Cheaper by the Box Load: Containerized Shipping a Boon for World Trade

By Janet Koech

It's hard to believe that a vessel 20 stories tall, a quarter-mile long and made from eight Eiffel Towers' worth of steel can float, much less be the future of cargo transportation between continents.

But the world's newest and largest containership, the Maersk Triple E, may become the most common class of cargo carrier on the seas. Copenhagen-based Maersk chose the name to reflect the ship's economies of scale, energy efficiency and environmental improvement. With a capacity of 18,000 standard 20-foot containers, or TEUs, the Triple E can hold the equivalent of 36,000 cars.[1]

Ever-larger ships have made transportation costs a smaller part of the prices consumers pay—and helped create a world in which Americans consume goods from around the globe. Ports and canals are expanding to accommodate them. The Triple E, which sails the Suez Canal between Europe and Asia, is so massive it can't yet navigate North American ports or even the expanded Panama Canal.

A vessel the size of the Triple E was unimaginable a half-century ago when the first containership, the Ideal X, sailed from Newark, N.J., to Houston with 58 containers. The early containerships—modified bulk vessels or tankers—could transport 1,000 TEUs or fewer. The increasing use of ships dedicated to container handling led to the construction of larger containerships.[2] Capacity quickly expanded from about 4,000 TEUs in the 1980s to more than 6,000 in the 1990s and 10,000 in the early 2000s.

Falling transportation costs have contributed to segmentation of production networks—components are now made wherever it is most cost-effective. Marc Levinson, author of *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger,* notes that "low transport costs help make it economically sensible for a factory in China to produce Barbie dolls with Japanese hair, Taiwanese plastics and American colorants, and ship them off to eager girls all over the world."[3]

By sharply cutting costs and enhancing reliability, container-based shipping has enormously increased the volume of international trade, made complex supply chains possible, facilitated the development of just-in-time logistics and simplified the large-scale transport of consumer goods. The separate evolution of telecommunications systems further increased the efficiency of cargo handling and flows at major ports.

The economic integration of widely separated regions has increased with expanded international trade, financial flows and movement of people. Efficiently distributing freight and transporting people have always been important aspects of maintaining the cohesion of economic systems, from empires to modern nation states and economic blocs. The opposite—poor transportation and communication infrastructure and remoteness—isolates countries from international markets, inhibiting their participation in global production networks. Transport costs are especially pronounced for landlocked countries, which are concerned not only about the quality of their transport networks, but also the ease of movement of goods across boundaries.

Globalization Is Not New

Containerization, along with other technological innovations in maritime, air and land-based systems, has reduced transport costs, improved efficiency and increased trade. This has accelerated the pace of global economic integration in recent decades. However, integration of world economies is not new. Historians single out two episodes of significant advancement in global economic integration. The first, from 1870 to 1913, was ended by the two world wars and the Great Depression, according to Kevin O'Rourke and Jeffrey G. Williamson in their textbook on globalization and history.[4] Postwar economic reintegration started in 1950 and continues today. During both episodes, transportation costs fell, reflecting productivity gains from innovations in transport technology.

Estimates of merchandise trade as a share of world output rose from the beginning of the 19th century until 1913, substantially dropped in the years leading to 1950, and recovered and surpassed 1913 levels by 1973 before continuing to still-higher levels (*Table 1*).

Between 1950 and 2012, the volume of exports increased an average of 6 percent annually, paced by rapid industrialization in developing countries beginning in the 1990s. Exports' share of gross domestic product (GDP) surged in the postwar period to 25 percent in 2012 from 14 percent in 1960 (*Chart 1*).

