Chapter 3

Technological and organizational change

3.1 Introduction

In his 1983 book *Networks of Power*, Thomas P. Hughes introduced the concept of large technical systems (LTS) in his pathbreaking account of the invention and evolution of electrification by integrating systems theory into historical narratives (Hughes 1983). His framework proves a fertile ground for depicting the introduction and expansion of containerization and its role in intermodalism.

Hughes (1983, 5–6) defines a system thus:

> A system is constituted of related parts and components. These components are connected by a network, or structure. . . . The interconnected components of technical systems are often centrally controlled, and usually the limits of the system are established by the extent of this control. Controls are exercised in order to optimize the system's performance and to direct the system toward the achievement of goals. . . . Because the compo-

> nents are related by the network of interconnections, the state, or activity, of one component influences the state, or activity, of other components in the system. . . . Those parts of the world that are not subject to a system's control, but that influence the system, are called the environment.

In the case of large technical systems, which rely on complex political and organizational arrangements for development and operation, like electrical systems and freight systems, Hughes (1983, 465) labels these systems "sociotechnical systems." His intention is to emphasize his claim that while individual and organizational actors play primary roles in shaping and directing these complex systems, systems themselves have "an internal drive and increasing momentum" (Hughes 1983, 462) as technical, financial, and organizational resources invested on the basis of earlier decisions become more difficult to alter as the systems evolve.[1] The actors that do the work of combining technological, political, and economic interests and resources into the creation, development, and expansion of systems are dubbed "system builders."

Following Joerges's (1988) account of Hughes, the evolution of LTS proceeds through three stages. The first stage spans invention, development, and innovation, and the dominant system builders are technical inventor-entrepreneurs, who, like Edison, are entrepreneurial in their development of both technology and customer base. Invention ends in the introduction of a new technical system that must be developed by embedding it within the political and economic context, after which innovation puts it into proper practice. The second stage is the transfer of the system to new political and economic contexts, which entails a myriad of organizational and often technical adjustments. The dominant system builders at this point are engineer-entrepreneurs, who adapt existing technologies to the local "technological style," which refers to the

[1] A similar, though perhaps more extreme view, is expressed by actor-network theory (ANT) (Callon 1986; Latour 1996, 1997, 1999).

geographical, economic, political, and organizational factors pertinent to a given location. The final stage spans growth, competition, and consolidation. The system builders at this stage, manager-entrepreneurs and financier-entrepreneurs, focus their efforts on rationalizing the system, making it more efficient, and concentrating capital. The changes that occur during this stage are often driven by system builders' attention to *load factor*, a term Hughes borrows from the power industry. "Load factor is the ratio of the average load to the maximum load of a customer, group of customers, or the entire system during a specified period" (Hughes 1983, 218). Maximizing load factor is equivalent to maximizing efficiency and often entails expansions into new customer bases. For example, one of the early pioneers of electrification, Samuel Insull, actively pursued transportation company contracts for street car power because his analyses suggested that peak energy consumption during commuting hours would complement that of lighting before and after commuting to and from work and that of stationary motors in the work place.

Another useful term introduced by Hughes is *reverse salient* in place of "bottleneck" and "disequilibrium." Drawn from military use, where it refers to a section of a battle line or military front that remains connected to the rest but has fallen behind, "the concept of a reverse salient refers to an extremely complex situation in which individuals, groups, material forces, historical influences, and other factors have idiosyncratic, causal roles, and in which accidents as well as trends play a part" (Hughes 1983, 79). A component of a system that holds the other components back on their way to achieve an actor-defined goal, some critical problem that stymies the full functioning of the system, is considered a reverse salient. Hughes calls solutions to reverse salients that sustain the current arrangement "conservative," and solutions that entail fundamental redesigns or the introduction of new, competing systems "radical" (Joerges 1988, 13). Summerton (1994a, 13) calls attention to the "particularly striking" reverse salient of congestion in physical systems, for which the solution may be not only increasing the physical size of a given network but also increasing the regularity and predictability of movements.

The contributions to *Changing Large Technical Systems* place great emphasis on boundary crossing by LTS (Summerton 1994b). In the introduction, Summerton (1994a, 7–10) summarizes the contributions. She argues first that researchers have conventionally treated LTS as individual systems, but that the contributions, particularly those of Braun and Joerges (1994), Bucholz (1994), Schneider (1994), and Usselman (1994), demonstrate that LTS are essentially "second-order systems" that integrate heterogeneous systems into a new system. For example, Bucholz (1994) suggests that railroads and telecommunications are generally considered independent LTS but were integrated into the traditional European armies prior to World War I and transformed them into a second-order military system. The second observation Summerton makes is that such processes of integration often cross both physical and institutional territorial borders. For example, the takeover of an American railway by a Canadian firm entails not only organizational crossing of national boundaries but also institutional changes to legislation permitting such takeovers. (See also Egyedi [1996] and Heins [2009].)

The LTS approach offers a useful framework for exploring the evolution of global freight transportation and containerization in particular. Born of a trucker's attempt to overcome highway congestion in the Northeast, containerization was created as a second-order system. Actual implementation varied in accordance with the specific needs and character of the major firms that first developed systems. Global growth in container traffic faced the reverse salient of heterogeneous country- and company-specific standards for rail gauges, truck chassis, and locking systems. The shipping industry is plagued by global imbalances in the flow of trade as well as by booms and busts in global trade that lead to cycles of undercapacity and overcapacity. In response, shipping companies have competed through economies of scale in ship size and through efforts to maximize the load factor for each journey. For example, as manufacturing moved from North America and Europe to East Asia, loaded containers fill ships travelling east to west, while empty containers dominate in the opposite direction, leading shipping companies to offer significantly lower rates for the latter journey. Fierce competition has led ultimately to organizational consolidation, as the terms of survival demand the construction of fleets of expensive ships and a global reach. Concentration of capital was also assisted by the deregulation of the transportation industry, which relaxed prohibitions against crossing institutional boundaries between transportation modes.

Hughes' three stages can be summarized as an initial growth phase, an accelerated growth phase, and a stabilization phase, which may be followed by a period of decline (Gökalp 1992). Thus they can be loosely mapped onto the S-shaped curve in measuring the growth of a new technology (e.g., the automobile) generally observed in technology and transportation studies (Garrison and Levinson 2006, 46–50). In this model, growth is slow when a technology is first introduced (stage one) and transferred to new locations (stage two). This is represented by the bottom of the S. Hughes' growth and competition are reflected in rapid growth for some time as the technology takes off (the middle of the curve). And finally, as the technology and industry mature, growth slows down and levels out (the top of the S).

