing role in attracting trading partners and potential investors. A port with a strong environmental record and a high level of community support is likely to be favored. From an environmental perspective, port planning and management should ensure sustainable development. The environmental sustainability of port projects and activities has become as important as economic and financial viability.

Measuring the **social value of ports** is an extremely difficult exercise. Many ports directly support a wide variety of community events and projects through sponsorship in an effort to attract community support. However, it is the indirect social contributions that most benefit local communities. For example, ports might invest in training and education programs. Such forms of social commitment are an important part of the success of ports, linking commercial responsibility to social acceptability and accountability.

Ports are challenged to improve their public image, which can be done by combining several approaches:

- **External communications policies and public events and festivities** in and around port areas – such as Port Days.
- Convince the general public of the **importance of ports** by presenting figures on employment effects and added value.
- Adopt a **green port management strategy** that focuses on mitigating externalities such as energy consumption, the emissions of pollutants, and waste disposal.
- **Stakeholder relations management**, such as the development of good relations with all parties concerned, particularly with respect to port expansion plans or redevelopment/regeneration plans focusing on older port areas (i.e. waterfront redevelopment).

Reinforcing the public image of ports is also a matter of attracting a new generation to work in the port. Ports have to offer attractive careers by offering good working conditions and the potential for career advancement, and by stimulating a sense of pride about the port.

11 THE PORT–CITY INTERFACE

The port–city interface is a core theme in discussing the public image of ports and the balance between economic, social, and environmental aspects. Ports and cities worldwide have developed extensive initiatives to (re)establish mutual links. The redevelopment of older abandoned port areas, also called waterfront redevelopment, is one of the focus areas.

A waterfront redevelopment program that respects the maritime heritage of the port and re-establishes the link between the city and the port can revive the public acceptance of ports. It can also bring new jobs to derelict port areas. In many ports, public and private investments have been channeled to revitalize older port areas encompassing housing, hotels, maritime heritage projects, sports, recreation, tourism, and local commerce. Residential, recreational, commercial, retail, service, and tourist facilities are mixed to create **multifunctional areas** with a broad range of employment opportunities.

At first glance, redeveloped docklands all over the world look very much the same. However, the objectives, approach, and focus of waterfront projects can differ considerably. For example, in the pioneering London Docklands scheme, the focus was on the provision of office accommodation. In Barcelona (Spain), the waterfront conversion project contributed to an unprecedented investment, tourism, employment, and population boom with a clear emphasis on the creation of leisure and shopping facilities and the rearrangement of traffic flows. Similar redevelopment initiatives have been taken in other port cities as well, turning port areas into very attractive places for living, working, and recreation.

Many waterfront projects bring in a **clear cultural component** through museums (e.g. the Guggenheim Museum in Bilbao, 'Museum aan de Stroom' in Antwerp), opera houses, and concert halls (e.g. Elbphilharmonie in Hamburg), and conference centers (e.g. Dalian International Conference Center in Dalian, China). The link with the maritime heritage is often enhanced by the establishment of port museums. The new urban waterfront also provides many **service jobs** linked to bars, restaurants, convenience stores, and jobs linked to the usual range of services expected by the new residents of the waterfront. Hotels

have become a prominent feature of urban waterfronts all over the world. These hotels are usually accompanied by a cluster of restaurants that look out over the water and often specialize in seafood. Increased visitor expenditure through multipliers can create **new investment and employment opportunities**. Waterfronts are also **recreation areas** with facilities for yachting harbors and marinas, watersport areas, and theme parks. Many ports provide jobs to people working in marinas, sailing schools, yacht and boat repair and maintenance yards, and similar waterfront operations.

A number of ports have become turntables in the **cruise industry**, with most cruise terminals located close to the city center. Cruise vessels near the city generally reinforce the maritime link between cities and ports and are visible signs of the touristic attractiveness of the city. Expenditure by passengers from visiting cruise ships may have a significant impact on the regional economy. This is most likely to occur where the port has relatively frequent visits by cruise ships, or the region is small. Cruise passengers may also spend time in the metropolitan area before or after their voyages, generating additional economic impacts through their visitor expenditures. Cruise vessels calling at a port also generate jobs at the level of pilotage, tugs, provisions, fuel, crew shore leave, passenger services, inspections, immigration, hotels, restaurants, local attractions, and other visitor activities in the port area. Further employment is provided by inland transportation involving cruise passengers, including by air, private car, bus, transit, and taxi. Some ports (e.g. Rotterdam, Amsterdam, and Antwerp in Europe, or Chongqing, Yichang and Shanghai in China) are regular ports of call for river cruises on major rivers (respectively the Rhine and Yangtze).

12 THE GREENING OF PORTS

From an environmental perspective, port planning and management should ensure sustainable development. The environmental sustainability of port projects and operations has become as important as economic and financial viability. As such, ports, as clusters of economic actors and activities, have adopted an environmental role and function and thus contribute to the greening of supply chains.

Ports, as nodes in extensive global transport networks, and intersections of large bundles of supply chains covering a multitude of commodities and cargo types, create environmental impacts through their various functions. Terminal activities are one source of the environmental impact of seaports which can be summarized in several categories, namely:

- Pollution related to **port construction and maintenance**.
- **Air emissions** of ships at berth and terminal handling equipment (such as cranes and yard equipment).
- **Noise** associated with cargo handling operations.
- The environmental effects and potential **congestion** associated with landside operations of barges, rail, and trucks.

Environmental impacts occur at **all stages of a terminal's life cycle**, such as port planning, terminal construction, terminal operation, terminal expansion, or terminal closure/termination. Regarding landside operations connecting

to inland transport, environmental impacts caused by intermodal connections and congestion lead to adverse effects such as air pollution. Depending on modal choices and the associated cost and transit time requirements from shippers, such environmental effects vary. Other port functions also generate environmental impacts, such as industrial and semi-industrial activities in ports and warehousing and distribution activities.

Port-related pollution damages the ecological balance of nature and the urban environment. It causes an adverse effect on global climate change, further increasing the risk associated with port operations. The development of a low-carbon economy is considered to be a fundamental way to solve environmental problems.

The greening of ports is attracting growing attention. In business practice, it is mirrored in the many green initiatives of individual ports and the coordinated actions of the wider port community. The emergence of the **green port** concept is closely associated with the growing environmental awareness of seaport actors. The concept of green port (or low-carbon port) was officially proposed at the United Nations Climate Change conference in 2009. Based on an organic combination of port development, utilization of resources, and environmental protection, the green port concept refers to a development characterized by a healthy ecological environment, reasonable utilization of resources, low energy consumption, and low pollution. The green port concept or sustainable and climate-friendly development of the port's infrastructure in a broader sense entails responsible behavior of all stakeholders involved in port management and operations.