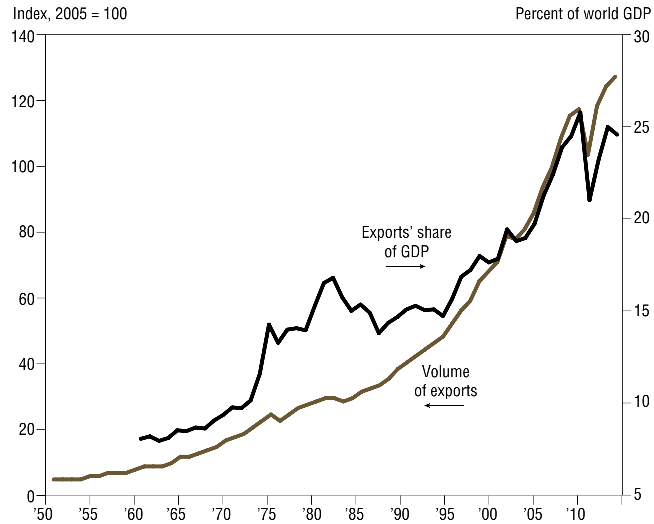
Other factors contributing to increased economic interdependence include falling tariffs and increased demand for goods and services amid rising income levels and living standards. This article focuses on the role of transportation technology, particularly containerization, in facilitating integration.

Technological Advances, Falling Transport Costs

Transport innovations enable production specialization and the division of labor, widening market areas and enhancing trade opportunities. Mechanized transport and industrial production facilitated mass production and global and regional trade. The development of high-capacity, low-cost mechanized transport networks and terminals dates back to the late 18th century.[5] Before that, the speed and efficiency of transport were very low and the cost of traveling long distances was prohibitively high. Largely subsistence economies created little demand for transport, and trade was minimal. Only the most prized

Chart 1

World Exports Substantially Increase in Most Recent Era of Globalization



SOURCES: International Monetary Fund; World Bank's World Development Indicators database; World Trade Organization.

Table 1

World Merchandise Exports as a Share of Gross Domestic Product

Year	1820	1850	1913	1929	1950	1973	1998	2005	2012
Percent	1	4.6	7.9	9	5.5	11.4	17.6	22.4	24.6

SOURCES: *Monitoring the World Economy, 1820–1992*, by Angus Maddison, Paris: OECD Publishing, 1995, for 1820–1950 data; World Bank and International Monetary Fund for post-1950 data.

merchandise—gold and silver, silk, spices, jewels and medicines—moved between continents. Land transportation was especially slow and costly before the introduction of steam railways and iron steamships, major 19th century innovations that helped create high-volume international trade.

Merchandise exports as a proportion of world output grew from just 1 percent in 1820 to about 8 percent in 1913, enabled by numerous transport innovations, low-cost mass-produced goods in Europe and North America and low-tariff trade. This growth in world trade created economic convergence and initiated interdependence among increasingly specialized economies.

Modes of transportation and technology evolved from small to large, slow to fast, simple to complex and rigid to flexible in accordance with internationally accepted standards. In Great Britain, canals were built in the 1760s to transport via horse-drawn barges the growing volumes of industrial raw materials, goods and foodstuffs. The canals, which replaced inadequate roads that stifled economic expansion, slashed transport costs and increased speed and reliability. For instance, the Bridgewater Canal in 1764 cut by one-third the average delivery cost per ton of coal transported seven miles to Manchester. The cost savings encouraged investment in a limited network of canals that helped kick-start localized industrialization in Britain's coalfields.[6]

Steam-powered railways created a cheap mode of transport that could move raw materials, goods and passengers and surmount difficult topography. Steam railways, together with steam-powered textile mills, helped Manchester become the world's first industrial city. By 1830, the first commercial rail line was built, linking Manchester to Liverpool, 40 miles away. Soon, rails were laid throughout developed countries, and by 1850, railroad towns were being established as trains provided new access to resources and markets in vast territories.

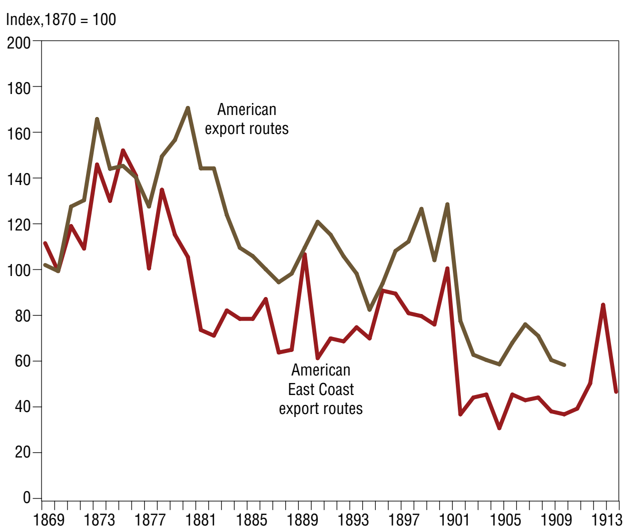
A thousand kilometers of railways operated in England, and more lines were quickly constructed in western Europe and North America. Railroads represented an inland transport system that was flexible in geographic coverage and could carry heavy loads. They were a significant improvement from the stagecoaches widely used in the 18th and early 19th centuries.[7]

