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Ocean Container Shipping: Impacts of a Technological Improvement

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Through the 1950s, ocean transport of general (dry non-bulk) cargo used break-bulk (i.e., on pallet) methods: pallets were moved, generally one at a time, onto a truck or rail car that carried them from the factory or warehouse to the docks. There each pallet was unloaded and hoisted, by cargo net and crane, off the dock and onto the ship. Once the pallet was in the ship's hole, it had to be positioned precisely and braced to protect it from damage during the ocean crossing. This process was then reversed at the other end of the voyage, making the ocean transport of general cargo a slow, labor-intensive, and expensive process.

All of this began to change in 1955. Malcolm McLean, believing that individual pieces of cargo needed to be handled only twice—at their origin when stored in a standardized container box and at their destination when unloaded—purchased a small tanker company, renamed it Sea-Land, and adapted its ships to transport truck trailers. The first voyage, to Puerto Rico, of a Sea-Land containership began in Newark, New Jersey, USA, April 26, 1956. Confrontations with shipping lines, railroads, and unions, however, delayed the company's maiden international voyage to Rotterdam until 1966. The containerization of international trade had begun.

In the years that followed, standardized containers were constructed, generally twenty or forty feet long without wheels, having locking mechanisms at each corner that could be secured to a truck chassis, a rail car, a crane, or other containers inside a ship's hole or on its deck. The use of standardized containers also meant that intermodalism of international trade, the movement of cargo from an origin in one

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country to a destination in another by more than one transport mode, became commercially feasible.

This paper demonstrates that the technological improvement in ocean shipping, containerization, has revolutionized the ocean transportation of general cargo. By handling individual pieces of cargo only twice, when loaded and unloaded from a container, less port labor and ship capacity are required to transport the same amount of cargo that would have moved as break-bulk cargo. The impacts of containerization on ocean shipping lines, shippers, ship design, trade flow networks, port competition, port design, port labor, port investments, and inland transportation are discussed. The discussion should prove to be insightful for future study of international trade flows. While it is clear that ocean container shipping plays an important role in international trade, it has generally been neglected in international trade research.

Shipping Lines

The restructuring of the ocean transportation of general cargo, which began with the advent of containerization, led to the formation of container shipping lines, ocean carriers specializing in the transport of containers. In 1980, the twenty largest container shipping lines, ranked by ship TEU (twenty-foot equivalent unit) transporting capacity, controlled 26 percent of the world's capacity. By 1995, the twenty largest lines controlled almost 50 percent of this capacity (Brooks, 1996). Of the latter, 49 percent belong to Asian operators and 33 percent to European operators, followed by the United States with 14 percent and others accounting for the remaining 4 percent. In 1997, the twenty largest container shipping lines ranked by TEUs transported (see table 1) accounted for 78.2 percent of the TEUs transported by the hundred largest lines (Dow 1998, 8D). Among these twenty lines, the top three—Sea-Land, Evergreen, and Maersk—account for 33.2 percent of the TEUs transported. While many of the ten top-ranked lines serve the transpacific trades, Sea-Land, Evergreen, and Maersk serve global networks, including the transpacific, transatlantic, and Mediterranean and Middle East trades.

Financial deterioration has accompanied the increase in concentration in the container shipping line industry. The estimated collective losses of container shipping lines operating in the transpacific, transatlantic, and Europe/Far Asia trades were $411 million in 1996 (Porter, 1996). The losses reflect the continuing imbalance between market supply and demand, exhibited by excess ship capacity and declining freight rates (see table 2).