PART I

Ports and maritime shipping

Chapter 1.1 Maritime shipping and international trade

Seaports are affected by a wide range of economic, technological, and geopolitical developments. Shifts in global production and international trade are affecting port activity levels and operations. The demand for port traffic is derived from world trade.

1 MARITIME SHIPPING AS A DRIVER OF GLOBALIZATION

Global **economic integration** is a key factor behind the rising significance of international trade. Historically, trade was prevalent but set up under constraining conditions in terms of the technical means to support it. Trading over long distances remained slow and expensive, limiting its scale and scope. By the early twentieth century, transport technologies such as the steamship became ubiquitous and efficient enough to support a complex international trade system. Particularly, the steamship enabled economies of scale that could not be achieved beforehand. However, it was not until the mid-twentieth century that the global regulatory regime became open enough to allow an expanded form of globalization.

Global trade is impossible without transportation, making efficient transport a key trade facilitator. By definition, almost all the cargo carried by maritime shipping is considered to be international trade. Transport costs (both freights costs and time costs) constitute a key component of **total trade costs**. These trade costs also include other costs incurred in getting goods to final users, other than the marginal cost of producing the good itself, such as policy barriers, information costs, legal and regulatory costs. Lower trade costs contribute to trade growth as it has been underlined that, for developing economies, a 10% reduction in transportation costs was associated with a 20% growth in international trade.

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Since the end of World War II, ongoing trade liberalism under the banner 'World Peace through World Trade', has led to gradual removal of political, regulatory, and cultural obstacles to trade. Integration processes took place both at the regional level and at the global level. The collapse of the Soviet Union and the opening up of China in the 1990s represented landmark events that incited the entry of close to two billion consumers as well as the related resources into the global economy. Regional trading blocs have been formed with differing levels of trade liberalization, such as NAFTA in North America, the EU Single Market in Europe, ASEAN in Southeast Asia, Mercosur in South America, and ECOWAS in West-Africa. An important share of international trade occurs **within economic blocs**, especially the European Union and NAFTA, which rely more on land transport modes such as road and rail. The European Union and NAFTA are considered the world's most integrated trade agreements, with 62.3% and 51.2% of their respective trade concerning member nations. For ASEAN, 75.5% of its trade concerns nations outside the agreement, implying a greater relative share of maritime shipping.

The **globalization of production** is a driver for the **globalization of trade** as they are interrelated. The **scale**, **volume,** and **efficiency** of international trade have continued to improve. The liberalization of global trade is supported by the continuing evolution of the World Trade Organization (WTO) and initiatives by organizations such as the United Nations Conference on Trade and Development (UNCTAD), or the World Bank. After World War II, a number of international corporations sought the support of intergovernmental organizations such as the United Nations for regulatory frameworks that enabled the pursuit of international operations. In such an environment, multinational corporations assumed growing importance as investors and traders. As a result, it might be argued that the slogan 'World Peace through World Trade' slowly shifted to 'World Peace for World Trade'. At present, inter-governmental organizations still play an essential role in shaping the rules of the game in international competition and global trade.

2 ONGOING GROWTH OF INTERNATIONAL TRADE

World trade has experienced a significant increase since the 1950s and represents a growing share of global economic output. In 2007, international trade surpassed 50% of the global Gross Domestic Product (GDP) for the first time, a share that was conventionally in the 20% to 25% range in the first half of the twentieth century. In the nineteenth century, this share was around 10%. Several factors explained this growth:

- **Income growth** linked with additional consumption of goods and services, some of which are traded.
- **Falling transport costs** allowing more options and opportunities to trade.

- **Trade liberalization** and the associated tariff rate reductions, easing trade transactions.
- **Economic convergence** of countries around trade agreements and common commercial policies.
- **Increase of intermediate goods trade** in the context of global production chains, outsourcing, and offshoring.

Between 1958 and 1988, income growth explained 67% of the real growth of world trade, while tariff reductions accounted for about 26% and transport-cost reductions roughly 8%. However, developed and developing economies might face different economic characteristics, and those play a different role in the growth of international trade. Low-income economies tend to have a high reliance on the trade of resources and low added-value goods; intermediate income economies are oriented around manufacturing; and high-income economies tend to be net importers of products and services.

The ongoing growth of international trade also impacted firms, many of which expanded to become multinational corporations. The benefits that multinational corporations derive from trade are varied:

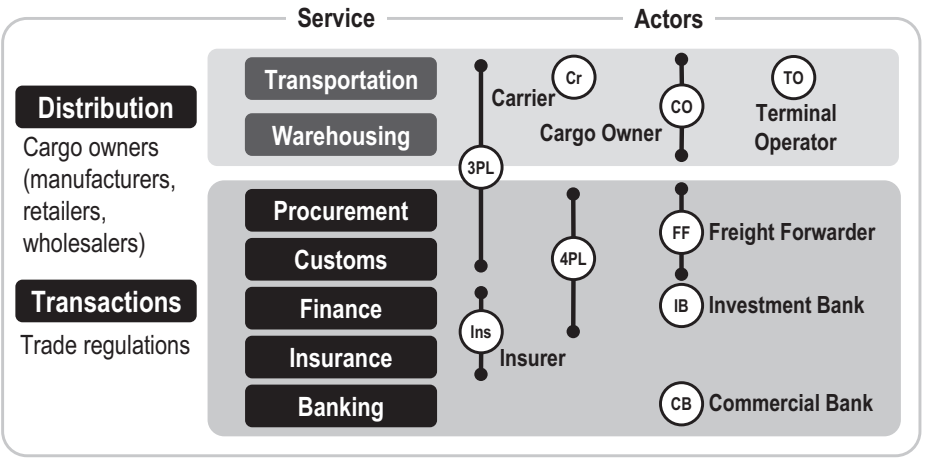
- **Competition**. Seeking new resources, markets, and processes in international markets increases the competitiveness of corporations.
- **Economies of scale**. International markets allow firms to produce larger quantities of goods, which enable lower unit costs.
- **Innovation**. International markets incite the development of new products or the adaptation of existing products to different market characteristics.