Trains on the first railway networks traveled 20 to 30 mph, three times faster than stagecoaches. The journey between New York and Chicago (a 700-mile distance) was reduced to 72 hours in 1850 from three weeks by stagecoach in 1830. The 2,600-mile transcontinental line between New York and San Francisco, completed in 1869, was a remarkable achievement that reduced the cross-country journey to just one week from six months, aiding territorial integration and opening a vast pool of resources and new agricultural regions in the western United States.[8]

Maritime routes linking harbors, especially between Europe and North America, were established at the beginning of the 19th century and mostly serviced by sailing ships until 1850.

Chart 2

Freight Rates Decline in 19th Century



NOTE: The freight rate indexes are aggregate rates on American export routes as reported by Douglass C. North and are deflated by the U.S. Consumer Price Index.
SOURCE: "Late Nineteenth Century Anglo-American Factor-Price Convergence: Were Heckscher and Ohlin Right?" by Kevin O'Rourke and Jeffrey G. Williamson, *Journal of Economic History*, vol. 54, no. 4, 1994, Table 1.

Development of fast and reliable intercontinental shipping passage was aided by the creation of accurate navigational equipment and mapping of sea currents and winds.

By the end of the 19th century, improved steam-power technology revolutionized maritime trade. Shipbuilding advances increased 1914 ship capacity to more than 12 times the 1871 tonnage—from just 3,800 gross registered tons to 47,000 tons.[9] The sailing ship's commercial utility faded as trade shifted to the steamship.

Accordingly, ocean freight rates dropped by about 70 percent between 1840 and 1910.[10] Douglass North, an economic historian, documented the revolutionary decline in transport costs in the 19th century. Chart 2 plots North's aggregate freight-rate index among American export routes, which declined more than 41 percent between 1870 and 1910. His wheat-specific American East Coast freight factor—freight costs as a proportion of the overall value of shipments, including insurance and other charges—fell 53 percent between 1870 and 1913.[11] Cotton freight-rate data from three American ports—Charleston, New Orleans and New York—similarly declined from 1840 to 1850 (*Chart 3*).

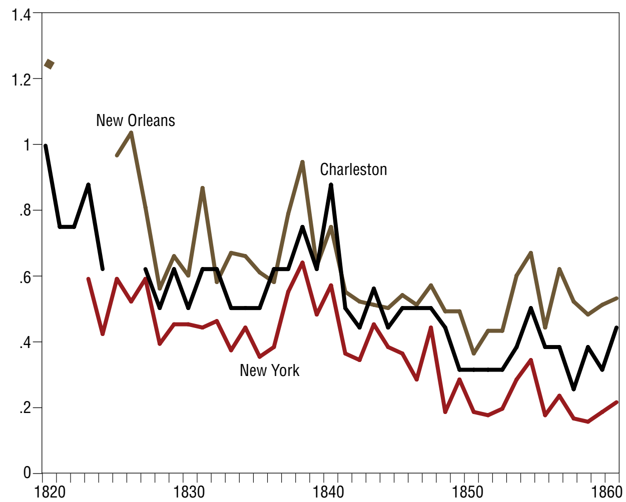
The Suez and Panama canals further shortened travel times and stimulated trade flows between East and West. The Suez, which opened in 1869, linked the Mediterranean Sea with the Red Sea and Indian Ocean. London to Bombay, India—separated by 6,274 nautical miles—was a 47 percent shorter journey via the Suez than around South Africa's Cape of Good Hope.[12] The Panama Canal, completed in 1914, similarly reduced trip times between the Atlantic and Pacific oceans (*Chart 4*).