Finding it difficult to raise freight rates, container shipping lines have sought to improve their financial condition by reducing costs—by forming alliances, merging, and investing in more cost-efficient ships. In the early 1990s, a number of the largest container shipping lines formed alliances. By sharing vessels and other assets (e.g., terminals) they could reduce operating costs without sacrificing frequency of service,

Table 1. The Twenty Largest Container Shipping Lines (for 1997)

Rank	Carrier	TEUs Transported (1,000s)	World Headquarters
1	Sea-Land Service	1,355	Charlotte, NC, USA
2	Evergreen Line	1,245	Taipei, Taiwan
3	Maersk Line	1,081	Copenhagen, Denmark
4	Hanjin Shipping Company	828	Seoul, South Korea
5	Hyundai Merchant Marine	677	Seoul, South Korea
6	American President Line	656	Oakland, Calif., USA
7	Orient Overseas Container Line	519	Wanchai, Hong Kong
8	China Ocean Shipping	514	Beijing, China
9	Yang Ming Marine Line	491	Taipei, Taiwan
10	Nippon Yusen Kaisha	470	Tokyo, Japan
11	Kawasaki Kisen Kaisha (K Line)	467	Tokyo, Japan
12	Mitsui OSK Line	430	Tokyo, Japan
13	Crowley American Transport	343	Oakland, Calif., USA
14	Hapag Lloyd	314	Hamburg, Germany
15	P&O Nedlloyd	313	London, UK
16	Zim Container	311	Haifa, Israel
17	DSR Senator Line	308	Hamburg, Germany
18	Mediterranean Shipping	285	Geneva, Switzerland
19	Neptune Orient Lines	269	Singapore
20	Cho Yang Line	215	Seoul, South Korea

Source: Dow, J. "Top 100 Container Carriers," Journal of Commerce, September 23, 1998, 8D.

yet retain their independence. By reducing its number of port calls, an alliance line would save ship capacity as well as improve transit times. The saved ship capacity, in turn, could be diverted to new service routes.

The alliances' anticipated annual cost savings ranged from $100 million to $150 million (Wastler 1997). However, in 1996 a number of shipping lines realized that

Table 2. Container Rates (Average in Markets): Major Trade Routes (Nominal US Dollars Per TEU)

	Trans-Pacific		Europe-Asia	
Time Period	Asia to US	US to Asia	Europe to Asia	Asia to Europe
1996, First Quarter	1,746	1,339	1,219	1,369
1996, Second Quarter	1,628	1,428	1,218	1,346
1996, Third Quarter	1,627	1,517	1,167	1,337
1996, Fourth Quarter	1,543	1,384	1,137	1,281
1997, First Quarter	1,473	1,280	995	1,112
1997, Second Quarter	1,407	1,277	1,036	1,156
1997, Third Quarter	1,369	1,428	1,067	1,187
1997, Fourth Quarter	1,362	1,182	1,056	1,157
1998, First Quarter	1,345	1,119	1,040	1,183
1998, Second Quarter	1,459	1,015	869	1,227

Source: United Nations Conference on Trade and Development. Review of Maritime Transport 1998, New York: United Nations, 1998.

anticipated cost savings would not be quickly realized. In response, P&O (a British carrier) and Nedlloyd (a Dutch carrier) surprised the maritime community by announcing that they would merge January 1, 1997, creating the world's largest container shipping line. The annual cost savings of the merged line were projected to be $200 million, 65 percent of which would be immediate from eliminating duplicated overhead, far in excess of cost savings from an alliance (Wastler 1997; Tirschwell 1997).[1]

Shippers

For the shipper, containerization meant less pilferage. Containers would be sealed at the origin and not opened until they arrived at the consignee. Also, less handling meant less damage to cargo. The delivery of cargo was faster and more reliable, resulting in substantial reductions in inventories. While a break-bulk ship often took a week to unload and reload, a containership might be in port for only six hours.

Container freight rates are increasingly based upon factors other than the value of cargo. As a consequence, container rates for high-value cargo are less than break-bulk rates, all else held constant. Hence, shippers, especially those of high-value cargo, are increasingly shipping more of their cargo in containers rather than as break-bulk cargo. This occurrence, the general decline in container rates, and the advantages of container over break-bulk ocean transportation service have contributed to the significant increase in international containerized trade. For the 1980-96 period, international containerized seaborne trade increased 433 percent, from 36.4 million TEUs in 1980 to 157.6 million TEUs in 1996 (see table 3).

