1
Learning from Past Transport Revolutions

Overview

There have been two kinds of change in human mobility since hominids began exploring the African savannah: incremental change and revolutionary change. For much of history, people made incremental improvements to their inherited technology and practices for moving about. Tinkering with wheels, sails and engines produced real transport advances, but these gradual changes do not provide understanding of what makes a transport revolution occur and where it can lead. This chapter focuses on revolutionary changes: the more dramatic instances of rapid shifts from prevailing to new mobility patterns. These sudden changes were disruptive. They broke patterns of how people relied on technology for enabling mobility and they quickly changed expectations of what the norm in trade and travel was. These revolutions thus show how transport alternatives can reshape society.

We discuss earlier revolutionary changes in this chapter to help readers of this book think about the revolutionary changes in transport that we expect will occur during the early part of the 21st century. With the possible exceptions of riding a new high-speed train in France or receiving confirmation that their first overnight express package arrived, few readers will have personally experienced a transport revolution at around the time it was launched. Our five vignettes of past transport revolutions should help evoke those dynamics of change that, sooner or later, will become a lived experience for those reading this book.

What do we mean by a revolutionary change in transport? We need a definition that provides a clear, measurable distinction between an incremental change and a revolutionary change. Here is our proposal: **a transport revolution is a substantial change in a society's transport activity – moving people or freight, or both – that occurs in less than 25 years**. By 'substantial change' we mean one or both of two things. Either something that was happening before increases or decreases dramatically, say by 50 per cent; or a new means of transport becomes prevalent to the extent that it becomes a part of the lives of 10 per cent or more of the society's population. The two key features of our definition are these: first, there is a change in how people or freight move; the mere availability of a new technology does not constitute a revolution. Second, the change occurs relatively quickly; by our definition, horseback riding would not qualify as revolutionary because its extensive adoption likely took hundreds or even thousands of years.

A new technology such as the unicycle or the Segway is not revolutionary until it results in a significant shift in the way people travel. This could take the form of a large number of new trips using the new mode or a shift to the new mode from an existing mode such as bicycling or walking. Even 'big' technological advances such as the Boeing 747 or the Airbus A380 aircraft do not count as revolutionary unless they result in large, rapid changes in transport activity.

Our concept of a transport revolution is thus behavioural, and differs from the usual way of characterizing transport revolutions in terms of availability of transport modes or technologies. An example of a more conventional characterization is in Table 1.1.

In this chapter, we present five examples of transport revolutions that expose the common and uncommon elements of major mobility change. Through these examples we identify some of the factors and forces that precipitate revolutionary rather than evolutionary mobility change. Our

Table 1.1 *Transport revolutions in human history*[1]

Era	*Approximate Date*	*Ways of moving people and goods*
Palaeolithic	From ca. 700,000 BP	First migrations of hominids from Africa
	From ca. 100,000 BP	First migrations of modern humans from Africa
	From ca. 60,000 BP	First migrations by sea to Australasia
Agrarian	From ca. 4000 BCE	Animal-powered transport
	From ca. 3500 BCE	Wheeled transport
	From ca. 1500 BCE	Long-distance ships in Polynesia
	1st millennium BCE	State-built roads and canals
Modern	1st millennium CE	Improvements in shipbuilding, navigation
	From early 19th century	Railways and steamships
	From late 19th century	Internal combustion engines
	From early 20th century	Air travel
	From mid 20th century	Space travel

Note: BP = before the present; BCE = before the common era (i.e. before Year 1 in the Christian dating system); CE = common era.

examples are meant to be illustrative rather than exhaustive of the range of factors associated with a significant reconfiguration of transport technology and socio-economic organization.

We begin with a transport revolution motivated by the belief that Britain's industrial revolution was generating more goods movement than existing roads and canals could accommodate. Britain's emerging railway entrepreneurs believed that the steam locomotive offered a technology that could deliver a faster and cheaper mobility option and thus generate considerable profit while meeting future demand. **A belief that existing transport is inadequate and that major improvements are required can thus be a key factor spurring the investment and risk-taking required to launch revolutionary new mobility.**

A different kind of transport revolution occurred during the Second World War, when the US suddenly restricted the production and use of automobiles, and the expansion of its road network, in order to accelerate military mobilization. **This revolution highlights the role that governmental authority can play in reorganizing mobility when national security is perceived to be at stake.** In this case, the reorganization was achieved through the imposition of gasoline rationing and industrial planning, used as tools to redesign radically the way people moved locally and between cities. By 1942, the private automobile had lost its place at the forefront of America's mobility growth. Intercity trains and local public transport were filled as they had never been before and mostly have never been since. This transport revolution ended as suddenly as it began, with a quick downsizing of military production and a rush back to car production that set the stage for a great suburban expansion.

Between 1950 and 1975, the third transport revolution we describe involved a profound transformation in the way people travelled over long distances. The rapid replacement of ocean liners by aircraft as the main means of travelling across the Atlantic represented a revolution in the intercontinental movement of people. **A key element of this change was the adaptation of transport technology invented for military use** – jet aircraft – to yield dramatic performance improvements in an existing mode. This example also shows how a revolution can trigger the subsequent reinvention of an apparently obsolete transport mode: in this case the reincarnation of the ocean liner as a cruise ship.

Our fourth example concerns another approach to adaptation where the innovation in technology occurs under public-sector initiative with a civilian focus. The reinvention of the passenger train began with the introduction of high-speed rail in Japan in 1964 and in Europe by 1982. Limitations of existing train technology and enterprise structure prompted innovators to 'go back to the drawing board' and develop a new railway system that had little in common with its predecessors. The result was a major change in the way that people travelled between cities 300–800 kilometres apart. **This transport revolution reinforces the concept that mobility options can be reinvented after a period in which they experience decline in the face of competition.**

From 1980 onwards, the movement of cargo by aircraft underwent a transport revolution that rounds out our consideration of these upheavals. Before this revolution, air cargo was being moved almost entirely in the holds of passenger aircraft, with limited integration into ground transport networks. Entrepreneurs at Federal Express applied 'hub and spoke' routing to flights carrying only cargo, integrated these with door-to-door delivery, and launched a revolutionary expansion in freight movement. From being an exceptional and expensive proposition, next-day delivery times became commonplace. This transformation in air freight service levels made it possible to develop global logistics networks that could support production and distribution on an unprecedented scale. **It shows how organizational changes can be as important for a transport revolution as changes in technology.**

We chose to explore these five transport revolutions because they illustrate a range of dynamics that could be expected to occur in coming transport revolutions. In their impact, they have not necessarily been the most important revolutions. Moreover, only some of their attributes will appear in the coming round of mobility changes. With an understanding of how things have happened in the past gained through review of these revolutions, there could be less surprise at the scenarios for revolutionary change presented later in the book and possibly even less surprise at the changes that will eventually occur.

Had we been seeking out transport revolutions of the greatest magnitude, rather than those that illustrate a broad spectrum of change dynamics, we might well have included the transformation of global logistics and manufacturing enabled by widespread adoption of standardized shipping containers. According to one economist, 'The shipping container may be a close second to the Internet in the way it has changed the international economy, and in that way, our lives.'[2] Box 1.1 provides excerpts from a recent book that elaborates this point. We provide current data about the movement of shipping containers in Chapter 2.

Box 1.1 Shipping containers[3]

On April 26, 1956, a crane lifted fifty-eight aluminum truck bodies aboard an aging tanker ship moored in Newark, New Jersey. Five days later, the *Ideal-X* sailed into Houston, where fifty-eight trucks waited to take on the metal boxes and haul them to their destinations. Such was the beginning of a revolution.

A soulless aluminum or steel box held together with welds and rivets, with a wooden floor and two enormous doors at one end: the standard container has all the romance of a tin can. The value of this utilitarian object lies not in what it is, but how it is used. The container is at the core of a highly automated system for moving goods from anywhere, to anywhere, with a minimum of cost and complication on the way.

Merchant mariners, who had shipped out to see the world [now have only] a few hours ashore at a remote parking lot for containers, their vessel ready to weigh anchor the instant the high-speed cranes finish putting huge metal boxes off and on the ship.

… at a major container terminal, the brawny longshoremen carrying bags of coffee on their shoulders [are] nowhere to be seen.

A 35-ton container of coffeemakers can leave a factory in Malaysia, be loaded aboard a ship, and cover the 9000 miles to Los Angeles in 16 days. A day later, the container is on a unit train to Chicago, where it is transferred immediately to a truck headed for Cincinnati. The 11,000-mile trip from the factory gate to the Ohio warehouse can take as little as 22 days, a rate of 500 miles a day, at a cost lower than that of a single first-class air ticket. More than likely, no one has touched the contents, or even opened the container, along the way.

The container, combined with the computer, made it practical for companies like Toyota and Honda to develop just-in-time manufacturing … Such precision … has led to massive reductions in manufacturers' inventories and corresponding huge cost savings. Fewer than one-third of the containers imported through southern California in 1998 contained consumer goods. Most of the rest were links in global supply chains, carrying what economists call 'intermediate goods', factory inputs that have been partially processed in one place and will be processed further someplace else.

BRITAIN'S RAILWAY REVOLUTION OF 1830 TO 1850

By the 1820s, Britain's industrial activity and global trade required the movement of large volumes of raw and finished materials between her cities. Most of this movement was on the extensive network of canals built up over the previous 50 years. Despite the significant profits generated for canal owners, canal capacity was not expanding as fast as the demand to move goods, and something more was needed. Some of the most intensive freight movement occurred between Liverpool, England's major Atlantic seaport of the 19th century, and Manchester, a rapidly growing industrial centre located 50 kilometres (about 30 miles) inland.

The considerable growth of freight transport made conditions ideal for developing new transport capacity. Between 1820 and 1825, the number of ocean-going vessels docking annually at Liverpool rose from 4746 to 10,837, with a commensurate increase in the weight of goods shipped.[4] Henry Booth, one of the entrepreneurs behind the ensuing railway revolution, characterized the Liverpool to Manchester mobility needs as ripe for a breakthrough. In 1824, 409,670 bags of American cotton arrived in Liverpool, much of it destined for Manchester's textile factories. The wealth generated by industrial development and colonial trade had spurred population growth in both cities, with Liverpool counting 135,000 inhabitants and Manchester 150,000 in 1824.[5] Each day in

1825, 22 horse coaches made the three-hour journey between the two cities, with up to seven more added when demand warranted.[6] They provided a total daily capacity of 688 passengers in each direction.

In 1820, three canal routes carried cargo between Liverpool and Manchester in circuitous routes of up to 80 kilometres. Journey time for the flat-bottomed canal boats, each carrying up to 29 tonnes (about 32 short tons), was 12 to 18 hours. Even with three alternative routes, canals were a profitable investment during their heyday. One estimate noted an annual return of over 50 per cent on the Duke of Bridgewater's investment in his privately held canal.[7] Another study documented that shares in the publicly traded Mersey & Irwell Navigation Company grew in value from the initial issue price of £70 in 1736 to £1250 in 1825, and paid an annual dividend of £35 per share.[8]

These profits, and the canals' limited capacity, led to discontent among Liverpool merchants and Manchester industrialists. Some were keen to invest in an alternative that promised strong competition for the canals in terms of cost and speed. They noted that Britain's first steam-hauled railway, the Stockton and Darlington, had produced an immediate reduction in the cost of transporting coal, and thus its price. One year after the railway opened in 1825, the price of coal at Stockton had fallen by more than 50 per cent.[9]

The first public prospectus for the 'Liverpool and Manchester Rail-Road' [*sic*] was issued in October 1824. Seeking to both raise investment capital and build public support for this project, the prospectus suggested that a new means of mobility was needed to serve the public interest by improving on the status quo:

> *… the [rail] transit of merchandise will be effected in four or five hours, and the charge to the merchant will be reduced at least one-third. Nor must we estimate the value of this saving merely by its nominal amount, whether in money or in time: it will afford a stimulus to the productive industry of the country …*
>
> *It is not that the water companies have not been able to carry goods on more reasonable terms, it is that they have not thought proper to do so. Against the most arbitrary exactions the public have hitherto had no protection, and against indefinite continuance or recurrence of the evil, they have but one security: IT IS COMPETITION THAT IS WANTED.*[10]

This argument for meeting mobility needs by a wholly new means attracted support from shippers and manufacturers. The railway revolution also faced vigorous opposition from sceptics who perceived it as a threat. Canal and turnpike operators suggested that the railway could wipe out the value of their investments and thus undermine the British economy. Simon Garfield quotes Cornwall Member of Parliament James Loch, who served as auditor of the

Bridgewater Canal, as demanding a high threshold of proof before Parliament chartered any more railways because '… it can never be advantageous to a country that much of its capital should be unnecessarily annihilated and a vast number of persons dependent on the existence of that capital reduced to poverty, except [when] such a sacrifice is demanded on the clearest public necessity, founded on incontrovertible general principles'.[11]

Such proof was hard to establish. There was little commercial experience to draw from. Moreover, accurate surveys for future rail lines were vigorously resisted by landowners who saw the insertion of rail infrastructure across their property as a costly disruption. Initial surveys of the Liverpool and Manchester railway had to be conducted at night, sometimes under false pretext, to overcome landowners' refusals to allow railway survey parties access to their property.

