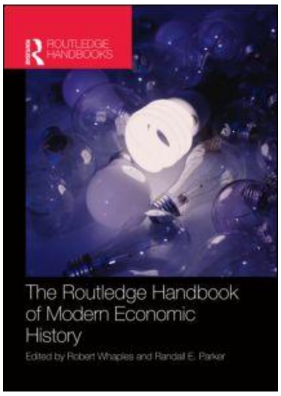

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THE ECONOMIC HISTORY OF TRANSPORTATION

Dan Bogart

Introduction

Around the year 1700, much of humanity was stuck in the mud. Unimproved roads made it extremely costly to move goods and people overland. Many rivers had navigation problems and ocean vessels were slow and risky. Of course there were exceptions. Some roads leading into major cities were well maintained and constructed using techniques dating to the Romans. Navigable rivers like the Thames in Britain or the Yangtze in China served as major thoroughfares for their respective economies. But these were areas privileged by geography. Most of the pre-industrial world languished under poor transport systems.

This state of affairs changed dramatically from 1700 to 2000. Much like the rest of the global economy, transportation experienced a "revolution" in technology, investment, and management. The speed of the revolution varied dramatically across time and space. In general, Western European nations led the way in improving their transport systems during the eighteenth and early nineteenth centuries. From 1850 onwards, European technologies and practices diffused throughout most of the world. For instance, almost every country in the world had a railway or steamship arriving at its major port by 1913. Although there were many advances by the early twentieth century, the speed and freedom of travel was still quite limited. Two innovations changed the nature of transport once again. The airplane and the automobile were initially adopted in the world's leading economies, most notably the United States. Subsequently, automobiles and airplanes became commonplace. Today one can travel by car or by plane even in the poorest countries of the world.

Technological change is only part of the story of the modern transport sector. Improvements required substantial infrastructure investments. The building of highways, railways, airports and the like involved substantial risks. Their irreversible nature meant that costs could not be easily recovered if revenue expectations were not realized. Partly for this reason, governments stepped in and either built the network or designed a framework in which private companies built, owned, and operated infrastructure. Governments also developed a large body of regulations determining where infrastructure could be developed and how it was used and priced.

This chapter reviews the major technological and infrastructural developments in overland, water, and air transport. Next, it reviews the major trends in prices and quantities. Like any other sector, outcomes in the transportation sector were the result of "equilibrium" forces. As technology, income, and market structures evolved, so did fares and the quantities of services purchased. The general trend was towards cheaper transport and higher traffic volume because of a combination of income and productivity growth. However, there remained substantial differences in outcomes across space, even after holding technology and income levels constant. Some of these differences in fares and traffic volumes were due to broader economic and political forces. For example, regulatory authorities sometimes acted to protect favored firms by imposing minimum fares or restricting entry. In other instances, authorities limited the monopoly power of transport providers or they imposed safety standards. Several cases are given later to illustrate some of the factors influencing outcomes in transport markets.

This chapter also examines the contribution of transport improvements to economic development. The classic approach is to measure the social savings, or the gain in consumer surplus that occurred due to a transport innovation. Another approach uses regional or state variation to measure the effect of transport improvements on income or population. The general conclusion is that transport improvements contributed to development, but there are sizeable differences across time and space. The effect of any single transport innovation depends on the quality of alternative transport modes in addition to managerial and regulatory decisions. Excessive market power, poor network design, and inefficiency in operations have all worked to limit the social benefits from transport innovations.

Finally, some have argued that transport improvements have introduced a number of social costs, particularly greater pollution. However, the evidence suggests that transport improvements and innovations have done more good than harm and thus this chapter takes a decidedly positive tone when discussing innovations like the automobile and airplane. Because the literature has yet to satisfactorily measure the social costs of transport over the last 300 years, it is hoped that in the future more can be said about this important issue.

Technological and infrastructural developments

The history of transport can be told through a series of technological breakthroughs and infrastructural developments. With this in mind, it is useful to start with the eighteenth-century context where road and river transport were dominant in much of the world. Advances in civil engineering knowledge marked one of the major breakthroughs of this period. Perhaps the most famous are the British engineers John Macadam and Thomas Telford, who developed new techniques for building roads and bridges. Dutch and French engineers also made advances in navigation that led to "canalizing" rivers and eventually canals.