Ship Design

In the early 1980s some experts predicted that containerships would not only become very large but would also be "non-self-sustaining," having no cargo cranes of their own (unlike break-bulk ships) and no roll-on roll-off (RO-RO) ramps and having to call at ports equipped with large dockside container cranes. The expectation was that these large ships, 3,000 TEU capacity or larger, would call at only a few ports, where large volumes of containers would be concentrated by land transportation, barges, and small feeder vessels. These so-called load center ports would be analogous to the "hubs" of the "hub and spoke" networks of airlines. In reality, strategy drove the ship design, and vice versa. Shipping lines whose strategies were based on loading centering did opt for larger, non-self-sustaining containerships. If their strategies were to call at a number of smaller ports, they invested in smaller vessels, self-sustaining containerships, and RO-RO vessels, which were able to load and discharge their own containers. If their strategies were to operate only in one ocean, they purchased vessels that were more than "panamax" size (too large to transit the Panama Canal).

Table 3. International Seaborne Trade: Container Throughput of World Ports

Year	TEUs (Millions)	Year	TEUs (Millions)
1980	36.4	1991	96.1
1986	61.0	1992	105.4
1987	67.2	1993	115.2
1988	74.0	1994	129.7
1989	80.9	1995	144.2
1990	87.1	1996	157.6

Source: Global Container Port Demand and Prospects, Surrey, United Kingdom: Ocean Shipping Consultants, 1997.

The rationale for these strategies is that non-self-sustaining (or cellular) containerships exhibit cost economies of ship size at sea (e.g., a 4,000 TEU ship has a 30 percent to 40 percent per TEU cost saving over a 2,500 TEU ship), diseconomies of ship size in port, and port charge diseconomies of ship size (Chadwin, Pope, and Talley 1990). Specifically, the size of a non-self-sustaining containership that minimizes the cost per TEU moved per voyage leg on a given route declines as (1) the number of port calls increase, (2) the time in port per port call increases, and (3) the distance of the route decreases (Talley 1990).[2] Thus, relatively large (small) containerships are expected to serve long- (short-) distance routes, calling at a small (large) number of ports, all else held constant.[3]

As of November 1996, the capacity of the world's containership fleet was 4.8 million TEUs and was expected to increase by 22 percent to 5.9 million TEUs by 1999 (Knee 1998). The carrying capacity of new containerships has increased about 5 percent per year on average over the past decade. Today, most of the ships under construction have a carrying capacity of 5,000 to 6,000 TEUs. In 1996 Maersk Line launched three (in a series of twelve) super-panamax containerships with these specifications: carrying capacity of 6,000 TEUs, 1,049 feet in length, wide enough to carry 17 containers across, the world's largest diesel engine, a cruising speed of more than 25 knots, and a fifteen-person crew. A super-panamax containership yields an 18 percent to 24 percent per TEU cost saving over a 4,000 TEU vessel. The British line, P&O Containers, has ordered two ships that will become the world's largest containerships with carrying capacities of 6,674 TEUs. A modern non-self-sustaining containership with a carrying capacity of 5,000 TEUs or greater has a price range of $60 million to $80 million.

Trade Flow Networks

Container shipping lines have adapted to their increasingly complex and dynamic environment by adopting different service strategies. Some have "load centered" by calling at only one or two ports on a range. Others have followed "multi-porting" strategies, stopping at several ports along the same coast. Some have maintained their service over the big volume, highly competitive routes between North America, Europe, and Asia, while others have focused on perhaps less competitive north-south routes. Some shipping lines have sought to provide door-to-door service, utilizing their own facilities and equipment as Sea-Land does, while others have contracted for rail, truck, or other intermediary services. Evergreen, Nedlloyd, and Senator Lines adopted round-the-world services, the former using relatively large ships in continuous eastbound and westbound circuits.

