1 The Triumph of the Automobile: and Its Incipient Decline

THE POWERED LAND TRANSPORT REVOLUTION STARTED IN BRITAIN

The First Industrial Revolution was born in Britain. It was based on two seminal innovations, which interacted and mutually reinforced each other. The blast furnace enabled the production of iron in large quantities by using coke made from coal to reduce iron ore, in the place of charcoal obtained from wood (at the cost of many of Britain's ancient forests). The steam engine made it possible to pump water efficiently from deep mines and thereby greatly facilitated the production of coal in much larger quantities and at lower cost. At first coal was moved from the mines by heavy horse-drawn carts. The idea soon emerged of reducing wheel-track friction by running the cars on rails, imitating the crude systems that already existed within the mines, using wooden rails. These were superseded by the use of iron wheels running on iron rails, offering better load-carrying capacity and lower friction. These early iron roads were used to move coal from the mines to ports or to the canals which had expanded significantly in the seventeenth and eighteenth centuries as a means of moving goods efficiently. By the beginning of the nineteenth century, stationary steam engines were widely used not only for pumping out mines but to spin machinery and power looms in the textile industry – the first example of large-scale industrial mechanisation.

The first commercially successful steam engine was built by Thomas Newcomen in 1712 and relied on the curious principle of spraying water on the cylinder to condense steam inside it, thereby creating a partial vacuum. The piston was driven by the pressure of the outside atmosphere, creating a linear force that pumped water from

the mine shaft. Not until 1781 did James Watt launch his engine that used an external condenser to create the vacuum and drove a crank to produce rotary motion. There is a splendid working example of a James Watt engine to be seen in the Power House Museum in Sydney, which originally provided power to a London brewery for decades. Working pressures and the power produced were low, and the engines were hugely bulky. It took almost a century of development of the steam engine before it could successfully be applied to transport. Richard Trevithick built the first high-pressure steam machine in the form of a locomotive and produced a series of locomotives from the end of the eighteenth century. In 1825 George Stephenson opened the Stockton and Darlington Railway, the world's first public railway, with his Locomotion No 1. His son's Rocket of 1829 won the Rainhill Trials, a competition to choose the motive power for the new Liverpool and Manchester Railway. Powered land transport became a practical reality for the first time. The application of steam engines to ships took place in parallel.

The British population, 10.5 million in 1801, almost doubled to 20.8 million in 1851 and almost doubled again to 40.4 million in 1901 as this first Industrial and Transport Revolution created fast economic growth, though this then slowed, to 48.9 million in 1951 and just under 59 million in 2001. Figure 1.1 tracks the growth of GDP and of transport and communications from 1855 to 1980. GDP multiplied sevenfold but transport and communication (T&C in the diagram) twenty-one-fold. This series reaches only from 1851 to 1981 but still gives a fascinating picture of the explosive development of powered transport.[1] The transport and communication intensity of the economy increased threefold during this period. Rapid economic development (the 'take off' described by economists) has thus both been supported by a huge increase in mobility and also been an enabler of it.

[1] Taken from *British Historical Statistics*, B. R. Mitchell, Cambridge University Press, 2011. A 2010 project to extend this work seems not to have come to fruition yet.