New systems of public finance were developed concurrently with advances in engineering know-how. Governments in several Western European countries entered into contractual arrangements with the private sector to build and operate roads, canals, and bridges in exchange for levying tolls. These public–private partnerships of the pre-industrial era were predicated on the existence of relatively stable political systems in which investments were secure from expropriation (both public and private). Just as important, these societies could draw on a range of informal institutions to govern infrastructure providers, making their exactions more palatable to the society. Governments also began to heed the call by providing public funds for large projects. One example is the royal highways of France, which were coordinated and financed by the monarchy. Another example is the British Navy, which played a key role in policing the seas, principally for British ships. More broadly, however, governments rarely spent large sums on transport infrastructure before 1800. It was only when military and economic interests coincided that public spending levels exceeded a few percentage points of central government budgets.

Transport progress was modest outside of Western Europe until the mid-nineteenth century. The available statistics on transport infrastructure provide one indicator that Europe was ahead. By the 1880s, Europe had 925,000 highway miles and 62,000 miles of navigable waterways. By comparison, the U.S. and Canada had 266,000 highway miles and 25,000 waterway miles. India was further behind: it had 58,000 and 5,000 miles of highways and waterways respectively (Mulhall 1884: 395).

The nineteenth century witnessed more dramatic changes in technology and infrastructure with the coming of the railway and the steamship. Steam locomotives were first shown to be economically superior to wagon transport in the densely populated regions of Britain in the 1820s. Relatively quickly railways spread to the rest of Britain, Europe, and the United States. By 1910, emerging railway networks could be found in most parts of the world, including India, China, Latin America, and Africa.

Railway penetration was more extensive in the advanced countries. Table 15.1 shows European railway networks were most developed in terms of railway miles per square mile. North and South American railway networks were not as dense geographically but they were well developed in terms of population. Asian networks were the least developed. China stands out in that it had the smallest railway network among all major countries. Even so, the penetration of railways in poor countries was greater than in other technologies, such as mechanization of textiles (Clark 1987).

Several factors account for the success of railways as a global technology. One was the substantial improvements in the design of locomotives, wagons, and rails. By the early 1900s, the

Table 15.1 Railway diffusion for selected countries in 1910

	Rail Miles per 1000 people	*Rail Miles per Square Mile*
Europe		
Austria	0.50	0.12
France	0.74	0.15
Germany	0.58	0.18
Italy	0.29	0.09
Russia	0.27	0.02
Spain	0.46	0.05
Sweden	1.58	0.05
U.K.	0.56	0.19
North America		
Canada	3.44	0.002
Mexico	1.03	0.02
U.S.	2.69	0.07
South America		
Argentina	2.64	0.02
Brazil	0.60	0.004
Asia		
China	0.01	0.001
India	0.11	0.02
Japan	0.11	0.04

Source: Bogart (2009).

cost of adopting railway technologies had decreased dramatically compared to the initial designs. Developments in global financing and corporate governance also proved crucial. For the first time in world history it was possible for foreign capitalists to invest and own transportation facilities in other countries. Colonialism helped to grease the wheels of investment, but other factors like social networks and the adoption of commercial codes also facilitated diffusion (Roth and Dinhobl 2008). Last but not least, rising global incomes fostered railways. Vast amounts of railway track were laid in Latin America, India, Russia, and the United States because these regions had abundant land and Europeans had great demand for their products.

The introduction of the steamship was arguably just as important as the railway in bringing the nineteenth-century world closer together. Steamships came on line in the mid- to late 1800s. They first replaced sail ships along routes where coal was plentiful. They eventually achieved dominance in the early 1900s. Like railways, steamships offered capacity and speed. They were the main vehicle for immigration from Europe to America (Keeling 2008). Probably the most famous example of a steamship is the *Titanic*. Its sinking in 1912 was notable in part because it marked the latest design, combining speed, size, and luxury.

The automobile and the airplane are the two most important transport technologies of the twentieth century. Prior to 1900, there were experiments with steam-powered automobiles but none was economically successful. The major breakthrough occurred in the late nineteenth century when the German Karl Benz developed the internal combustion engine for vehicles. Automobiles became increasingly common in the 1910s. The development of the assembly line was one factor. Henry Ford perfected the use of the assembly line at his plants in Michigan and is credited with a number of organizational innovations. The automobile industry grew enormously over the ensuing decades. Near its peak in the 1970s, production of motor vehicles, bodies and trailers, and parts accounted for 15 per cent of durable goods production in the U. S.[1] The significance of auto production was underlined in 1953 by the assertion of General Motors' chairman, Charles Wilson, that "what's good for the country is good for General Motors, and vice-versa."

