WATER TRANSPORT SYSTEMS AND PORT DEVELOPMENTS

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Summary

This paper examines the changing business environment for ocean carriers and ports in terms of the new technologies that might be adopted in the period 2000–2010. It opens with a discussion of the two key supply segments, liner and tramp shipping, and explores their nature and how they have evolved since World War II. Issues like economies of scale and new technology adoption are discussed, paving the way for an examination of alternative vessel designs, cargo handling technologies, and other technologies that may be adopted by vessel or port terminal operators. The importance of new Internet-based technologies is examined with reference to both carrier and cargo management. The paper concludes that the greatest potential for change at the beginning of the twenty-first century in the maritime transport and port industries comes from external technological changes. The information technology revolution is changing the way the shipping industry does business more than hardware and equipment technologies. Breakthrough technologies in other industries, by enhancing and enabling transportation systems to be more efficiently managed, hold the most promise for developments in these transport systems in the early part of the twenty-first century.

1. Introduction

The modern era of maritime transport was ushered in by the advent of the steam engine. Wooden ships and sail gave way to iron ships powered by steam. A long era of growth in maritime transport followed as trade needs were served more efficiently, and transport activities could be better predicted. Trading horizons expanded and the world economy grew. Transit time was no longer at the whim of prevailing winds and both passenger and freight traffic increased dramatically.

The advent of the jet engine played havoc with the market for long-haul ocean passenger transport as people switched from long ocean liner voyages to more convenient plan travel. Passenger vessels changed radically between 1950 and 2000. In 2000, only ferries and cruise ships remain in most of the developed world, although some small passenger ships can still be found in inter-island services in remote areas of Indonesia, the Philippines, and the Caribbean, and on the great rivers, such as the Nile and the Amazon.

In spite of the growing volume of freight moving by air, the bulk of international freight moves by water. Cargo transported by ship falls into two broad categories: bulk and unitized cargo. The former usually travels via tramp vessels and includes both liquid (including crude oil and oil products) and dry bulk, with iron ore, grains, and coal having the highest transport volumes. Unitized cargo (predominantly containers) is transported primarily by ships in the liner trades. Unitization is the process of consolidating cargo into a more manageable form for transport, be it a pallet or a container. There are many types of vessels to service specialized needs but these general categories provide a useful starting point to understand maritime transport and port systems.

Liner shipping companies offer scheduled transport services to third party logistics service suppliers and cargo owners whose markets are increasingly global. Rather than contracting for the use of the whole vessel, as is the case in the tramp sector, cargo owners only purchase the space necessary at a particular time, thereby sharing the vessel with many others. Containers carry most of the world's component parts, semi-finished, and finished goods. The transfer of goods within the car parts industry from one country to another provides an excellent example of goods using the liner sector of the shipping market.

Container traffic is important because the timely delivery of the container's contents creates jobs and generates income across a large population base. It is very important for the future economic health of many nations that container trade continues to grow. Manufacturers can buy components in many places, consolidate them in one or a number of locations for assembly and then transport them to a third location to be sold. Sometimes component parts move seven or eight times before reaching the retail market.

The tramp market transports both dry and liquid bulk products. In contrast to the liner carrier, the tramp vessel does not operate on a fixed schedule or itinerary but sails to meet the current demand with a service where one ship usually carries the cargo for one cargo owner. The successful operator is able to match the ship's capability to the market demand while minimizing the number of voyages in ballast (with no cargo). Ship owners supply vessels on a voyage or time basis. Vessels may be chartered by the cargo owner from the ship owner or operator for as little as a single voyage or as long as the life of the ship. The charter contract may be for only the vessel itself, as in the case of a bareboat charter, or include crew in the cases of voyage or time charters. Not all vessels in the oil trade operate in the charter market as many are owned by the oil companies and only transfer crude oil from port storage depots to refineries, and refined products from the refinery to the local distribution point.