As international trade depends on the provision of distribution and transactional services, the demand for these services has increased substantially, leading to the growth of carriers, cargo owners, terminal operators, third-party logistics service providers (3PL), freight forwarders, and insurers. International transportation and transaction service providers represent a complex ecosystem aiming at supporting international trade and extracting added value. The providers of transportation services, like manufacturing firms, have become large multinational corporations due to the extensive markets they cover.

International trade requires several types of services assumed by a number of actors (Figure 1.1):

- **Distribution services** are related to the function of transportation and warehousing, which are physical operations performed on trade goods. A carrier, such as a truck or a maritime shipping company, and a terminal operator provide transportation services while a cargo owner can have own account transportation and warehousing.
- **Transaction services** include activities for managing international trade. Procurement involves finding suppliers, setting up contracts, and ensuring continuity in the supply. Customs comprise the regulatory compliance so that traded goods meet national standards and duties are paid. Freight forwarders regularly assume this function on behalf

FIGURE 1.1 Services Supporting International Trade



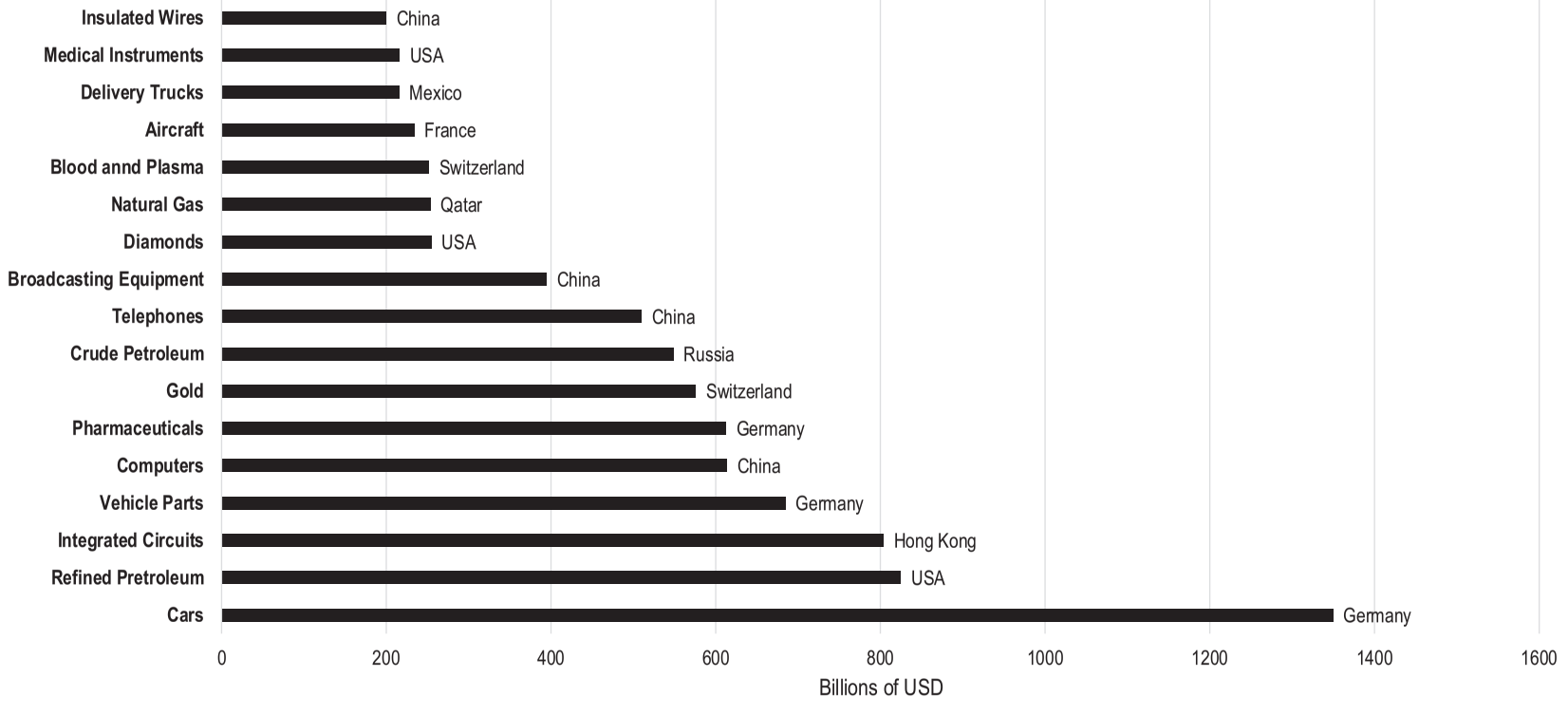
of their customers. Finance provides capital to invest in trade activities, such as the purchasing (leasing) of equipment and the construction of facilities, an activity performed by investment banks. Cargo also needs to be insured against common risks (delays, theft, damage), a function assumed by insurance companies, some also involved in finance. Since many trade transactions are settled through currency exchange drawn from corporate deposits, commercial banks are major actors in settling transactions and letters of credit.

In recent years, actors known as third-party logistics providers (3PLs) have offered a wider range of trade services to their customers by controlling crucial transportation and transaction services. Several 3PLs are carriers that have decided for strategic purposes to expand their range of services to provide added value by combining the physical assets they control (ships, vehicles, warehouses) with procurement and customs services. Fourth-party logistics providers (4PLs) have also emerged, mainly focusing on non-physical asset trade services.

The nature of what is being traded, and the main traders involved, influence the transportation modes used for international transportation (Figure 1.2). Maritime transportation dominates, handling about 80% of the volume and 70% of the value of international trade.

Many of the world's most traded goods require specialized maritime transport conveyances. Cars are the most traded goods in terms of value, implying the deployment of a car carrier fleet. The second most traded commodity is refined petroleum, which is carried in tankers. A wide range of commodities is carried in containers, such as vehicle parts.

FIGURE 1.2 World's Most Traded Goods and Lead Exporter, 2016



Source: Observatory of Economic Complexity, Massachusetts Institute of Technology.