Highway expansion was also crucial to the diffusion of automobiles. The auto industry needed public authorities to provide paved roads. Otherwise their new cars would have been stuck in the mud. As in the eighteenth century, new systems of public finance were developed to meet this need. For example, the gasoline tax was increased in the United States in order to help build the Interstate Highway System. Gasoline taxes increased from 1.2 per cent of the U. S. federal government internal tax revenues in the late 1940s to 2.5 per cent in the 1960s when the interstate highway network was being built. After the network was built, gasoline taxes declined as a per cent of total federal revenues. In the 1990s, they represented 1.7 per cent of all federal internal tax revenues (Carter *et al.* 2006: Table Ea609–35).

The airline industry began with the innovations of numerous entrepreneurs and engineers. The Wright brothers were the first to achieve flight with an airplane. Their design was improved in the 1920s and 1930s, including the introduction of the jet engine. Initially, most commercial aviation firms were small, but by the 1930s the industry became more concentrated. Following a series of regulations, the U.S. airline industry came to be dominated by Eastern, American, United, Trans-continental, Western, and Pan American airlines. Each firm was given a regional monopoly. In some cases their market power has persisted even to the present day.

Like most transport sectors, government involvement in the airline industry is extensive. Cities or regional governments often own airports. Allocation of scarce airport "slots" has proved to be a key regulatory tool and has sometimes led to restrictions on entry by rival airlines. Governments are also largely responsible for safety in air travel. Major accidents and threats to security have led to greater government involvement, much like the attacks on the World Trade Center in 2001 led to the creation of Transportation Safety Administration in the United States.

The evolution of the transport market

Purchases of transportation services have exploded over the past three centuries. Declines in fares and freight charges have been equally dramatic, as have been quality improvements. This section provides a brief overview of the market for domestic flights in the U.S. since 1930 to illustrate these trends for one sector. Comparisons with other sectors are discussed as well.

Table 15.2 reports selected statistics for the domestic airline sector using data from the *Historical Statistics of the United States* (Carter *et al.* 2006). Passenger miles flown (the main measure of output) increased from just 85 million in 1930 to more than 340,000 million in 1990. The average annual growth rate in services was 15 per cent and was especially rapid between 1930 and 1970 when air travel was an emerging industry.

Trends in real average passenger fares can be gleaned from revenues per passenger mile divided by a consumer price index. Airfares differ by time of purchase, thus there is no single market price even for the same flight. According to this metric, passenger fares have fallen substantially. In 1950, a typical 500-mile flight in the U.S. would have been purchased for approximately $260 in 2010 constant prices. By 1990, a 500-mile flight could be purchased for approximately $115 dollars. There was an even greater decline in average passenger fares between 1930 and 1950 at the same time that services were becoming more widespread.

Speed and safety are two of the most important aspects of quality in air travel. Domestic air travel has become dramatically safer based on the number of fatalities per passenger mile travelled. The chances of dying in a plane crash in 1990 were a small fraction of what they were in 1940. The speed of air travel has also increased. Average speeds went from 180 to 350 miles per hour between 1950 and 1970.

Sectors exhibiting radical decreases in prices and quality improvements usually see a greater growth relative to other sectors. Air travel was no exception. U.S. domestic airline revenues as a percentage of gross domestic product (GDP) increased from less than 0.1 per cent in 1940 to 1 per cent by 1990. A similar story could be told for other transport sectors as they progressed from novelty to a mature industry. For example, rail freight services in the U.S. grew by an average of 9.4 per cent per year between 1850 and 1910. The most rapid growth occurred in

Table 15.2 Selected statistics for domestic air travel sector in the U.S.

Year	*Millions of passenger miles*	*Revenue per passenger mile in constant 2010 dollars*	*Fatalities per 100 million passenger miles*	*Average speed in mph*	*Revenues as a per cent of U.S. GDP*
1930	85	1.123			
1940	1052	0.818	3		0.076
1950	8007	0.520	1.1	180	0.19
1960	30567	0.466	0.9	235	0.404
1970	104156	0.341	0	350	0.691
1980	200829	0.314	0.005	404	0.93
1990	340231	0.233	0.0085	408	0.999

Source: Carter *et al.* (2006): Tables Df1112-1125, Df1229-1245, Df1177-1189, Df1203-1215, Cc1-2, and Ca9-19.

the 1850s, 1860s, and 1870s. Railroad freight rates and travel times also declined to a fraction of their initial level (Fishlow 1966).

What accounts for the rapid growth in output in the transport sector? Higher incomes are certainly one factor. Travel is a normal good: an individual wants to travel more as his or her income increases. The same holds in the aggregate as well. Britain was the richest economy in the early nineteenth century. It also had the largest transport sector (Ville 1990). In the late nineteenth century, the U.S. became the richest economy in the world. It soon became the largest consumer of transport services as well.