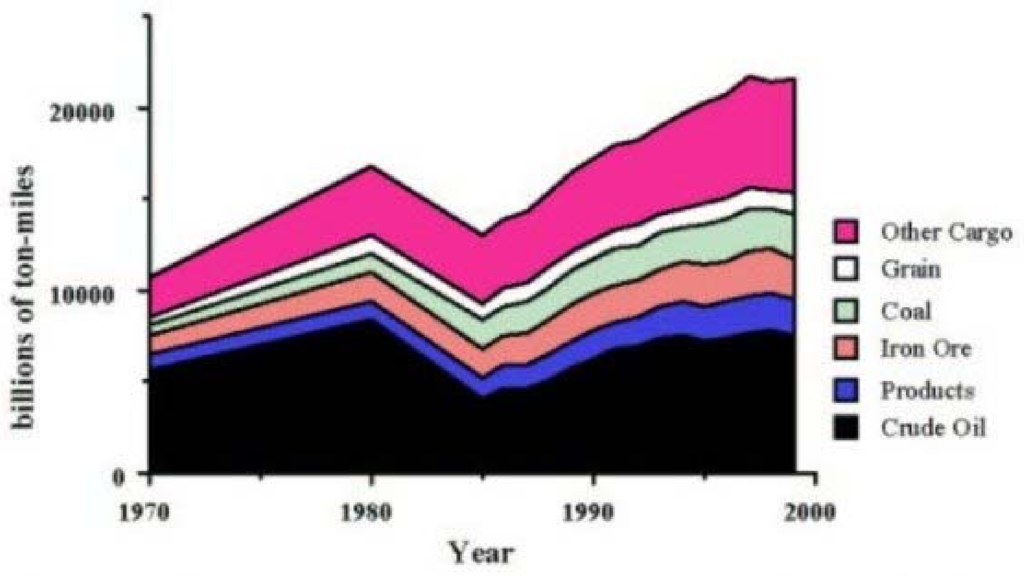

Figure 1. World seaborne trade
Created with data from Fearnley & Egers Chartering Co. as cited by United Nations Conference on Trade and Development (UNCTAD) in *Review of Maritime Transport 2000*, p. 14, Table 5.

Based on ton-miles, the oil trade (both crude oil and oil products) is the most important trade in ocean shipping (see Figure 1). This figure also illustrates the general importance of dry bulk cargoes to world shipping demand. While not dominant in terms of ton-miles, the value of the goods in the container trade (included in Other in Figure 1) increases the liner sector's importance to a level that rivals that of the tramp sector in terms of freight revenues.

Given the importance of matching supply to demand in the bulk sector, the supply of shipping is driven by demand in terms of ton-miles. However, it is not a simple matter to forecast long-term supply needs in a market which is volatile in the short term. Investment in a ship is made on an assumption of a vessel having an economic life of 15–20 years; in reality, vessel life may be 10 years with poor maintenance or 25 with continuous scrutiny and preventive maintenance. Trade volatility can be driven by political events, famine, or even changing sources of supply for basic products like steel or aluminum. Ship owners have been known to invest on rumor and readily available mortgage funds or state aid. The potential for economies of scale drives investment.

It was apparent very soon after World War II that there were significant economies of scale possible from increased ship size. The addition of vessel tonnage added significantly to its cargo-carrying capacity (and revenue-generating ability) but very little in the way of crew or fuel costs. The dimensions of the Suez Canal, and later the Panama Canal, originally capped growth in vessel size. Once an owner decided to build a vessel exceeding these limitations, port and channel depth on the route(s) planned for deployment became the primary restrictions on increasing vessel size.

In 1945, the largest tanker was 23 814 dwt (deadweight tonnes). The key limit on vessel size in those days was the transit draft of the Suez Canal at 10.4 m. The closure of the Suez Canal in 1956 sparked major tanker owners to reconsider the dimensions of new tankers. The *Universe Apollo* marked a milestone in 1959 as the first tanker to break the magical 100 000 dwt mark. The upper limit of vessel size in the tanker sector was reached in 1980 with the lengthening of the Ultra Large Crude Carrier *Seawise Giant* to 564 739 dwt. Port depth was the limiting factor for this vessel, which required a draft of 24.6 m. A similar phenomenon occurred in dry bulk shipping. Although the larger vessels were less flexible than their predecessors, dry bulk ships (with the exception of iron ore carriers) in excess of 200 000 dwt were common by the 1970s.