Commodity prices illustrate the impact of these advances. Mainly due to transport improvements, commodity prices in Britain and the U.S. tended to converge between 1870 and 1913. Wheat prices in Liverpool exceeded prices in Chicago by 58 percent in 1870, by 18 percent in 1895 and by 16 percent in 1913.

The Boston–Manchester cotton textile price gap fell from 14 percent in 1870 to almost zero

Chart 3

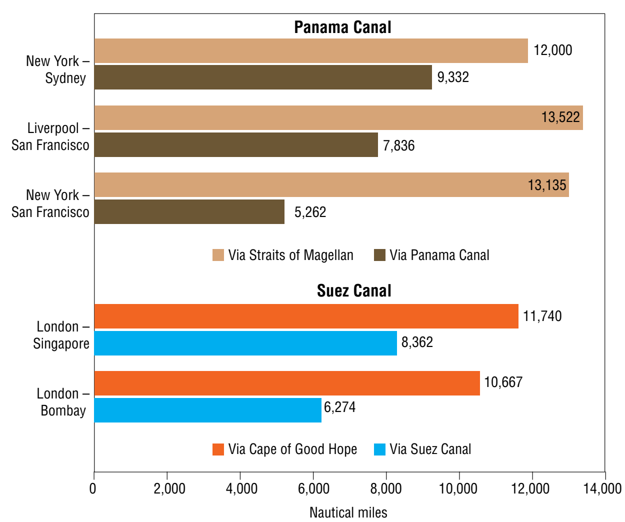
Cotton Freight Rates Steadily Fall in 1800s



NOTE: Cotton freight rate data are missing for New Orleans (1821-1824) and Charleston (1825-1826).
SOURCE: "Ocean Freight Rates and Productivity, 1740-1913: The Primacy of Mechanical Invention Reaffirmed," by C. Knick Harley, *The Journal of Economic History*, vol. 48, no. 4, 1988, Table 10.

Chart 4

Suez and Panama Canals Shorten Maritime Distance



SOURCE: "Transport Shaping Space: Differential Collapse in Time-Space," by Richard D. Knowles, *Journal of Transport Geography*, vol. 14, no. 6, 2006, Table 2.

in 1913; the Philadelphia–London iron bar price gap declined from 75 percent to 21 percent, according to historians O'Rourke and Williamson. The authors note that the "impressive increase in commodity market integration in the Atlantic economy [of] the late 19th century" was a consequence of "sharply declining transport costs."

Similar trends can be documented for price gaps between London and Buenos Aires, Argentina, and between Montevideo, Uruguay, and Rio de Janeiro.[13]

However, even as such technological improvements as motorized shipping continued reducing transport costs through the first half of the 20th century, rising wartime protectionism and the Great Depression largely unraveled economic integration achieved in the 19th century. After World War II, governments around the world undertook the difficult task of rebuilding both physical infrastructure and international trade.

Global integration was slowly reestablished in the second half of the 20th century, and export shares of world output edged higher, into the double digits, as seen in Table 1. Development of propeller aircraft, flying at 300 to 400 mph by the 1950s, greatly reduced journey times, although the benefits were limited to a tiny sliver of the wealthy.

Beginning in the late 1950s, the introduction of jet engines increased aircraft speed by 50 percent, further shortening travel times. Airlines also used larger planes to reduce the cost per seat, accelerating adoption. Today, air transport is an important carrier of high-value, low-bulk cargoes. For a wide array of products, including fresh flowers, electronic components and airplane parts, air cargo is a cost-effective means of international delivery. International aviation moves about 40 percent of world trade by value, although far less in physical terms.[14]

International trade has expanded by unprecedented proportions in the past half-century. Even with goods moving by air and electronically, as in the case of high-value cargo such as software, ships still carry more than 90 percent of world trade by volume. Many commodities are transported in bulk, with specialized vessels developed to accommodate this trade. Giant tankers move petroleum products from producers to consumers, and other vessels carry such cargo as cement, coal, iron ore and grain.

Just about everything else that's not considered bulk—flat-screen TVs, clothing, shoes and boxes of cereal—travels across the sea from factory to market aboard fleets of containerships. These vessels have played a critical role in furthering the integration and interdependence of world economies. To be sure, technology has aided the process through expanded use of computers and telecommunications that manage and track the intermodal movement of containers.