The Liverpool and Manchester's proponents failed to secure enabling legislation from Parliament in 1825. Opponents characterized the uncertainties associated with rail transport as presenting excessive risk, which, at the outset of transport revolutions, can appear especially formidable. Financial risk could ruin investors in canals and turnpikes. Safety risk could injure or kill passengers, employees and bystanders in horrific accidents. Environmental risk could undermine agriculture and wildlife once the English countryside was penetrated by machines generating enormous quantities of noise and smoke. At the outset of some transport revolutions, the risks of breaking away from existing technology and established organizational arrangements can be magnified by the uncertainty of what might unfold. But the growing demand for mobility did not ease up, and may have even been stimulated by a pre-emptive 25 per cent reduction in canal charges.[12]

By 1826, when Parliament did approve the Liverpool and Manchester's charter, some key sceptics had been won over. The Marquess of Stafford, who then controlled the Bridgewater Canal, was enticed to become a major shareholder in the railway. He was offered 1000 shares in the Liverpool and Manchester at £100 per share. This was one-quarter of the railway's initial capitalization and offered the opportunity to appoint three members to the company's board of directors.[13]

Major landowners along the rail line became convinced that their natural resources and agricultural produce would be worth more if trains could carry them to new markets. Not all the advances in support for this project came through a clearer understanding of what the railway could do. The 1825 legislative proposal had been definite about the intended use of steam locomotives. The 1826 act and debate surrounding it left the matter of propulsion intentionally unspecified. If steam locomotives did not prove themselves, the Liverpool and Manchester's promoters would rely upon other means. The uncertainty over how much a new technology would become a part of this new venture appeared to facilitate sceptics' acceptance of this transport revolution.

Table 1.2 *Expected and actual performance of the first trains to carry passengers and freight*[15]

	Expected (1st year)		*Actual (1st 6 months)*	
	Number	*Net revenue*	*Number*	*Net revenue*
Passengers	90,000	£10,000	188,726	£43,600
Freight (tonnes)	305,000	£70,000	36,400	£22,000

The technical innovation behind this revolution was introduced to a large audience at the now famous Rainhill steam locomotive trials of 1829, held well into the Liverpool and Manchester railway's construction. George Stephenson's 'Rocket' achieved immortality for itself and its designer by hauling heavy loads and reaching a top speed of 48 kilometres per hour (reported as 30 miles per hour). This performance made quite an impression on those who saw it and on the many more who read reports about the event in the UK and US newspapers. The Rocket's tour de force set a new benchmark for inland transport because,

> *Rainhill demonstrated that man was now freed from the constraints of animal power for land transport, that he was going to be able to travel two to three times faster than animal power had ever permitted, with consequent reductions in journey times … This was widely understood at the time (though not invariably accepted immediately). All the improvements made to transport over the preceding century with much effort were insignificant by comparison …*[14]

The Liverpool and Manchester Railway's commercial results proved to be similarly dramatic following inauguration on 15 September 1830. Performance during the first six months is shown in Table 1.2 in comparison with what the railway's architects had anticipated five years previously. The expectation that more would be earned from freight than from passengers turned out to be wholly wrong.

Faced with new competition, canal companies lowered their rates and thus attracted shipments that were both less time sensitive and more price sensitive than the goods moving by rail. Ransom notes that profits on the Bridgewater canal stopped growing after the Liverpool and Manchester railway was inaugurated, and

> *though goods traffic on the L & M railway increased over the ensuing years, so, in general, did traffic on the Bridgewater Canal … Even the canal's passenger traffic continued and was not decimated as the road coaches were – it seems that although the waterway journey between*

> *Liverpool and Manchester took longer than the rail journey, it was also cheaper. The eventual ascendancy of railways over canals was a much more gradual affair than their ascendancy over roads …*[16]

Canal operators thus adopted a new commercial strategy following the railway revolution that has kept their business going to this day. Those in the road transport business also made adjustments to accommodate the much greater efficiency and speed of railway transport in moving people. These changes required embracing a wholesale substitution of rail for coach in moving passengers between cities.

Intercity horse coaches could not compete with the railway on either speed or price. Before the railway, coach journeys from Liverpool to Manchester took three hours at prices of twelve shillings for an inside seat and seven shillings for an outside perch. The train cut the travel time to two hours. A seat cost seven shillings for first class and five shillings for second class, which was itself more comfortable than the interior of a horse coach. The full capacity of the coach services between these two cities had peaked at 108,000 travellers per year before the railway, but the Liverpool and Manchester carried 460,000 passengers in its first year.[17] Faced with such a competitor, horse coach operators did one or both of two things: they joined the rail revolution as investors and partners, and they shifted their operations to provide much more local mobility.

Coach operators quickly shifted their intercity operations to much more local 'omnibus' service, carrying people on short journeys that railways did not serve. They also began moving freight to and from the nearest railway station. Once the railways reached London, the city's two largest coach operators, William Chaplin and B W Horne, merged their businesses in 1846 and became major carriers for the railways.[18] Horne also bought into the London & South Western Railway and became its chairman. Horse-powered coaches quickly disappeared from Britain's intercity roads, but they remained a fixture of local travel for decades following the railway revolution.

The discrepancy between pre-construction expectations and the actual performance highlights two outcomes often arising from transport revolutions. First, new transport revolutions often produce results that differ considerably from the predictions made about their future. Second, established organizations that were delivering mobility before the revolution rarely quit the business. Instead, they attempt to refocus their mobility offerings to take account of new competition and reposition their service.

Britain's railway revolution marked a major milestone in expanding the efficiency, speed and capacity of overland transport. The growing demand for goods and passenger movement during the Industrial Revolution encouraged the integration of available technologies such as iron rails and steam engines to produce faster, more reliable and cheaper inland mobility over long distances. Once the potential of this breakthrough was evident, existing transport technology and techniques were adapted to provide other forms of mobility, filling niches that the steam railway could not serve well (at least in its infancy). As a result, British society experienced a quantum leap in mobility, while the canal and horse coach continued to move people and goods over and above what the growing railway network could deliver.

Britain's railway revolution ushered in a new era of mobility that was incompletely anticipated by both its architects and those who were sceptical of such massive change to the transport system. The new mobility was eagerly embraced by those who could subsequently afford to travel or to buy products that were shipped using the new transport capacity.

The great wartime pause in motorization in the US

The great pause in the growth of mass motorization that occurred during the Second World War receives scant attention in most accounts of transport achievements in the US. The dramatic abatement in the production and use of motor vehicles is typically viewed as an anomaly compelled by the necessity to shift manufacturing from civilian to military production, and the rationing of key resources including rubber and gasoline. Driving less was thus seen as just another of the many sacrifices demanded from Americans during the war, like meatless Tuesdays and drinking coffee without cream or sugar. Yet this understanding of temporary sacrifice captures only part of the story behind the most ambitious effort in the US to date to restrain personal mobility. This effort deserves closer attention in order to understand the full story behind the transport revolution that put the growth in mass motorization on hold so decisively and so effectively.

All belligerents in the Second World War limited civilian automobile production and restricted the use of cars, but the scale of motorization in the US going into the war put her effort to restrict the automobile in a class by itself.[19] In 1941, Americans owned almost 30 million cars, about three-quarters of the world total.[20] Those cars were driven a total of more than 440 billion kilometres. Annual vehicle production in 1941 was 3.8 million cars, an output that had been exceeded only in 1928, 1929 and 1937. Indeed, as wartime destruction spread across Europe, civilian auto production in America picked up because more Americans were working in military production and thus earning the means to purchase cars. Automakers were profiting greatly from this indirect, but quite powerful, boost to their sales produced by the start of hostilities in Europe.[21]

As the war expanded, the stakes involved in curtailing automotive production were very high. Gropman wrote that in 1941, automobile manufacturing in the US 'was equal to the total industry of most of the countries in the world' and went on to explain the implications for industrial production:

> *…[it] was spread over 44 states and 1,375 cities … More than 500,000 workers produced autos and trucks when the United States entered the war – one out of every 260 Americans. And 7 million others – one out of every 19 Americans – were indirectly employed in the industry. Automobiles consumed 51 percent of the country's annual production of malleable iron, 75 percent of plate glass, 68 percent of upholstery leather, 80 percent of rubber, 34 percent of lead, 13 percent of copper, and about 10 percent of aluminum.*[22]

With auto production taking up so much manpower and resources, the US could not meet its military production needs at the speed demanded when it entered the war in December 1941 without reducing the number of cars being built. The key question was how far to go in converting car production capacity to military manufacturing? Government and industry failed to answer the question before Pearl Harbour was bombed, setting the stage for a transport revolution.

On 29 May 1940, after Holland and Belgium capitulated to invading German forces, and less than one month before France's surrender, the US became serious about industrial mobilization. President Roosevelt signed an administrative order establishing the National Defense Advisory Commission (NDAC). The Commission was charged with developing a voluntary plan to reorient American industry towards military production. NDAC's transport division was chaired by Ralph Budd, president of the Association of American Railroads. Budd was strongly averse to government intervention. Under Budd's leadership, the transport planning efforts undertaken by NDAC were 'usually preliminary or perfunctory' because 'Protecting the transportation sector from the regulatory hand of government remained Budd's first priority'.[23]

Railroads were not the only industry to resist closer links to defence mobilization, and by 1941, NDAC had achieved so little that the Roosevelt administration brought the effort to mobilize industry within government. The Office of Production Management (OPM) was created to orchestrate military manufacturing and the Office of Price Administration and Civilian Supply (OPACS) was launched to regulate non-military production at a level that could support optimal military output.

Both OPM and OPACS negotiated with the automotive industry, yielding rival plans for converting civilian vehicle production to military output. OPM shared the auto industry's perspective on manufacturing priorities, likely the result of its two chief negotiators' backgrounds in the automotive sector. OPM's negotiations were led by William Knudsen, who had been a vice-president of General Motors Corporation, and John Biggers, a former executive at the Libby–Owens–Ford Glass Company, a major automotive supplier. They accepted industry's contention that not all auto production facilities could be converted to military manufacturing, and that there was nothing to be gained by stopping production at the plants that had no defence production capabilities. The OPM plan proposed a remarkably precise 20.15 per cent reduction in the output of personal vehicles (i.e. cars) between 1 August 1941 and 31 July 1942.[24]

OPACS had a different plan. Director Leon Henderson and assistant administrator Joseph Weiner were academics trained in economics and law. They approached the need to reduce auto production from a broader perspective that sought to balance inputs and outputs across sectors. Henderson and Weiner were particularly concerned that the auto industry's enormous appetite for raw materials would cripple other economic functions. For example, steel going into passenger cars would hamstring food processing plants that required steel for canning. Weiner was confident that sharply restricting the output of passenger cars would pose fewer difficulties than trying to maintain production. He claimed 'That the civilian population can get along without them [passenger cars] in time of emergency and that such existing goods can be made to last longer was demonstrated during the depression and undoubtedly will be demonstrated in the present war.'[25]

OPACS pressed for a 50 per cent reduction in auto production, more than twice that proposed by OPM. In late August 1941, a plan was reached to reduce car output by 6.5 per cent in the coming quarter, with cuts increasing each quarter thereafter to reach a 43.3 per cent overall reduction by the summer of 1942. This plan was just starting to be implemented when Japan attacked the Hawaiian Islands on 7 December 1941.

The War Production Board (WPB) replaced OPM on 16 January 1942, and its chair Donald Nelson wasted no time in calling a halt to US car production. His first official act was to order a cessation of all passenger car production and light trucks by 10 February 1942.[26] **The industry's claim that its manufacturing capacity could not be converted to military production was quickly disproved as the major manufacturers pulled car assembly lines apart, retrofitted as much as 75 per cent of this machinery to produce war materiel from anti-aircraft guns to heavy bombers, and literally threw the remaining material and equipment into scrap heaps.** One month after WPB's stop-production order had been issued, automotive capacity was being converted with extraordinary rapidity: '… discarded machinery is pushed out with such great haste that workmen do not even have time to apply a cover or a coating of grease to protect metal against the elements.'[27]

From the 3.8 million personal vehicles that rolled off the assembly lines in 1941, production shrank to just 143 vehicles in 1943. This left more than 25 million civilian vehicles in operation for the war's duration,[28] but two key resources available to run them were in short supply. America's access to natural rubber was cut off in late 1941 by the Japanese occupation of Southeast Asia. Pre-war consumption had been around 600 million tons annually, and by 1941 a stockpile of a year's supply had been amassed.[29] By 1944, the stockpile had shrunk to slightly more than 100 million tonnes despite massive investment in synthetic rubber manufacturing. In the intervening years, new tyres were strictly rationed. Noting that pre-war drivers had replaced an average of one tyre per year, a journalist described tyre rationing as a 'slow paralysis' of America's car fleet and suggested that

> *If businessmen and housewives gauge their driving against standards of absolute necessity, they will find very little of it is imperative. The choice is theirs to conserve tires or to become pedestrians within six months to two years.*[30]

Petrol (gasoline) rationing began in 17 states along the East Coast from the middle of May 1942 and was extended nationwide by December of that year. It was necessitated not by any lack of petroleum supply, which the US had in relative abundance at that time, but by constraints on transporting fuels from refineries along the Gulf and West coasts that had shipped the bulk of their output by ocean-going tankers. These ships had come under attack by submarines, and were being diverted to supply military operations in Europe and the Pacific. Government officials emphasized the grave risks facing those who moved oil by tanker to justify the utmost efforts to conserve petrol (see Box 1.2).

BOX 1.2 WARTIME APPEAL TO REDUCE PETROL CONSUMPTION[31]

WASHINGTON, 23 April, 1942 – Following is the joint appeal to automobile owners issued by Harold L Ickes, Petroleum Coordinator; Donald Nelson, War Production Board chairman; the Price Administrator, Leon Henderson; J B Eastman, Defense Transportation Director, and the War Shipping Administrator, Emory S Land:

It is not possible to transport enough petroleum to the seventeen Eastern States to meet both essential war needs and normal civilian demands. Very substantial reductions in gasoline consumption must be achieved immediately. Motoring-as-usual is out. Already hundreds of men have been lost at sea trying to bring in the oil needed for war. No patriotic American can or will ask men to risk their lives to preserve motoring-as-usual.

Since the sailors' lives are at stake every time a tanker plies between the Gulf Coast and the East, it is unthinkable that they be asked to take the risk of going down on a burning ship in order that some one may have gasoline to go to a bridge party or the ball game. In fact, it is unthinkable that they be asked to take this risk for any purpose except to fill those requirements which are absolutely essential.

If a motorist fills up the tank to go to a picnic, some defense worker may not be able to get to his job. If a man drives to work alone every day, instead of working out a car-sharing plan with his neighbors, he may take gasoline from a truck that is hauling for a war plant.