Containerization, like other successful transportation technologies (Grübler 1990), appears to be following suit. Figures 3.1 and 3.2 depict the growth of containerization on the world stage and within the U.S., respectively. Both plots exhibit the same pattern: comparatively slow growth until the early 1990s followed by a period of more rapid growth. If the S-curve trajectory is to hold true for containerization, these

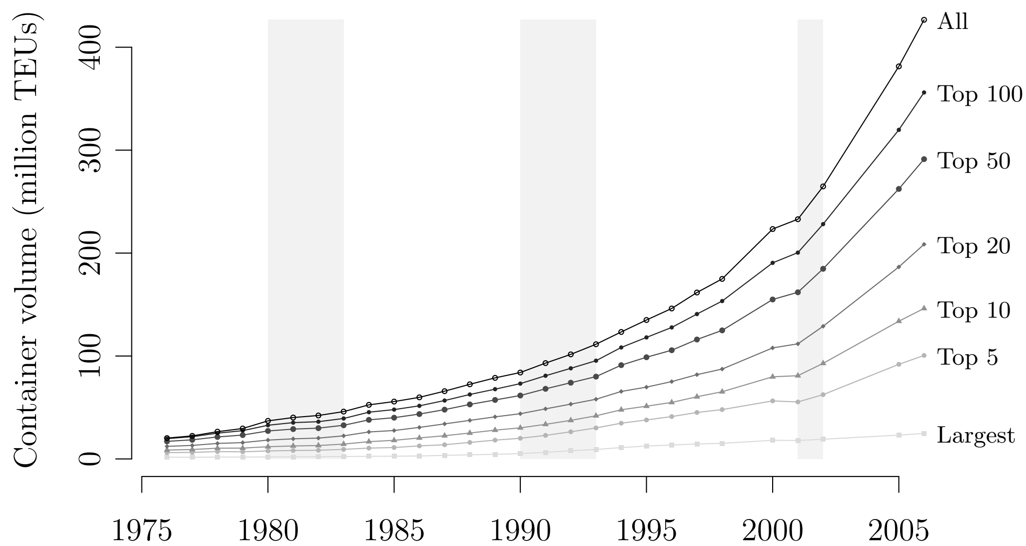

Figure 3.1: Total volume of containers handled by world ports. Each line represents a different grouping of ports. Demonstrates the rapid increase in total volume from the early 1990s.
Source: Containerisation International Yearbook

plots suggest that, as a technology, containerization has not yet reached maturity. The recent economic crisis, which is not yet reflected in available data, may be a turning point, but this will not be apparent for some years yet. The year-on-year growth rates plotted in Figure 3.3 suggest a fairly even rate of growth in container volume that averages about ten percent, which implies a doubling of volume every seven years. The U.S. shows greater variability with a mean of roughly seven percent, which implies a doubling of volume every ten years. Of particular note is the higher rate of growth after the early 1990s. Two points are relevant here. First, growth was more rapid than in previous decades. Second, the growth rate increased steadily while the world growth rate remained steady, suggesting that there were changes unique to

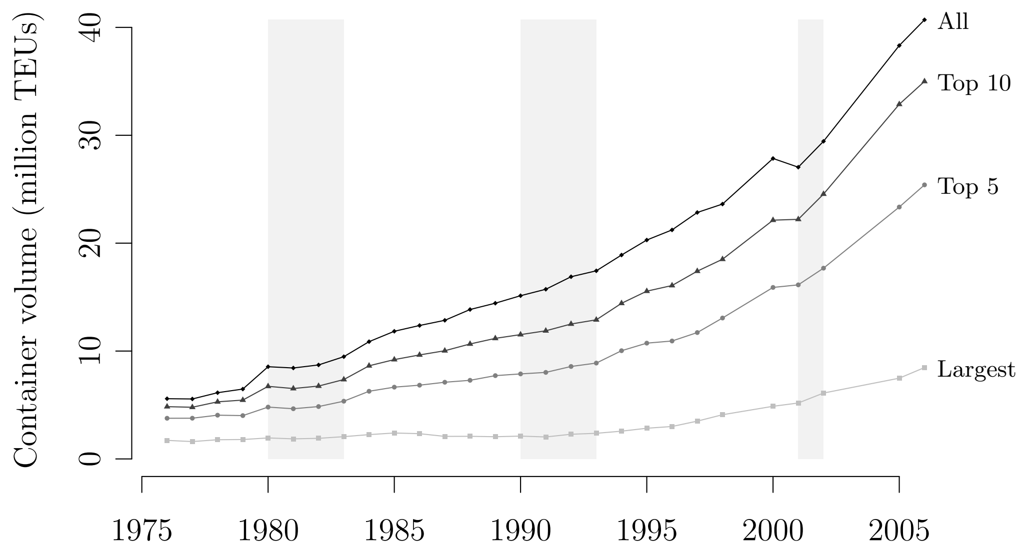

Figure 3.2: Total volume of containers handled by U.S. ports. Each line represents a different grouping of ports. Demonstrates a steady increase through the early 1990s followed by rapid growth.
Source: Containerisation International Yearbook

the US responsible for more rapid growth. These points will be discussed below.

3.2 Stage One: Invention, development, and innovation

3.2.1 Nineteenth century intermodalism

Intermodalism and multimodalism refer most generally to the transport of goods from origin to destination via more than one mode of transportation. Efficiencies can be gained either by increasing the average speed of the modes of transportation involved or by reducing the time and cost of transferring goods from one mode to the other. It

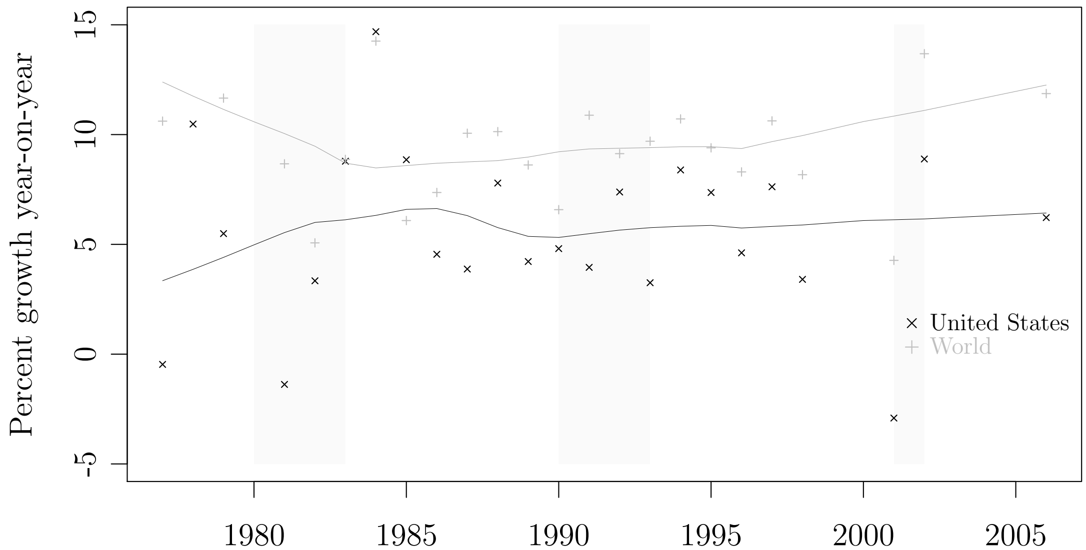

Figure 3.3: Containerization growth rate for the United States and the world. Note that world growth rates during this period are consistently higher than rates for the U.S. The dashed black line represents the U.S. locally weighted regression line for available data. The dashed grey line represents the world's locally weighted regression line. Grey background indicates periods of recession in the U.S.
Source: Containerisation International Yearbook

is this latter concern of reducing or eliminating the obstacles to the smooth circulation of goods into which containerization as a technology falls.