Frustration Spurs Innovation

A trucker, Malcolm McLean, grew increasingly irritated by lengthy port waits as dockworkers offloaded bales of cotton from his truck to ships for export. He wondered whether the transfer could be expedited were he to drive his truck onto the ship and drive it off at the destination, without anyone dockside touching his cargo.

Before 1956, ocean transport of general cargo used break-bulk methods of loading cargo—pallets were moved, generally one at a time, from a truck or railcar that carried them from the factory to the docks. There, each pallet was unloaded and hoisted by dockworkers (or by cargo net and crane for heavier loads). Once a pallet was in the ship's hold, it had to be positioned and braced to protect it from damage during sometimes rough ocean crossings. The process was slow, labor intensive and expensive. Cargo ships typically spent as much time in port loading and unloading as sailing.

McLean's big idea of handling cargo only twice, once at the shipper's location and again at the final destination—never while in transit—came to fruition on April 26, 1956, during the containership Ideal X's five-day trip from New Jersey to Houston. There, cranes hoisted the containers from the ship onto 58 trucks that hauled the big boxes to their final destinations. The voyage marked the beginning of a maritime shipping revolution in the global movement of goods.

Cargo in that era typically took a week's worth of labor to load, and another week to unload, at a cost of about $5.83 a ton. The Ideal X's loading costs were a tiny fraction of that, approximately 15.8 cents a ton.[15] With containerization, the movement of general cargo became less labor intensive and more capital intensive, spelling the end of thousands of cargo handlers' jobs. Worldwide, about 70 percent of dockworkers lost their jobs with the adoption of containerization.[16] Mechanization of ship loading and unloading reduced loss, damage and pilferage and, in the process, lowered insurance costs and greatly reduced ships' time in port.[17]

Containerization facilitated the integration of separate transport systems to allow the seamless shifting of cargoes between transport modes. The emergence of intermodal transportation was also hastened by improved technology and techniques for transferring freight. Today, containers filled with goods quickly move between warehouse, ship, train and truck.

What Was Revolutionary?

Container shipping has a dynamic history of little more than a half-century, an era that began with the Ideal X's voyage. In the early years, vessel capacity remained limited in scale and in geographic deployment, and the ships used to carry containers were converted World War II tankers. McLean's initial design for a container was a box—8 feet tall, 8 feet wide and 10 feet long—constructed from 2.5 millimeter-thick corrugated steel. At the outset of the development of the container system in the late 1950s and early '60s, there was no standard for container size and construction.

Like many technological innovations, the container faced an initial period of experimentation. Shippers were unwilling to immediately adopt it, preferring to wait until they were sure containerization would prevail and an industry standard for containers and handling was established. In the mid-1960s, the adoption of standard container sizes—the now-universal 20 and 40 TEUs—hastened global acceptance.

The container itself was not new; railroad box cars were transported on ships as early as 1929 between New York and Cuba.[18] What was revolutionary was the seamless transfer of cargo from one mode of transport to the next, including integrated inland transport with trucks, barges and trains—with the boxes never opened while in transit.

Standardization Increases Adoption

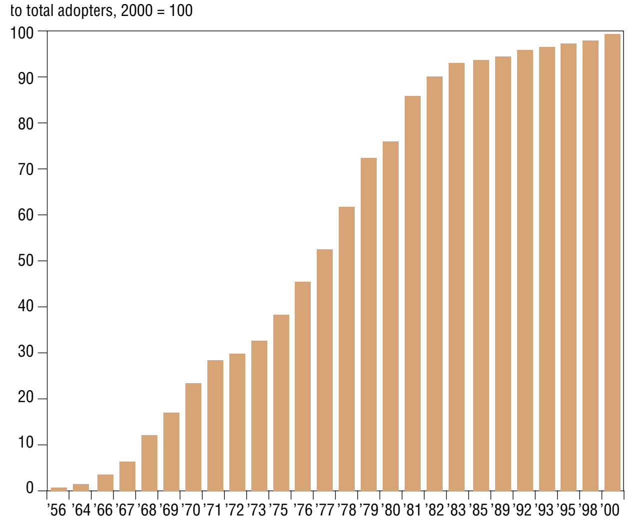
Following widespread adoption of containerization in the 1970s (*Chart 5*), construction began on the first cellular containerships, on which shipments were stacked in "cells."[19] Economies of scale have driven construction of ever-larger containerships since 1980. The greater the number of containers carried, the lower the cost per unit of good being shipped.