As for liner shipping, the true upper limits of vessel size are not yet known. For a long time, the largest container vessels were approximately 4500 TEU (twenty-foot equivalent unit), constrained by the dimensions of the Panama Canal. Once the industry determined that this was an artificial limitation, its original reticence to adopt larger "post-Panamax" vessels disappeared, albeit slowly. American President Lines (APL) ordered the first five post-Panamax container ships for delivery in 1988. It was another four years before Hyundai Merchant Marine followed APL's lead. As ship-related cost savings are projected to be as high as 20% for a post-Panamax vessel compared to a Panamax counterpart, container lines have continued to order more and larger ships 1995–2000 in an effort to reduce ocean costs per-TEU. The largest vessels built by the turn of the twenty-first century were two 6690 TEU ships for P&O Nedlloyd. Even larger vessels are on the drawing boards in 2000.

Economies of scale in container ship size are greater on longer routes. This means that vessels operating on the trans-Pacific route get better scale economies than those on the trans-Atlantic, with the latter capping out at 5000–6000 TEU. Technically, there is no reason that a 15 000 TEU container ship cannot be built. However, the reality of its commercial deployment rests on the length of the trade route, the port cargo-handling capabilities on the route and, of course, the port draft.

The next section explores the state of new technologies in vessel design and propulsion before moving on to technologies in cargo handling with portside ramifications. The article then looks at other technologies that influence the water transport and port industries before closing with commentary on what may be expected in future water transport and port systems.

2. Alternative Propulsion Systems/Vessel Designs

The OPEC oil crisis of the 1970s led to a massive recession in 1982–1983 that left most in the transportation industry unsure about the future. Forward-looking research of the day focused on the likelihood of a fossil fuel shortage; it was expected in 1977 that proven crude oil reserves would be exhausted by 2003 and that marine transportation would grind to a halt unless alternative propulsion methods based on coal, nuclear power, wind, or solar energy sources could be introduced to the industry in a cost-effective way. Those gazing into the crystal ball at the time looked at changes in bulk and general cargo handling systems and alternative fuel propulsion systems. It was the latter that held the most interest.

While earlier examination of alternative propulsion systems was driven by the OPEC oil crisis and the recession of 1982–1983, there are three alternative propulsion systems that warrant comment: nuclear power, sail assist, and coal-fired systems.

- Nuclear-powered vessels were seen as a possibility in the post-World War II era, with three built in the 1960s. The cargo ship *Savannah* was built in 1962 for the US Department of Commerce but did not reach the normal vessel lifespan of 20 years. The bulk carrier *Otto Hahn* was built in Germany, launched in 1964, but not completed until 1968. It disappeared from the register in 1984 or 1985. The longest surviving of these nuclear-powered ships was *Mutsu*, a cargo ship built for the Japan Nuclear Ship Development Agency in 1969. It had a longer life but was designated a research vessel in the mid-1980s. The demise of nuclear-powered commercial shipping was due to the high cost of replacing the reactor and growing public sentiment against the concept. Nuclear-powered shipping remains the purview of the military at the turn of the twenty-first century.

- While there have been significant advances in sail technology from 1970 to 2000, the return of sailing ships except for sail-assist systems does not meet modern trade needs in most parts of the world. There are small niche trades where, at a particular point in time, freight rates might be depressed sufficiently that sail becomes a viable option if a bulk commodity is to be moved. That said, it is worth noting that even when fuel oil prices rose dramatically in the 1970s, only niche grain markets became economical with sail assist. Market acceptance of the concept has not materialized in this era of time-driven logistics systems and global distribution. Furthermore, any potential return to favor will be delayed if the latest high-speed cargo vessels are widely adopted.

- Coal-fired engines were seen as a serious propulsion option in the early 1980s. Coal-fired vessels were put into service delivering Australian coal to Japan. However, only this route adopted the technology. Australian shipping interests also examined fluidized bed combustion as an alternative, but widespread acceptance failed to develop.

Clearly, none of these alternate propulsion systems captured the interest of the commercial shipping community to the extent that naval architects had hoped.

What is the state of propulsion systems in 2000? Since 1980, new sources of fossil fuels came on stream. Although they are more expensive, their discovery dulled the appetite of those in the shipping community for the propulsion systems so closely monitored two decades earlier. Propulsion systems in 2000 use older technology but are both more cost-effective (through continuous refinement) and more environmentally friendly. An example illustrates this. Celebrity Cruises' ship *Millennium* is the world's first cruise ship to use a combined gas turbine and steam turbine integrated with an electric drive system. The system provides the benefits of reduced exhaust emissions, as well as less engine noise and vibration. Energy that otherwise would be lost in exhaust from the gas turbines is captured to produce steam for the steam turbines. The true test of any new design is whether it acquires broad acceptance; for this system, more time is needed to evaluate its commercial potential.