In a sense, the first bags and boxes employed to transport goods could be considered the precursors to containerization. They were employed with the same fundamental ends in mind: to simplify loading and unloading and to protect goods from damage and theft. Containers, however, are products of rationalization and mechanization under contemporary capitalism. It is thus best to go back no further than Dr. James Anderson's 1801 articulation of a container for transporting goods and his 1845 patent for a container that could be easily transfered between horse-drawn carriages and the expanding number of railcars. In the United States, precursors could be seen in the "pantechnicon vans" and "lift vans" of the early twentieth century. Pantechnicon vans were wooden crates approximately twelve to eighteen feet long and up to seven feet wide that were drawn by horses and used to transport household effects from one home to another. Lift vans isolated the crate so that it could be loaded by cranes onto horse-drawn carriages or trolleys and were available for transatlantic shipping (Palmer and DeGiulio 1989, 285–86).

Multimodal principles were also employed in moving commercial goods in the U.S. at this time. As early as the 1830s, the Baltimore & Ohio Railroad offered "piggyback service," in which container vans were carried on flatcars. Similar efforts were made by the Long Island Railroad after 1885, when it started "Farmers' Trains" to transport produce to New York City's East River in produce wagons lashed to rail flatcars. Also, from 1843 to 1857, the Pennsylvania Railroad Company carried sectionalized canal boats on flatcars within Pennsylvania (Palmer and DeGiulio 1989, 285–86). So clearly, the concepts and advantages underlying rapid transfer of "containerized" cargo is a long-standing one in transportation.

3.2.2 Early twentieth century

A seamed system

Early transportation legislation embodied two seemingly contradictory approaches, one privileging the market and the other depending on government regulation. Both, however, led to decades of legally mandated modal separation (Palmer and DeGiulio 1989, 311–324). Based on the perception of railroads as monopolists (Rose et al. 2006, 3), the Interstate Commerce Act of 1887 embraced antitrust views that saw free market competition as the best regulator of prices and rates. The second approach, embodied in the Shipping Act of 1916, treats the transportation industry as a public utility that exists to serve the public interest and must therefore be controlled to prevent excessive rates, discrimination, and other abuses. Driving the Shipping Act is the existence of shipping conferences over given routes, which are essentially rate-setting cartels that were established to counter overcapacity and cutthroat competition. The U.S. government felt that such protection was warranted as it saw the loss of domestic maritime capacity through competition with foreign carriers as undesirable from a military standpoint (Branch 1996; Kendall and Buckley 2001; Levinson 2006).

To effect these goals, both laws established government control over routes and rates for interstate transportation. Originally only applicable to railroads, the Interstate Commerce Act was expanded in 1935 to cover motor carriers, in 1940 to cover water carriers, and in 1942 to cover freight forwarders (Palmer and DeGiulio 1989, 311–313). Common carriers subject to the act were obliged to submit their rates, routes, rules, and practices to the Interstate Commerce Commission (ICC) for approval before they could be implemented. The rates had to be reasonable and nondiscriminatory. While the ICC had jurisdiction over motor carriers, railroads, and certain water carriers, the government also created the Federal Maritime Commission (formerly the United States Shipping Board) to regulate both domestic and international common carriers by water.

The impact of this organizational framework was to ensure decades of modal separation. Cross ownership of more than one mode of transportation was seen as anticompetitive and actively blocked. Railroads in particular were forbidden from owning shipping lines and trucking companies. The former prohibition was explicitly stated in the Panama Canal Act of 1912 (Rose et al. 2006, 3) and the latter enforced by the ICC as essential to land-based competition. Despite efforts by some transportation economists and and independent analysts to advocate for a coordinated national transportation system that took into account all modes and encouraged intermixing them, Congress passed further legistlation in the late 1930s that produced "a 'national' system composed of separate transportation industries and separate transportation markets, each now defined variously as technology or mode and governed by several equally disconnected policies and regulatory agencies" (Rose et al. 2006, 32–33). Legislation was used to ensure that each mode, in Hughes' terms, functioned as an independent, first-order system. The transportation system as a whole then could be thought of as a system with clear seams between modes or as a collection of independent systems.

One outcome of this separation, which becomes a major motivation for deregulation after the advent of containerization, is that freight transportation providers could not offer joint through rates. Through rates are door-to-door prices for shipping goods, and a joint through rate covers a journey that requires multiple modes to complete. Thus, for instance, rather than quote a single price for pick up, transport, and delivery, a water carrier could only offer a price from port to port; the other legs of the journey would involve separate prices quoted by trucking companies or railroads. This compelled shippers[2] to spend additional effort and build additional expertise in transport arrangement or depend on a single alternative quoted by an intermediary (Palmer and DeGiulio 1989, 314–315).

On the docks

Mechanization crept slowly onto U.S. docks during the first two decades of the twentieth century. Advances were generally limited to replacing onboard hand-operated winches with steam-powered versions. Similarly, some winches were also installed on

[2] In keeping with the conventions of the literature on transportation, companies that send their products to other destinations are referred to as "shippers," while the companies that transport goods are referred to variously as "shipping companies," "liner companies," and "logistics providers."

the docks, but this was fairly rare, although the most advanced European shipyards were installing their first large cranes for moving cargo from ship to shore (Barnes 1915). Additionally, small trucks came into use for hauling goods away from the pier, and later fork-lift trucks were introduced to move goods around the docks, augmenting the dollies that longshoremen traditionally used.

Intermodalism

While change was slow on the docks, it was advancing more rapidly on the rails. Intermodal operations rapidly became commonplace over the first half of the twentieth century, exploding at mid-century. Carfloat service (railcars on barges) from Greenville, NJ to New York City began in 1904 and constituted ninety percent of the city's water-borne cargo by 1929. In the 1920s modern rail container services were introduced between Cleveland and Chicago, trailer-on-flatcar (TOFC) service began between Chicago and Milwaukee, and by 1928 the Pennsylvania Railroad had established container service between New York, Baltimore, Philadelphia, Pittsburgh, Cleveland, and Buffalo. However, in 1931, the Interstate Commerce Commission (ICC), which licensed and controlled insterstate transportation, passed down the *In re Container Service* decision that quashed truck and rail integration for nearly twenty years in keeping with its emphasis on weakening railroads' monopolistic powers by sustaining modal competition. In their findings, the ICC concluded that because the shippers greatly benefited from TOFC services, this sought-after service did "not need the encouragement" of lower rates, which it deemed "unreasonable, unjustly discriminatory, and unduly prejudicial." The higher rates subsequently attached to container services than breakbulk shipping by the Commission made it impossible for the railroads to compete with other modes of transportation, and they thus ceased such services, reestablishing the modal separation between trucking and rail (Palmer and DeGiulio 1989, 290–292).

Meanwhile, in the UK during the late 1920s, British Railways also introduced railway containers to gain all the benefits attributed to boxing cargo (reduced breakage, reduced theft, ability to prepackage, and intermodal convenience). These containers were small by current standards (about 2–4 tons), some were refrigerated, and some were open. There were also cargo-specific containers. The extent of intermodalism's importance was such that some containers were "demountable truck bodies which can be freely moved by both rail and road vehicles." (Hammond 1957, 208)

3.2.3 Mid-century

Military role

The military's role in developing and disseminating technological advances in logistics has been consistent and significant over the twentieth century, if of secondary importance. At mid-century, the military contributed in two ways. First, logistics took on renewed importance after early failures at the beginning of World War II and led to the improvement of pallet design and use. Maloney (1996, 2–3) argues that between the wars, commercial shippers had realized cost savings by cutting back on packaging, but that this weaker packaging was not up to the rigors of military deployment. After spectacular losses as cartons of supplies disintegrated under wet conditions in Guadalcanal and in the North African and Pacific Theaters, the military reinvigorated its logistics departments, which issued new standards for packaging and developed techniques for palletizing cargo.