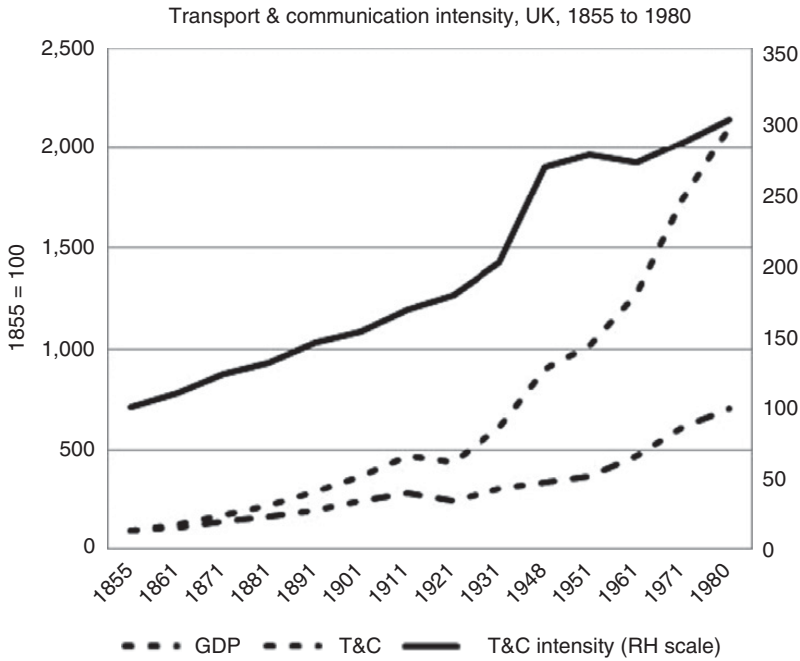

FIGURE 1.1 The UK transport revolution
Data source: British Transport Statistics

Before the invention of the railway, passenger transport was overwhelmingly by road, with a rapid improvement in infrastructure and journey times beginning in the eighteenth century, thanks to the use of macadam surfaces and the institution of turnpikes.[2] Rail very rapidly took over medium- and long-distance travel, as the network expanded. Horse-drawn local transport remained but trams and powered omnibuses took over from the close of the nineteenth century.

The advent of the railways transformed Britain.[3] The railway network grew dramatically during the nineteenth century, with most of the main lines completed by the middle of the century. There was

2 For a fascinating discussion of this, see *The Rise and Rise of Road Transport, 1700–1990*, Theo Barker & Dorian Gerhold, Macmillan, 1993.

3 For a lucid and well-researched account of this, see Christian Wolmar's *Fire & Steam, How the Railways Transformed Britain*, Atlantic Books, 2007.

considerable duplication and waste through the railway mania that led to the building of a good number of lines that never repaid the investment in them. The heavy cuts to the network, recommended by Dr Beeching in the 1960s and forever associated with his name, attracted much sentimental opprobrium but mainly made sense, especially as the railways in Britain had suffered from persistent underinvestment and technological lag, compared to those in the rest of Europe and in North America. Britain still retains a substantial and reasonably well-balanced railway network. It has undergone a technological transformation with the elimination of the steam engine, with its lamentable thermal inefficiency, huge maintenance requirements and harsh working conditions for those who operated and cared for it. Not to mention the grime it spread all around it. Modern signalling and power-operated doors have greatly reduced the incidence of accidents to passengers, making the railways a very safe form of transport.

THE RAILWAYS IN BRITAIN ROSE TO DOMINATION AND THEN RETREATED INTO NICHES

Railway passenger transport in fact reached its apogee, in terms of the number of passenger journeys made, just after World War I – see Figure 1.2. The apparent collapse for 1914 to 1919 is the result of no statistics having been published in wartime, perhaps to conceal them from the enemy. After that, the number of journeys made declined until 1980, apart from a brief revival during World War II, with many lightly used rural lines closed. Since then, there has been a remarkable revival of passenger rail travel, as shown (using the more telling metric of passenger-kilometres) in Figure 1.3. The 1939 to 1943 gap is again caused by the absence of published statistics. While the number of journeys declined on trend from 1945 to 1985, the passenger-kilometres held constant, reflecting a growth in average journey length. This was caused by rail virtually disappearing from the market for short journeys and re-concentrating on longer inter-city trips and commuting. The trend reversal seems to

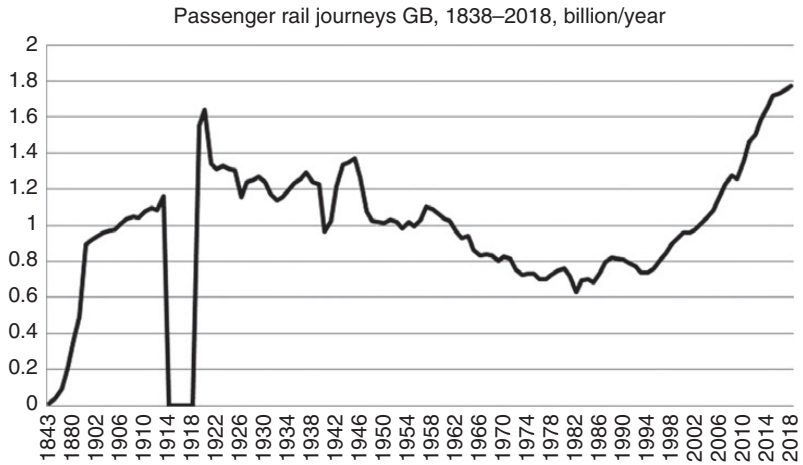

FIGURE 1.2 Growth, decline and resurgence in rail passenger journeys
Data source: Transport Statistics GB[4]