Motorists are asked by their government to reduce their gasoline consumption to the absolute minimum – not any specified percentage, but as much as they possibly can.

Government officials did not hesitate to regulate the ways in which civilians used cars during the Second World War. For most of 1943 a ban on 'recreational' driving was in effect. Those caught by vigilant police officers were summoned before local rationing boards and could be stripped of their gasoline coupons as punishment. The hearings were open to the public and covered by the press to drive the message home, as described in Box 1.3.

BOX 1.3 PUBLIC HEARINGS ON WARTIME DRIVING BAN VIOLATIONS[32]

Beginning Tuesday, all the neighbors may come in and hear accused pleasure drivers try to explain to local rationing boards why they should not be penalized by the confiscation of some or all of their gasoline coupons.

Until now, the hearings, which in this city have resulted in several dozen penalties of varying severity in the last two weeks, have been in private. With the shift of scene, from 535 Fifth Avenue to local boards throughout the city, the hearings will be public, Russell H. Potter, acting district manager of the Office of Price Administration, announced last night.

Close cooperation between police in many parts of the East Coast area and OPA officials in speeding cases was praised by Mr. Potter. In several recent cases and in more still to be heard, he said, speeders have been fined in police courts and then reported to the OPA, which has taken away some of their coupons for having wasted gasoline and rubber.

Mr. Potter said he had informed all local boards in the twelve county districts that hearings on pleasure-driving charges are to be public. Motorists who have been cited will have an opportunity to testify and, if they wish, to produce witnesses. Motorists who are found guilty may appeal to the district OPA office.

Among the penalties announced yesterday was one of six coupons – the equivalent of eighteen gallons of gasoline – imposed on Charles Gabriel of 70-23 Seventy-first Street, Glendale, Queens, who went Sunday-driving with a girl companion in his car along the Grand Central Parkway, Queens.

According to the OPA inspector and motorcycle patrolman who halted the car Jan. 10, Mr. Gabriel said he was following a soldier friend who was driving a motorcycle to help if the motorcycle should break down. According to Mr. Potter, all of the motorists in the latest set of cases, including Mr. Gabriel, admitted infractions of OPA rules or orders. Among them was Mrs. Lena Adler, who gave her address as 1932 Narragansett Avenue, The Bronx. Mrs. Adler's A book was taken up last Sunday when her chauffeur driven car let a passenger off at a Bronx theatre. Mrs. Adler at the time protested to an OPA inspector that she was on her way to a cemetery and would 'fight this through to a finish'. She was fined four coupons.

As well as the stick of cancelling the rations of wasteful drivers, there was the carrot of extra rations for participants in 'car sharing clubs' that pooled travel by neighbours or co-workers in a single vehicle. News reports emphasized the positive and suggested that the car in wartime was becoming a 'sociable drawing room on wheels'. Reporting on this new phenomenon, Coan wrote,

… car sharing – also called the group riding plan or club and many other names – establishes a new outlook on motoring. That basic American institution, the automobile, is undergoing changes. Drivers are learning to know one another. Through proximity, they are taking the chips off their shoulders. [33]

Figure 1.1 *Poster promoting car-sharing produced by the US government during the Second World War*[34]

Major war production plants joined in the transport demand management effort by charging workers a fee of ten cents for each empty seat in their car on entering their parking lots. Government advertising reinforced the message that car travel should be shared wherever possible. The poster shown in Figure 1.1 illustrates the graphic connections that were made between conservation and patriotism and between wasteful driving and aiding the enemy.

Americans proved quite accepting of these changes to their mobility, perhaps because a majority did not yet consider cars to be essential to daily life.[35] A Gallup poll in January 1942 asked a nationwide sample, 'If it were not possible for you to use your car, would this make any great difference to you?' A majority of 54 per cent answered there would be no great difference and 73 per cent said they could get to work without a car.[36]

Another reason for the openness of the US to this transport revolution was its participatory implementation. In Canada and the UK, petrol rationing was administered by civil servants. In the US, rationing boards were run largely by volunteers. Derber notes that 'the board of neighbors idea facilitated the recruitment of many prominent and highly capable citizens who would have otherwise been unobtainable. This resulted in both securing community acceptance for rationing and in providing a very capable rationing board.'[37]

The number of car vehicle-kilometres declined by 41 per cent from 1941 to 1943, rising slightly in 1944 and a little more in 1945.[38] Car sharing met some of the mobility demand, but many travellers turned to public modes of transport including buses and trams (streetcars), and local, regional and intercity trains. This turned out to be a 'golden age' for public transport in the US, one that would be followed by a steep and long-lasting decline.

The success of local public transport and intercity railway carriers in providing for a surge in traffic while facing wartime restrictions on equipment, fuel and personnel was an extraordinary accomplishment. Passenger trains' share of intercity travel rose fourfold from 8 per cent of total passenger-kilometres in 1941 to 32 per cent in 1944, and intercity bus travel more than doubled, from 4 to 9 per cent (see Figure 1.2).[39] Rail's share of freight movement increased from 61 per cent of total tonne-kilometres (tkm) in 1940 to 72 per cent of a much larger total in 1943.[40] Public transport ridership rose dramatically from 1940, when close to 13 billion trips were recorded, to 1946, when there were some 23 billion trips.[41]

Wartime travelling conditions were far from comfortable. Most trains and buses were crowded, schedules for long-distance trains were particularly unreliable, and railways and transit companies were perennially short staffed. Some sense of the conditions under which people travelled by train and bus during this transport revolution is offered by Cardozier, who wrote,

> *… the demand for transportation exceeded the supply and travelers became accustomed to long waits and discomfort. … passenger trains*

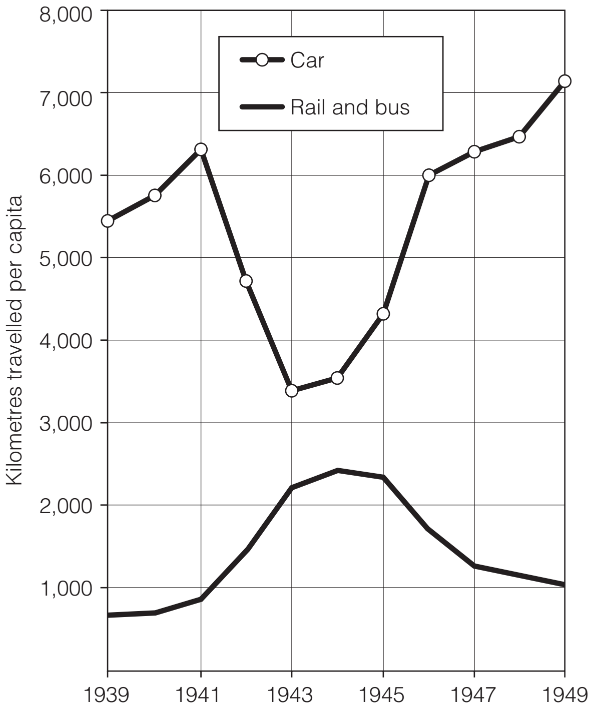

Figure 1.2 *US intercity travel, 1939–1949*[42]

> *… were always crowded; it was not unusual to board a train and find dozens of soldiers and sailors sleeping on the floor. Any limitations on the number passengers allowed per car were ignored, and trains accepted passengers as long as there were places for them to sit, stand or lie down.*[43]

Public transport providers, most of which remained privately owned, were aware that service quality was generally poor and that extra efforts would be needed to retain their new riders once wartime restrictions were lifted. In its 1945 *Transit Fact Book*, the American Transit Association adopted a defensive tone:

> *A decline in traffic after the war was inevitable. Every management recognized that. The problem is to hold the decline to a minimum. That means that new equipment must be procured at the earliest possible moment and that maintenance of equipment must be restored to pre-war standards or better as fast as the manpower and materials to do it can be obtained.*[44]

As the end of war drew within sight, government officials guiding the civilian economy shifted their priority from maximizing efficiency to stimulating production. Their primary goal was to avoid a steep recession, as had occurred following the First World War's rapid demobilization. Their solution was to boost civilian industries that could pick up as much as possible of the manufacturing capacity created over the previous three years. The winding down of military production was seen to require a parallel winding up of consumer purchasing in order to avoid a steep downturn.

The car took top billing as a product to fill the looming void in manufacturing that would arise once the armed forces were no longer in combat. All the steel, rubber, chrome, glass, leather, gasoline and other materials that could not be spared during wartime would rapidly glut the market unless these commodities could be absorbed into consumer production. And the defence workers skilled in building aircraft, ships and tanks would be readily employable in car manufacturing. This challenge demanded fast action, since 'Within hours after Japan surrendered, billions of dollars worth of government contracts were cancelled, including $1.5 billion in the Detroit area alone, and hundreds of thousands of people were thrown out of work'.[45] Suddenly, rail's efficiency in providing high levels of mobility with low inputs became a liability. Trams and trains were entirely off the radar when government searched for means to stimulate post-war prosperity. WPB authorized car plants to resume vehicle production in the second half of 1945, and 69,500 cars rolled off the assembly lines that year. In 1946, production was back in full swing and over 2 million cars were built.[46]

Intercity passenger train travel became the first casualty of this post-war return to mass motorization. Passenger-kilometres by train dropped by 30 per cent between 1945 and 1946 and by another 30 per cent from 1946 to 1947.[47] Ridership on local public transport reached a peak of some 23 billion trips in 1946, but then fell steeply such that by 1960 there were only about 9 billion trips and by 1971 only 6.5 million, the lowest post-war total.[48] Most intercity railways and many transit companies invested in new equipment after the war, but the pace of producing this more specialized transport technology lagged well behind the mass production of the car. During the several years that it took for new passenger trains, trams and subway cars to arrive in service, momentum had swung against public transport in the US. It would not be until the 1970s that the post-war decline in ridership was reversed. Then, massive government assistance was committed to saving the remnants of the country's passenger trains and public transport operations.

The wartime experiment in putting the brakes on motorization revealed how quickly and dramatically the often characterized 'love affair' with the automobile could be set aside. One key condition for success was the call to sacrifice in the name of a serious threat. Another seemed to be community participation in adjusting the burden imposed by the rationing of fuel and tyres.

The halt to car production ensured that new mobility needs would have to be met by transport alternatives. For example, after 1941, people hired into wartime jobs could no longer buy a new car, but would go to work by public transport or by riding in somebody else's car. A year-long ban on recreational driving spurred the discovery of ways to enjoy free time without a vehicle. Even after the ban was lifted in 1943, the limited supply of tyres and fuel reinforced the perception that a car no longer provided unlimited mobility benefits. The car's wartime mobility role was reshaped by a fixed ration of gasoline and by the unpredictability of having to deal with a flat tyre. Either constraint could leave drivers stuck in a sudden state of immobility that was far more constrained than the public transport services available to those without cars.

What the US wartime experience shows above all is that in an emergency government can act to change transport activity dramatically and effectively. Supported by a clear rationale and sufficient but flexible authority, the US government was quickly able to reduce Americans' reliance on automobility. **Government can be a prime instigator of a transport revolution.**

THE BIG SWITCH IN TRANSATLANTIC TRAVEL IN THE 1950S

Over the past four centuries, the Atlantic Ocean has been the busiest avenue for very long-distance movement of goods and people. Movement between Europe and the Americas was initiated by the rise of empires, and then accelerated by commerce and migration. For most of the time that people have sought to move across the Atlantic, there was little choice about how to make the trip. Ships offered the only option until the 1930s, and remained the predominant means of making this journey during the 1940s and early 1950s. Transatlantic ship crossings had improved from being dangerous and uncomfortable[49] to offering luxury for some and widespread comfort for many travellers, while providing reliable and efficient movement of cargo.

During the 1950s, the balance of options for intercontinental mobility shifted decisively. As shown in Figure 1.3, between 1949 and 1973, air travel across the Atlantic exhibited the kind of unbroken growth that signals a transport revolution. **The number of people crossing the Atlantic by air surpassed those making the journey by sea in 1957**, and in 1958 the first commercial jet planes began flying across the Atlantic, simultaneously expanding the speed and reducing the cost of intercontinental air transport.

During subsequent decades, transatlantic air travel set the pace for transforming flight between continents from an expensive luxury service to a popular mode of transport. This transport revolution grew out of airlines' and aircraft manufacturers' success in commercializing the major advances in military aircraft design and propulsion achieved during the Second World War. Domestic air travel in North America and Europe during the late 1930s would be at least somewhat recognizable to those who have flown recently aboard propeller aircraft, but flying between continents was another matter.