The military's second contribution during World War II and the Korean War was to expand the use of pallets and mechanization to less developed ports, like Tacoma (Magden and Martinson 1982) as well as overseas ports (Cargo Handling

1956a). This facilitated the expansion of mechanized loading and unloading in the commercial sector as similar technologies could be employed at more points in the system.

Efforts toward unitization

The military was not alone, of course, in recognizing the advantages of palletization and seeking more efficient and secure packaging methods. Experiments with palletization and unitization dating from the late 1920s led to rapid adoption, deep penetration, and international standardization by the late 1950s. This evolution offers three insights into the development of containerization. First, it makes it clear that unitization was a technique for reducing labor costs. Second, it suggests that the history of the container is more a product of gradual systemic evolution than a disruptive innovation. Third, it shows that efforts toward intermodal standardization precede the container-proper.

As discussed previously (Section 3.2.2), efforts to containerize cargo stretched back to the early twentieth century. They took on renewed vigor after dockworkers had asserted their dominance over production on the docks (see Chapter 8 for a fuller account). Though counteracting labor gains was the major motivation for increasing palletization, palletization possessed other positive attributes that attracted employers and were later used to praise containers. They reduced breakage, as goods were prepackaged and therefore handled less and better insulated against shocks. They reduced theft, as it was not easy to discreetly abscond with an entire pallet or to open one up. And they increased the flow rate of goods through the port, as packaging and sorting was handled elsewhere, relieving dockside congestion.

Tooth (1956, 225) calls palletization "an integral part of the revolution in goods handling methods which is still taking place in industry generally and which is fundamentally affecting cargo handling." The extent of this revolution from scanty use prior to World War II to the end of the 1950s is conveyed in Table 3.1, which shows the proportion of palletized cargo at selected East and Gulf Coast ports. While the range of values reflect the nature of the cargo handled by the different ports, together they demonstrate that palletization was widespread by 1957 and that it dominated freight movements in some ports, e.g., Manhattan, where 94 percent of cargo was palletized.

Port	LT (%)	MT (%)
New Orleans Commercial	74	65
Baltimore Commercial	90	91
Hoboken Commercial	36	38
Manhattan Commercial	94	80
Brooklyn Commercial	17	34
New Orleans Army Terminal	66	40
Hampton Roads Army Terminal	16	20
Brooklyn Army Terminal	41	50

Source: Maritime Cargo Transportation Conference (1957)

Table 3.1: Percent of palletized cargo in long tons (LT = 2,240 lbs) and measurement tons (MT = 40 cubic feet) in selected East and Gulf Coast ports in 1957

Refitting the freight system for palletization laid down some vital technological components that contributed toward containerization. Hartman and Fish (1957) note Rotterdam's paving of its docks while repairing World War II damage specifically to facilitate the use of forklift trucks. This growing trend contributed to trucks' ability to access piers, which is a necessity for containerizaiton. Tooth (1956) reports that flatbed vehicles for stacking pallets were introduced after the war, a precursor to the chassis used to mount containers today. He also states that warehouses were being specially built for pallets, e.g., measured in multiples of pallet dimensions that were subsequently marked out on the floors. This, too, reflected a steady advancement toward the standardization of space and warehouse construction exhibited today (Bowen 2008). The use of forklifts inside ships also spurred ship redesign (Cargo Handling 1956b), which became vital for the transition from tankers and freighters to full-fledged containerships.

Finally, the impetus toward international standardization of pallet sizes was first recognized and acted upon in relation to pallets, setting an example for containers. Pallet standardization began in Sweden in 1946, quickly spread throughout Scandanavia, and was made international by 1952 (Tooth 1956). The importance of standardizing pallets (and other technological products) lay in overall efficiency considerations. In the warehouse example above, for instance, standard sizes ensured that no space was wasted as pallets were brought in and out of the warehouse; there would always be a space of exactly the right size. It was also vital for forklift manufacturing. Standard sizes ensured that a particular forklift would be able to handle a given pallet and that the forklift itself could be sold to a wider market. Standardization was also reflected in truck and ship design. In essence, standardization turned the pallet into a "module" that could be efficiently plugged into any variety of transport and storage modes, which often simplified and expanded markets (Sturgeon 2002), as the container will later (Heins 2009).

Intermodalism

By mid-century signs of containerization's imminent birth were plentiful. Efforts toward intermodal transfers between sea and land were stepping up. And pressures to increase the size of containers in use led to notable intermodal experiments in the 1940s, including the development of the first truly modern containers.

Following the railcar barge model operating in New York Harbor, Seatrain Lines, Inc. began to transport railcars on specially designed ships across the Caribbean from Belle Chasse, Louisiana to Havana, Cuba. Several years later they expanded this service to Hoboken, New Jersey. The railroads viewed this service as a direct competitor, as evidenced by a litany of unsuccessful litigation to stop the service (Levinson 2006, 53; Palmer and DeGiulio 1989, 287–288). This litigation was initiated primarily during the early 1940s, when the *In re Container Service* decision was in effect. This suggests since the railroads were effectively priced out of the intermodal market, they were employing legal means of protecting their market by entrenching modal separation.

This did not stop them from moving back into intermodal operations as soon as the opportunity arose, however. In 1953, the New Haven Railroad Company filed for clarification of the ICC's position regarding TOFC as embodied in the *In re Container Service* decision. The decision handed down established that railroads served in these joint transportation services as "connecting carriers" rather than shippers, which maintained a separation of modes acceptable to the ICC (Columbia Law Review 1966). This clarification led to an immediate and rapid expansion of TOFC service, nearly doubling the number of Class I railroads offering such services in the eight-month period preceding January 1955. Over the next eight years, TOFC loadings quadrupled from 168,150 annually to 797,500 (Palmer and DeGiulio 1989, 292–293).

Illustrating perhaps a somewhat myopic view of intermodalism or support for their own expansion into intermodalism, the railroads do not appear to have opposed initial efforts by Trailerships, Inc. in 1947 to transport truck trailers on converted military ships from New York City to Albany. Nor did they oppose similar service offered by TMT Ferry, Inc. from Florida to Puerto Rico (Palmer and DeGiulio 1989, 288). Together this and the previous example demonstrate that intermodalism was gaining momentum in the wake of World War II, facilitating shippers' and shipping companies' efforts to circumvent growing labor power and costs in the ports.

In addition to the feasibility of transferring large containers, i.e., truck trailers and box cars, between sea and land, there was a concurrent upward pressure on the size of containers and pallets already in use. As Tooth (1956, 228) asserts, "It has already been stated that the employment of pallets is affecting cargo-handling in most countries and also that there is very little unit load traffic passing through the major ports of the world. To explain this apparent contradiction, it must be said that in many countries large pallets, capable of carrying economic loads for modern quay cranes and ships' purchases, are being used as dock tools." The import here is that ships and docks prefer pallets larger than those in use in factories and by rail (less than 40x48 inches with 1–2 tons capacity). This, in turn, implies pressure from the transportation industry toward scaling up cargo unit size by combining a number of pallets into one unit, a unit that will eventually emerge as the container.