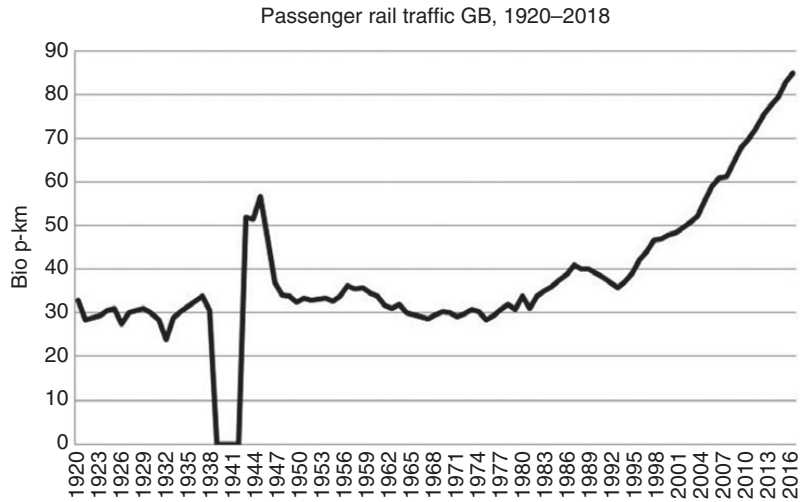

FIGURE 1.3 Renewed growth in rail passenger traffic
Data source: Transport Statistics GB

have started in about 1985, as the refurbishment of British Rail – poorly begun with the inept 1955 Modernisation Plan – finally became effective. The disruption caused by the politically inspired

[4] www.gov.uk/government/statistics/transport-statistics-great-britain

and over-complicated privatisation of British Rail initially reversed this trend but growth soon resumed. Tory Secretaries of State for Transport like to claim that it was privatisation that led to the reversal of the declining trend but the statistics do not support this. In reality, this return to growth is attributable to growing congestion on the road network and to the railways' creative use of airline-style yield management and pricing. The intended, very belated, construction of a limited high-speed network can be expected to produce some more growth in rail travel but its impact on the overall numbers will be very minor.

Passenger rail has not, in the end, declined in absolute terms, although it has clearly done so relative to road transport. It has moved from being the dominant, quasi-universal, mode into a set of specialised niches: a few long-distance routes and, dominantly, commuting into large urban areas, primarily London. Qualitatively, too, the glamour has gone out of rail travel. Most of the famous named expresses have disappeared. No more magnificent engines and handsome carriages, painted in distinctive colours. Comfortable compartments with plush seats have been replaced by plasticky airline-style cramped seating, except in a very few retro tourist trains. Dining cars with table settings and proper meals have been replaced by bland buffets, except for a few trains. Little boys no longer dream of becoming engine drivers. Travel by rail has become a commodity, more marked by frustration at delays and cancellations than by excitement. There are portents in this for the future of the automobile.

Rail freight in Britain grew, declined and revived only modestly – see Figure 1.4. It reached its peak before World War I, stagnated between the wars, revived during World War II (although annual statistics were not available), held up for ten years thereafter, went into a secular decline from 1953 to 1995, and has enjoyed a modest recovery since. The 1955 Railway Modernisation Plan included a major investment in large new marshalling yards to speed up traditional wagon-load rail freight – which was then lost to road haulage after this was denationalised. The primitive technology of British

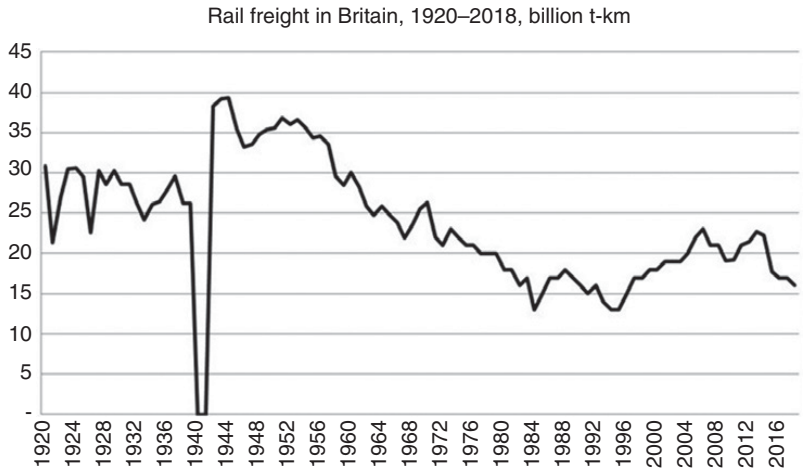

FIGURE 1.4 The rise and fall of rail freight in Britain
Data sources: Inland Transport Statistics GB 1900–1970, Transport Statistics GB

freight trains – mainly steam-hauled, loose-coupled and unbraked apart from the engine and guard's van – was no help either.