3 THE CONTAINERIZATION OF TRADE

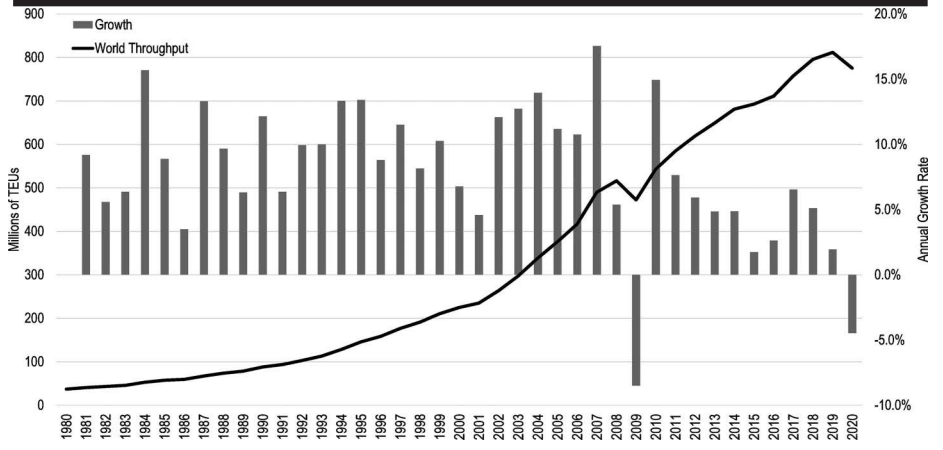
3.1 The emergence of the container

The container and the associated maritime and inland transport systems have proved to be instrumental to the consecutive waves of globalization and global trade growth since the 1970s. The launching of the first containership by Malcolm McLean in 1956, the Ideal X, marked the beginning of containerization. The first transatlantic container service between the US East Coast and Northern Europe in 1966 marked the start of long-distance containerized trade. The first specialized cellular containerships were delivered in 1968, and containerization expanded over maritime and inland freight transport systems. Container shipping developed rapidly due to the adoption of **standard container sizes** in the late 1960s. The cost savings resulting from faster vessel turnaround times in ports, the reduction in the level of damages and associated insurance fees, and the integration with inland transport modes such as trucks, barges, and trains became acknowledged as clear containerization advantages.

The container offered a standard around which physical distribution systems could operate. Hence, emerging container shipping networks allowed changes in the economic and transport geography as they significantly reduced maritime costs between production and consumption centers across the world. Container shipping also became an **essential driver in reshaping global supply chains** allowing sourcing strategies of multinational enterprises and developing global production networks. New supply chain practices increased the requirements on container shipping in terms of frequency, schedule reliability/integrity, global coverage of services, rate setting, and environmental performance. The outcome has been an ongoing growth of the global container throughput (Figure 1.3).

The large-scale adoption of the container combined with the globalization process drove the global container port throughput from 36 million TEU (Twenty Foot Equivalent Unit) in 1980 to 237 million TEU in 2000, 545 million TEU in 2010, and more than 740 million TEU in 2017. Global container throughput reached approximately 802 million TEU in 2019, increasing by

FIGURE 1.3 World Container Throughput, 1980–2019



2.3% compared to 2018, including full and empty containers. Container traffic, the absolute number of loaded containers being carried by sea (excluding empties), has grown from 28.7 million TEU in 1990 to 152 million TEU in 2018. The ratio of containerized trade over container port throughput shows that a container on average is loaded or discharged multiple times between the first port of loading and the last port of discharge.

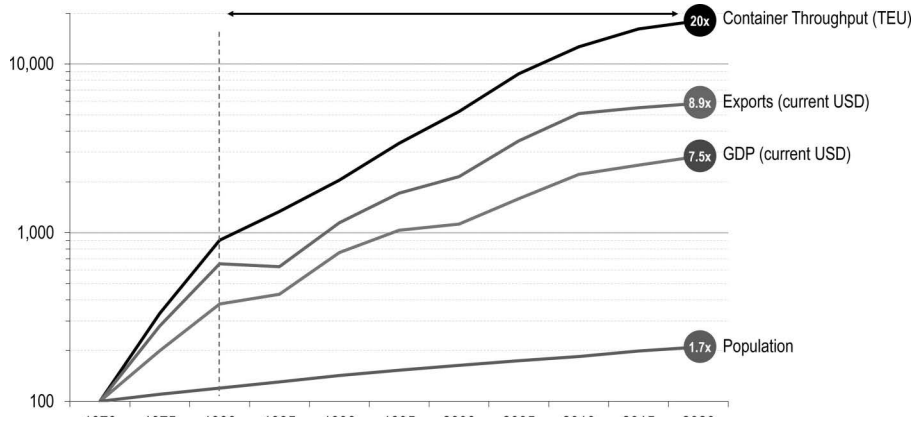
The container has evolved from a transport unit to a supply or commodity chain unit. Containerization is inherently linked to the **transport of load units** (containers) across several transportation modes. It is more than a box as it acts as a vector for production and distribution. Containerization has led to various changes in the geography of transport, trade, and distribution, particularly in how production and physical distribution interact. The container can be considered revolutionary, as new practices have taken place after its introduction. It has become a ubiquitous transport product servicing mobility requirements at almost all stages of supply and commodity chains and is able to be carried virtually everywhere there are transport infrastructures.

3.2 Containerized trade networks

Before containerization, many goods subject to trade had to be handled manually. Emerging worldwide container shipping networks allowed changes in the economic and transport geography as they significantly shortened the maritime cost distances between production and consumption centers around the world. Container shipping also became an essential driver in reshaping global supply chain practices, allowing global sourcing strategies of multinational enterprises, pull logistics solutions, and the development of global production networks.

Containerization has been the most dynamic physical component of globalization, far exceeding the growth of the value of exports and the GDP (Figure 1.4). As globalization developed, each new individual, GDP, or export

FIGURE 1.4 Global Trade and Container Throughput 1970 = 100



Sources: Population and GDP from World Bank, World Development Indicators. Exports from World Trade Organization. Container port throughput compiled from Containerization International.

unit was associated with a higher level of container flows. While up to 1980, the growth of container port throughput was on a par with the growth of the value of exports, a divergence is noted afterward with container flows growing faster than trade flows. Containerization entered the acceleration phase of its diffusion cycle as the fundamental support of export-oriented strategies pursued by Asian economies.

The composition of international trade goods carried in containers is impressive in its diversity. The 20 most important SITC (Standard International Trade Classification) categories accounted for 65% of the global containerized trade, underlining that the container has been used to carry any possible good that could be fitted in. However, many of the most significant categories of containerized trade are the outcome of comparative advantage factors, namely labor, that can be temporary and subject to change. If these advantages were to shift because of technological changes (e.g. automation), then a notable share of the containerized trade could be impacted.