According to Palmer and DeGiulio (1989), Leathem D. Smith conceived of perhaps the first truly modern container in the early 1940s. Though delayed by World War II, he drew up blueprints in 1943, found an initial customer in Agwilines, a principal New York shipper in 1944, and began production of containers in 1945 that were purchased and then leased out by Safeway Container Corporation. In the case of *Smith v. Dravo Corp.* in 1953 for unlawful appropriation of trade secrets, it was reported that:

> He envisioned construction of ships especially designed to carry their cargo in uniformly sized steel freight containers. These devices (which, it appears, were the crux of his idea) were: equipped with high doors at one end; large enough for a man to enter easily; weather and pilfer proof; and bore collapsible legs, which (1) served to lock them (a) to the deck of

> the ship by fitting into recesses in the deck, or (b) to each other, when stacked, by reason of receiving sockets located in the upper four corners of each container, and (2) allowed sufficient clearance between deck and container or container and container for the facile insertion of a fork of a lift tractor, and (3) were equipped with lifting eyelets, which, together with a specially designed hoist, made possible placement of the containers upon or removal from a ship, railroad car or truck, while filled with cargo.

By the spring of 1946, Brodin Lines, Grace Lines, Delta Lines, and Stockard joined Agwilines in leasing his containers, and by March 1948 roughly 600 containers of his design had been sold, though manufactured by Dravo Corporation after Smith's death in a 1946 boating accident.

Levinson (2006) prefers instead to attribute the design of the first container to Keith Tantlinger, who worked for Brown Industries in Spokane, Washington. "In 1949, he had designed what was probably the first modern shipping container, a 30-foot aluminum box that could be stacked two high on barges operating between Seattle and Alaska or placed on a chassis and pulled by a truck" (Levinson 2006, 49). Construction materials appear to be the primary difference, but regardless of which features one chooses to designate as those essential to the modern container and thus as a starting point, the essential point here is that by the late 1940s the idea of large, enclosed containers that could be stacked and transferred among ships, trains, and trucks was clearly in circulation and gaining momentum.

3.2.4 Early Containerization

Pride of place for combining inland trucking with ocean shipping through containerization is generally granted to Malcolm McLean, former president of McLean Trucking

Company, most notably in Levinson's (2006) recent *The Box*. The narrative so far questions the originality of his ideas, though not the significance of his active innovation. In fact, McLean may well have been the first individual to conceive of and operationalize containerization as a system of integrated, multimodal transportation. While Smith and Tantlinger's early designs were intended to enable simple intermodal transfers, they were offered simply as a shipping technology. McLean had sought to bind the heterogeneous components of trucking, shipping, and loading into a single system for door-to-door freight delivery, thereby developing a new second-order LTS.

According to Levinson (2006), McLean worked his way up from truck driver in 1934 to owner of one of the largest trucking companies in the U.S. twenty years later. In 1953, concerned that increasing highway congestion was cutting into his profits and that war-surplus cargo ships would be purchased by domestic shipping lines at costs that would allow them undercut his prices, McLean had a brainstorm: rather than drive on congested roads, load the trailers onto ships and sail around the congestion. McLean's technological style reflected his impetuous, strong-minded, risk-taking character. Having decided to buy his own ships without recourse to careful financial calculations, he brought Tantlinger from Brown Industries to his company, Pan-Atlantic, and simply told him to design a system similar to his Seattle designs that would work with dedicated boats.

McLean's container service began in 1956, a decade after Smith's "Safeway" containers. The system as a whole follows a familiar pattern: cranes lift the containers off of truck chassis, load them onto ships by depositing them in specially designed frames in the holds of converted military ships that would carry them to distant ports (originally East and Gulf Coast ports) to be offloaded by cranes back onto trucks for final delivery. This basic model, as I have shown, had been developed and experimented with over the preceding decades. However, this narrative does not intend to question his adventurous entrepreneurial innovation. In the face of institutional obstacles to owning both a trucking firm and a shipping firm, McLean sold his trucking firm, the third largest in the US at the time, and gambled everything on his venture. So while the concepts McLean employed represent a reintegration of existing concepts and is thus not particularly noteworthy, his role as an innovator in sparking the wholesale adoption of containerization cannot be disputed.

3.3 Stage Two: Transfer

3.3.1 Domestic

While McLean was shaking up the East Coast, Matson Navigation Company had noted the potential of McLean's operation and was moving steadily toward employing containerization for its routes from the West Coast to the Hawaiian Islands. But Matson embraced a different technological style. For Matson, established in 1882, shipping served as an adjunct to its main operations of sugar and oil production, and it had no drive to move rapidly. Citing the lack of reliable information on the cost effectiveness of containerized shipping, Matson adopted a more scientific approach (Levinson 2006, 59–61). The company hired Foster Weldon, a Johns Hopkins University geophysicist and pioneer in operations research, who determined that almost half of Matson's existing door-to-door shipping costs was due to labor. "[T]his cost has increased steadily in the past and will continue to do so indefinitely as long as the operation remains a manual one. There is certainly no indication of a change in the current trend of spiraling longshore wages with no corresponding increase in labor productivity" (Weldon 1958, 652–653). The only solution deemed viable was automation. After more than two years of painstaking research, cautious experimentation, and financial calculation, Matson finally intiated its container service on 31 August 1958 from San Francisco. By this time the company had begun developing fully dedicated ships for the trade, putting them into service by 1960. With Matson's more conservative endorsement of a full embrace of containerized intermodal transport on the West Coast and McLean's flashy intervention into the East Coast market, the industry's shift toward containerization was solidly established.

Opinions about the future success of containerization remained diverse for some time, however. First, the wide variety of cargo, ships, and loading processes present in most ports led some observers to abandon any hopes of standardizing dock procedures.

> The types of cargoes handled in a port require operations on the whole gamut of techniques, from the most primitive form of labor to automation. . . As ships differ considerably with each other and cargoes may differ also even within the hold of the same ship, the level of mechanization or automation required for the loading and unloading of a ship may also vary considerably. . . Moreover, for a given ship and a given cargo the equipment used may vary accordingly as the cargo is stowed in the bows or a layer is about to be closed. . . The great diversity due to the ships used, the area of the ship where cargo is stowed, the type of cargo handled and the equipment involved make it extremely difficult if not well nigh impossible to standardize operations. (Picard 1967, 9–11)

Second, some advocates of palletization believed that containers were too restrictive. "I have never believed in containers. It is my opinion that it should be the exception, not the rule, that transport concerns should supply containers. Goods should be packed on or as near as possible to the production lines, and they should be so packed and reinforced that they can withstand the treatment to which they are subjected by reasonable and modern transport" (Markussen 1962, 9).

Others, however, were completely sold. "In my view on suitable distance services, the containering of freight is the method of the future. Like most new ideas it is difficult to start and in its early days is somewhat of a tender plant. In ten years time I am sure that we shall wonder why we did not start this long ago."(Sidey 1962, 19) In *Cargo Handling*, an industry journal oriented toward logistics providers, Crake (1962, 21, emphasis in original) lists the advantages of containerization:

> *To the customer, a door to door service.*
>
> *A decrease in transport costs.*
>
> *Reduction in loss, damage and pilferage.*
>
> *Reduction in packaging expenses.*
>
> *Reduction in warehouse space and inventories.*
>
> *Simplification of tariffs on the joint road, rail, water rate and under a single Bill of Lading.*
>
> *To the shipowner a quicker turnround in port.*
>
> *An increase in the annual transport capacity per unit.*
>
> *Maintenance of a given service with less ships.*
>
> *Decrease in cargo-handling costs.*
>
> *Decrease in claims for damage and pilferage.*

These claims reflect those made in earlier stages of unitization and provide the underlying logic for shippers and shipowners to adopt the new system. The importance of countering labor costs ("cargo-handling costs") will be addressed in more detail in Chapter 8. Financial analyses of bulk, pallet, and container shipping costs in the same journal added weight to the economic case for moving to containers, e.g., (David 1957).