This recovery was essentially attributable to the railways concentrating on the market sectors in which they have a real comparative advantage, to wit hauling bulk commodities and intermodal (containers). Coal movements – mainly to power stations – grew but then declined, as Britain moved from coal- to gas-fired thermal electricity generation. Intermodal freight grew to compensate. Once again, the quasi-universal transport mode became a specialised one, quite limited in scope in a country of short distances and high population densities, unfavourable to rail freight. Hopes of rail freight regaining a share in the ever-growing cross-Channel trades by means of the Channel Tunnel accessing longer hauls were dashed. The British rail gauge is the same as that in most of Europe (except for Spain, Russia, Finland and the Baltics) but the British loading gauge is significantly smaller, such that normal-sized European rail vehicles cannot run in Britain. This, therefore, means investment in special wagons able to run in Britain, which has happened only for some specific market

segments, such as new car carriers and company trains – for example, Ford's movement of parts between its British and continental plants. The special fresh fruit and vegetable trains from southern France and Spain that used to run via the train ferries have been displaced by trucks, many of them using the freight shuttles through the Channel Tunnel. There is limited intermodal freight movement through the tunnel, to and from more distant destinations.

ROAD BECAME AND REMAINS THE DOMINANT LAND TRANSPORT MODE

Even though 1946's demobilisation peak volume was surpassed in 2007, rail – the great mobility enabler of the nineteenth century – has been completely dwarfed in significance by the growth of road transport, retaining a significant market share only for commuter and long-distance travel. As Figure 1.5 shows, the use of light four-wheel road vehicles – cars, taxis and vans – has grown enormously and now completely dominates passenger transport within Britain. The flexibility and universality of the automobile has caused it to win hands down, despite greatly increased traffic densities and congestion. While rail travel has enjoyed a revival, the steady decline in travel by bus and coach is notable. Motorising the individual has enormously increased our range of choices, in terms of where and how we live, work and play, and has had a powerful influence on economic development. The motor car hugely boosted the trend to suburbanisation (which was started by the railways) and suburbanisation hugely supported the growth in the use of cars. This symbiosis has turned into a powerful mutual dependency. Which is not to say that it is eternal, as we shall see later.

Similarly, road has captured the major share of freight tonnage, thanks to its inherent flexibility – see Figure 1.6. Water transport also expanded for a time, mainly based on coastal shipping of bulk commodities, principally coal, which then declined as power generation switched away from it. Britain built a comprehensive canal network from the seventeenth century but which only allowed for very narrow