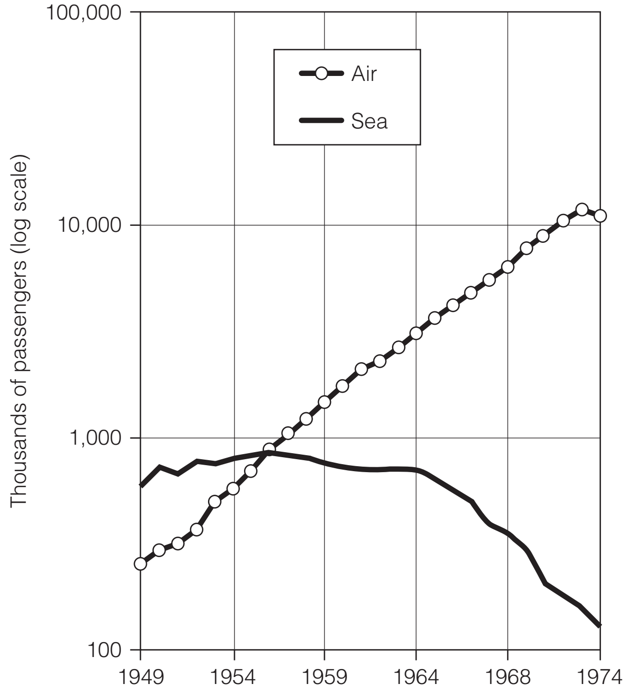

Figure 1.3 *Air vs. sea travel across the Atlantic Ocean, 1949–1974*[50]

During the 1930s, flights linking Europe with Africa, North and South America and Asia were pioneered by carriers using 'flying boats'. The carriers included Imperial Airways in Britain, Pan American Airways (Pan Am) in the US and Australia's QANTAS. These massive propeller aircraft landed and took off on water because existing airport runways were too short to accommodate their take-off requirements. Flying boats were relatively slow and had to make frequent refuelling stops, but still reached their destinations three to five times faster than ships. Pan Am's flying boat from San Francisco to Hong Kong was scheduled over five days and Imperial's Southampton to Sydney service took nine days. Flying boats rivalled the first class service on ocean liners with sleeping berths, dining rooms serving freshly cooked meals, bars and lounges. And the 20 to 70 passengers on these pioneering intercontinental flights paid fares that were up to six times the cost of passage on an ocean liner, roughly equalling what would be charged for a flight on the supersonic Concorde during the 1980s.[51]

Advances in aviation technology during the Second World War rendered flying boats obsolete and set the stage for an intercontinental transport revolution. Virtually all the elements found in today's aircraft were introduced to meet military needs during the period 1940–1945. Jet engines had propelled the German Messerschmitt ME 262 and the British Gloster Meteor in dogfights at Mach 0.8, the cruising speed of today's commercial jets. More importantly for the early post-war period, bombers such as the B-29 were designed to fly long distances above the range of ground-based anti-aircraft guns. These long-range bombers advanced airframe designs enough for later commercial flights to be able to fly across oceans and stay above bad weather. The bigger runways that were built for bombers could accommodate aircraft with the fuel payload needed to fly between continents. Government-led war production had yielded many key ingredients of modern air travel, but a post-war integration was needed to adapt these breakthroughs to a commercial framework that would make intercontinental aviation a part of the transport mainstream.

In 1950, transatlantic flying already represented the world's busiest air travel market.[52] Airlines were then carrying over one-third of travellers crossing the Atlantic.[53] Large pressurized propeller aircraft such as the Lockheed Constellation, DC-6 and Boeing 377 Stratocruiser had replaced flying boats.[54] Air France and Belgium's Sabena had made the least change from the flying boat business model by being the first to offer all-sleeper flights across the North Atlantic in 1947.[55] Given the flight time of 12 to 14 hours, with refuelling stops in Gander, Newfoundland and Shannon, Ireland, providing each traveller with a bed was attractive. But travelling in a bed moving at almost 600 kilometres per hour was a luxury that could be afforded only by the elite. Business leaders, government officials, celebrities and dignitaries who flew across the Atlantic paid a premium fare in exchange for saving three or four days at sea. Many more could not afford the cost of flying. New and refurbished ocean liners served this broader market, thereby supporting a modest growth in business in the early 1950s, illustrated in Figure 1.3.

Ships such as Cunard's *Queen Mary* and *Queen Elizabeth* offered refined luxury and spacious accommodation in first class suites that were priced far above the transatlantic airfare. These great liners, and many lesser ships, also offered spartan accommodation in multi-berth tourist cabins for those who were travelling on a budget. Indeed, **passenger ships had been the first low-cost carriers in international travel for a previous generation**, facilitating the mass departure of Europeans to the New World at 'immigrant fares' as low as £1.50 in 1904.[56]

North American airlines were especially eager to expand their market, and targeted the large US middle class in two ways. Carriers cut their transatlantic fares in the spring of 1952 and introduced 'fly now pay later' credit arrangements to attract American leisure travellers to take their holidays in Europe.[57] The typical two-week vacation period in the US made taking a holiday in Europe by ship impractical. Bringing the price of flying within reach of the American middle class opened up a major market for intercontinental tourism. Transatlantic airlines embraced this opportunity, and their adoption of 'tourist class' was so popular that it remains a synonym for economy airfare. Tourist travel contributed to an accelerated growth in air travel in 1953 and 1954. Meanwhile, Pan Am was pressing aircraft manufacturers to build a commercial jet that could cross the Atlantic without refuelling.

Jet aircraft promised a major advance in expanding air travel through a combination of better performance, higher productivity and lower operating costs in an era where fuel was a near-negligible component of airline expenses.[58] Jet engines were much simpler and thus cheaper to maintain than propeller engines. One study cited airline estimates that a Boeing 707 would yield a 30 per cent reduction in operating costs per seat mile compared to a Lockheed Constellation.[59] **Aircraft productivity would be greatly improved because the seven- to eight-hour flight times between Europe and North America would enable a plane to make a return flight every 24 hours**.

The British de Havilland Comet was the world's first commercial jet. In 1952, British Overseas Airways Corporation (BOAC) inaugurated a Comet service between London and Johannesburg. Even with refuelling stops in Rome, Beirut, Khartoum, Entebbe and Livingstone, the Comet made the trip in 23.5 hours compared to the 40 hours propeller planes had required.[60] However, the Comet lacked the range for a non-stop flight between New York and London or Paris and was beset by a series of initially mysterious crashes resulting from a design flaw that took several years to re-engineer. The Comet's tarnished safety record dealt a setback to the de Havilland's commercial jet development and opened the door for US manufacturers Boeing and Douglas to overtake the British in producing civilian jets. But it would take a push from the US airlines for the manufacturers to seize this opportunity.

Pan Am's competitors appeared satisfied to expand their fleets with large propeller planes, based on manufacturers' claims that commercial jets were not yet ready for the North Atlantic. But Pan Am's president Juan Trippe was intent on pushing Boeing and Douglas to meet his company's needs. To meet Trippe's demand, manufacturers would have to deliver major innovations in airframe and jet engine designs.

Boeing had become the US leader in jet airframe design because of an unusual energy advantage. Designing the first generation of jet aircraft had required wind tunnels producing tremendous airflows to test aerodynamics at close to the speed of sound. Rodgers pointed out that 'Wind tunnels drew vast amounts of current, and the cost of electricity to run them was a major consideration. Because of the newly built Grand Coulee Dam, power in the Pacific Northwest was cheap.'[61] It is thus not a coincidence that America's first civilian jetliner was designed by a company with access to vast amounts of low cost electricity to run a 13.4-megawatt wind tunnel.

The plane that emerged from this test bed was the Boeing 367-80, known as the 'Dash 80', a dual purpose prototype that was intended to yield both a commercial passenger jet and a tanker used for mid-air refuelling of military aircraft. This approach enabled Boeing to spread development and production costs across both military and civilian markets, but it did not offer a design that could carry 160 passengers across the Atlantic non-stop. The factor limiting the Dash 80's length (which determined passenger capacity) and fuel payload (which determined its operating range) was the power of its Pratt & Whitney J-T3C jet engines, the civilian variant of a design powering the first generation of B-52 bombers. However, Trippe knew that Pratt & Whitney was developing a more powerful engine for the military.

In a negotiating coup that became a legend in post-war airline history, Trippe persuaded Pratt & Whitney to move their prototype into production even before any aircraft had been purchased. Trippe threatened to go to the UK and buy from Rolls-Royce if there was no American engine powerful enough to move Pan Am's planes from New York to London or Paris without refuelling. He also committed to buying 120 of these powerful engines even before he had secured any aircraft that could make use of them.[62] After Pratt & Whitney agreed, Trippe played Boeing and Douglas off against each other to design planes that could use these powerful engines for the non-stop Atlantic crossing.

On 13 October 1955, Trippe addressed the annual general meeting of the International Air Transport Association, suggesting that mass mobility by air would 'prove to be more significant to world destiny than the atom bomb'.[63] As a result of Trippe's negotiating acumen, the jet aircraft had come to serve aviation's biggest market faster than would have otherwise occurred. Aircraft manufacturers' incremental adaptation of military designs could have added years to the jet's emergence as the predominant means of trans-Atlantic travel.

The first commercial Boeing 707 flight was operated by Pan Am between New York and Paris on 26 October 1958, three weeks after a BOAC Comet 4 had flown the first paying passengers across the Atlantic by jet. Initially making a refuelling stop in Gander, Pan Am reached Europe in 8 hours and 41 minutes. By the spring of 1959, the 707-320 was flying non-stop between New York and London and Paris at the speeds that are offered today, with Douglas's DC-8 entering the North Atlantic service in September 1959.[64] Over 90 per cent of the seats were occupied, and Pan Am's transatlantic air passenger volumes doubled within five years of launching the 707.[65]

The airlines' bonanza came at a high cost for the aircraft manufacturers. Designing a jet for the transatlantic market had cost Boeing a great deal more than allocated for designing a joint platform civilian and military aircraft. According to one account, '… it wasn't until 1964, nine years after Boeing sold its first 707, and twelve years after the company started heavy spending specifically for the prototype, that Boeing recouped its entire investment in the jetliner … The expenditure on all aircraft delivered to the break-even point was over 2 billion dollars.'[66] Aircraft manufacturers took over a decade to cash in on the jet age, but the passenger shipping industry would take even longer to develop a workable strategy that could adapt to aviation's progress.

Ocean traffic held steady for a few years following the introduction of jets, but steamship lines had to reduce fares to keep passengers sailing. Cunard introduced significant economy fare discounts in 1962, in direct response to competition from jet aircraft.[67] The shrinking revenues occurred at the same time as shipping lines faced growing operating costs. As the resulting losses from operating transatlantic liner services mounted, schedules were cut back steadily during the 1960s. Some ships were redeployed to warm water cruise itineraries during the winter months, while others were simply laid up and sold off, either for scrap or to new operators who could dramatically reduce operating costs.

Although shipping companies had been operating cruises as a sideline to passenger transport since 1844, when P&O Lines pioneered a 'special Mediterranean tour',[68] **the cruise lines that emerged following the beginning of the jet age were specialized carriers, operating symbiotically with the expansion in global tourism that air travel had facilitated**. The full-time cruise ships that emerged during the 1970s were almost exclusively operated under 'flags of convenience' from jurisdictions such as Liberia, Panama and the Bahamas to avoid the high taxes and wages existing in most American and European jurisdictions and thus dramatically reduce operating costs. A 1973 inventory of passenger ships noted that since the jet age arrived on the North Atlantic there had been a 75 per cent decrease in the number of passenger vessels flying the American and British flags and a 40 per cent reduction in French-flagged passenger ships. Conversely, the number of passenger ships flying the Liberian flag had increased by 270 per cent, Panamanian registry had grown 190 per cent and Greek-flagged ships were up 260 per cent.[69]

Cruise lines soon began to work cooperatively with airlines, booking many of their passengers on air packages that included flights to and from their cruise. After 1974, only Cunard's *Queen Elizabeth 2* was making regular crossings between Europe and North America, offering transatlantic passage mostly during the summer months.[70] Today's cruise ship industry is growing and profitable, but it offers a very different kind of mobility from what the ocean liners once provided. For most of today's long-distance ocean travellers, their ship has become a destination in itself whose transport function is only incidental to the 'fun' of cruising. Only a handful of travellers now use ships for travel between continents. Nearly all people disembarking today's great passenger ships head directly to the airport to complete their journey.

This great transformation highlighted the ways in which military conflict can generate technology that becomes available for civilian transport. The same forces that triggered a sudden suppression of civilian travel by automobile during the Second World War produced the infrastructure and technology that would vastly expand mobility once hostilities were over. The longer runways and larger aircraft that were put to civilian use immediately following the war instantly turned pre-war flying boats into museum pieces. While the jet engine took a decade to become widely used in civil aviation, its arrival accelerated the speed and extended the scope of this transport revolution. Once the aircraft manufacturers had been cajoled into building civilian jets, the means to make intercontinental flights a widely used transport option were at hand.

As in the railway revolution in the UK more than a century before, the ascendancy of a faster and more powerful transport alternative did not doom its predecessor to an industrial extinction. Ocean liners largely disappeared, but cruise ships emerged as a thriving and profitable niche for marine transport. Once the technology breakthroughs attained in pursuit of military objectives had diffused through the civilian transport sphere, both flying and sailing were barely recognizable from their previous manifestations, yet both have remained a vital element among the world's transport options.

The high-speed rail revolution of 1960 to 1985

By the late 1950s, growth in aviation and car ownership was drawing travellers away from long-distance trains. For some major railway companies these trends would lead to bankruptcy. That of the Penn Central Corporation was the most spectacular of these downfalls, the largest corporate collapse of its time.[71] In the UK, an investigation into railways' future that came to be known as the 'Beeching Report' proposed major reductions in British Rail's network. It started from the premise that '… the industry must be of a size and pattern suited to modern conditions and prospects'.[72] The modern conditions were seen to require shrinking Britain's rail network to eliminate capacity that was not being used as travellers chose driving and flying alternatives. In 1958, a special inquiry conducted by the US Interstate Commerce Commission also emphasized the fact that travellers were leaving the rails for other mobility modes. The Commission noted,

> *the inescapable fact … seems to be that in a decade or so [the passenger train] may take its place in a museum along with the stagecoach, the sidewheeler and the steam locomotive … [T]his outcome will be due to the fact that the American public now is doing about ninety percent of its travelling by private automobile and prefers to do so.*[73]

But that is not what happened. **The railway's anticipated slide into obsolescence was decisively reversed**. This first occurred through exceptional projects, notably Japan's pioneering Shinkansen between Tokyo and Osaka and France's innovative Train à Grand Vitesse (TGV) between Paris and Lyon. But the passenger train's second arrival as a renewed means of passenger travel has spread across much of Europe, and also beyond Japan to Korea and Taiwan.