Transport efficiencies captured the economic impact of containerization. Quicker handling and less time in storage meant faster transit from manufacturer to customer, reducing financing costs for inventories sitting unproductively on railway sidings or in dockside warehouses awaiting a ship. Containerization, combined with

Chart 5

Adoption of Containerization Increases Following Container Standardization

Percent of countries adopting relative to total adopters, 2000 = 100



NOTES: Containerization adoption is defined as the year when the first container port was constructed. The chart plots the cumulative share of countries engaged in international maritime trade that adopted containerization by a given date, relative to the total adpoters at the beginning of the 21st century. Some years are not shown either because no container ports were constructed in those years or container adoption data were not available.
SOURCE: Containerisation International Yearbooks, several editions.

telecommunications advances, made just-in-time manufacturing practices possible—producing goods as customers need them and shipping with the expectation that they will arrive at a specified time.

These efficiencies also became an essential driver in reshaping supply-chain practices and allowing multinational global sourcing strategies. As freight costs plummeted, manufacturers shifted production to the most cost-effective locations. Segmentation of production would have been unattainable without containerization and development of the intermodal transport network.

Closing Distances, Spurring Trade

The distance between countries has a negative impact on the volume of trade, according to the so-called gravity model of international trade (which is based on Newton's universal law of gravitation). This model explains trade flows between two countries as being directly proportional to the product of each country's "economic mass," as measured by GDP, and inversely proportional to the distance between the countries.[20]

Ambitious public works projects in the late 19th and early 20th centuries significantly shortened the effective maritime distances between regions of the world. The Suez and Panama canals stimulated bilateral trade flows between East and West. The Suez Canal not only provided remarkable cost savings on distance, making the far reaches of Asia and Australia accessible, but it also provided impetus to the building of large, fast and economical steamships that eventually led to the decisive switch from sail power over the 1870 to 1880 period.[21]

Ship size grew dramatically, with the largest going from 3,800 gross registered tons in 1871 to 47,000 tons in 1914. With the advent of containerization, vessels have significantly increased to Triple E capacity of 18,000 TEUs—three times the size of ships in the 1990s. Port infrastructure has expanded to meet the needs of the increased vessel size.

A hundred years after the Panama Canal's completion, its latest expansion is nearly complete, with improvements made to allow the passage of larger ships—oil supertankers, military ships and larger containerships. The canal significantly shortens the trip between the U.S. East and West coasts.

Following the canal's expansion, ships double the size of current Panamax vessels—the largest that can ply the original canal—will be accommodated, dramatically increasing the volume of goods that can be carried.[22] U.S. manufacturers may realize new opportunities to expand exports at considerably lower cost to new markets, such as between the U.S. West Coast and South America's eastern coast, particularly Brazil, an important emerging-market economy.

Inland Nations Less Able to Benefit

The trade benefits of broader market access from distance reduction contrast with the increased costs that landlocked countries incur to access world markets because of separation from maritime transport networks. These countries' transport costs average 50 percent more than those with readily available world market access, and they engage in about 60 percent less trade than their coastal counterparts.[23] Landlocked nations also must depend on neighbors' infrastructure while maintaining sound cross-border political relations and administrative practices.

The container has substantially contributed to the integration of various transport systems that link maritime and inland transport networks as goods move from producers to consumers. Containerization offers ship, rail and road networks greater ease of movement and standardization of loads, improving efficiency and reducing transportation costs. Conversely, poor infrastructure and connection of the various transport modes increases costs, which inhibits access to international markets and curtails global competitiveness.

The quality of infrastructure is even more important for countries that lack direct access to the sea. Their overall transport costs are affected by the quality of other countries' infrastructure in addition to the distance to get goods to consumers. Transportation infrastructure improvements and the ease of transit between countries are significant factors facilitating trade and economic integration. Additionally, increased intraregional trade and collaboration can bolster economies of scale from the export of large quantities of products, improving cost competitiveness.