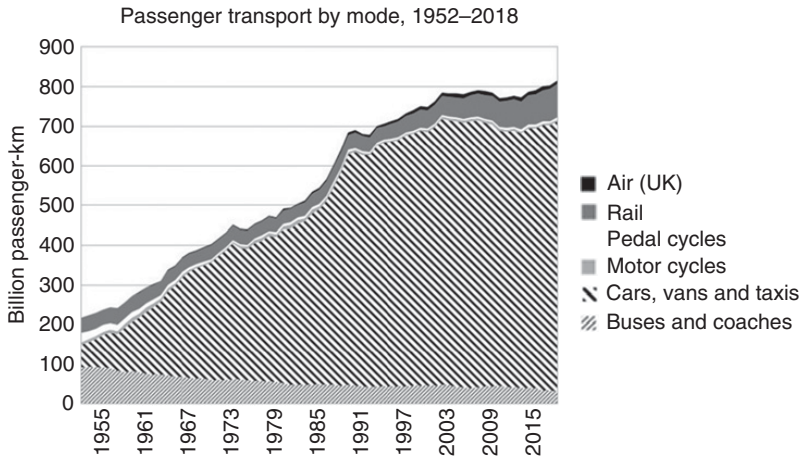

FIGURE 1.5 The triumph of the car
Data source: Transport Statistics GB

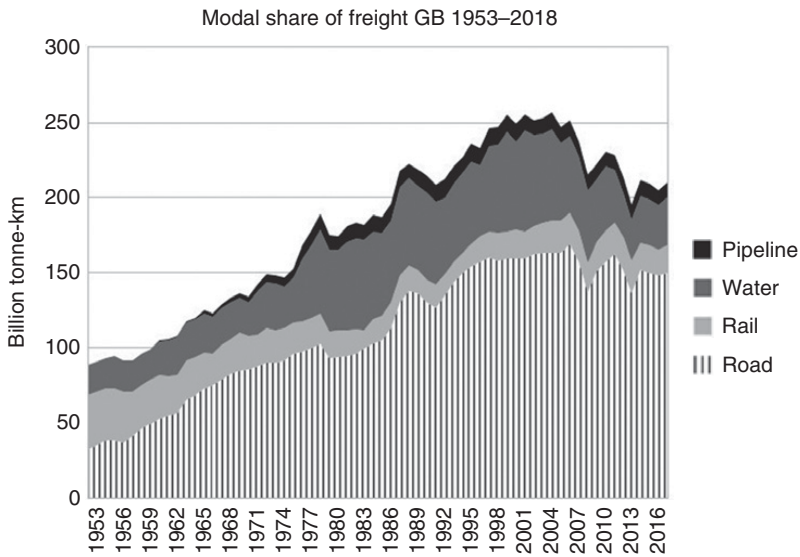

FIGURE 1.6 The growth of road freight
Data source: Transport Statistics GB

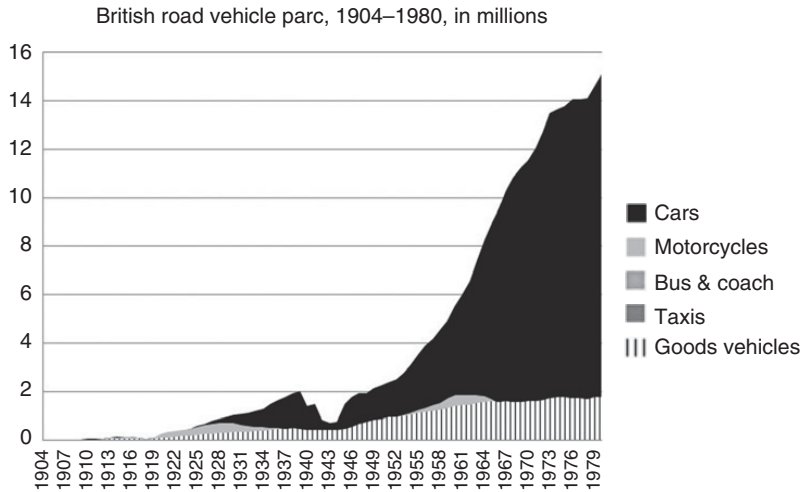

FIGURE 1.7 The road vehicle explosion
Data source: British Historical Statistics

barges, so that it has fallen into disuse other than for recreational purposes, in contrast to the continuing extensive traffic on rivers and wide-gauge canals in continental Europe.

THE ROAD VEHICLE PARC GREW EXPLOSIVELY AFTER WORLD WAR II

Figure 1.7 shows the rise in the number of vehicles operating on British roads from 1904 to 1980. A very modest start was made before World War I. It is interesting to note that motorcycles were as popular as cars until the late 1920s, as they were more affordable in terms of both acquisition cost and fuel consumption, and required less space for garaging. They enjoyed a brief revival as a serious means of personal transport in the 1950s and early 1960s but are now essentially used for recreational purposes. Goods vehicles grew steadily in number, with only a slowing during the two world wars. Note that here they include both light and heavy commercial vehicles. The growth of the passenger car parc (or fleet) started in earnest in the 1930s – Britain, with France, was an early motoriser among European countries. Most

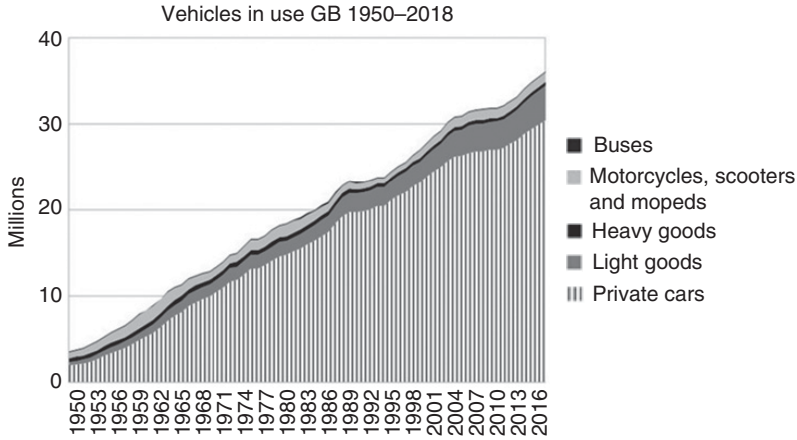

FIGURE 1.8 Continuing growth – and the van phenomenon
Data source: Transport Statistics GB

private cars were taken off the road during World War II, as fuel for personal use became almost unavailable. The parc really took off in the early 1950s, with the end of fuel rationing and growing real disposable incomes.

