Chapter 2
Shipping Makes the World Go Round

From Sail to Steamships

Until fossil fuels arrived, wood from forests determined the wealth and power of nations. Trees were the energy source that industry used to make iron, glass, brick, and ceramics; the fuel to heat and cook with, and also the material for homes, barns, furniture, tools, fences, barrels, wagons, and hundreds of other products (Perlin 2005; Conners 2002). No wonder Paul Bunyan was a superhero!

A large seventeenth century sailing vessel was constructed with enormous amounts of wood, about 2000 oaks from 50 acres. A billion acres of forests made America rich, since European forests were greatly depleted, especially of the tall, straight mast trees needed for battle and merchant ships.

For many centuries, wooden sailing ships went about 4–6 knots on average (4.6–7 mph). If winds were not good, voyages could be very slow. Hell on Earth was being abandoned by the winds in the horse latitudes. It took the Mayflower 66 days in 1620 to travel the 3236 miles between Southampton, England and Boston, Massachusetts, at an average speed of 1.77 knots (2 mph) (MQ 2003). By the 1850s, Clipper sailing ships could go as fast as 20 knots in good winds, but averaged about 5–8 knots (5.8–9.2 mph) over long distances (Spilman 2012).

The ability to utilize water transportation and especially to exploit the energy of winds was extremely important to the development of earlier commerce, since a ship could carry many times as much cargo as any land-based system (Cottrell 2009).

In the nineteenth century, steam-powered boats of wood, and later iron and steel, dominated river, lake, and eventually ocean traffic because they could carry a great deal more cargo and travel faster than sailboats. By 1840, steamboats burned about 900,000 cords of wood in the U.S., 20 % of all fuel-wood sold, stopping every two hours to refuel their huge boilers.

A.J. Friedemann, *When Trucks Stop Running*,
Energy Analysis, DOI 10.1007/978-3-319-26375-5_2

In the eighteenth century, nearly everyone in America lived near coasts and navigable lakes and rivers, because it was cheaper to move a ton of cargo across the Atlantic on a ship than 30 miles inland over land (McPherson 1988).

Warehouses, factories, and workers were located and lived near ports to lower costs. Millions of workers and horses drove, dragged, and pushed cargo through city streets to and from piers, where cargo sat in warehouses along the dock. Items were counted and recorded, then dragged to the side of the ship, carried up gangplanks, and tightly secured in the hold, since loose cargo knocking around could sink a poorly loaded ship in rough seas.

At the next port it was all hauled out onto the dock, where buyers looked for their shipments, customs inspectors opened each box to assess duties, carpenters fixed damaged crates, and clerks inspected each label, moving cargo destined for other ports into a transit shed, and then reloaded for shipment to the next port, where the process was repeated. Is it any wonder: Labor was as much as 75 % of the total cost of moving goods by sea.

Once steamships began burning coal in the 1850s, more and more of them were made of iron. As the decades passed, the speed, size of ships, and amount of cargo carried accelerated dramatically.

The Container Ship Revolution

In 1956, containerization really took off when Malcom McLean bought a steamship line and altered a large ship to hold containers of standard dimensions, the same size his truck fleet carried. These containers could seamlessly and efficiently be transferred between truck and ship with no need to unload the contents. This radically reduced transport costs due to less labor needed, warehousing, port congestion, loading and unloading time, and less damage or theft. The stevedore's loss was the world's gain.

In 1965, dockworkers could load only 3750 pounds on a ship per hour. Today, in the container ship era, we load 18 times that weight per hour—66,000 pounds of cargo with far fewer laborers, in just hours rather than week(s). Ships that are 1300-feet-long ply the seas carrying up to 18,000 20-foot containers piled 20 high. These leviathan ships have created a smaller world, erasing geographic barriers. The role of containerization in global trade can be clearly seen in Fig. 2.1 (Economist 2013).

Without containers and very large fuel-efficient ships, there would be no globalization. Ships can move 38,580 short tons of cargo 3000 miles across the Atlantic cheaper than a truck can carry that much weight just 180 miles (ECORYS 2009).

Containerization meant that goods were packed just once and lifted onto trains, trucks, and ships interchangeably. Ships could load and unload in just a few hours instead of a week or more.