The catalyst for this rail transport revolution was the introduction of technology that enabled trains to become much more effective at meeting an important subset of travel needs: trips between 200 and 1000 kilometres along densely populated corridors. This required reconceptualizing the rail mode's historic role as a universal mobility provider. Banister and Hall suggest that the 'strangest point of all' in this exceptional transport comeback is that high-speed trains '… are literally the fastest things on earth … represent an incremental technology, evolving out of the basic steel wheel on steel rail … system that George Stephenson borrowed … from the Northumbrian colliery tramways of his apprenticeship'.[74] **The high-speed rail revolution thus involved creating a new relationship. It was between the train technology that had evolved over more than a century in delivering universal mobility, on the one hand, and the specialized technology that had been developed to move people rapidly over the busiest travel corridors, on the other hand.**

While Europe and North America were extending the frontiers of flying and driving, it was the Japanese who pioneered an organizational and technical redesign of passenger trains that yielded a breakthrough in the rail mode's performance. The attributes of the renewed passenger train were first brought together in the Japanese Shinkansen, which means 'new trunk line'.

First, the railway's role in providing mobility was no longer conceived of as being universal. Instead of being developed around the premise that early railways had embraced, namely that trains could move everything everywhere, the Shinkansen was designed to add new capacity on Japan's busiest transport route, the corridor between Tokyo and Osaka.[75] Plans to build a new rail line between Japan's two largest cities had been approved in 1939, with construction actually starting in 1941.[76] Had this initial development not been destroyed by bombing in 1944, Japan's post-war passenger rail trajectory might have been quite different. For one thing, the pre-war railroad had been run as part of a public bureaucracy that had changed little since the 19th century. In 1949, the Japanese National Railway (JNR) emerged as a public corporation, a new form of public enterprise. This attenuation from the civil service was intended to curb the power of militant public employee unions that appeared threatening to the American occupying government.[77] JNR would enable a more dynamic approach to rail management.

The second ingredient of this transport revolution was significant government support for rail technology research. The breakthroughs in rail vehicles, infrastructure and propulsion systems that made the Shinkansen concept a success were achieved only after the war, when Japan's industrial trajectory was intentionally redirected away from aerospace and military production. During this formative period of the high-speed rail revolution, the UK, Canada, the USSR and the US were devoting much of their research capacity to building new aerospace and atomic energy capacities.[78]

Instead of working for military suppliers and aerospace industries in the early 1950s, some of Japan's top electrical, mechanical and civil engineers were drawn to the Railway Technical Research Institute (RTRI), the scientific arm of the old rail bureaucracy that had become part of JNR. Their goal of developing high-speed intercity passenger trains was something that had dropped off the agendas of other nations' technology policies. In May 1957, RTRI held a conference marking the organization's 50th anniversary. Engineers presented a paper entitled *High Speed Railway in the Future* that outlined how newly designed infrastructure and rolling stock could enable a passenger train to cover the 550-kilometre distance from Tokyo to Osaka in three hours. Key design elements were a purpose-built track and signal system, and the use of lightweight electric multiple-unit trains that could attain unprecedented speeds. The presentation was seen as an 'epoch-making event' in modern railroad development because it was the first time a new technology was put forward to gainsay the conventional wisdom that trains were becoming obsolete.[79]

At the time the RTRI went public with its proposed innovation, Japan's parliament had already approved a five-year plan for incremental upgrading of the narrow-gauge line between Tokyo and Osaka. Such an approach would not have yielded the performance breakthrough that the Shinkansen's designers eventually achieved. JNR's president, Shinji Sogo, created a way to move beyond such incrementalism by launching a special commission of investigation into Japan's railway future in May 1956. Directed by JNR's vice-president of engineering, Hideo Shima, the commission explored the need for an entirely new rail line between Tokyo and Osaka.[80] In a late-life memoir, Shima emphasized the revolutionary spirit that animated his work on railway reinvention:

> *At the time, air and car traffic were showing remarkable growth. I thought that building a line that would soon fall behind the advancing transport world would be regrettable for the future of JNR and in meeting social expectations. I decided to build a railway that would be useful and rational for a long time into the future.*[81]

The commission released its findings at about the time that the RTRI presented its breakthrough in high-speed train technology. Taken together, these findings showed a promising fit between the dramatic growth in travel demand that was projected to require expansion of all modes and the high-speed train's ability to offer a major increase in capacity. The commission's most conservative forecast predicted that travel between Tokyo and Osaka would more than double between 1957 and 1975, while freight volume would more than triple. Even taking construction of a proposed superhighway between Tokyo and Osaka into account, JNR's analysis projected that roads could handle just 10 per cent of the growth in passenger travel and only 5 per cent of the increase in freight traffic.[82]

Within a week of the RTRI symposium, JNR president Sogo formally requested the Ministry of Transport to authorize 'improving' the line between Tokyo and Osaka, known as the Tokaido ('east sea route') line. His request cleverly sought to gain approval in principle for rail development that went beyond the incremental upgrading that had been called for in JNR's five-year plan.[83] Detailed cost estimates of building an entirely new high-speed line or pursuing more extensive upgrading of the existing narrow-gauge line were left to be developed after the government had given a green light to proceed.

Sogo's ability to gain this approval in principle gave JNR momentum in developing more detailed plans for deploying new rail technology. In August 1957, the JNR's Tokyo–Osaka line investigation commission began work and quickly focused on adapting the new high-speed technology to rail's most promising market segment in Japan. What would become the Shinkansen service concept was refined during this phase of analysis. The major innovation was to separate this new rail infrastructure from existing rail tracks and stations. As for most other railways, JNR's infrastructure had been designed to serve many purposes by accommodating local, intercity and long-distance passenger services along with freight trains on the same tracks. The Shinkansen would break from the universal mobility model that had predominated since the Liverpool and Manchester Railway.

Instead of trying to serve all mobility needs at the same time, the Shinkansen would focus on a niche that could take full advantage of the train's improved speed capabilities. Just as aviation innovators were doing during the 1950s, JNR's leadership proved adept at creating a mobility option that could offer the travelling public something new compared with what railways had previously provided and what other modes could deliver. Shinkansen was designed to be faster than a car, while also more frequent, cheaper and more convenient than a plane. This design proved to be a winner, with its first success being a formal approval from the Japanese Cabinet for the project's launch on 19 December 1958.[84]

Gaining a policy commitment to realize the Shinkansen concept was neither straightforward nor inevitable. **Shinkansen sceptics could be found both within Japan's rail industry and abroad**. These critics saw no need for the major expenditure in new technology and infrastructure because they viewed rail technology as being of diminishing value compared to the advances in aviation and road transport. A nation that was determined to catch up with, and even overtake, US and European economic development had made a costly error by investing so heavily in rail.[85] One critic wrote,

> *Unfortunately, motor vehicle and air transport capacity was 10 years too late to save the country from the expense of the Shinkansen … Up until the mid-1950s, JNR did not have the funds to build the Tokaido Shinkansen and if it had waited until the end of the 1960s before deciding whether to launch the project, it would have questioned the need for constructing the new line. Instead, it probably would have added more double-tracked narrow-gauge sections to the high traffic-density areas.*[86]

Financing the Shinkansen tested the resolve and ingenuity of railway innovators, who had to articulate their vision to those who were less inclined to see trains as having a bright future. When Japan's cabinet had authorized construction of the new line in 1958, a budget of ¥194.8 billion was approved, the equivalent of $541 million in 1958 and $3.84 billion in 2007.[87] Japan's fiscally constrained government approached the World Bank for a loan of $140 million for the project ($995 million in 2007 dollars).[88]

After detailed evaluation of the project, the Bank agreed to loan $80 million on 24 April 1961 ($570 million in 2007 dollars). This was the third largest loan that the Bank had made and its largest transaction to date with Japan.[89] *Business Week* reported that the World Bank's support for Shinkansen '… enrages many an American railroad man who would love to have access to similar sources of financing'.[90] But what railway executives outside Japan had not yet grasped, and would take decades to figure out, was that access to a major infusion of capital was dependent on providing something more than just the same kind of mobility that railways had been delivering for decades. In securing the World Bank loan, JNR leadership convinced a major international organization operating at 'arm's length' that a reinvention of the passenger train would succeed. In short, JNR took its transport revolution to the bank.

World Bank funding raised the stakes of the Shinkansen project because the Japanese government's international credit rating now depended on JNR turning this initiative into a commercial success. JNR's strategy was illustrated by an executive, interviewed shortly after the inauguration, who stated, 'We just can't lose money with so much business waiting for us.'[91]

Shinkansen has produced a steady stream of profits on the Tokaido line, offsetting to some extent the losses on additional lines that were developed in less populated and prosperous corridors.[92] One report noted in 2005, 'Income from the Shinkansen lines totals about $19.2 billion per year, which is 47 percent of the JR group's rail operations income.'[93] When JNR was restructured and partially privatized in 1987, the Shinkansen network was valued at ¥8.5 trillion (equivalent to just over $100 billion in 2007).[94] These assets comprised the Tokaido, Sanyo, Tohuku and Joetsu Shinkansen lines, totalling 1833 route kilometres. There have since been 471 additional route kilometres of Shinkansen lines built, making for a current network of 2304 route kilometres; 374 route kilometres are under construction.[95]

The Shinkansen concept has proven itself and created a transport revolution in so doing. In less than 25 years the Shinkansen became the backbone of Japan's intercity rail system, absorbing much of the forecast growth in travel that accompanied Japan's rapid economic expansion in the 1970s and 1980s. Japan's internal air services grew much more slowly than would have been the case without Shinkansen. Between Tokyo and Osaka, Japan Airlines' load factor (share of seats occupied) dropped below 50 per cent during the first year of Shinkansen operation. All Nippon Airways, the other major carrier between Tokyo and Osaka, reported an 8 per cent drop in passengers, in a market that was reported to be growing at 7 per cent annually.[96] By the 1990s, Shinkansen began to show signs of maturity in that annual travel volumes stabilized in the range of 70–75 billion passenger-kilometres a year, and now account for about 30 per cent of intercity rail travel.

Ordinary trains still play a vital transport role, but there is no question that the Shinkansen has become established as the core intercity rail service. As Japan's achievements in reinventing the railway became apparent, the lesson of this dramatic departure from traditional passenger services was not lost on railway entrepreneurs in other countries.

It was France that first succeeded in transplanting the Shinkansen's revolutionary potential into a society with much higher levels of motorization and domestic air travel. By adapting Japan's high-speed rail formula to work in Western Europe, the French established this innovation as a transport revolution with a much greater relevance than many experts had judged possible.

France had a well-developed air and highway network that was expanding to meet post-war intercity travel growth. France thus had a less compelling rationale than Japan for investing in high-speed trains. To deliver a long-term pay-off by reducing the need for highway and airport expansion, the French TGV would need to attract travellers away from cars and planes. This was a different proposition from providing new mobility to people who had not yet become accustomed to the speed of air travel or the convenience of the car. Thus transport experts in the 1970s were equivocal about the transferability of the Shinkansen's success to Europe and North America. But France had a particular impetus to innovate in the rail sector that had not been at work in Japan.

Whereas the management of JNR had conceived of the Shinkansen as a means to build upon an existing growth trend, France's TGV initiative was spurred by a decline in the rail sector, which was losing traffic to air and road competition. To reverse these declining fortunes, French railway management, government officials and rail equipment manufacturers developed a new approach to designing, deploying and operating passenger trains. This required recasting the relationships between government, public enterprise and private industry to deliver a new transport option.

Expending the financial and political resources needed to create a successful future for trains was a higher priority for the French government than for its counterparts in England and North America. French railways had been nationalized just before the Second World War when, in return for taking control of insolvent carriers, the government assumed responsibility for both past rail debts and future rail financing. The Société Nationale des Chemins de fer Français (SNCF) – French National Railways – was created as a 'mixed enterprise' akin to a public–private partnership in today's parlance. The investors who had been bought out in 1938 remained silent partners, holding 49 per cent of the joint venture's equity. Profits from a consolidated and 'modernized' SNCF were to pay dividends to these investors until 1982, when their shares would be repurchased.[97] But the profits never materialized, necessitating that dividend payments be made from the public treasury during SNCF's first 43 years of operation.

SNCF's financing arrangements caused French government officials to encourage private- and public-sector collaboration in an effort to bolster the rail mode's commercial fortunes. This approach contrasted with their US and UK counterparts, who emphasized either public or private efforts to address the rail mode's challenges. British Rail was a fully public enterprise, for which the primary remedy for loss-making services was seen to be the retrenchment proposed in the Beeching report. In the US, private railways took the lead in economic restructuring by petitioning regulatory bodies – notably the Interstate Commerce Commission – for permission to abandon unprofitable services. But in France, the passenger train's incipient decline stimulated a broader consideration of policy options that blended public and private innovation.

In France's public sector, administrative reorganization had been identified as the key to economic renewal in an influential 1967 policy review known as the 'Nora Report'.[98] It presented a set of commercial principles for future operation of publicly owned enterprises, putting '… emphasis upon the need for them to operate as much like private enterprises as possible, putting commercial requirements before public service'.[99] Reluctance to embrace such a paradigm was dispelled by the oil-shock-induced economic crisis of the 1970s, when reducing public enterprise deficits became imperative.

The Nora Report proposed differentiating potentially competitive market services from the social and public interest functions pursued by public enterprise. Where public enterprise was to produce a good, or provided a service, below its cost, a contract would be called for to specify quantities and prices and the subsidy that government would allocate in the public interest. Rather than providing indirect subsidies through accumulating public enterprise deficits, debt write-offs and other forms of creative accounting, the Nora Report called for explicit valuation of what a public service was worth. Conversely, commercially competitive services were given a 'green light' to make money.

SNCF management embraced the Nora Report's recommendations as a validation of their goal to reinvent rail service from within and became enthusiastic adopters of its approach.[100] Application of these principles in 1971 led to creation of a five-year business planning model, contracts with government for non-commercial services, and other aids to give management more effective conditions for commercial development. But in order to reverse the train's commercial fortunes, these tools would need to be deployed in a strategy that focused on meeting new mobility needs.