Figure 1.8 shows the number of vehicles in use on British roads from 1950 to 2016, excluding special vehicles, taxis and Crown vehicles (the categories used in the statistics behind Figures 1.7 and 1.8 are not compatible). Buses are relatively few in number. The population of two-wheelers (motorcycles, scooters and mopeds) has fluctuated. The population of heavy goods vehicles has remained fairly steady. They have grown in weight and – above all – been used more intensively to shift a steadily increasing tonne-kilometres of road freight, thanks to IT and telecommunications support which enables much more efficient routing. Light goods vehicles (mainly vans) and private cars have shown the fastest growth, which has continued with the growth of courier vehicles (propelled first by the abolition of the Post Office monopoly and then by on-line shopping) and the increased ownership of second cars. The car is truly king of the road and an integral and fundamental part of daily life.

US RAILROAD PASSENGER TRAFFIC BOOMED IN THE NINETEENTH CENTURY BUT THEN ALMOST VANISHED

The United States provides the contrasting example of the development of transport in a new country, with vast expanses and distances, and, on average, low population density. The United States rapidly followed Great Britain in the development of railways. As in Britain, the railroads developed at an astonishing speed, and had an immense impact on American society.[5] They were instrumental in the opening up of the West, the Manifest Destiny of the early United States. Initial growth was rapid, with a veritable railroad mania developing and the use of rail transport intensified by the Civil War.[6] By the 1880s, most of the national rail network was in place. The railroad was the stuff of romance well into the twentieth century.[7] At its peak, the network was immense, reaching virtually every important city and town, although thinner in the lightly populated West than in the more densely populated East. As in Britain, there was a veritable railroad fever and many marginal lines were built. Even today, after rationalisation and the closure of many small branch lines, the US rail network is 250,000 km in length, the longest in the world, followed by China, Russia and India, but with only 35,000 km of the network used for passenger traffic (Amtrak plus commuter lines).

Passenger transport by rail in the United States has gone from experimental to dominant (flanked by local horse-drawn vehicles) and back to niche. This is an almost perfect example of a category life cycle as shown quantitatively in Figure 1.9. Passenger rail traffic continued to increase rapidly after the Civil War but had begun to plateau by the late 1910s. Apart from a short-lived boost in 1917–18 from World War I mobilisation, the trend was flat. A decline in fact began in the 1920s, with the rapid growth of personal motorisation. It became precipitate

5 This is well related in Christian Wolmar's *The Great Railway Revolution: the Epic Story of the American Railroad*, Atlantic Books, 2013.

6 Ibid.

7 Well described with numerous illustrations in *Hear the Train Blow*, Lucius Beebe & Charles Clegg, Grosset and Dunlap, 1952.

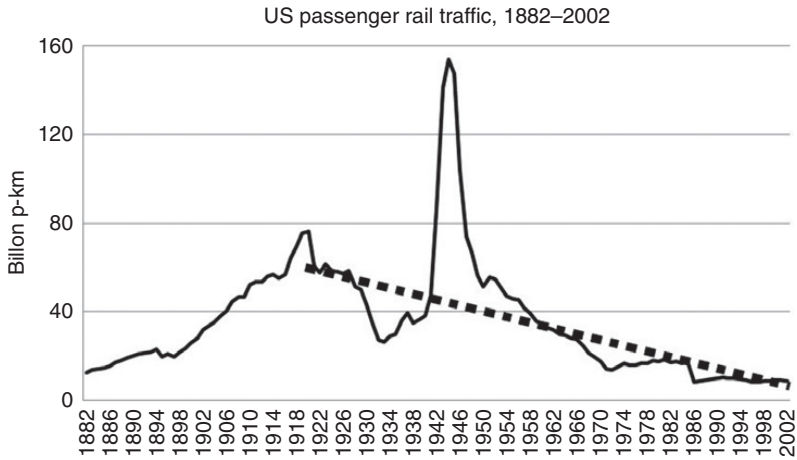

FIGURE 1.9 The US passenger rail life cycle
Data source: International Historical Statistics

with the Great Recession, with some recovery until the massive boost provided by World War II and a small blip from the Korean War. But the downward trend resumed in the late 1940s (the trend is the dashed line in the figure), until by 1972 passenger traffic was back down to the level of 1882. It has remained at a low level since. Apart from the modernised and electrified North East Corridor from Washington, DC, to Boston via New York, the rest is a skeleton of long-distance Amtrak services patronised by enthusiasts and tourists, plus a limited number of commuter networks in major metropolitan areas, notably New York and Chicago. Long-distance rail travel is now for tourists and nostalgics.