Greater investment and productivity growth were also driving the growth in transport output. As mentioned earlier, infrastructure investments like the construction of roads, seaports, canals, railway tracks, and airports played a crucial role. The role of productivity is perhaps less obvious. Productivity growth implies that the same amount of goods or services can be supplied with fewer inputs, like labor and capital. Productivity growth is significant in any industry because it allows firms to charge lower prices and still cover their fixed costs of investment. In the U.S. domestic airline sector, labor productivity (or passenger miles flown per worker) increased by a factor of 18 between 1930 and 1990.[2] Although not as spectacular, labor productivity has increased in other transport sectors as well. In U.S. railroads, for example, labor productivity is estimated to have increased by a factor of 3 between 1840 and 1910 (Fishlow 1966).

Technological change is one of the key drivers of productivity growth. In the air and rail sectors, improvements in jet engines and locomotive power increased average haul sizes and fuel efficiency. "Organizational" change is another contributing factor. One example was the reduction in risks associated with the British Navy routing out piracy in the Caribbean Sea (North 1958). There is debate in the literature as to the significance of the British Navy's contribution to productivity growth when compared with steam power and steel hulls (Harley 1988); nevertheless, it is clear that investments in safety were a public good, and, without the assistance of the British Navy, ocean shipping would have been more expensive. Another example of organizational change involved the turnpike roads of eighteenth-century Britain. In this case, tolls were used to finance road improvements because the existing system for financing highways was inadequate. Following the introduction of turnpikes, carriers adopted larger wagons and faster carriages, eventually contributing to lower transport costs. Private investments in vehicles and public investments in roads were complementary (Bogart 2005).

Increases in economic "density" have been another important factor in determining productivity growth. As urban populations increase, planes, trains, and automobiles can run more frequently and at a higher percentage of capacity. An excellent example comes from the shipping of grain and cattle in the nineteenth century. Beef was a desired American import in Europe but a problem arose because ships could not be filled with beef cattle alone. As it turns out, grain was used to fill the empty cargo space, and, when combined in the same ship, cattle and grain freight rates were reduced to very low levels. However, the opportunity to combine complementary freight was only available on certain routes, such as New York to London, where there was a high volume of services (Harley 2008).

Cost decreases translate into the greatest price reductions when competition is most vigorous. But obviously competition does not always prevail in transportation. Entry is costly because of the large fixed costs in setting up transport services. The small number of firms is significant because it aids efforts in collusion. The Joint Executive Committee is one telling case where collusion seems to have been partially successful. The Committee fixed the market share among several railroads shipping grain from the Midwest to the Eastern seaboard of the U.S. in the 1880s. According to some accounts, individual railroads were deterred from cheating on the cartel because they expected to be sanctioned by the other railroads belonging to the Joint Executive Committee (Porter 1983).

The fear of collusion has led transport users to lobby for government regulation of fares and freight charges. However, the implementation of regulation has been difficult in practice. Perhaps the most famous example is the Interstate Commerce Commission (ICC), which was made responsible for regulating railroads in the U.S. during the late 1800s. Its early success was limited by a Supreme Court decision that weakened its powers to set railroad rates (Kolko 1965). In another case, the colonial government of India introduced maximum freight charges for railways in the nineteenth century. But it also introduced minimum freight charges to limit ruinous competition. There is some evidence that the colonial government kept minimum rates high because it wanted to maintain high profits on the railway lines that it owned (Bell 1894: 205–15). In both of these cases, government regulation was compromised to some degree by the conflicting interests of governing authorities.

The extent of government ownership has been another important factor in transport markets. Governments were always involved in building and operating transport infrastructure, but prior to railways they rarely owned the wagons and ships that provided the transport services. In the nineteenth century, governments began to take over these functions. As one indication, the fraction of world railway miles owned and operated by private companies declined from over 90 per cent in 1860 to just above 70 per cent in 1912. Government ownership increased because of both new construction and nationalizations of privately owned railways. Many of the nationalizations occurred on a line-by-line basis, as national authorities targeted particular railway companies. In other cases, like Switzerland and Japan, laws were passed transferring ownership over much of the network to the central government. The reasons for greater government ownership varied. Military interests were certainly a factor since railways were an input into the state's war machine. Political and economic factors mattered as well. For example, democratic countries tended to have less nationalization than more autocratic countries (Bogart 2009).

The effect of government ownership on transport performance is a topic of major interest among scholars and policy makers. In a number of cases it appears that nationalizations of railways in the nineteenth century reduced operating efficiency (Bogart 2010). One explanation is that governments tend to care more about rewarding constituencies with extra railway stations and employment. Matters are more complicated, however, when privately owned railways receive substantial government subsidies or when railways represent an important source of tax revenue. India provides one case in point. Here greater government ownership in the nineteenth century seems to have reduced operating costs (Bogart and Chaudhary 2012).