During the 1970s, SNCF's management began planning to break away from the traditional railway model of offering a universal mobility mode, as the Japanese had done a decade earlier. But SNCF would have to do even better in creating a mobility alternative because the train would now be competing for travellers against established air and road networks. As in Japan, France's point of departure for this transport revolution was its most heavily travelled corridor, between the Ile de France, the region centred on Paris, and the Rhône-Alpes region centred on Lyons, whose respective populations in 1982 were just over 10 million and just over 5 million.[101]

As had occurred in the Tokyo–Osaka travel corridor, the existing rail infrastructure between Paris and Lyon had reached the point of overload. **Adding track capacity was judged essential, but the decision to develop an entirely separate line for high-speed passenger trains and devote existing tracks to freight and local passenger train movements provided the essence of France's rail transport revolution**. SNCF planners set a goal of linking Paris and Lyon by train in two hours to make rail the preferred mobility mode between these cities. A two-hour train ride would thus prove especially attractive to those making a same-day return trip between Paris and Lyon.

The question facing SNCF's leadership was what kind of infrastructure and propulsion technology could yield a two-hour travel time at a cost acceptable to officials who held the French treasury's purse strings? A key factor in reaching an answer was for SNCF to remain integrally involved in developing what would come to be known as the TGV. Like JNR, SNCF became a leader in developing high-speed trains by nurturing its own design and engineering capacity through close partnerships with private manufacturers, rather than by leaving such efforts mostly in the hands of external designers. This approach gave SNCF executives the ability to fend off competing transport innovations, which would have diluted, and quite possibly diverted, their efforts to launch this transport revolution.

The competing French technology that had begun to draw resources and initiative away from TGV development was the Aérotrain, an innovative vehicle suspended on an air cushion, generated by huge turbofan engines, while pulled along a track by linear induction. Research support for this innovation had been provided by France's Regional and Economic Development Ministry, with no participation by the Transport Ministry. During the late 1960s and early 1970s, development of the TGV and the Aérotrain project proceeded in parallel.

This competitive development of new high-speed ground transport resembled German efforts during the 1970s and 1980s to develop both the Inter-City Express, based upon high-speed rail technology, and the super-fast Transrapid, which utilized magnetic levitation technology.[102] Unlike the German Federal Railway, SNCF was able to convince its political leaders that deploying the TGV would meet both commercial and technical needs, and that proceeding with the Aérotrain would squander resources and inhibit a turnabout of the railway's fortunes. As a result, the TGV project moved into advanced development during the 1970s and the Aérotrain project was cancelled.

An important effect of SNCF's partnerships with the railway supply industry was to align the capacity for introducing new rail technology with the pay-offs from deploying it. This linkage between a public railway operator and major private manufacturers made it possible to add an industrial development dividend into the investment calculus applied in making the commitment to high-speed rail. In addition to the revenues anticipated from bringing travellers back to the rails, there would be profits and jobs in an industrial sector that was seen to be shaky.

When considering the trade-offs around a major investment, public officials often tend to value maintaining existing jobs and profits more highly than developing new jobs and future profits. This is especially true if the existing sector appears threatened with industrial decline. French rail manufacturing was sufficiently at risk from a decline in passenger train travel, while also being a beneficiary from the gains of rail revitalization, for this to weigh in favour of government's investing in the TGV. Investing in the less certain pay-off from the Aérotrain's new technology also appeared likely to come at the expense of existing jobs and profits in the rail supply sector.

The results of the TGV's development and implementation paralleled Japan's experience. It demonstrated that a high-speed rail-based transport revolution could work in a 'western' setting. France's high-speed rail initiative provided the clearest evidence of passenger trains' potential to meet a modern mobility need better than any alternative, and in so doing generated profits in a competitive travel market. Figure 1.4 documents the rapid growth of TGV ridership in the first decade of its operation between Paris and Lyon. Patronage climbed from 6.1 million in 1982, the TGV's first full year of service, to 37 million in 1991.

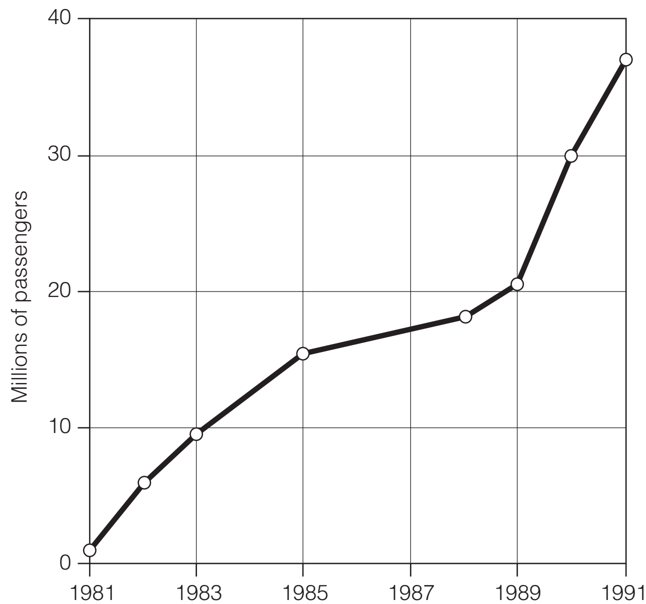

Figure 1.4 *TGV ridership, 1981–1991*[103]

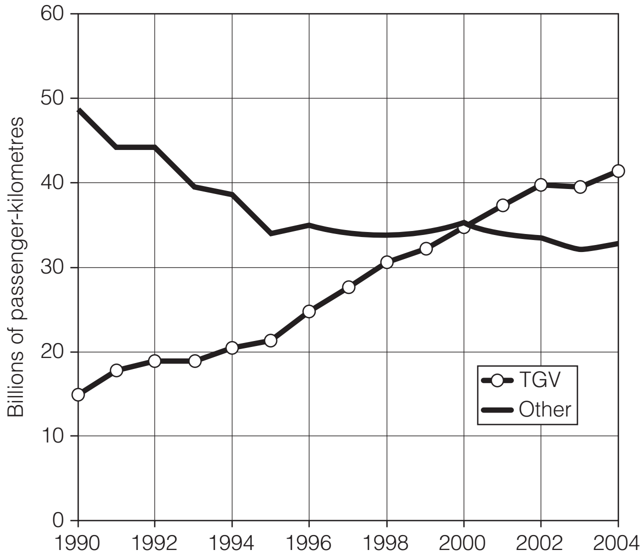

Figure 1.5 *TGV ridership and total SNCF ridership, 1990–2004*[104]

During the late 1990s, the TGV evolved from a train primarily serving the Paris to Lyon travel market into a high-speed ground transport network radiating from Paris to most corners of France. Unlike the Shinkansen, whose standard track gauge prevented interoperability on Japan's narrow-gauge rail network, the TGV could make full use of SNCF's conventional electrified lines to extend service beyond the high-speed infrastructure. Through such incremental expansion, as well as additional high-speed tracks to Tours, the Belgian border and Channel Tunnel, Marseille and most recently Strasbourg, the TGV has become an important element of the French railroad system.

Figure 1.5 shows how travel by TGV ridership grew in the 1990s and beyond, in comparison with travel by other French railways (SNCF). TGV's share of travel grew from just over a quarter to just over a half of the total. Travel by TGV grew continuously, and appears to have reversed a decline in rail travel in France in the mid-1990s. The TGV has become the mainstay of intercity travel by rail.

This high-speed rail transport revolution has spread beyond France's borders and is evolving into a trans-European high-speed train network. From Stockholm to Rome and London to Berlin, high-speed trains have become the mainstay of Europe's intercity train service. They contribute important diversity to the mix of intercity travel options that is much less developed in North America, but has seen adaptation in Taiwan and Korea.

The high-speed train revolution reveals the capacity of government and industry to collaborate on both the technical and organizational redesign of a mature mobility mode. The breakthroughs that launched both the Shinkansen and the TGV required looking beyond both the existing arrangements by which railways had long established their role as a universal mobility provider, and the breakthroughs in aerospace and road transportation. When available evidence suggested to many in the UK and the US that the train was reaching the end of the line in its industrial development, innovators in Japan and France identified a promising combination of new technology and technique, and then succeeded in introducing it to their venerable railway institutions so as to renew their roles as a mobility providers.

The air freight revolution of 1980 to the present

People began moving freight aboard aircraft, particularly mail, almost as soon as the first powered aircraft flew. **The first recorded carriage of mail by plane – which happened in India – was in 1911**: some 6000 letters and postcards were flown from Allahabad across the river Ganges to Naini, a distance of 8 kilometres. They were postmarked with a special 'First Aerial Post' cancellation, with the proceeds going towards the Oxford and Cambridge Hostel for Indian students started by the Holy Trinity Church in Allahabad. The US postal service established regular airmail delivery between New York and Washington DC in May 1918.[105] Since then, the most urgent freight shipments, such as emergency medical supplies, have been moved by air. There was considerable growth in goods movement by air in the decades after the Second World War, but the way in which air transport supported commerce and trade changed considerably during the 1980s.

This change followed the launch by Federal Express of a hub-and-spoke network for dedicated air cargo flights and the integration of this new air freight network with local trucking to offer overnight door-to-door delivery across North America, which became known as air express. The resulting transport revolution then expanded to cover and connect all continents.[106] It has enabled and accelerated structural changes in manufacturing, retailing and distribution that are often considered an integral part of contemporary 'globalization'. According to Rodrigue et al, 'the fundamental question [regarding transport's role in globalization] does not necessarily reside in the nature, origins and destinations of freight movements, but in *how this freight is moving*' [emphasis in original].[107]

Before this revolution, air freight was largely overshadowed as an aviation industry concern by airline passenger operations. Most cargo that moved by air went in the bellies of passenger planes, on schedules that had been developed for the movement of people.[108] Shippers had to deliver their own cargo to the airport or pay a freight forwarder or local courier company to collect and deliver it.[109] As well, postal services offered 'special delivery', but this did not guarantee a specific arrival time. These air cargo arrangements could move freight faster than ordinary mail, railway express or trucking, but they did not provide the guaranteed expedited delivery that people now take for granted and rely on.

In the US, overnight delivery actually became less available when airlines acquired wide bodied jet aircraft in the 1960s, consolidated passenger schedules and cut back their overnight flights. Fewer overnight flights meant less overnight air cargo capacity. Moreover, unlike railways in the US, which had integrated local delivery into their 'Railway Express' service, airlines were slow to match their considerable speed between airports with seamless ground connections. US airlines appeared satisfied to leave the work of collecting, assembling and delivering small shipments to freight forwarders, who received 40 per cent of the industry's cargo revenue in the late 1960s and early 1970s.[110]

The arrangements for a transport revolution that would transform the relationship between aviation and freight were first applied by Fred Smith, a pilot and owner of Arkansas Aviation Sales. **Smith believed that moving air cargo on dedicated planes that were not providing passenger service, and integrating it with a door-to-door delivery operation, would yield a faster and more efficient freight transport option that could unleash an immense demand**. Smith's ideas were first mooted in a Yale University economics course in 1965, where he identified the hub-and-spoke concept as the key to overnight delivery, effected chiefly by air. The first iteration of this idea was not particularly well developed, nor was it well received by his professors, but Smith was determined to explore its potential. He had two independent studies completed in 1972 indicating an untapped market for express delivery of small packages in the order $1 billion,[111] $4.9 billion in 2007 dollars.[112]

Smith initially focused on the movement of cheques for clearance by the US Federal Reserve Bank as a promising niche to enter the overnight delivery market. This led him to name the fledgling courier company Federal Express. In the 1970s, clearing a cheque drawn on a bank in one Federal Reserve district and deposited in another could take up to four days, because of the time it took to move the cheques between the banks. In 1970, Smith estimated the float on such transactions at $3 million daily, equivalent to $13 million in 2007 dollars. This money could be saved by Smith's proposed delivery service, which would dispatch small 'Federal Express' jets to each Reserve Bank district in the late afternoon, fly the cheques to a central sorting station by the middle of the night, and then deliver cheques to each Reserve district the next morning. Cheques could easily be moved on specially configured Falcon executive jets, which were just below the aircraft size that would require route and schedule approval from the US Civil Aeronautics Board.[113]

Although the Federal Reserve Bank did not become a customer of Smith's new company, the Federal Express name stuck. FedEx began operations on 17 April 1973, flying 14 planes to 25 cities. That night, 186 packages were collected directly from shippers, driven to the nearest airport where a FedEx jet was waiting, flown to the carrier's Memphis hub and sent on to destination airports where trucks completed their delivery the next morning. The logistics worked, but FedEx lost $29 million developing the business over the next two years. By 1975, the model had blossomed. By combining the hub-and-spoke aviation network with a ground delivery system, FedEx took the lead in American, then global, delivery of urgent shipments, which it has never relinquished. FedEx now serves over 375 airports in 220 countries with 672 planes, handles over 6.5 million shipments daily (3.3 million of them express), with FY06 revenue of $32.3 billion ($21.4 billion express).[114] The International Air Transport Association has regularly ranked FedEx first in scheduled freight tkm, noting that the carrier flew 15.1 million tkm globally in 2006.[115]

As both its freight volumes and markets served grew, FedEx became a technology pioneer. It developed leading-edge information systems and use of the Internet that opened the door to real-time logistics management on a global scale. In 1979, FedEx launched 'COSMOS (Customers, Operations and Services Master Online System), a centralized computer system to manage people, packages, vehicles and weather scenarios in real time'. The carrier had installed an electronic communication system in all its delivery vehicles by 1980, and introduced a computer-based shipping system for its customers in 1984. Instead of trying to operate a growing global logistics network using paper copies of waybills and sorting packages by hand, FedEx collaborated with suppliers to develop bar code labels, scanners and automatic sorters. Their bar codes for shipments went far beyond retailing applications so that each package's bar code contained all the information needed for effective logistics. By 1982, FedEx had machines to print bar-code labels, scanners to read them and a computer system to keep track of the information. In 1986, a hand-held device was deployed – the SuperTracker – that could digitize signatures. Online tracking of shipments was introduced in 1994.[116]

The explosive growth of air freight that followed FedEx's launch of the transport revolution soon attracted three major competitors. United Parcel Service (now UPS), Dalsey, Hillblom and Lynn (now DHL) and Thomas Nationwide Transport (now TNT) each adapted their existing organizations and technology to provide integrated pickup, air freight and delivery across expanding, eventually global networks.[117] UPS, which began as a local delivery service for department stores in Seattle in 1907, was operating a national package delivery service, mostly by truck, at the time FedEx started up. In 1982, UPS began offering overnight express delivery and by 1988 the company launched its own airline to fly express shipments across America and beyond. An aspect of UPS operations is described in Box 2.4 (Chapter 2).