About one out of every ten containers handled worldwide is handled in ports of the **Yangtze River Delta**. In East Asia, export-oriented industrialization policies undertaken by Hong Kong, Taiwan, and South Korea sustained the strong growth in container throughput handled by these economies from the 1980s. China developed similar strategies in the late 1980s, resulting in elevated growth first in the Pearl River Delta and then in the Yangtze Delta port system and the Bohai Bay region. In the past ten years, Shanghai, Guangzhou, Shenzhen, Qingdao, and Ningbo joined Hong Kong, Busan, and Singapore as the world's busiest container ports. The Rhine-Scheldt Delta (Belgium/the Netherlands) was the world's number one container handing region in the world till the mid-1990s when south China took the lead. While the dynamics of containerization and container flows are well known, much less is known about what is being carried by containers, particularly as it concerns commodities.

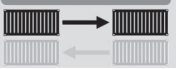
Several growth factors are at play to explain the substantial growth of containerization and, more interestingly, how the contribution of these factors varies in time. While additional traffic resulting from organic economic growth is the most salient factor, imbalanced trade flows (empty containers) and the configuration of shipping networks relying on transshipment hubs (double counting) have also contributed to additional containerized flows and port handlings. As economies of scale are applied to maritime shipping, transshipment becomes more salient. The number of containers being transshipped increased from around 11% of all cargo handled by container ports in 1980 to about 30% in 2015, which is also a notable factor in the growth of containerized traffic.

3.3 Containerized growth dynamics

The conventional growth dynamics of containerization have mainly relied on an array of drivers, which include (Figure 1.5):

- **Derived growth**. Often labeled as organic growth, derived growth is an economic development outcome with greater quantities of containerized cargoes being traded. Globalization also implies a growth of the average distance over which containerized freight is being carried. In both cases,

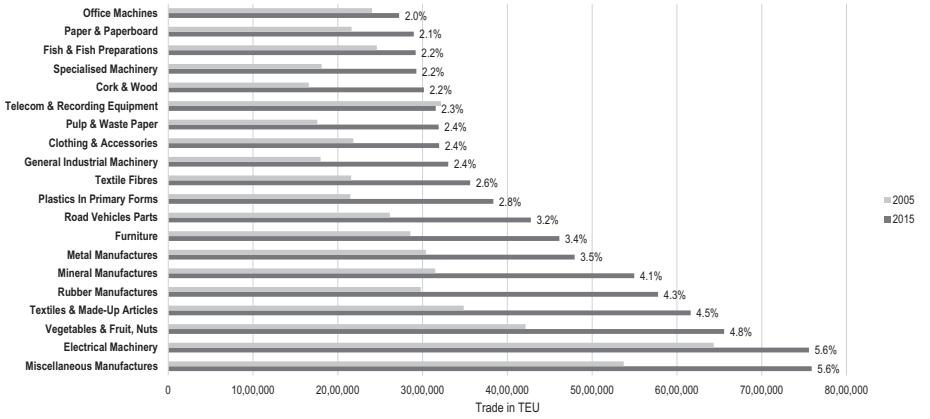
FIGURE 1.5 Containerization Growth Factors

FACTOR	Volume Growth	Volume Decline
Derived 	• Economic and income growth • Outsourcing and offshoring • Complex supply chains	• Economic recessions • Trade protectionism • Automation
Substitution 	• Capture of bulk and break-bulk markets • New niches (commodities and cold chain)	• Peak substitution • Composition of container fleet
Incidental 	• Trade imbalances • Repositioning of empty containers	• Trade protectionism • Automation
Induced 	• Transshipment (hubbing, relay and intersection)	• Changes in shipping networks (more direct services)

greater containerized capacities are required, average voyage days per vessel increase, and the number of vessel roundtrips per year decreases. The dynamics based on derived demand may have reached maturity in containerization potential as many global supply chains are now fully containerized.

- **Substitution-based growth**. Initially, substitution was the main factor behind containerization with the gradual capture of the breakbulk cargo market. This process has been particularly visible in many ports, as illustrated by rising containerization degrees (the ratio between containerized throughput of the port and the total general cargo volumes). Since almost all break-bulk cargo that could be containerized has been containerized, this substitution process is essentially near completion in developed economies. It is also rising rapidly in emerging economies and developing countries. This leaves the possible further containerization of niche markets, namely commodities and temperature-sensitive cargo.
- **Incidental growth**. Production and trade imbalances in the global economy are reflected in physical flows and transport rates and lead to specific container repositioning strategies. Containerized flows are rarely balanced, implying that empty containers must be repositioned to locations where export cargo is available.
- **Induced growth**. The growth of deep-sea services and the use of larger containerships has led to the setting up of intermediary hubs connecting different systems of circulation via transshipment. Intermediary hubs emerge in locations offering clear advantages over direct port calls at mainland ports. The setting up of intermediate hubs occurs around specific regions ideally suited for maritime hub-and-spoke distribution patterns. Transshipment has proven to be a major driver for global container port throughput, with substantially higher growth rates than observed for gateway traffic. The worldwide transshipment incidence has steadily increased from around 18% in 1990 to around 35% in 2018.

FIGURE 1.6 Global Containerized Trade by Main Cargo Category (in TEU)



Source: MDS Transmodal, World Cargo Database. Note: Groups are at the SITC 2 digits level.

It is estimated that in 2015, 135.5 million TEU of trade was carried in containers, compared to 88.5 million TEU in 2005 (Figure 1.6). The composition of global containerized trade shows an extensive diversity of the goods being carried, with no particular category (SITC two digit level) dominating. The four most important categories accounted for 20.6% of the containerized trade volumes in 2015:

- Miscellaneous manufactures (SITC 89) include articles made of plastics (e.g. bags), toys, sporting goods, or office supplies. The manufacturing of these goods has been highly impacted by outsourcing and offshoring since it requires significant labor input.
- Electrical machinery (SITC 77) includes machines powered by electricity, such as electric cables, appliances, batteries, and integrated circuits. The production of these goods has also been substantially internationalized, particularly for electronics.
- Vegetables and fruits (SITC 05) compose an important segment of transportation by refrigerated containers. This sector has been the object of notable growth with more reliable cold chain logistics.
- Textiles and made-up articles (SITC 65) include yarn, woven fiber, blankets, linen, curtains, and carpets. The textile industry has been the object of internationalization for several decades.