Until the early 1980s, most ocean container cargo from Asia bound for the Eastern United States was shipped across the Pacific, through the Panama Canal, to a US East Coast port. In April 1984, however, the routing of this cargo began to change. The

US flag shipping line, APL, began offering landbridge service[4]—i.e., rather than all-water service to the East Coast, its ships began calling at ports along the US West Coast, where containers were unloaded and put on rail cars for the trip east. APL acquired double-stack trains (bearing its logo) and contracted railroads for operation over their rail lines. Double-stack trains consist of platform rail cars capable of moving containers stacked two high. Their appeal is their cost advantage over conventional COFC (container on flat car) trains: for slightly more locomotive power, the same labor, and slightly more fuel, 200 containers can be transported on a double-stack train as opposed to 100 containers on a COFC train. In comparison with all-water service, landbridge service (even by double-stack trains) is more costly, but it is five to six days faster than a Panama Canal passage. Today, several shipping lines (including three of the world's largest container shipping lines, Sea-Land, Maersk, and Evergreen) operate double-stack trains from the West Coast.

Landbridging has been a major stimulant to the growth of West Coast container ports (especially the Long Beach and Los Angeles ports) and, in turn, a detriment to East Coast ports, especially the Port of New York/ New Jersey. In the mid 1980s, East Coast ports captured 22 percent of Asian ocean container traffic; by 1997, this share had declined to 15 percent (Mongelluzzo 1998a). This decline would have been worse if not for the gains by East Coast ports in all-water Asian trade via the Suez Canal, growing from zero in 1991 to 6% of all ocean container service between the United States and Asia by mid 1996 (Rose 1996). The speed and the economics of larger containerships have made this trade somewhat competitive with that of the Pacific and landbridging trade. All-water service via the Suez Canal from Singapore to New York, a 9,000-mile route, takes twenty-two days, one to two days longer than passage across the Pacific and landbridging to the East Coast. Although freight rates are generally 10 percent lower in this trade, all the rate revenue goes to the shipping lines rather than being shared with railroads.

APL was the forerunner not only in double-stack train service but in domestic containerization as well. APL realized very quickly that empty westbound maritime containers (formerly filled, eastbound landbridged containers) could be filled with domestic cargo destined for West Coast cities. During the last five years of the 1980s, domestic containerization spread beyond just West Coast destinations into markets throughout the United States and Canada. Railroads made significant commitments to domestic containerization, establishing double-stack train service between markets not related to maritime activity and even replacing, in some cases, TOFC (trailer on flat car) with COFC service. It is estimated that, in North America, domestic containers account for 35 percent of all rail container moves (Slack 1994).

Port Competition

Port competition has intensified under containerization, i.e., intensified in attracting and retaining shipping lines. The lines put pressure on ports to reduce the time and cost of ship calls; if they do not, ships might call at a rival port.[5] Further, ports must have sufficient destination cargo to make calls worthwhile; and ports with sufficiently wide and deep channels, whether natural or manmade, have a competitive advantage in attracting larger containerships. A port's location in having speedy access to major

Table 4. The World's Twenty Largest Container Ports (for 1997)

Rank	Port	TEU Throughput (1,000s)	Country
1	Hong Kong	14,500	China
2	Singapore	14,120	Singapore
3	Kaohsiung	5,693	Taiwan
4	Rotterdam	5,340	Netherlands
5	Busan	5,234	South Korea
6	Long Beach	3,505	United States
7	Hamburg	3,337	Germany
8	Antwerp	2,969	Belgium
9	Los Angeles	2,960	United States
10	Dubai	2,600	United Arab Emirates
11	Shanghai	2,520	China
12	New York/New Jersey	2,470	United States
13	Yokohama	2,330	Japan
14	Tokyo	2,322	Japan
15	Felixstowe	2,213	United Kingdom
16	Manila	2,115	Philippines
17	Kobe	2,100	Japan
18	Keelung	1,981	Taiwan
19	Tanjung Priok	1,900	Indonesia
20	Bremen/Bremerhaven	1,700	Germany

Source: A survey conducted by the American Association of Port Authorities.

shipping lanes also gives it a competitive advantage. The introduction of the new generation of containerships in US trades is dividing the US container ports into two camps—the elite tier of load center ports, having deep channels and excellent inland infrastructures to accommodate these ships, and the second tier of feeder ports, unable to accommodate these ships, receiving much of their cargo either by smaller ships or by rail from load center ports. See table 4 for the world's twenty largest container ports.