In 1969, DHL began flying customs paperwork for ships en route to the US west coast across the Pacific so that cargos could be cleared ahead of the ship's arrival. It entered the overnight parcel delivery business in 1979, established an air freight hub in Cincinnati in 1983 and added a European hub in Brussels in 1985. DHL has been particularly successful in Europe, and today is a wholly owned subsidiary of Deutsche Post. Volumes at DHL's Brussels hub have grown from 60 tonnes nightly in 1988 to 1000 tonnes nightly in 2000. TNT was an Australian trucking company dating from 1946 that established a British subsidiary in 1978 and launched its own air operation in 1987. TNT, now based in The Netherlands, created a European 'super hub' in Liège, Belgium in 1998 notable for its location on the Trans-European high-speed rail network.[118]

Behind the innovation of FedEx and its competitors, and in response to intensive lobbying by the carrier, governments liberalized policy frameworks that had limited the reconfiguration of airline routes into hub-and-spoke networks. **Commercial liberalization in the airline industry began with air cargo**, when the US Civil Aeronautics Board raised the weight limit on air taxi (unscheduled) services in 1972, thereby allowing FedEx to launch its hub-and-spoke system using Falcon jets. The removal of all restrictions on cargo aircraft size in 1977 enabled FedEx to expand its capacity.[119]

The US Airline Deregulation Act of 1978 pioneered the elimination of restrictions on which routes an air carrier could fly and what prices could be charged. The European Union emulated this deregulation of aviation at a slower pace, stretching the process from 1984 to 2001 with a series of three legislative packages that progressively deregulated flying between member states. Air cargo was usually at the vanguard of airline deregulation.

While the elimination of regulations stimulated air cargo innovation, the implementation of international trade agreements – including the North American Free Trade Agreement and Europe's single market – and the World Trade Organization's increasingly liberal trade regime have encouraged growth in the demand for fast, reliably scheduled movement of cargo over long distances.[120]

Air transport effectively shortened the time required to keep production lines moving across continents. Integrators such as FedEx offer a 'just in time' delivery of both manufacturing inputs and finished products that reduce the need to maintain inventory and open the door to flexible production arrangements in which different parts of the production process exploit lower costs in varied locations. E-commerce has connected this global logistics system directly to the individual consumer, with integrators fulfilling orders taken over the Internet in as little as 24 hours.[121] In a highly publicized sales phenomenon, FedEx teamed with Amazon.com to deliver Harry Potter books directly to purchasers on the day of their release, moving 250,000 copies in 2000 and 400,000 in 2003.[122] As we write, Amazon is preparing to fulfil more than a million pre-orders in the US (more than 1.6 million worldwide) for the seventh and final book in the series.

The transport revolution in air cargo has changed both the way that many products are created and how they are distributed. **This revolution introduced new information technology to the movement of goods, but such technical innovation followed organizational change. Air transport networks were established around cargo hubs and surface transport was integrated to create**

a door-to-door delivery system that could make the most of aircraft performance characteristics.

Air cargo's transformation – from an adjunct to passenger flights into an everyday link between shippers and recipients around the globe – also highlights the role that a visionary entrepreneur can play in launching new mobility options. Fred Smith forged unprecedented relationships among aviation, surface transport and information systems to deliver a service that had not previously existed. Although the intended launch customer did not turn out to be an early adopter of overnight delivery, many more individuals and organizations found a need for this service once it emerged. **Transport revolutions can thus depend on the capability of an entrepreneur to bring a new mobility option into being, so that others may make use of it.**

REFLECTIONS ON PAST REVOLUTIONS

Gaining perspective on major mobility changes

The five examples of transport revolutions we have explored can help prepare readers for the major changes we see coming. A prerequisite for making the most of a major change is learning to distinguish it from the ongoing adaptation of existing arrangements. This is not as easy as it might seem. Media and advertising constantly hype very modest mobility changes as big and important breakthroughs. Revolutionary change in mobility can be identified in several ways evident in the five examples:

1 **From the launch of railway service**, we see that revolutions can have a high degree of unpredictability in their immediate outcomes. Entrepreneurs in the UK expected to create a major change in how freight moved, but the first railways turned out to yield a major change in how people moved. This unpredictability extended to the adaptation of horse-drawn coaches and barges, which quickly reconfigured to provide alternative services (e.g. local feeder service by horse coaches). **Anticipating the effects of a revolution may be quite challenging. The divergence between 'conventional wisdom' and unexpected results of change offers a signal that the change was indeed revolutionary.**

2 **The US pause in expanding motorization shows that revolutionary change can move quickly.** What may seem to be entrenched mobility patterns can change dramatically in response to government interventions such as regulation of vehicle production and fuel distribution. Striking results emerged from this brief period when the US made enhancing the efficiency of its transport system a top priority. **Individual sacrifice was justified in the name of national security, a recipe for legitimating sudden and dramatic behavioural change.**

3 **From the revolutionary shift in transatlantic travel, we see that moving faster exerts a powerful attraction, especially when the cost of such speed is no more than that of moving more slowly.** We also see how the dynamics of a transport system play out as the established modes adapt to new circumstances and find a role where their technology can meet new needs. **Because moving faster confers great advantage to armed forces, military research and development is a prime source of new technology that can revolutionize civilian transport.**

4 **From the high-speed rail revolution, we see that major change does not always reflect the linear notion of progress in which newer mobility modes eventually displace older ways of moving about**. The experts who suggested that passenger trains were obsolete, and that they would join the stage coach in transport museums by the end of the 1960s were (or should have been) surprised by the Shinkansen and TGV. **When mature organizations and established technologies are redesigned to yield higher performance, the resulting revolution can unlock significant amounts of hidden value within the transport system.** Major assets such as central city rail terminals that would have been otherwise written off gain a new life at a fraction of the cost of replicating their functions for another mode (e.g. adding a new airport).

5 **From the revolution in air freight, we see that changing the relationship between transport modes can yield just as big a difference as introducing organizational and technical innovations to a single mode.** The door-to-door speed of freight movement was significantly increased without any increase in the speed of the aircraft and trucks that moved the shipments. This was done by creating a network of aircraft and delivery vehicles that could deliver a new form of mobility – guaranteed overnight delivery – which has changed the ways in which people do business.

Characterizing profound mobility change along four dimensions

Assessing the significance of a transport revolution using four dimensions of change facilitates understanding of what the revolution means for human society. The dimensions are **scale** (people and freight move farther), **speed**, **efficiency** (usually fuel efficiency but sometimes other kinds) and **accessibility** (best thought of in terms of who cannot use the system, whether for physical, financial or other reasons). Over the course of history these key attributes have been valued differently. The attraction of doing better along one or more of these dimensions has inspired visionaries, entrepreneurs and leaders to develop new transport options that have persuaded large numbers of people to change the ways in which they have travelled or shipped goods.

Change that expands the scale and speed of transport is easily noted. The expressway, the airport and the cargo hub have a physical presence that embody the expansion of trade and travel across much of the globe. The desire to be well connected to other places appears to be strong, as does the desire to obtain products from distant places. The five revolutions we highlighted above provide considerable evidence that people will pay to move farther and faster, but there is also evidence that such a willingness to pay has its limits. Supersonic air travel existed between 1976 and 2003, but could not be sustained at fare levels that would pay for its long-run costs.[123]

The efficiency and accessibility dimensions of a transport revolution strongly influence economic and social opportunities. However, the resulting benefits and burdens are unevenly distributed, unless there are compensatory mechanisms. Some revolutionary changes can trigger decline, and even collapse, as seen in the abandoned UK shipyards of John Brown in Glasgow and Cammel Laird in Birkenhead following the transatlantic jet revolution. The same forces of change unleashed by jet aircraft made the Hawaiian Islands into a thriving economy fuelled by tourism. But, as the distance between the Clyde and Mersey rivers and the beaches of Waikiki makes clear, the winners and losers from a transport revolution are often quite disconnected.

The evidence of a particular transport revolution may be most apparent in just one of these dimensions, but the effects of change could eventually be revealed along all four dimensions. The changes that result from a transport revolution can be so large as to create barriers to further change. When new forms of technology or new organizational arrangements prove successful and attract huge investments in major infrastructure, their existence creates resistance to further change. The infrastructure 'locks in' a particular combination of technology and organization. The 'lock in' provides resistance to further change. The value of existing structures, both physical and organizational, is perceived to be so high that further innovation is seen to be too costly.[124] This is why transport revolutions are very much the exception in the history of human mobility, and are largely unfamiliar to those who work in transport and those who use it.

The rest of this book focuses on identifying the nature of the interconnected problems that could motivate dreamers and doers to propose innovative solutions and then move them into the mobility mainstream. We turn next to situating the performance of contemporary transport systems, the first step in gauging their potential for such change.

NOTES

1 Table 1.1 is based on Table 10.3, p307, of Christian (2004). That table is © 2004 by the University of California Press and is used here with permission.

2 The economist is William Baumol of New York University, quoted in Hensel, B, 'Globalization, a sea change in shipping; when containers came to Houston, it marked an industry milestone', *Houston Chronicle*, 23 April 2006, http://www.chron.com/CDA/archives/archive.mpl?id=2006_4103177.

3 The quotations in Box 1.1 are respectively from pp1, 1–2, 2, 5, 7, 10–11 and 268 of Levinson (2006). They are © 2006 by the Princeton University Press and are used here with permission. The first quotation describes the first related undertaking of Malcolm McLean, an entrepreneur whose foresight and perseverance were critical to widespread adoption of containerization. There were several antecedents, some of which Levinson noted, essentially dismissing them with the following: 'All over the world, the main methods for handling containers in the years after World War II offered few advantages over loose freight' (p32). An unnoted antecedent to which this dismissal would not have applied was the one that first integrated sea–rail–road container service, inaugurated in November 1955 between Vancouver and points in the Yukon, via Skagway, Alaska. Containers (2.1 by 2.4 by 2.4m) were moved from Vancouver to Skagway by a ship designed to carry containers, then by train from Skagway to Whitehorse, Yukon, and then by lorry to points in the Yukon (McCague, 2007). White Pass & Yukon president Marvin Taylor told an interviewer, 'Our system became an international showpiece and was visited by transportation executives from all over the world. Many of them later paid us the ultimate compliment by imitating elements of the design' (Elliot, 1987). The rail part of the system went out of service in 1982 during a depression in the Yukon's mining industry.

4 For ships arriving at Liverpool, see p21 of Carlson (1969).

5 For information on Liverpool and Manchester's populations, see pp5–6 of Booth (1969).

6 For details of Liverpool–Manchester coach traffic, see p23 of Carlson (1969).

7 For the return on the Duke of Bridgewater's investment, see p100 of Priestley (1831).

8 For the returns on shares in the Mersey & Irwell Navigation Company, see p27 of Carlson (1969). These returns may seem larger than they were. The dividend in 1825 was 2.8 per cent of the share value, and the appreciation of the share value in real terms across the period 1736 to 1825 was 2.4 per cent per year. The latter estimate is based on information at http://measuringworth.com.

9 For the price of coal at Stockton, see p95 of Garfield (2002).

10 The quotation from the prospectus is as relayed on p11 of Booth (1969).

11 The comments of James Loch are as reported on p134 of Garfield (2002).

12 The pre-emptive tariff reduction is noted on p60 of Carlson (1969).

13 The enticement of the Marquess of Stafford is noted on pp148–149 of Carlson (1969).

14 The quotation is from pp52–53 of Ransom (1990).

15 The anticipated performance is from pp181–182 of Carlson (1969); the actual performance is from p199 of Garfield (2002).

16 The quotation about canal traffic is from p58 of Ransom (1990).

17 For data on coach services before the railway and rail passengers after, see pp56–57 of Ransom (1990). A shilling in 1830 had the purchasing power of about $7.00 (£3.50) in 2007.

18 For what happened to London coach operators, see p43 of Turvey (2005).

19 For petrol rationing in Canada, see Derber (1943). For rationing and other restrictions in the UK see Dunnage (1943).

20 The data on car ownership and use in this paragraph are from AMA (1948).

21 For the impact of the European war on car ownership in the US, see p132 of Cardozier (1995).
22 This quotation is from p34 of Gropman (1997).
23 These quotations are from p26 of Koistinen (2004).
24 The information in this paragraph is from pp134–135 of Koistinen (2004).
25 This quotation is from p131 of Weiner (1942).
26 For the actions of the War Production Board, see p34 of Gropman (1997).
27 Quoted in Raskin, A H, 'Mass magic in Detroit', *The New York Times*, 1 March 1942, pSM4.
28 The data on vehicle production are from p4 of AMA (1948); those for vehicles in use are from p17. The statement concerning the production of a total of 143 personal vehicles in 1943 is not a misprint.
29 For the information about rubber, see p148 of Koistinen (2004).
30 The quotation on the need to drive is from Coan, P B, 'Car outlook is dark: Frugal, smart and slow driving is urged on motorists to make tires last', *The New York Times*, 1 March 1942, pXX1.
31 Box 1.2 contains the 'Text of appeal of war chiefs to motorists on gas', *The New York Times*, 24 April 1942, p11. The item is used here with the permission of Associated Press.
32 The material in Box 1.3 is from 'Violators of pleasure driving ban may face neighbors at hearings', *The New York Times*, 24 January 1943, p38. The item is © 1943 by The New York Times Co. and reprinted with permission.
33 This quotation is from Coan, P B, 'Nation enters "car sharing" era to make its tires last', *The New York Times*, 12 July 1942, pXX5. It is © 1943 by The New York Times Co. and reprinted with permission.
34 The poster is *When You Ride Alone You Ride With Hitler!* by Weimer Pursell, 1943. Originally in colour, it was produced by the Government Printing Office for the Office of Price Administration. This copy came from the National Archives and Records Administration, Still Picture Branch (NWDNS-188-PP-42), http://www.archives.gov/exhibits/powers_of_persuasion/use_it_up/images_html/ride_with_hitler.html.
35 Most US households did not have a car. There were, as noted above, just under 30 million cars on the road. The 1940 Census had shown there to be some 132 million persons in the US living in about 35 million households. (See *16th Census of the United States – 1940: Housing, Volume II, Part 1, United States Summary,* http://www2.census.gov/prod2/decennial/documents/36911485v2p1ch1.pdf.)
36 See Gallup, G '54% of owners don't think autos vital, Gallup finds in a survey on tire rationing', *The New York Times*, 23 January 1942, p14.
37 The quotation is from p138 of Derber (1943).
38 The data on vehicle-kilometres travelled are from p64 of AMA (1948).
39 These shares, and the data in Figure 1.2, are based on p20 of Wilson (1997). Note that intercity air travel per capita expanded by a factor of eight during this period, but still amounted to less than 2 per cent of intercity travel in 1949. The actual increases in rail and bus travel per person in the US were from 592 and 261km in 1941 to 1881 and 529km in 1944. Meanwhile, car travel per person declined from 6306km in 1941 to 3537km in 1944 (3397km in 1943). Note that a majority of intercity trips were still made by car, even at the peak of the pause in the growth in motorization.