While there has been no technological revolution on a grand scale, there are two concepts worth noting: the hovercraft and the hydrofoil. Both were introduced after World War II but have only become established commercially since 1980, principally for passenger transport. The basic principle of the hydrofoil concept is to lift a ship's hull out of the water and support it dynamically on wing-like lifting surfaces (hydrofoils) to reduce the effect of waves on the ship and to reduce the power required to attain modestly high speeds. Hydrofoil vessels have captured interest because, skimming the surface of the water, they can attain speeds of more than 50 miles an hour. They are well used in ferry services but not so much in the cargo field.

Bendall believes that the fast catamaran cargo ship will evolve from the fast ferry technology now appearing commercially. She notes, for example, that Incat's version of the freight/passenger fast ferry catamaran model has been introduced into service on the Australian domestic Bass Strait service. Its speed of 51 knots lightship, 35 knots fully loaded, and its capacity for 800 deadweight tonnes of cargo, 400 passengers, and 105 tourist cars fills the market niche between air and sea freight, offering higher speeds of delivery than possible with traditional vessels and freight rates below those of air cargo but above those of conventional ocean carriage.

With higher speed vessels, there is a need to maximize strength and minimize structural weight in the hull design. The Australians have designed and built aluminum hulls in an effort to gain propulsion efficiencies on shorter haul routes where a premium revenue return would make this feasible. Wider adoption outside this use is not foreseen as traditional routes are unlikely to find such hulls economic commercially and steel will continue to be the metal of choice.

The most imaginative propulsion technology to appear in the last five years of the twentieth century is high-speed water jet propulsion as exemplified by the planned trans-Atlantic *FastShip*. The concept calls for five Rolls Royce engines to drive individual Kamewa water jets, enabling the 860-foot vessels to sustain service speeds of up to 40 knots in a proposed scheduled service from Philadelphia to Cherbourg. Taking less than four days for the ocean leg, *FastShip* promises to provide a seven-day door-to-door transportation network for shipping high value and/or time sensitive cargo from the middle of Europe to the middle of the USA.

In sum, naval architects have gradually improved hull designs and vessel propulsion systems so that vessels at the turn of the twenty-first century benefit from this state of continuous improvement. Most new hull technology has grown out of interest in high-speed ships and has been based on the ability of naval architects to use more sophisticated computer technologies to model concepts at an early staget. While the current focus is on vessels with more fuel-efficient hulls and reduced environmental impacts (from wakes, noise, and vibration), diminishing returns from these improvements are expected. There is no sign of a revolution on the horizon to match that of the switch from sail to steam.

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Biographical Sketch

Dr. **Mary R. Brooks**, a native of Halifax, is a specialist in transportation management and policy (particularly for maritime industries), export strategy, and international strategic management. Since

1979, she has held various teaching and research appointments at Dalhousie University, including research associate positions with the Dalhousie Ocean Studies Programme, the Canadian Marine Transportation Centre, and the Oceans Institute of Canada, as well as a visiting appointment with the Institute of Southeast Asian Studies in Singapore. In 1995, she was a Visiting Fellow of Australia's Bureau of Transport and Communications Economics and in 1998 an Expert Advisor to the Federal Maritime Commission, Washington, DC, in the matter of the regulation of liner shipping. Dr. Brooks is Professor of Marketing and Transportation at Dalhousie University's School of Business Administration and in July 1993 was appointed Director of the Centre for International Business Studies at Dalhousie University. Dr. Brooks holds the William A. Black Chair of Commerce at Dalhousie University. In the area of professional service, Dr. Brooks has been active in the Canadian Transportation Research Forum, serving on its board 1983–1992 and as its President 1990–1991. She serves on the Committee on International Trade and Transportation, Transportation Research Board, Washington DC, and was Membership Secretary and Treasurer of the International Association of Maritime Economists from 1994 to 1998. She is a member of the Chartered Institute of Transport, and a Director for the Halifax International Airport Authority. Dr. Brooks received her undergraduate degree from McGill University in 1971, her MBA from Dalhousie University in 1979, and her PhD in Maritime Studies from the University of Wales in 1983. Her PhD thesis was entitled *Determinants of Shipper's Choice of Container Carrier: A Study of Eastern Canadian Exporters*.