Support from the military also helped tip the scales in containerization's favor. The military feared a third large conflict and recognized the need for rapid transport and turnaround to maintain its effectiveness (cf. Virilio 2006) and the desirability of achieving this by reducing handling. According to Crake (1962, 20), "The essential point is to have a domestic system which dovetails readily in terms of standardised material techniques and know-how." The military settled on roughly seven-foot steel cubes called "Conex boxes," and military orders for these containers provided impetus for domestic suppliers, which led to their promotion of private sector use by manufacturers. Suppliers "have aimed their sales policy at the shipper, the forwarder, the domestic carrier and the shipping industry" (Crake 1962, 20).

3.3.2 International

Interest in containerization was not limited to the United States. Smaller containers tailored to European rail gauges and truck chassis were coming into widespread use in Europe, though they were steadily replaced by larger containers after standardization agreements in 1966. The Japanese Shipping and Shipbuilding Rationalization Council urged the Ministry of Transport in 1966 to endorse containerization. After conducting studies of U.S. ports, new port legislation was approved in August 1967, and container cranes began operating by the end of the year (Levinson 2006, 186–188). Meanwhile, regular trade between the U.S. and Asia was given a boost by the military during the Vietnam War.

According to Levinson (2006), early in the war, logisitics were hopelessly mangled and supplies were failing to reach U.S. troops in a timely manner. This was due to a lack of coordination among military divisions and to Vietnam's shallow coastal waters, which compelled goods to be offloaded in nets onto barges—sometimes as far as four miles offshore—and ferried in to shore. Military logistics experts advocated increased use of unitized cargo, which referred during World War II to carrying goods on pallets, but to Conex boxes by this point. However, Robert McNamara, then Secretary of Defense, was aware that shipping companies had developed new technologies and brought a number of executives together for a meeting in late 1965.

The outcome was a series of minor experiments that produced no results other than demonstrating that the private sector might possess efficiencies that the U.S. military lacked. Finally, another logistics crisis in late 1966 and a need for increased supplies compelled the military to contract out container freight transport. McLean's Sea-Land won the bidding and immediately transformed Cam Rahn Bay and Da Nang into massive container ports. Soon after they went into service in the second half of 1967, the cargo backlog was cleared and supply chains smoothed.

However, the ships, laden with military cargo to Vietnam, returned empty on the return journey. Japan's rapidly growing export market provided the perfect opportunity to increase the load factor of each shipping company's system by increasing the total cargo transported by each ship on its return journey. Japan lay near the shipping route, had television, radios, and other goods to ship to the U.S., and, as mentioned above, was actively embracing containerization. Matson had entered the trade early to ship Japanese products to California and hoped to supplement this by supplying military bases in Japan and Korea. Sea-Land was in the opposite position. With a military contract, it hoped to pick up goods on the way back to the U.S. Matson partnered with Nippon Yusen Kaisha Line (N.Y.K.), and Sea-Land with Mitsui. A number of Japanese carriers also entered into competition as well. Overcapacity on the route laid the foundation for a phenomenal growth in transpacific trade (Levinson 2006).

3.4 Stage Three: Growth, competition, and consolidation

3.4.1 Growth: The homogenization of space

While load factor concerns drove growth in the transpacific arena, the greatest obstacle to the growth of containerization was a lack of standard container sizes and mounting equipment. Each company was employing often uniquely sized containers to suit their specific needs. Rail systems were incompatible on both sides of the Atlantic and within the U.S. itself. Because of the inflexible mounting systems installed in ships to ensure that containers would not shift during transit and threaten to capsize the ship, the ships were only capable of carrying containers designed specifically for them. Thus, if this situation were to persist, each container shipping company would have to maintain its own fleet of containers, supply them to all its customers, and operate its own cranes and other equipment in every port of call, a sure show stopper.

In 1958, the United States Maritime Administration (Marad) decided that standardization was required. It was motivated primarily by an interest in ensuring that companies that received its subsidies to build ships did not go bankrupt, leaving Marad with a ship that was useless to any other container operator. The Navy also lent its support for this effort, since it feared logistics chaos if it commandeered ships with unique container systems in the time of a conflict. Thus, standardization arose in part out of the Navy's need to be able to quickly assemble a second-order freight transport system in a time of war. Levinson (2006, 127–149) provides an account of the twelve year struggle that went into the International Standards Organization (ISO) full specfication for containers that constituted a major step forward in allowing a container to be packed in Masan, Korea and transported by truck, ship, and rail to Chicago without being unpacked.

As Sturgeon (2002) suggests, modularity in a value chain can increase efficiency and reduce costs. Using the example of the electronics industry, he argues that the ability to codify specifications for transfer from a brand name firm to a contract manufacturer through the use of such tools as electronic data interchange (EDI) and computer-aided design (CAD) files based on ISO standards enables better economic performance. Codification removes firm-specific data transfer standards, thereby attenuating the close bond between design (and marketing) and production. This flexibility is expressed in the lead firm's ability to work with a number of contract manufacturers and in the contract manufacturer's ability to work for a number of lead firms. (See also North [1981, 26] on the role of standardization in reducing transaction costs.)

The standardization of containers achieved a similar end. When a producer uses a container that can be transported by most trains, trucks, and ships, the producer is able to contract out the movement of its goods to any number of logistics providers. Symmetrically, a logistics provider can be assured that it can handle the products, whatever they may be, of a wide variety of potential customers. In effect, shipping companies ship homogenous units of space rather than specific goods. This arrangement not only allows for price competition but also enables companies in rapidly changing markets to shift their business or acquire business that more directly reflects its immediate needs.

3.4.2 Competition: Deregulation and overcapacity

The shipping industry has been plagued historically by boom and bust cycles. In times of increasing trade, cargo space becomes scarce, transport prices rise, and shipping companies start placing orders for new, expensive, and often larger ships. However, the long time required to construct a cargo vessel leads to construction backlogs, and many ships are not built before the global trade again turns downward. This results in a glut of cargo space, plummeting transport prices, and inevitable bankruptcies (Levinson 2006, 222, 227).

To combat the destructive elements of this cycle, shipping companies traditionally formed “conferences” along established shipping routes that set minimum prices for cargo. The goal was to eliminate race-to-the-bottom strategies of underbidding one’s competitors and encourage competition on the basis of service instead. They were also intended to guarantee a share of trade for each member and limit competition. Sanctions for violations were directed more toward shippers than shipping companies. Liner companies would refuse to carry the goods of any shipper who employed services outside the conference. For larger shippers, this was a very effective deterrent (Branch 1996; Clarke 1997; Kendall and Buckley 2001). The U.S. Shipping Act of 1916 recognized that this system held some benefits and sought to control rather than abolish the system. It did so by requiring that conferences justify their rates in terms of operating costs and be approved by the Federal Maritime Commission (Palmer and DeGiulio 1989, 317). In effect, liner conferences functioned as legally sanctioned cartels that dominated shipping over particular geographical areas (cf. Chapter 8).