Container ports are finding themselves less and less in control of their destinies (American Association of Port Authorities 1991), and "even the largest ports have become pawns rather than dominant players in the worldwide transportation game" (Slack 1993). Natural hinterlands are disappearing, i.e., cargo to and from regions via the closest port can no longer be guaranteed. The container, in facilitating the physical movement of freight across many modes, has made the container port but one of many links (or nodes) in an intermodal (or supply) chain. Door-to-door container traffic (in which land-way routing is decided in conjunction with waterway routing) has given shipping lines even greater control over port choice.

The US Shipping Act of 1984 deregulated ocean shipping, authorizing intermodal (or through) rates and service contracts between ocean and inland carriers. Ocean cargo to and from the United States could now move door-to-door via a single bill of lading, leaving the choice of port of call to the ocean carrier. As a consequence, rather than cargo driving port choices, a longtime maritime maxim, port choices in many instances began driving the cargo. By choosing the same port as their load center, shipping lines could make arrangements with inland carriers for relatively inexpensive service to and from the port. US container ports now found themselves competing more intensively, not only against nearby rivals, but also against ports hundreds of miles away.

Lines have made considerable shifts in their port calls in recent years, dropping one port and moving to another with ease. Some ports have incurred net gains in liner calls, e.g., the Port of Hampton Roads, while others net losses, e.g., the Port of Baltimore (Starr 1994). The vast majority of liner losses are not the fault of ports, i.e., not attributable to internal problems, but rather due to liner service rationalizations and organizational changes such as the utilization of larger ships and the formation of alliances. Port internal problems that do contribute to liner losses include labor problems and delays in dredging.

Port Design and Labor

Containerization has also affected port design. Prior to containerization, general cargo was loaded/unloaded from break-bulk ships having on-board cranes and docked at finger piers (piers extending into the water, perpendicular to port berths) and was stored in warehouses. Since non-self-sustaining containerships have no cranes aboard, break-bulk ports aspiring to become container ports had to become more capital intensive—not only investing in dockside cranes but also in other types of mobile and infrastructure capital. Finger piers were eliminated; berths were redesigned so that containerships could be docked parallel to berths for easier loading/unloading by dockside cranes. Warehouses were removed and land cleared for open-land storage of containers. If land was plentiful, containers were stored on truck chassis for easy movement to and from ships; if not, they were stacked on land one upon another, several containers high.

The increased use of containers, coupled with new cargo handling techniques, led to a significant decrease in the demand for port labor. Huge job losses resulted, ranging from 40 percent to 60 percent in many countries (Zarocostas 1996). In the United Kingdom, dock jobs fell from 80,000 in 1967 to 11,400 in 1986 (Chadwin, Pope, and Talley 1990). Even in recent years, significant losses have occurred. In the United Kingdom, port employment declined by 44 percent between 1989 and 1992. In France, work rule reforms introduced in 1992 led to employment declines of up to 66 percent in six major ports. In Australia, waterfront reforms introduced in 1989 led to a 42 percent reduction, over two years, in stevedore labor.

Although dock jobs dramatically declined,[6] longshoremen unions were reluctant to accept changes and negotiated work preservation schemes. In some cases, work rules, gang sizes, and compensation patterns remained the same as for handling break-bulk cargo. On the Atlantic and Gulf coasts of the United States, labor-management negotiations led to a "fifty-mile rule" (reserving all "stuffing and stripping" of containers in or near ports for unionized longshoremen), guaranteed annual incomes regardless of hours actually worked, and agreements that required shipping lines to use union labor for their vessel calls.