4 THE SHIFT IN GLOBAL TRADE PATTERNS

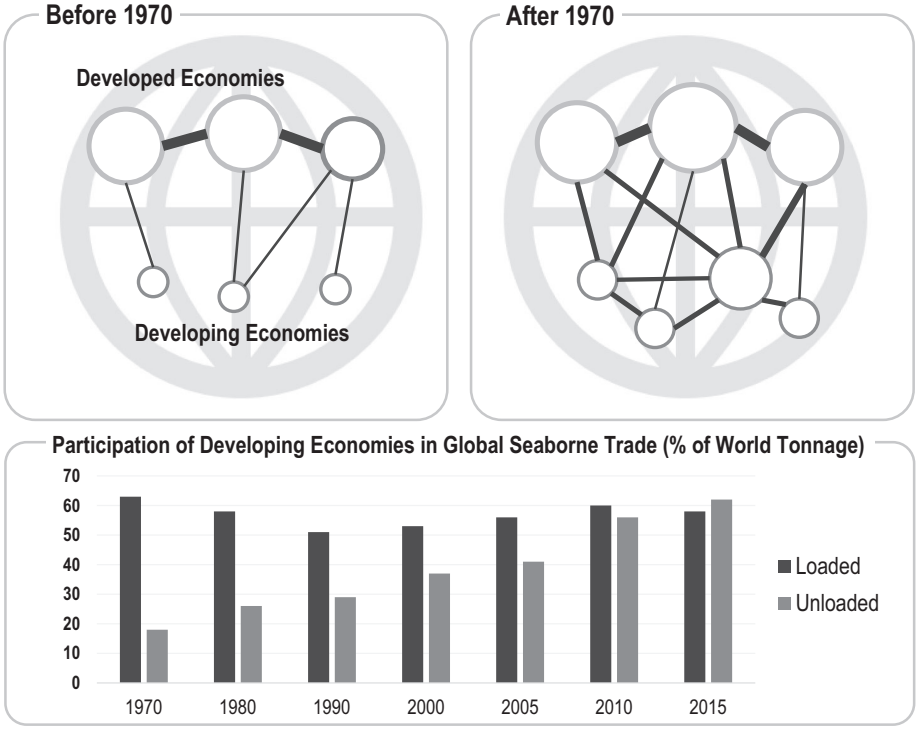
The recent decades have seen important changes in international trade flows. Prior to the 1970s, global trade flows were dominated by three major poles, North America, Western Europe, and the developing economies of East Asia (Japan, South Korea, and Taiwan). A trade dichotomy was observed between developed and developing economies as raw materials were mainly flowing north and finished goods were flowing south. This

situation can mainly be explained by differences in development levels, better economies of scale in developed economies, and unequal trade relations set up during the colonial era.

From the 1970s, this situation changed as economic development took place across a range of nations in Latin America (Mexico), Southeast Asia (Malaysia, Thailand, Indonesia), and East Asia (China, South Korea, Taiwan) (Figure 1.7). Many manufacturing activities that had emerged in developed economies were relocated to lower input cost locations, because of cheaper labor. Emerging multinational corporations were actively involved in this process. Such a structural shift is well illustrated by the variation in the share of developing economies in seaborne trade, which used to be highly imbalanced with much more cargo being loaded than unloaded. Economic development resulted in a growing share of developing economies as a destination for cargo. Consequently, global trade is now characterized by significant flows of cargoes (raw materials, intermediate and finished goods) from developed to developing economies.

A growing share of international trade occurs within regions (and particularly economic blocs) even if long-distance trade has increased in absolute numbers. Trade predominantly takes place within Europe, North America, and East Asia, commonly referred to as the triad. Still, a shift in trade relations between the northern and southern hemispheres, particularly between

FIGURE 1.7 Changes in Global Trade Flows



Source: Seaborne trade data adapted from UNCTAD, Review of Maritime Transport.

developed and developing economies, has occurred. The structure of global trade has become much more complex in its relations and diversified in what is being traded. The pattern of trade relations is mainly explained by the following factors:

- **Geographical proximity**. The intensity of trade relations is commonly a function of proximity unless notable advantages can be found further away. The European Union has significant trading linkages with adjacent areas in Eastern Europe, North Africa, and the Middle East. North America also maintains important trade linkages with Latin America, notably Mexico, as part of the USMCA (United States–Mexico–Canada Agreement). Shorter distances have an important impact on the modes used for trade, with maritime shipping less suitable outside short sea shipping. Still, a key advantage of maritime shipping is that it substantially attenuates the negative effects of long distances on trade, as the development of containerized shipping underlines.
- **Resources availability**. The scarcity and availability of resources have shaped maritime networks for close to two centuries and remain the main component, ton-wise, of maritime shipping. Energy, mineral, and agricultural trades have distinct shipping networks and specialized port facilities designed to handle bulk cargoes such as petroleum, natural gas, coal, grains, alumina, and iron ore.
- **History and culture**. The trade networks established during the colonial era have endured in relations such as those between Europe and Africa or between the United States and Latin America. China has commercial historical ties with Central Asia and Southeast Asia which have been recreated and expanded in recent decades. Irrespective of the political context, trade networks tend to endure because of the reciprocal systems of supply and demand on which they depend.

Another characteristic of the contemporary commercial setting concerns **imbalances in trade flows**. For instance, China exports more than it imports with partners such as the United States and the European Union. Trade imbalances directly reflect imbalances in shipping flows. For bulk trade such as energy and minerals, it is common that a return trip will be empty. For containerized trade, the load factors of return trips are lower, and the share of empty containers higher. The imbalanced trade structure is also reflected in the composition of container imports and exports that differs substantially. Further, trade imbalances imply the repositioning of empty containers that accounts for about 20% of global container moves.

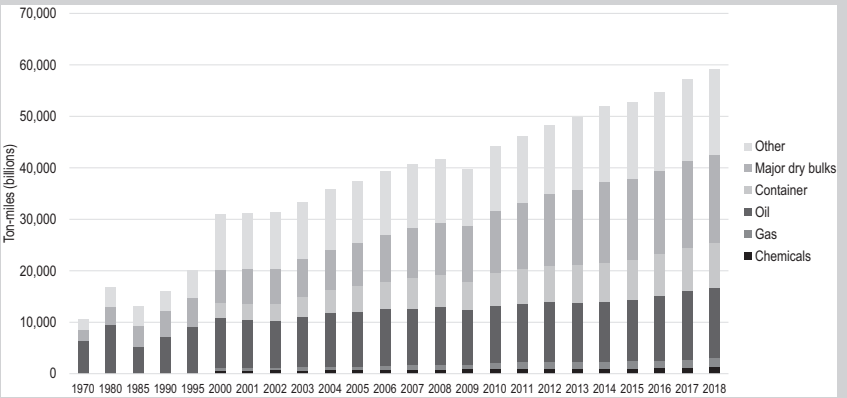
Geographical and economic shifts in international trade are directly observable in the evolution of the level of trade intensity by ocean, as the Trans-Pacific trade has grown faster than the Trans-Atlantic trade. The most significant trade flows are between Asia and North America (especially the United States), between Europe and North America, and between Europe and Asia. The associated maritime routes are the most commercially used with sizeable trade going through chokepoints such as the Strait of Malacca (30% of global trade transiting), the Suez Canal (15%), the Strait of Gibraltar, and the Panama Canal (5%). These bottlenecks allow connection between the major systems of maritime circulation