In a system based on operating costs, the dramatic savings of containerized transport over traditional break bulk transport undermined the conference system from the beginning. Within a few years of McLean’s first containership, Sidey (1962, 18) asks the rhetorical question, "Is it right that one or two small Lines in a Conference can stop or delay the bigger and more forward thinking members going forward with the new development? This has happened in a number of Conferences. The result is that the development, if any, is stunted and mis-directed and also on many occasions one is left wondering whether the Conference looks upon container operators as allies or as people who should be stopped at every possible point." Much of the struggle played out in container liner companies's efforts to shift rate setting away from the railroad-style setting of rates for each commodity by weight and toward single prices for single containers, regardless of weight (Levinson 2006, 224–227). In this sense, the conference system acted as a reverse salient in the development of intermodal transportation.

The system was substantially weakened during the era of deregulation in the late 1970s and early 1980s. Prevailing opinion in the U.S. was that prices and services should be set in an open market. Following deregulation of the airlines, trucking, and railroads under President Jimmy Carter, shipping took its turn with the Ocean Shipping Act of 1984 (Lewis and Vellenga 2000, 28; Rose et al. 2006). The act strengthened conferences' antitrust immunity and shifted the burden of proof in rate setting from the conferences to the shippers and the FMC. Conference members were also permitted for the first time to offer through rates, making the 1984 Act the major step forward toward true intermodalism. Despite these gains, however, the legislation embodied several clauses that would further undermine the conference system. First, through rates had to be negotiated by shipping companies individually with landside transportation providers. Second, conference members were given the right to independently file a tariff outside of the conference, which essentially gave stronger players the freedom to opt out. The significance of this clause is evident in the thousands of actions that were filed very soon after the legislation passed. And finally, to counter the monopoly power of the conferences, shippers were legally authorized to form associations for bargaining rates with conferences (Lewis and Vellenga 2000, 27–29).[3] Deregulation of shipping was more or less completed with the amendment of the Shipping Act of 1984 by the Ocean Shipping Reform Act of 1998 (OSRA). This act further undermined the conference system by allowing shipping companies to enter into confidential contracts with shippers while limiting conferences to toothless guidelines for member contracting (Federal Maritime Commission 2001; Lewis and Vellenga 2000). The provisions of this law were also actively taken up, as evidenced by the 200 percent increase in service contacts and amendments in the space of roughly a year (Federal Maritime Commission 2001).

Deregulation led to one other major development for intermodalism. Soon after the passage of the Motor Carriers Act of 1980 and the Staggers Rail Act of 1980 that deregulated these industries, the courts abandoned the ICC's historical efforts to prevent cross-ownership of transportation modes (Shashikumar and Schatz 2000; United States Court of Appeals 1984). As a result, rail companies could now own trucking firms or shipping firms and vice versa, allowing for the first time truly intermodal firms. Firms that chose to exploit this possibility and cross modal boundaries were able to assemble a second-order transportation system and greatly expand their geographical reach.

With deregulation and the entrance of major new competitors in containerized shipping, competition became fiercer than ever. Many of these new carriers flew Asian flags, reflecting growing U.S. and European trade with Asian manufacturers (Slack 2004, 26). Perversely, a primary means of competing in a market characterized

[3]Conferences and the emergence of shippers' associations express the organizational component of spatial struggles among factions of capital. This struggle reflects that discussed in chapter 8 between labor and capital to establish geographical monopolies. It remains unexamined here, but will surely be a component of future research.

by overcapacity is for the individual carrier to increase capacity. This is because the per tonne or per TEU shipping costs decrease as ships increase in size (Cullinane and Khanna 2000, 186). Thus a shipping company can offer lower rates if it uses larger ships. As a consequence the size of containerships has grown rapidly, particularly since 1995. Containerships had grown rapidly until the mid-1980s, when they levelled out at 4,500 TEUs (the equivalent of an average Manhattan block stacked nine or ten high), the maximum size that would fit through the Panama Canal. From 1995 larger, so-called "post-Panamax ships" were introduced, which have quickly exceeded 8,000 TEUs and even reached 12,000 TEUs (the equivalent of a 20-story building covering an average Manhattan block). And though 12,000 TEU ships will probably remain the largest in operation for some time, 18,000 TEU vessels are now being considered. These ships require deeper channels and berths than many ports can offer, putting pressure on ports to undertake massive, expensive dredging projects to accommodate them (Cullinane and Khanna 2000, 182–184).

3.4.3 Consolidation: Mergers, acquisitions, and alliances

Of course, for such large ships to make a profit at their lower rates, they must fill the great majority of their container slots. That is, as ships scale up in size, maximizing load factor takes on increasing importance for shipping companies' financial viability. Recognizing the tendency toward overcapacity and seeking to reduce the risk of investing in such large ships, carriers faced three options, according to Clarke (1997, 21–23). First, they could enter into consortia agreements so long as total market share was restrained to roughly one-third. Second, they could form global alliances that would share resources across the globe. The primary difference between these two options is that the latter goes beyond pooling and rationalizing ships to sharing equipment, technical standards, and vessel ownership. Finally, the third option would be to remove the anti-trust immunity of shipping conferences. To these can be added a fourth, mergers and acquisitions (M&As). In practice, all four have been pursued, but M&As and alliances have dominated the landscape.

As firms invested in large capacity that they could not sustain, they became targets of takeovers. According to Slack (2004, 26–27), there were at least ten major M&As between 1990 and 2000. One particularly striking example is that of CP Ships, a smaller, Canadian niche carrier, which grew to be one of the top ten container carriers by acquiring at least six lines after 1995: CAST, Lykes, ANZDL, Contship, TMM, and Italia (Alix, Slack, and Comtois 1999; Slack 2004). This and other mergers and acquisitions have concentrated ownership into fewer hands.

In a dynamic relation with these M&As, global alliances formed and reformed at a rapid rate during the 1990s. First, an alliance between Sea-Land and Maersk formed in 1991. In 1995, APL, OOCL, MOL, and Nedlloyd formed the Global Alliance. In response, NYK, P&O, Hapag Lloyd, and NOL formed the Grand Alliance and Hanjin, DSR-Senator, and Cho Yang came together in the United Alliance. The composition of these alliances shifted as M&As took place with companies from competing alliances, notably the acquisition of the U.S. line APL by Singapore's NOL and the merger of Britain-based P&O with the Dutch line Nedlloyd. As a result Nedlloyd left the Global Alliance to join the Grand Alliance, and NOL, APL, and MOL reformed the Global Alliance as the New World Alliance with HMM (Slack 2004, 25–27). By 1995, John Snow, CEO and chairman of CSX, stated that just three alliances controlled 70 percent of the market (quoted in Brooks 2000, 169).