The supply of longshoremen that remains is expensive and tends to be inflexible when demand conditions change. In 1997, the annual wages of US West Coast longshoremen ranged from $96,865 for general longshoremen to $113,808 for marine clerks to $148,477 for foremen (Mongelluzzo 1998d). The antiquated dispatch system of the West Coast International Longshore and Warehouse Union (ILWU), which allows workers to decide where they will work, often has workers arriving at their assigned vessels one to two hours late. Further, union work rules make it difficult and costly to fill additional shifts. During peak shipping seasons, labor shortages are a persistent problem at the Ports of Long Beach and Los Angeles, delaying containerships for days and diverting some ships to the Port of Oakland. Labor shortages are a combination of the attrition rate (averaging 5.8 percent per year) among general longshoremen and the difficulty of getting into the longshoremen union. Many individuals work for years as "casuals," waiting for an opening as a registered longshoreman, then working for only 10 or 15 more years before retiring.

Some port employers say that the ILWU has lost control of its membership. Between mid 1996 and mid 1998, there were 135 illegal walkouts at West Coast ports, costing the shipping industry more than $150 million and US consumers $500 million

(Mongelluzzo 1998e). Employers may sue the union for damages but are often reluctant to do so.

Port Investments in the United States

Modern container ports require enormous infrastructure investments, which are often made without assurance that traffic will be forthcoming, unlike that for their break-bulk predecessors. By 2010, it is projected that 33 percent of the container volume moving through US ports will be carried on ships having a 4,500 TEU transport capacity or greater (Mongelluzzo 1997), placing major demands on ports to provide deeper channels, wider turning basins, bigger cranes, more extensive container storage areas (50 to 75 acres of storage land per ship berth), on-dock railroads, and more efficient land-gate complexes. Currently, the only US container ports with channel depths that can accommodate 6,000 (and larger) TEU containerships (when filled to or near capacity) are the West Coast ports of Los Angeles, Long Beach, Seattle, and Tacoma and one East Coast port, Hampton Roads.

For the 1996–2000 period, US ports have planned more than $6 billion in capital spending (Amerman 1997). Ten ports account for 80 percent of this planned spending; ranked in order by size of expenditure, they include Los Angeles, Long Beach, Seattle, the Georgia Ports Authority (the ports Savannah and Brunswick), Houston, the Port Authority of New York/New Jersey, Miami, Port Everglades, Tacoma, and New Orleans. The planned investments in on-dock rail yards, highway and rail access, grade separations, and overpasses are almost as large as those in marine terminals. The Port of Los Angeles plans to spend $1.33 billion: more than $200 million on basic highway–rail grade separations (for the Alameda Corridor), [7] access improvements, and general infrastructure and $175 million for a dredging and landfill program to create more than 230 acres of new land for future development. The Port of Long Beach plans to spend $1.23 billion: $150 million to build six overpasses, separating vehicular and rail traffic; $170 million for completion of the new Pier S Marine Terminal; $200 million to develop the Pier T Marine Terminal on the grounds of the former naval station; and another $200 million to develop a portion of the latter terminal on the former naval shipyard.

While investments in modern container facilities are necessary for US container ports to attract and retain shipping lines, there is also a downside to such investments. First, container ports, especially on the West Coast, have incurred huge debts and, for some ports, credit ratings have declined. The ports of Los Angeles, Long Beach, Oakland, Seattle, and Tacoma have a combined outstanding debt of $3.37 billion (Mongelluzzo 1998b). Second, the majority of traffic at most US container ports is transhipment traffic that does not remain in or is not from the immediate hinterland of the port and hence could possibly move through a number of ports in a coastal region. Thus, ports may not secure the market shares they are seeking. If they are unable to repay their debt, the burden might then be shifted to taxpayers. Third, excess port capacity may occur, placing pressure on ports to lower their rates. Increasingly, public ports are unable or unwillingly to finance the full cost of such investments, turning to private investment alternatives such as port privatization[8] (sale to the private sector) as found in Argentina, Brazil, and the United Kingdom and port investments by marine terminal operating companies and shipping lines.