where the transatlantic, the transpacific, and the Asia–Europe routes dominate. north-south flows are complementing these east-west routes, many of which interact at major transshipment hubs around Singapore, Dubai, and the Caribbean (Panama, Cartagena, Kingston). The evolution of international trade shapes the structure of maritime shipping networks and port development as shipping lines tend to organize their services to connect the dominant trade flows directly, and the less dominant trade flows indirectly through transshipments.

Box 1.1 World seaborne trade by cargo type, 1970–2018

Weight-wise, raw materials dominate maritime trade as they are ponderous and carried over long distances (Figure 1.8). Oil, iron ore, coal, and grain accounted for 28% of the ton-miles carried by maritime shipping, while other dry cargoes, which include containers, accounted for 40%. Oil is the most significant commodity, with 25% of ton-miles in 2018, but this share is significantly lower than in 1970 when it accounted for 60% of global ton-miles.

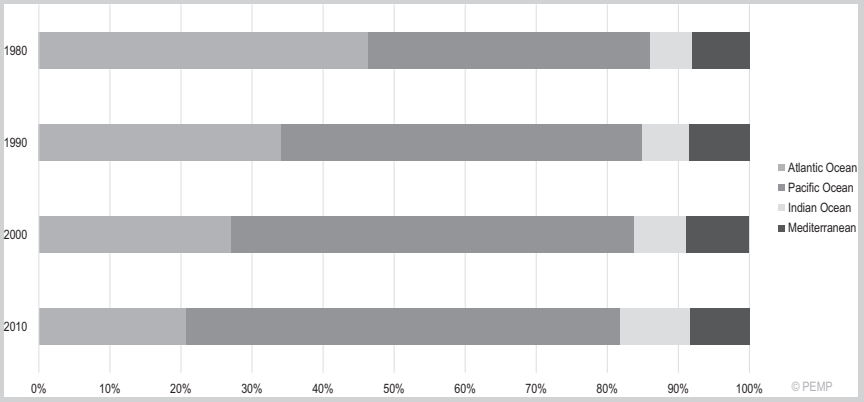
FIGURE 1.8 World Seaborne Trade by Cargo Type, 1970–2018



Source: UNCTAD Review of Maritime Transport, various years.

Since the 1980s, a significant rebalancing of the intensity of trade by ocean has taken place, particularly over containerized trade (Figure 1.9). As the international trade taking place over the Pacific Ocean increased, the Atlantic Ocean experienced a relative decline of its share. While the Atlantic accounted for 46% of global trade activity in 1980, this share decreased by more than half to 21% in 2010. The share of the Indian Ocean doubled to 10%, but this figure does not account for the substantial traffic transiting along the Asia/Mediterranean/European trade route.

FIGURE 1.9 Trade Intensity by Ocean, 1980–2010

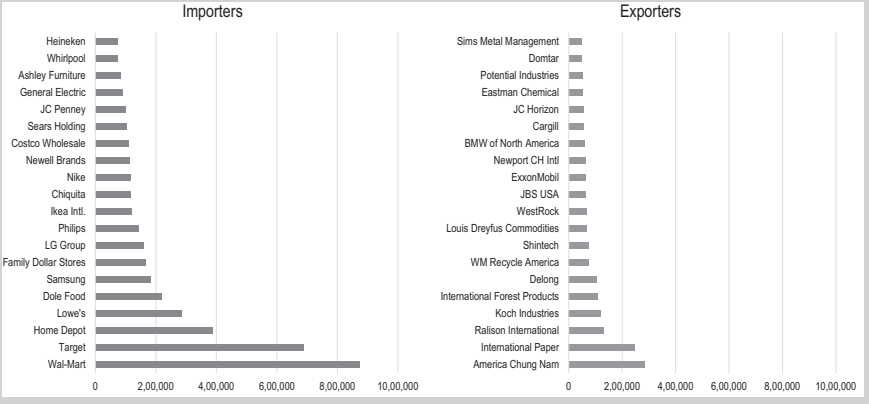


Note: Measured by port TEU activity along oceanic ranges.

Box 1.2 American foreign trade by maritime containers

American containerized trade is characterized by an asymmetry between the nature of its imports and exports (Figure 1.10). North American retailers account for a substantial share of containerized imports, mostly involving finished consumption goods bound to major inland freight distribution centers. The largest importers, such as Wal-Mart, Home Depot, Target, Costco, Ikea, and Lowe's, are all mass (Big Box) retailers relying on high volume and low margin goods, which are predominantly produced in China. It is worth mentioning that about 60% of all Chinese trade surplus with the United States is the outcome of American-owned firms operating in China and importing their output to the United States.

FIGURE 1.10 American Foreign Trade by Maritime Containers, 2017 (in TEUs)



Adapted from *Journal of Commerce*, US top 100 importers and exporters. Data from PIERS.

Exporters show a completely different profile. A major category of containerized export concerns recycles with exporters such as America Chung Nam, Ralison International, WM Recycle America, or Potential Industries. Other major exporters include diversified resource-based (Koch Industries) forest and paper products (e.g. International Paper, International Forest Products), agribusiness (e.g. Cargill, Archer Daniels Midland), or chemicals (e.g. Shintech, Dow, DuPont). Yet, a significant containerized trade imbalance remains.

The trade asymmetry being depicted is reflected in the relative value of imports and exports. While the average value of American imports is about $4.75 per kilogram, the value of exports stands at $2.50 per kilogram. This has also had significant impacts on North American logistics. The import-driven segment involves a series of stages to reach a multitude of outlets with a freight density correlated with population density. Since the retail trade is essentially unidirectional, many retail goods are transloaded at gateways into domestic containers while the maritime (ISO) containers are re-exported empty. The export-driven segment relies on the massification of shipments at major gateways and inland ports.