An Era of Greater Integration

Societies and economies around the world have generally become more integrated due to increases in the speed of trade, factor movements and communication of information. More recently, the pace of economic globalization has been particularly rapid and stands in contrast to the earlier period of integration halted by two world wars and the Great Depression in the 20th century.

Over the past 200 years, technology has transformed the scale of transport systems from small to large and improved transport speed from slow to fast, slashing costs and increasing trade flows and global interdependence.

Containerization, a technological improvement in shipping, has revolutionized the ocean transport of general cargo and simultaneously facilitated intermodal transportation, in which ocean, inland waterway, highway, railway and air transport form continuous interrelated networks, increasing efficiency and reliability. Production processes as a result have become more segmented—instead of producing goods in a single process at a single location, firms are increasingly breaking manufacturing processes into discrete steps and performing each at whatever location minimizes costs.

Notes

[1] TEU stands for 20-foot equivalent unit, which is used to measure a ship's cargo-carrying capacity. One TEU represents the cargo capacity of a standard intermodal container, 20 feet long and 8 feet wide. There is a lack of standardization with regard to height, which ranges between 4 feet and 9 feet.

[2] All containerships are composed of cells that hold containers in stacks of different heights depending on ship capacity. Cellular containerships also offer the advantage of using an entire ship, including below deck, to stack containers.

[3] See *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*, by Marc Levinson, Princeton, N.J.: Princeton University Press, 2006.

[4] See *Globalization and History: The Evolution of a Nineteenth-Century Atlantic Economy*, Cambridge, Mass.: MIT Press, 1999, for details on the two globalization episodes.

[5] See "Transport Shaping Space: Differential Collapse in Time-Space," by Richard D. Knowles, *Journal of Transport Geography*, vol. 14, no. 6, 2006, pp. 407–25.

[6] See *An Economic History of Transport*, by Christopher I. Savage, London: Hutchinson University Library, 1966.

[7] A stagecoach is a type of covered wagon, drawn by horses, for transporting passengers and goods. Stagecoaches were widely used before the introduction of railway transport.

[8] See *The Geography of Transport Systems*, by Jean-Paul Rodrigue, Claude Comtois and Brian Slack, London and New York: Routledge, 2013.

[9] See note 5.

[10] See note 8.

[11] See "Late Nineteenth-Century Anglo-American Factor-Price Convergence: Were Heckscher and Ohlin Right?" by Kevin O'Rourke and Jeffrey G. Williamson, *Journal of Economic History*, vol. 54, no. 4, 1994, pp. 892–916.

[12] See note 5.

[13] See "Real Wages, Inequality and Globalization in Latin America Before 1940," by Jeffrey G. Williamson, *Revista de Historia Económica*, vol. 17, no. S1, 1999, pp. 101–42.

[14] See "International Air Transport: The Impact of Globalisation on Activity Levels," by Ken Button and Eric Pels, in *Globalisation, Transport and the Environment*, Paris: Organization for Economic Cooperation and Development (OECD) Publishing, 2010, pp. 81–120.

[15] See note 3.

[16] See *The Blackwell Companion to Maritime Economics*, by Wayne K. Talley, Oxford, U.K.: Wiley-Blackwell, 2012.

[17] See note 16, chapter 1, for a description of the nature of work and activity of a container port.

[18] See "Growing World Trade: Causes and Consequences," by Paul Krugman, *Brookings Papers on Economic Activity*, vol. 26, no. 1, 1995, pp. 327–77.

[19] "Adoption of containerization period" refers to the year a country's first container port was constructed.

[20] See "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence," by Jeffrey H. Bergstrand, *The Review of Economics and Statistics*, vol. 67, no. 3, 1985, pp. 474–81.

[21] See "The Suez Canal and World Shipping, 1869–1914," by Max E. Fletcher, *The Journal of Economic History*, vol. 18, no. 4, 1958, pp. 556–73.

[22] A class of ships known as Panamax was built to the maximum capacity of the Panama Canal and its locks.

[23] See "Infrastructure, Geographical Disadvantage, Transport Costs, and Trade," by Nuno Limao and Anthony J. Venables, *World Bank Economic Review*, vol. 15, no. 3, 2001, pp. 451–79.

Suggested Reading

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