Inland Transportation in the United States

If container ports have inadequate inland transportation systems, shipping lines may reroute their ships to rival ports. As larger and larger containerships call at fewer and fewer ports, railroads are being relied upon more and more to distribute cargo over wider inland areas, placing an enormous strain on their infrastructure, which hasn't significantly expanded in fifty years.[9] In Oakland, railroads move freight on a track layout that was designed around the turn of the century; in Long Beach, railroads use one track in handling 50 percent of the port's cargo.

Also, intermodal rail equipment has been in short supply, especially in Southern California. The Union Pacific (UP), which handles about two-thirds of the intermodal traffic of Southern California, suffered a severe shortage of intermodal rail cars and locomotives in the region during the summer of 1997. At one point, the region had a backlog of 3,000 eastbound containers; in Long Beach/Los Angeles, the containers experienced delays ranging from several days to a week. The equipment shortage reached such a critical level that UP took the unprecedented step of chartering an APL ship to transport containers from Long Beach/Los Angeles, through the Panama Canal, destined for Savannah. Also, some shipping lines, e.g., Hanjin and K Line, responded to the equipment shortage by rerouting their ships—making other ports their first ports of call along the Pacific Coast.

The shortage of rail equipment has also affected port labor productivity. As containers back up, there are fewer chassis being returned and therefore a chassis shortage in storage areas. Recently, Long Beach/Los Angeles had a 20,000-chassis shortage, resulting in the ports using 30 percent to 35 percent more labor for storage-stacking of containers than if they remained on chassis.[10]

Two distinct types of trucking firms service container ports: (1) harbor (or local) truckers who move containers within the port's local area or within the port itself and (2) over-the-road truckers who move containers to and from distant inland locations. However, each experiences the same major port problem—too much time is spent waiting in line. Harbor truckers are paid by the number of containers moved and over-the-road truckers by the mileage traveled. The greater the time spent waiting in line in port, the lower their incomes. Truckers criticize the ports for allowing the loading and unloading of containerships around the clock, but only keeping their gates open for trucks eight to ten hours a day. In California, one legislator has proposed legislation requiring ports to stay open longer for truckers.[11] Truckers also face delays in port when containers must be repaired prior to port departure. Container-hauling truckers are generally unorganized, having little power to address their concerns. However, this may change in the future, especially if the current movement to organize them succeeds.

Conclusion

Containerization, a technological improvement in shipping, has revolutionized the ocean transportation of general cargo. Its impacts are numerous. Containerization led to the formation of ocean shipping lines specializing in the transport of containers. The container shipping line industry has become more concentrated, but its financial condition has deteriorated. The lines have sought to improve their financial position by forming alliances, merging, and investing in larger and more cost-efficient ships. For the shipper, containerization has meant less cargo pilferage and damage, faster and more reliable transportation service, and reduced freight rates, especially for transportation of high-value cargo. As a consequence, international containerized seaborne trade (in TEUs) increased 433 percent between 1980 and 1996. Containerization has also affected ship design; modern containerships are non-self-sustaining, i.e., without on-board cargo cranes (unlike break-bulk ships), which allows for greater cargo utilization of the ship.

World trade flow networks have changed under containerization. Networks that were once all-water in the transport of break-bulk cargo may now consist of landbridging networks utilizing double-stack container train service. Container shipping lines have adopted such new service strategies as load centering and round-the-world services.

Competition among container ports is intense, unlike that experienced by their break-bulk predecessors. Cargo to and from regions via the closest port can no longer be guaranteed. Container ports are but one of many links in a supply chain and are becoming pawns in a game of global commerce. Modern container ports are more capital intensive than break-bulk ports, requiring enormous infrastructure investments, which are often undertaken without assurance that cargo will be forthcoming. The huge debts incurred to finance these investments have resulted in declines in credit ratings for some ports. Many break-bulk ports have been redesigned to create container ports; finger piers have been eliminated so that containerships can be docked parallel to berths for easier loading/unloading by dockside cranes. Huge losses in dock worker jobs have occurred under containerization; the supply of dock workers that remains is expensive and tends to be inflexible when demand conditions change. As larger and larger containerships call at fewer and fewer ports, railroads are being asked to distribute containerized cargo to and from ports over wider inland areas, placing an enormous strain on their infrastructure.