IN CONTRAST, RAIL FREIGHT IN THE UNITED STATES HAS NEVER STOPPED GROWING

The contrast with the continuing development of US railroad freight transport could not be greater. Rail freight has just grown and grown. It was instrumental to the development of the economy in the nineteenth century, as can be seen in Figure 1.10, which shows how the transport intensity of the economy developed over 130 years. Using

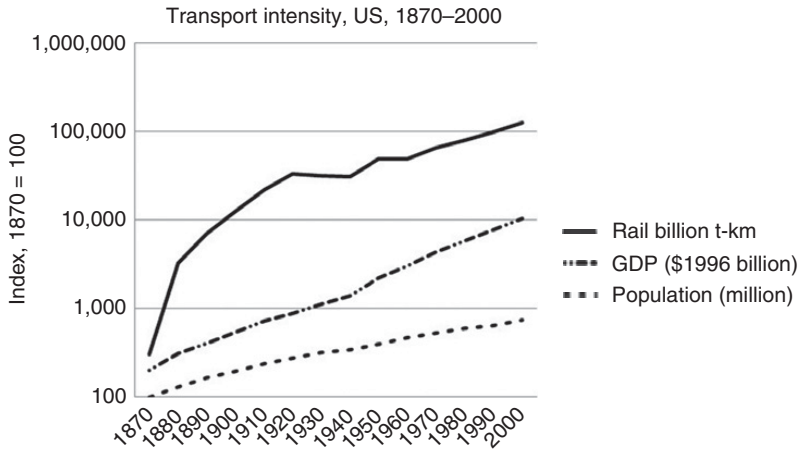

FIGURE 1.10 Transport intensity, United States
Data source: International Historical Statistics, the Americas, 1750–2005

only rail freight tonne-kilometres neglects the role of water and horse-powered transport at the start of the series and of trucks at the end. Nevertheless, population grew 7-fold from 1870 to 2000, real GDP 97-fold and rail freight 1,155-fold. The transport intensity of the economy therefore increased at least tenfold from 1870 to 1920, after which rail freight grew in parallel with the economy.

Figure 1.11 shows the development of the absolute level of rail freight in the United States. The ceaseless-growth trend was only disrupted by the Great Depression and the World War II bounce-back caused by the country's massive mobilisation and production of military equipment. It has, in fact, accelerated since 1990. US freight railroads have invested massively in technology and modernisation (they were pioneers in diesel-electric traction and centralised train control from the 1930s), accompanied by a major consolidation of lines through mergers and acquisitions, and a clear separation between long-distance and local companies. Rail vehicles are completely standardised and interchangeable between the different railroads. Huge trains laden with bulk minerals (especially coal) run to power stations and export ports. Equally huge trains laden with containers

FIGURE 1.11 The relentless growth of US rail freight
Data source: International Historical Statistics

(often stacked two-deep thanks to the generous loading gauge) and trucks on flat cars cover immense distances. New automobiles are delivered in special car carriers. These railroads are profitable private companies that have transformed themselves from universal general carriers into long-haul specialists with robust business models, seemingly impervious to life cycle effects. The contrast with the United Kingdom could not be stronger and is mainly attributable to the very different sizes of the two countries and consequent length of hauls. The other difference has been between pervasive and often detrimental state intervention in Britain's railways (including nationalisation in 1948) and the United States's free enterprise approach (apart from the US Rail Road Administration taking charge in wartime).