Today the U.S. has 360 commercial ports, kept open by dredging. Every year, 400 million cubic yards are dug out of navigation channels, berths, and private

Fig. 2.1 Thinking inside the box. *Sources* World Trade organization; US Bureau of Labour Statistics; Bernhofen et al. (2013); Economist (2013)

Table 2.1 Growth of shipping from 1970 to 2012

Type of ship	Max tons per voyage	Average mph	Million tons per year 1970	Million tons per year 2012
Container Ship	195,000	24–29	90	1498
Bulk carrier	400,000	11.5–17	1165	4567
Oil tanker	510,000	11.5–15	1440	2796

Source Stopford (2010), UNCTAD (2012)

terminals. If this dredged material were laid out between New York and Los Angeles, it would be 20 feet deep and as wide as a four-lane freeway (AAPA 2015).

Containerization accelerated the movement of factories and farms to the cheapest locations for labor and land. Many businesses began to depend on long, complex supply chains from countries around the world instead of locally made parts and goods.

In addition to container ships, bulk carriers that haul coal, ore, grain, and other commodities, and oil tanker vessels have revolutionized global shipping. The scale of change, as shown in Table 2.1, is staggering. Wooden sailing ships once carried 300–1000 tons (Stopford 2010) at 5–9 miles per hour (mph) whereas ships today can carry as much 510,000 tons at greater speeds as shown in Table 2.1.

Ninety Percent of Global Trade Is Carried by Ships and Barges

Pound for pound and mile for mile, today's ships are the most energy-efficient way to move freight. Table 2.2 shows the energy efficiency of different modes of transport by kilojoules of energy used to carry one ton of cargo a kilometer (KJ/tkm). As you can see, water and rail are literally tons and tons—orders of magnitude—more energy efficient than trucks and air transportation.

Table 2.2 Energy efficiency of transportation in kilojoules/ton/kilometer

Kilojoules of energy used to carry one ton of cargo one kilometer	Transportation mode
50	Oil tankers and bulk cargo ships
100–150	Smaller cargo ships
250–600	Trains
360	Barge
2000–4000	Trucks
30,000	Air freight
55,000	Helicopter

Source Smil (2013), Ashby (2015)

Ships use marine diesel engines that can attain efficiencies over 50 % (AASHTO 2013; Smil 2013) and used just 10 % of global transportation oil to carry 8.8 billion tons of cargo in 2012.

In 2009 in the U.S. by weight, 60 % of the cargo carried by ships and barges was energy products: 46 % oil and petroleum products, 13.2 % coal, and 1.2 % fertilizer (U.S. Census 2012).

Although trucks don't appear impressive in Table 2.2, they waste 10.3 times less oil than cars when you consider how many tons can be hauled per gallon of gas (ton-mpg). The National Research Council estimates the average auto gets 15 ton-mpg and the average class 8b truck 155 ton-mpg (NRC 2010; Table 2.1). If average truck mileage can be increased from 6.5 to 12.5 mpg, trucks could get 275 ton-mpg (Mele 2009). Already, with today's technology, trucks are capable of getting 10 mpg, so this is within reach.

Air freight, by comparison, is a gluttonous use of fuel, energy that could be more efficiently used by trucks, rail, and ships. It is likely that when oil begins to decline, so will this mode of transport. This will free up 7 % of transportation fuel for trucks and locomotives, since jet fuel is similar to diesel in crude oil refinery processing.

Conclusion

In 1957 nearly a third of freight moved by water, now only 4 % does, despite more than half of Americans living in coastal counties. This is despite ships and barges being orders of magnitude more energy efficient than air freight and trucks, and despite 25,000 miles of navigable rivers, coastal waters, lakes, and canals (NFRCP 2010).

How could this happen? The reason is simple. Cheap oil and the $425 billion (2006 dollars) 47,800 mile interstate highway system enabled trucks to provide faster door-to-door service. In the 1980s, just-in-time deliveries began, reducing fuel efficiency even further since trucks often arrive partly-full with just the goods needed, and may return empty (see Fig. 2.2). Fast service on taxpayer-subsidized