Maersk and Sea-Land: Slow dance to merger

One alliance that led to a merger is of particular pertinence to this dissertation, that of Maersk Line and Sea-Land Service Inc. Sea-Land's origins under under Malcolm McLean have already been discussed (Section 3.2.4). Sold by McLean to R.J. Reynolds in 1969, divested by R.J. Reynolds in 1984, and taken over by CSX, a large conglomerate with strong holdings in rail, by the late 1980s Sea-Land moved rapidly into cooperative arrangements at the global scale. According to Brooks's (2000, 166–171) authoritative account, these began with joint ventures with French and Italian companies to serve the Middle East. Taking advantage of the provisions for cooperative working agreements permitted by the Shipping Act of 1984, Sea-Land chartered five of its new Econships, the world's largest at the time, to P&O and Nedlloyd with transatlantic vessel sharing agreements. These agreements and others with Norasia were undertaken with "the express purpose of improving asset utilization and reducing costs" (Brooks 2000, 168), i.e., increasing load factor.

Maersk Line, a susidiary of the A.P. Møller Group, is one of the oldest and largest shipping lines in the world. Well established on the Europe-Far East and trasnpacific routes, Maersk decided in 1987 to make an aggressive push to complete its global service by entering the North Atlantic container trade. Though it managed to acquire ten percent of the transatlantic market within three years, a lack of profitability drove it to rationalize its transatlantic operations, including negotiations with CSX for the purchase of Sea-Land. Though negotiations only resulted in a vessel sharing agreement, "throughout the early 1990s, rumours of the Sea-Land Maersk relationship being a slow dance to merger circulated in the industry" (Brooks 2000, 169). Even after CSX CEO and chairman John Snow adamantly rejected these rumors in 1995, Maersk and Sea-Land announced a global alliance in 1996 when P&OCL left its alliance with Maersk to join Grand Alliance.

This alliance was considered one of the most complete at the time and served both companies well. Geographically, their routes were generally complementary, with Sea-Land strong in the Northeast and Maersk in the Southeast. CSX operated U.S. rail lines that provided a valuable land-bridge across the country. In 1996, Maersk's profits rose 23 percent to almost US$350 million with slot utilization (a measure of load factor) in the high 80s, well above the industry average of 62 percent. Meanwhile, Sea-Land was expected to cut costs by US$100 million per year by 1998 and as much as US$150 million by 2000.

By the late 1990s, perhaps in response to the alliance's success, Snow softened his stance on a possible sale, saying that as a conglomerate with a portfolio of unrelated firms, it was willing to sell Sea-Land at the right price (Brooks 2000, 171; Tirschwell 1999). In a press conference in April 1999, Snow sought to quash speculation about an imminent sale after it announced a three-way split of Sea-Land into separate operating companies for terminals, international container transportation, and domestic shipping, a strategy that often presages a sale of one of those components (Watson 1999c). Despite his denials, CSX agreed to sell Sea-Land's international service to Maersk mere months later for $800 million, including 18 terminals (Brennan 1999d).

Impacts of M&As and alliances

M&As and alliances have produced three primary changes in the container shipping industry, which reflect the primary motivations of Hughes' third stage: rationalizing the system, making it more efficient, and concentrating capital. Slack, Comtois, and McCalla (2002) describe two of them. First, alliances have introduced more uniformity in the industry as they have expanded service across the globe, offering similar numbers and frequencies of services to a similar number of ports, though the ports themselves often differ radically (Slack 2004, 36). Second, container shipping has become more intensified as asset pooling has allowed the companies to incorporate a greater range of ports into their regular services and to build up services, transporting greater volumes on larger ships.

The third impact has been the exertion of new pressures on ports. These pressures take two primary forms. First, as discussed above, there were new demands on physical infrastructure due to the larger ships employed, which continue today. Progress in ship size is to some extent constrained by limitations in the physical infrastructure of ports, and this has been identified as a new reverse salient in the growth of the system overall. The wider, deeper hulls demand costly dredging, the widening of the Suez and Panama Canals, and even, in one case, the raising of an entire bridge (United States Army Corps of Engineers New York District 2009). Second, there were competitive pressures as alliances sought to consolidate their port calls at load centers.

The concept of the load center was originally introduced by Hayuth (1981). Because of the high daily operating costs of a ship, which increase with size, operators have two options for reducing time and therefore overall costs in port. The first is to decrease the turnaround time in port, and the second is to reduce the number of ports of call. These two approaches cut out port charges and allow the ships to transport more goods over a given time period. Affiliated with the reduction of the number of ports of call is the trend toward concentrating traffic along a smaller number of primary routes. Channeling services on high volume routes contributes greatly to maximizing load factor and thus profitability. The result is a hub-and-spoke network in which feeder services transport goods between smaller ports and load centers, while high volume "expressways" ferry goods back and forth between distant load centers.

Hayuth argued that this establishes a hierarchy among ports, with load centers dominating subnetworks. By concentrating throughput in one port, this arrangement promises large profits for actors in those ports that become load centers while other ports lose traffic and income. Alliances and large companies that sought to establish load centers in the 1990s therefore had a great number of supplicants willing to make significant sacrifices to obtain the supposed benefits of becoming a load center. Thus, interport competition increased significantly during this decade of consolidation. One such example will be explored in Chapter 5. However, as Notteboom (2009, 61) notes, the pressure toward load centers is stronger at the level of the individual shipping line or alliance than it is at the port level, since not all lines will choose the same port to serve as their load center.

The introduction of more uniformity suggests the rationalizing of the freight transportation system, as mergers and alliances reorganize and expand it in their quest for profits. Increased profits require increased efficiency, and sector consolidation has been oriented toward increasing the load factor by reducing overcapacity. Load factor maximization has suggested to a number of shipping companies the use of load centers and ever larger, ever more expensive ships. Landside, these expenses are reflected in the higher costs of erecting larger cranes and dredging deeper channels. Both intensify the use of capital and entail ever larger risks, as the cost of failure mounts.

3.5 Conclusion

This chapter has described the evolution of containerization and intermodalism as a large technical system that has steadily merged existing first-order systems into a novel second-order system. The account is at variance with the stages identified by Hughes (1983) and Joerges (1988) only in suggesting that intermodalism was not developed *de novo* as a complete system, like the electicity networks explored by Hughes, but rather existed conceptually for some time and acquired the various components that comprise it today through gradual accretion.

The first stage of invention, development, and innovation was characterized by a seamed system. U.S. legislation geared toward combatting the abuses of the rail barons of the late-nineteenth century legally isolated each mode of transport and granted the ICC the power to set rates and license routes. Traffic congestion, labor struggles, and modal competition drove shipping companies and stevedoring companies to actively pursue mechanization, leading ultimately to McLean and Matson's innovative efforts to ship cargo in containers that could be rapidly switched from ships to trucks, crossing modal boundaries and merging modes into a second-order system. The benefits of this system were quickly recognized, and the container made its appearance around the world.

Containerization has grown rapidly down to the present day, though it is unclear how the recent economic crisis will impact its long term prospects. Rapid growth was fueled not only by the increase in global trade facilitated by containerization but also by a perverse pressure to compete through economies of scale. More expensive ships with greater capacity was the preferred method of reducing shipping costs and competing in a glutted market. This unsustainable contradiction between overcapacity and continuing growth produced financial strains on firms that soon led to mergers, acquisitions, and alliances that concentrated ownership, capital, and control in the shipping industry. These mergers rationalized the transportation system by reducing overcapacity. Concurrent deregulation allowed firms to cross organizational boundaries by acquiring or merging with firms that provided other modes of transport. The result has been the emergence of a seamless, second-order system that operates on a much broader geographical scale than previously. The spatial implications of these changes will be explored in the Chapter 4.