US container cargo is projected to more than double in the next twelve years and to increase sevenfold over the next fifty years, severely stressing the nation's port, rail, and highway infrastructures (Mongelluzzo 1998c; Wauben 1997). Whether the capacity of the US transportation infrastructure will be sufficient to handle these projected increases and, if not, what the impact on international trade will be, are current concerns.

Notes

1. The 1997 profits of the P&O-Nedlloyd merged company were $666 million before factoring in merger costs, a 25 percent increase over the individual carriers' 1996 profits. In April 1997 Neptune Orient Line (NOL) of Singapore agreed to acquire APL, the second largest US container shipping line, identifying $130 million in annual cost savings from consolidating information technology, vessel, container and inland services and from reduced terminal expenses (Tirschwell 1997). By the end of 1997, the absorption of APL by NOL had resulted in a loss of $39 million for the group. Recently, Hanjin Shipping Company of South Korea acquired a majority stake in DSR Senator Line of Germany and began merging the two lines' operations.
2. Ship voyage costs include ship operating and capital costs incurred at sea, ship operating and capital costs incurred in port, and port charges. For further discussion of containership costs, see Lim (1994, 1996) and Talley (1986).
3. However, while TEU unit costs are lowered, greater excess ship capacity may occur on some routes, contributing to an even greater decline in freight rates.
4. Some authors have distinguished among landbridging, minibridging, and microbridging: landbridging referring to cargo movement that crosses a body of land between two ocean legs; minibridging referring to cargo movement that crosses one ocean by ship and then crosses a body of land but ends at a port on another ocean; and microbridging referring to cargo movement that crosses one ocean by ship and then proceeds by rail to an inland location (Chadwin, Pope, and Talley, 1990). For this paper, landbridging is an all-encompassing term, capturing all three of these possibilities.
5. A 3,000 to 4,000 TEU containership incurs a cost of $40,000 to $60,000 a day at sea and perhaps half that in port.
6. In 1970, 30,000 longshoremen were employed in the Port of New York/New Jersey; by 1986 this number had declined to 7,400 dockworkers. For further discussion, see Chadwin, Pope, and Talley (1990).
7. The Alameda Corridor is a rail corridor, currently under construction, that will consolidate more than ninety miles of rail operations into one twenty-mile corridor, creating a high-capacity intermodal rail link between the ports of Los Angeles and Long Beach and rail lines leading eastward. The corridor will be fully "grade separated," i.e., all 200 railroad crossings at street level along the corridor will be eliminated. The rail tracks will, for the most part, run through a trench. The corridor will not only improve transportation efficiency, rail and highway, but will also generate environmental, economic development, and safety (i.e., eliminating vehicle-train accidents) benefits. The corridor is expected to cost $2 billion, to be financed by $800 million in tax-exempt bonds issued by the Alameda Corridor Transportation Agency, a $400 million loan from federal transportation funds, $350 million from a Southern California transportation agency, and a total of $400 million from the two ports.

8. Port privatization is also underway in Taiwan, Turkey, South Africa, and South Korea. For a discussion of port privatization, see Thomas (1994) and Everett and Robinson (1998).
9. At the Port of Long Beach, 50 percent of the cargo is handled by rail.
10. Some ports fear that larger railroads will act to favor one port over another (Kaufman 1997). However, there is no evidence to support this fear.
11. Another proposed solution for reducing truck as well as rail port congestion is to provide inland sorting facilities or inland land-locked ports. Containers would be shuttled by rail to an inland sorting facility immediately after they are unloaded from the ship, where they would be sorted and placed on over-the-road trucks and trains for delivery to their final or intermodal destinations. Containers destined for ports would follow the reverse procedure. Shuttle trains could run as often as needed, virtually eliminating port "dwell time" for containers.

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