The impact of transport on economic development

It has long been argued that transport improvements generate development. But the size of these developmental effects is still in debate. This final section reviews the literature studying the impact of transport improvements. It also discusses the channels by which transport influences development.

Nineteenth-century boosters often argued that railroads were crucial to economic development, but they did not have a clear method to test their argument. Economic historians of the 1960s approached this issue using a novel approach known as the "social savings" methodology. The goal is to measure how much consumer surplus was gained from railways at some benchmark date, say 1860 or 1890. The reasoning is that railway customers would have relied on alternative transport modes, like wagons and boats, in the absence of railways. A simple approximation for the gain in consumer surplus is the difference between freight rates for wagons and railroads multiplied by quantity of rail traffic in 1860 or 1890. Prices are meant to capture the marginal costs of each technology under perfect competition and the quantity of traffic proxies for consumer demand.

Early research showed that the social savings of railways were surprisingly small in the U.S. According to two prominent studies, U.S. GDP would have been lowered by only a few percentage points in 1860 or 1890 had railways never existed (Fishlow 1965; Fogel 1970). Similar conclusions were reached for railways in European countries (O'Brien 1983). The view that railways were indispensible for nineteenth-century development was largely debunked for more developed economies. For less developed countries, like Mexico and Brazil, railways had much larger social savings and could be considered "crucial" if not indispensable (Summerhill 2005; Coatsworth 1979).

The social savings methodology is controversial, however. Critics point to a number of problems. First, it is not clear what the price of road or water transport would have been in the absence of railways. Congestion would have increased on roads and rivers with the increased traffic volume. The cost of using alternative transport modes is arguably underestimated as a result (McClelland, 1968: 114). Second, the social savings calculation omits spillovers. Railways increased demand for iron and steel and increased competition in manufacturing. The size of these backward and forward linkages is unclear. There are also changes in economic geography to consider. In theory, lower transport costs can lead to agglomeration of economic activity, like the emergence of cities. The standard social savings methodology has no way of measuring the effects on urbanization.

Yet, the social savings methodology has yielded a number of insights that are worth mentioning. First, railways offered time savings as well as monetary savings. One study quantifies the value of time saved on British railways and shows it was equal to approximately 10 per cent of GDP in 1913. Railways were important in this regard because walking was the alternative for many low-income passengers (Leunig 2006). Second, the social savings methodology shows how different transport modes can serve as substitutes. Countries without effective road and water transport often had higher social savings from railways. A case in point is Brazil, where mule trains represented the alternative to railways (Summerhill 2005). A third insight concerns technology diffusion and access. Necessarily there must be a large number of customers if any transport improvement is going to have a large social savings. In some countries, like Spain, the railway had a smaller impact than it might have had because its total revenues represented a small share of GDP (Herranz-Loncán 2006). One potential culprit is poor regulation or network design.

A second general method seeks to measure the effects of transport on economic outcomes more directly. It uses regression analysis to compare income or population density in economies with and without transport innovations, or to measure economic changes before and after transport innovations are introduced. Most studies in this second vein find that transport improvements have effects on income and population density. Often the key questions revolve around the size of the effect. One study estimates the effect of highways on suburbanization in the U.S. between 1950 and 1990. During this period, central city population declined by 17 per cent. The analysis compares the differences in population across cities depending on the number of new highway miles. The estimates imply that one new highway passing through a central city reduced its population by about 18 per cent (Baum-Snow 2007).

Estimates of the effects of transport improvements are useful in informing policy discussions. Transportation improvements are often expensive. If the developmental effects are small relative to the costs, then transport funding should be reduced. More generally, if transport innovations change the way we live, as in the case of suburbanization, then it is useful to know how much.

The literature also speaks to the importance of transport improvements in the development of economies over the long run. As transport costs are crucially linked with trade costs and the extension of markets, transport improvements have been shown to be one of the most important developments in any economy.

As a final remark, transport innovations have been difficult to implement historically because they involve vexing issues like eminent domain and taxation. In addition, some economies have made inefficient use of their transport infrastructure due to excessive monopoly power and regulatory failures. History tells us that attention needs to be paid to transport effectiveness if the social gains of transport are to be realized.

Notes

1 Figures obtained from U.S. Department of Commerce, Bureau of Economic Analysis, http://www.bea.gov/industry/gdpbyind_data.htm

2 Author's calculation based on Carter *et al.* (2006): Df1112–25.

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