5 INTERNATIONAL TRADE AND MARITIME SHIPPING SERVICES

International trade relies volume-wise for about 80% on maritime transportation, which involves several markets such as dry bulk, roll-on/roll-off, general cargo, and containers.

5.1 Maritime services in dry bulk shipping

The maritime transport of **major bulks** such as iron ore and coal typically relies on end-to-end services between a port of loading (connected by rail to mines) and a port of discharge. Economies of scale in vessel size are significant in dry bulk shipping, so operators will try to maximize vessel size on the end-to-end tramp service. The nautical accessibility in the port of loading and port of discharge, the charter price level, and the availability of vessel types play a decisive role in vessel size choice. Inland transport costs per ton-kilometer are typically 20 to 30 percent higher than sea transport costs per ton-kilometer.

Consequently, market players make a trade-off between, on the one hand, the minimization of inland transport costs by routing the bulk flows via the ports that are closest to the final destination and, on the other hand, maximizing the scale economies in vessel size by calling at the ports that offer the best nautical accessibility. This exercise in some cases leads to multiple calls whereby a large Capesize vessel will first call at a deepwater port to discharge part of the cargo and then proceed to the second port of call with a less favorable nautical access to discharge the remainder (e.g. a call sequence starting in Dunkirk and ending in Antwerp). Another practice consists of lightening deepsea vessels on stream, whereby floating cranes discharge part of the load

to barges given decreasing vessel draft (e.g. lightening operations on River Scheldt to access the Canal Ghent-Terneuzen).

The vessels deployed in the **minor bulk segments** (grain, fertilizers, minerals) are generally much smaller, so that vessel operators have a much wider range of potential ports of call at their disposal. The eventual call patterns will be determined by factors such as proximity to the market, the specificities of the distribution network (centralized or decentralized), the number of cargo batches on the vessel, and the need for dedicated terminal facilities (e.g. grain silos).

5.2 Maritime services in the roll-on/roll-off (RoRo) market

The operational characteristics of maritime services in the RoRo segment depend on the submarkets considered:

- Intra-regional **RoRo and ropax services** are typical of the end-to-end type with a port of call at either side of the route. The shipping services follow a fixed schedule with medium to high frequencies (sometimes several times a day). The ferry capacities tend to vary greatly with the cargo density on the route and the one-way distance. For example, in Europe, large units are deployed on the English Channel and parts of the Baltic (e.g. 120 trucks per voyage on the Dover-Calais link and several hundreds of passengers between Travemünde and Finland). In contrast, vessel capacities on services in smaller markets (e.g. the Irish isles) tend to be much smaller. Trucks using ferry services can have a long pre- and end haul by road (for instance, a truck driving from Dortmund to Zeebrugge to catch a ferry to Hull and onward by road to the final destination, Manchester).
- The market for **unaccompanied RoRo transport** is based on end-to-end services with dedicated RoRo freight vessels, which often have reserve space for containers.
- The **deepsea and shortsea car carrying trade** is another submarket in the RoRo market. On intercontinental routes, the operators deploy Pure Car and Truck Carriers (PCTC) with capacities of up to 8,000 CEU (car equivalent unit), resulting in significant cost savings on the sea leg (economies of scale). The number of ports of call is kept to a strict minimum as shipping lines aim for a short port time and they face a shortfall in the number of ports that have the infrastructure to accommodate large quantities of new cars. As a result, a significant part of the market is concentrated in large car handling ports. The port of Zeebrugge in Belgium is a good example, with 2.96 million units handled in 2019. The position of the main ports is strongly entwined with their proximity to the main buyer markets and the spatial concentration of car assembly plants. A number of large car ports have successfully combined deepsea services with intra-regional shortsea services. The resulting hub-and-spoke network configuration is combined with growing local clusters of automotive logistics companies. While road haulage is by far the dominant mode of inland transport to/from car terminals, rail and barge play an ever more important role in securing inland access for the larger car ports, particularly in Belgium, the Netherlands, and the Rhine and Yangtze river basins.

5.3 Maritime services in the general cargo market

The diversity in maritime service configurations is probably highest in the market of **conventional general cargo**. In contrast to the bulk cargo market, where parcel sizes are usually big enough to fill an entire ship, the general cargo market deals with the shipment of consignments smaller than a ship or hold size. Given the enormous variety of different cargoes involved, there are several ways in which breakbulk cargoes can be shipped. The most common is the conventional liner-type concept of weekly fixed-day services, characterizing the liner shipping industry, which is something the deepsea trade of conventional cargo has never really been able to achieve. Instead, the following service/schedule options can be distinguished in the case of breakbulk shipping (the typology is based on Dynamar):

- Services of a specific frequency operated with dedicated ships.
- Services offering sailings within a certain period, deploying trip charters.
- Services operated on inducement but still within a more or less defined trade lane.
- A mixture of two or three of the above options.
- 'Parcelling', such as tramping, whereby a vessel is chartered (usually on a trip-out basis) once a specific cargo volume is available.

The conventional general cargo market includes many specialized ships designed to carry specific cargo loads. For example, heavy-lift vessels do not operate on fixed routes, but they are attracted to those areas where large investments in the oil and gas industry are being made. Conventional reefer ships mainly carry high-value foodstuffs that require refrigeration and atmosphere control on an end-to-end service (e.g. bananas from a port of loading in Latin America to a specialized terminal in Europe). Examples of reefer cargoes include fresh and frozen fruit (e.g. bananas, deciduous and other citrus fruits), vegetables, fish, meat, poultry, and dairy products. Reefer shipping is a prime example of a one-way (and for some products seasonal) business with cargoes mainly exported from the southern hemisphere to the rest of the world. The reefer shipping sector is increasingly being put under pressure from container shipping.

5.4 Maritime services in container shipping

The most advanced structures in maritime services are found in **container shipping**. Shipping lines design the networks they find it convenient to offer, but at the same time they are bound to provide the services their customers want in terms of frequency, direct accessibility, and transit times. In the last two decades, increased cargo availability has made carriers and alliances reshape their liner shipping networks by introducing new types of liner services on the main east-west trade lanes.

Observing recent developments in liner shipping, productivity has been improved by using larger ships and devising **new operational patterns and co-operation between shipping lines**. Since the 1990s, a great deal of attention has been devoted to larger, more fuel-economical vessels, and this indeed has produced a substantial reduction in the cost per TEU of capacity provided. Alliances and consolidation have created multi-string networks on the major trade routes, and both shippers and liners have adapted. The networks are based on traffic circulation through a network of specific hubs. A more detailed analysis of the container shipping market is provided later in this book.