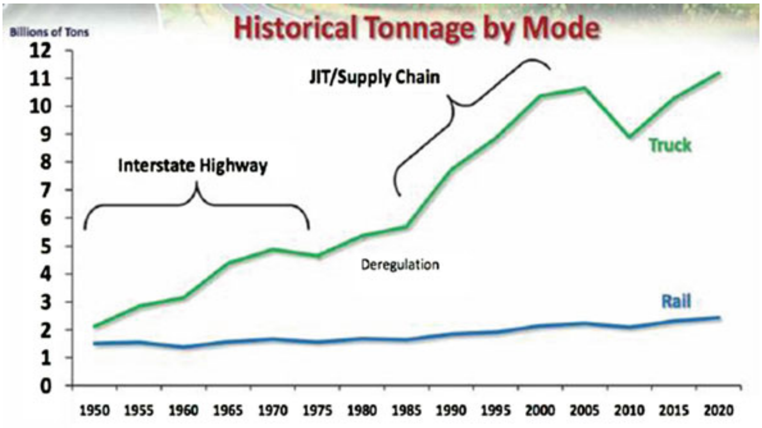

Fig. 2.2 Historical tonnage by mode: billions of tons 1950–2020. *Source* NRC (2014)

roads made water and rail transport less able to compete with trucks, despite their much better fuel efficiency.

We've traded away energy to gain time. We've traded away our energy security for getting stuff as soon as possible. Do we really have to have it RIGHT NOW?

Allowing such waste reflects a short-sighted U.S. energy policy that encourages quick returns on investment over the longer-term goal of making finite oil last longer.

There are many studies on how to improve marine transportation's share of freight, but without a major transformation of the transportation system it is hard to see how ships and barges could compete with trucks. To do this would require major changes, such as shifting funds from roads to the marine highway system (and rail). Furthermore, oil prices need to be much higher. This could be done with oil taxes to pay for maintenance and upgrades to the marine highway system, which is falling apart, and to encourage Americans to buy fuel-efficient vehicles.

Waiting for oil shortages to force the price of oil up is a bit like an alcoholic waiting until the tremors, psychotic hallucinations, and disorientation of delirium tremens starts before putting the bottle down. It is a bit late in the game.

References

AASHTO. 2013. *Waterborne freight transportation*. American Association of State Highway and Transportation Officials.

AAPA. 2015. *U.S. public port facts*. American Association of Port Authorities. Accessed 18 Sept 2015.

Ashby, M.F. 2015. *Materials and sustainable development, table A.14*. Oxford: Butterworth-Heinemann.

Bernhofen, D. et al. 2013. *Estimating the effects of the container revolution on world trade*. Lund University, Working Paper 2013/4, Department of Economics, Lund University.

Conners, T. 2002. *Products made from wood*. Lexington: University of Kentucky.

Cottrell, F. 2009. *Energy and society. The relation between energy, social change, and economic development*. AuthorHouse.

Economist. 2013. *The humble hero. Containers have been more important for globalization than freer trade*. The Economist, May 18.

ECORYS. 2009. *Study on European energy-intensive industries*. ECORYS SCS Group.

McPherson, J.M. 1988. *The battle cry of freedom: The civil war era.* Oxford: Oxford University Press.

Mele, J. May 1. 2009. *Truck efficiency: More than MPG*. FleetOwner.com.

MQ. 2003. *The Mayflower Quarterly*. The General Society of Mayflower Descendants. 69: 4.

NFRCP. 2010. *North American marine highways*. National Cooperative Freight Research Program, National Academies Press.

NRC. 2010. *Technologies and approaches to reducing the fuel consumption of medium- and heavy-duty vehicles*. National Academies Press.

NRC. 2014. *Reducing the fuel consumption and greenhouse gas emissions of medium- and heavy-duty vehicles*. Phase Two: National Academies Press.

Perlin, J. 2005. *Forest journey. The story of wood and civilization*. Woodstock: Countryman Press.

Spilman, R. 2012. *Are modern ships slower than sailing ships? Probably not.* The old salt blog. Sept 17.

Smil, V. 2013. *Prime movers of globalization. The history and impact of diesel engines and gas turbines*. Cambridge: The MIT press.

Stopford, M. 2010. *How shipping has changed the world and the social impact of shipping*. Global Maritime Environmental Congress.

UNCTAD. 2012. *Review of maritime transport.* United Nations.

U.S. Census. 2012. Table 1085. *Waterborne commerce by type of commodity: 1995 to 2009.* U.S. Census Bureau, Statistical Abstract of the United States.

http://www.springer.com/978-3-319-26373-1

When Trucks Stop Running
Energy and the Future of Transportation
Friedemann, A.J.
2016, XV, 132 p. 14 illus. in color., Softcover
ISBN: 978-3-319-26373-1