However, a much lower but unknown share of trips in urban areas were made by car, and overall it is likely that trips by car were a minority of all trips, before and during the war.

40 The freight data are from p251 of Koistinen (2004).

41 The data on public transport ridership are from Figure 1, p12, of APTA (2007).

42 The transport data in Figure 1.2 are from p20 of Wilson (1997). Population data used to estimate per capita values are from the US Bureau of the Census, *Historical National Population Estimates: July 1, 1900 to July 1, 1999*, http://www.census.gov/popest/archives/1990s/popclockest.txt.

43 The quotation is from p232 of Cardozier (1995).

44 This quotation is from p2 of American Transit Association (1945).

45 This quotation is from p157 of Cardozier (1995).

46 These data are from p4 of AMA (1948).

47 These data are from p20 of Wilson (1997).

48 The data on public transport ridership are from Table 6, p12 of APTA (2007).

49 See Fox (2003), particularly Chapter 9, for the experience of transatlantic travel between 1820 and 1910.

50 Figure 1.3 is based on data in Civil Aeronautics Board (1975).

51 A transatlantic Clipper ticket cost $675 in 1939 (see *Boeing 314 – Pan Am Clippers – USA*, The Aviation History On-Line Museum, updated 2006, http://www.aviation-history.com/boeing/314.html). This equalled $4636 in 1983 dollars according to *The Inflation Calculator*, http://www.westegg.com/inflation/. In 1983, the New York–London Concorde fare was $4417 (see 'British Airways', *The New York Times*, 29 December 1983, p1). A ticket for the 1936 inaugural voyage of the Cunard liner *Queen Mary* cost $100 (see 'RMS Queen Mary 65th anniversary invitation: Pay 1936 fare', *Canada Newswire*, 27 February 2001, p1).

52 See para 11 of Siddiqi, A (2003) 'The beginnings of commercial transatlantic services', *History of Flight*, US Centennial of Flight Commission, Washington DC, http://www.centennialofflight.gov/essay/Commercial_Aviation/atlantic_route/Tran4.htm.

53 For Atlantic airline traffic in 1950 see p470 of Bender and Altschul (1982).

54 Pressurised passenger aircraft could fly at twice the altitude of flying boats and thus avoid much bad weather. Pressurization was also a spin-off of military development, with the Boeing 307 Stratoliner adapting this technology from the B-17 bomber just before the start of World War II. For details on the B-307, see http://www.boeing.com/history/boeing/stratoliner.html.

55 For all-sleeper flights see p22 of Speas (1955).

56 On immigrant fares, see p48 of Kendall (1979). £1.50 in 1904 had the purchasing power of about £108 ($205) today; it was also the equivalent of seven or eight days of average earnings in the UK at that time.

57 For attracting the US middle class on to transatlantic planes, see p470 of Bender and Altschul (1982).

58 The jet aircraft of the 1950s appear to have used much more fuel than the piston-engined aircraft they replaced. Peeters et al (2005) concluded, 'The last piston-powered airliners were at least twice as fuel-efficient as the first jet-powered aircraft' and '… the last piston-powered aircraft were as fuel-efficient as the current average jet' (p3). However, jet fuel is less refined than fuel for piston engines and costs less.

59 For estimates of the Boeing 707's cost advantage, see p15 of ICAO (1958).
60 For comparison of the Comet jet with propeller planes see p19 of Serling (1982).
61 The quotation about low cost electricity for the wind tunnel is from p94 of Rodgers (1996).
62 For Trippe's order of the new engines see p34 of Gandt (1995).
63 Trippe's words are on p37 of Gandt (1995).
64 For jet aircraft performance in the late 1950s, see p193 of Rodgers (1996).
65 For Pan Am's passenger volumes, see p40 of Gandt (1995).
66 The quotation about Boeing's investment is from p197 of Rodgers (1996).
67 On Cunard's fare discounts, see p256 of Kendall (1979).
68 On cruises in the 1840s, see p361 of Kendall (1983).
69 On ship registrations, see p21 of Alderton (1973).
70 Until her announced retirement in June 2007 (to become a hotel and tourist destination in Dubai in 2009), the *Queen Elizabeth 2* was still plying the Atlantic on occasion, although she served mainly as a cruise ship. Cunard's flagship is now the *Queen Mary 2*, the world's second-largest passenger ship – the cruise ship *Freedom of the Seas* is larger – and the only passenger ship with a regular transatlantic schedule. At the time of writing, 52 voyages between the US and the UK, France or Germany are planned for 2007–2008. (See http://www.cunard.com.)
71 For Penn Central, see Daughen and Binzen (1971).
72 The quotation on Britain's rail future is from p1 of British Railways Board (1963).
73 The quotation from the Commission's report is in Hosmer (1958).
74 The quotation on high-speed rail evolution is from p157 of Banister and Hall (1993).
75 Givoni (2006) points out that increasing railway capacity in congested corridors was a primary impetus behind the launch of high-speed rail in Japan, France and Italy. Countries with rail capacity that appeared overbuilt in relation to transport demand, including the US and the UK, did not make the commitment to advancing this mobility niche very far. Germany's efforts to add rail transport capacity were slowed by a parallel focus on even faster 'trains' propelled by magnetic levitation. For a contrast between the German and French approach to developing high-speed rail see Dunn and Perl (1994).
76 For early plans for a new line between Tokyo and Osaka, see Kakumoto (1999).
77 For reasons behind the emergence of JNR, see Yoshitake (1973).
78 Smith (2003), p226, wrote, 'Scientific and engineering initiatives which in the West were devoted to military projects in aviation and the development of atomic power were adapted in Japan to peaceful industrial uses. Teams of highly trained and capable engineers were recruited into the railway industry.'
79 On the RTRI conference presentation, see p81 of Strobel and Straszak (1981).
80 On JNR's move beyond incrementalism, see Nishida (1977).
81 This quotation is from p46 of Shima (1994).
82 For JNR's traffic projections, see Knop and Straszak (1981).
83 On the JNR president's request, see p174 of Hosokawa (1997).
84 For the Cabinet's approval, see p178 of Hosokawa (1997).
85 For critics of the Shinkansen concept, see p81 of Strobel and Straszak (1981).
86 The quotation on timing of transport is reproduced from pp27–28 of Kakumoto (1999).

87 See p178 of Hosokowa (1997); and 'Japan is building speedy rail line', *The New York Times,* 26 April 1959, p20. The dollar equivalencies of yen of that period assume an exchange rate of 360 yen to the dollar, and subsequent dollar inflation based on http://futureboy.homeip.net/fsp/dollar.fsp.

88 JNR's vice-president of engineering was dispatched to Washington to persuade World Bank officials that the Shinkansen was a low-risk investment and did not rely upon experimental technology, which was explicitly prohibited from support in the Bank's lending criteria. Hideo Shima convinced the officials that the Shinkansen was a novel integration of proven rail technologies that had been developed in response to Japan's railway safety research programme. See p48 of Shima (1994).

89 For the World Bank loan for Shinkansen, see p200 of Hosokawa (1997).

90 The quotation is from 'Japanese build a super-railroad', *Business Week,* 1 December 1962, p89.

91 The quotation is from 'Japan's fast train: How it's working out', *US News & World Report,* 25 January 1965, vol LVIII, no 4, pp69–70.

92 As with other transformative transport technologies, cities and regions that had not been touched by the initial revolution sought the new train technology so as not to be left behind in economic and social development. Shinkansen expansionary zeal reached its apex in 1970 when Japan's parliament passed the Nationwide Shinkansen Development Law which authorized a 7000km network of high speed trains to be built by 1985. When Japan's economy was battered by the 1973 oil shock, parliament revised this plan to prioritize certain lines and put others on hold. The Shinkansen network thus grew more slowly than initially desired, but has expanded to serve most major cities on Honshu, the largest Japanese island, and also been extended onto Kyushu, the third largest island. This information is from p48 of Hood (2006).

93 The quotation is from p2626 of Endo (2005).

94 For the value of the Shinkansen network, see p13 of Okada (1994).

95 See the Japan section of 'High speed lines in the world', Union internationale des chemins de fer (UIC), Paris, http://www.uic.asso.fr/gv/article.php3?id_article=22.

96 For the impacts of the introduction of Shinkansen on air travel, see Chapin, Emerson, 'Japan's airlines step up service', *The New York Times*, 14 March 1965, pS21, and Chapin, E, 'New Japan Train Cuts Air Travel', *The New York Times*, 28 February 1965, pS18.

97 For the historical arrangements concerning SNCF, see Jones (1984).

98 For the Nora Report, see Groupe de travail du comité interministériel des entreprises publiques (1967).

99 This quotation is from p229 of Hayward (1986).

100 For SNCF management and the Nora Report, see Fourniau and Ribeill (1991).

101 For information on Paris and Lyons, see p4 of Institut National de la Statistique et des Études Économiques – Île-de-France (1999); and p1 of Institut National de la Statistique et des Études Économiques – Rhône-Alpes (1999).

102 For the comparison between French and German strategies, see Dunn and Perl (1994).

103 Figure 1.4 is based on Figure 1.3 of Perl (2002).

104 Figure 1.5 is based on data in Tables 3.3.7 and 3.3.8 of European Commission (2006).

105 See Jeppu, Y V, 'Story of the first airmail', Dakshina Kannada Philatelic Association (dkpna), http://www.geocities.com/dakshina_kan_pa/art4/airmail.htm; and US Centennial of Flight Commission http://www.centennialofflight.gov/essay/Government_Role/1918/POL2.htm.

106 For the impact of this transport revolution, see p8 of UK DfT (2002).

107 This quotation is from p157 of Rodrigue et al (2006).

108 For how air freight was moved before the 1980s, see p150 of Upham et al (2003). According to Airbus (2006) p78, by 2005, 58 per cent of air freight was moving in dedicated freighters, with the remainder moved in the belly holds of passenger aircraft. The share moving in freighters is projected to increase to 65 per cent by 2025.

109 For what shippers had to do, see pp5–6 of Birla (2005).

110 For data on cargo revenue, see pp32–34 of Sigafoos and Easson (1988) and pp104–105 of Trimble (1993).

111 For the early history of FedEx, see pp2–3 of Birla (2005), pp40–42 of Sigafoos and Easson (1988) and pp126–127 of Trimble (1993).

112 The value of the market in 2007 dollars is estimated using http://futureboy.homeip.net/fsp/dollar.fsp.

113 This part of the history of FedEx is on p5 of Birla (2005), pp37–38 of Sigafoos and Easson (1988), and pp106, 108–109, 116 and 131 of Trimble (1993).

114 For the information about the launch of FedEx and its subsequent progress, see pp1–2 of Birla (2005) and the 'Corporate history' and 'Our companies' sections of *About FedEx*, http://www.fedex.com.

115 See 'Scheduled freight tonne-kilometres', extracted from *World Air Transport Statistics (WATS 2006)* International Air Transport Association, Montreal, Quebec, 2007, http://www.iata.org/ps/publications/wats-freight-km.htm. The same source indicates that Korean Air Lines performed the most *international* scheduled tonne-kilometres, with FedEx being fifth in this respect.

116 For details on technology innovation at FedEx, see various parts of Birla (2005) and *About FedEx*, http://www.fedex.com.

117 The information on these companies was from p50 of Direct Communication Group (2003); pp43–46 of Kingsley-Jones (2000); and DHL (2006) DHL International GmbH., http://www.dhl.com/publish/g0/en/about/history.high.html.

118 For a discussion of high-speed rail and air freight, see pp157–181 of Wardman et al (2002), who conclude that the integration may not have much potential.

119 For this aspect of FedEx's history, see pp212–215 and 219–220 of Trimble (1993); and *About FedEx*, http://www.fedex.com.

120 For the impact of trade liberalization of air freight, see p14 of *The Economic and Social Benefits of Air Transport*, Air Transport Action Group, Geneva, Switzerland, 2005, http://www.iata.org/NR/rdonlyres/5C57FE77-67FF-499C-A071-4E5E2216-D728/0/ATAG_EconomicSocial_Benefits_Air_Transport.pdf.

121 For a discussion of integrators fulfilling orders, see p149 of Upham et al (2003).

122 For the 'Harry Potter' logistics in 2003, see p36 of Birla (2005) and *About FedEx*, http://www.fedex.com.

123 For a brief discussion of how rising oil prices sealed the fate of the Concorde, see p268 of Perl and Patterson (2004).

124 For a recent discussion of barriers to change posed by 'lock-in', also known as 'path dependence', see Geels (2004).

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