IT REMAINS THE LARGEST MODE FOR LONG-DISTANCE FREIGHT

Rail has lost share of long-distance freight in the United States since 1940, as Figure 1.12 shows, but has continued to grow and remains the largest mode. This may seem surprising, given that road is usually

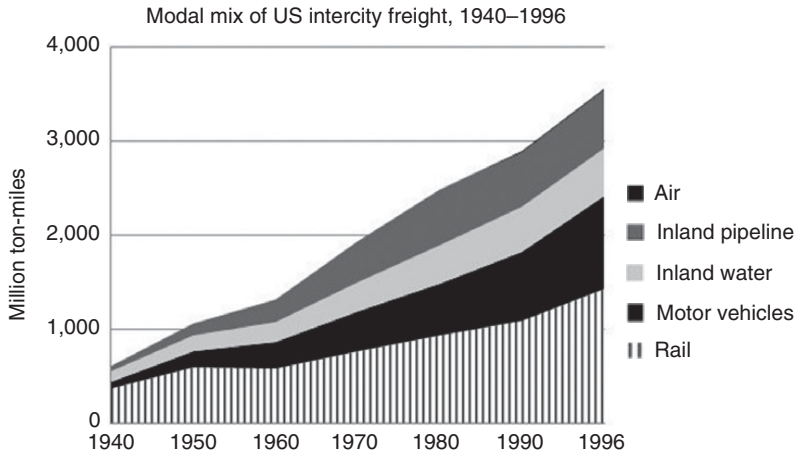

FIGURE 1.12 A high rail share of long-distance freight
Data source: Historical statistics of the United States

assumed to dominate the scene. Of course, it does so for local haulage and is larger in aggregate. There is simply a rational division of labour, with rail dominating bulk freight (notably coal, upon which the United States is still heavily reliant for electric power generation) and long hauls. The US railroad industry has been a major beneficiary of containerisation and of the country's increasing dependence on manufactured imports. Air freight has grown vigorously but remains very small in terms of ton-miles. So here we have a different manifestation of the lifecycle one in which a particular activity is partly but not wholly superseded by a newer one, a segmentation of the market and of the means of satisfying its needs. As in passenger transport, road freight wins on flexibility but not on cost over long distances.

RAIL TRANSPORT PROVOKED THE FIRST INSTANCES OF GOVERNMENT INTERVENTION AND REGULATION

Rail is interesting not just as the first form of powered land transport, with its own life cycle. It was also the first non-military industrial sector to provoke government intervention and regulation, for reasons of economic development, financing, protection of property,

safety, standardisation and anti-trust. This took very different forms in the nineteenth century heyday of railway development in different countries: largely laissez-faire in Britain, state-interventionist from the start in France and initially interventionist at the State level then changing to rules-based regulatory in the United States.[8] Large-scale industry usually forces governments to intervene in some or all of these aspects. Most relevant from the perspective of this book is Dobbin's argument that industrial policy is rooted in the nature of the national polity itself, and that this can radically change from one approach to another, as in the US example, as that polity changes.

ROAD OVERWHELMED RAIL IN PASSENGER TRANSPORT FROM BEFORE WORLD WAR II

The development of passenger transport has been the diametrical opposite, as can be seen in Figure 1.13. Cars (including light trucks, vans and SUVs used for passenger transport) have absolutely dominated the fast-growing overall volume of traffic since before 1940, the

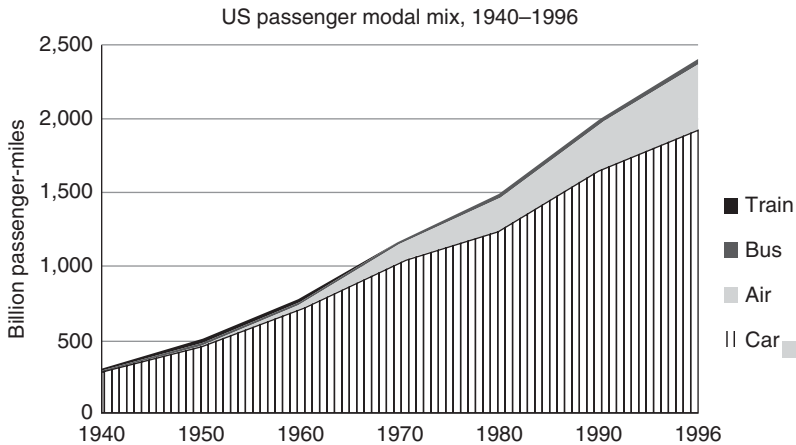

FIGURE 1.13 Dominated by the car – and the airplane
Data source: Historical statistics of the United States

[8] All this is thoroughly described in *Forging Industrial Policy*, Frank Dobbin, Cambridge University Press, 1994.

result of the United States's early mass motorisation. Air transport has made significant inroads since the 1950s. Bus and train are completely marginal today. Rail was squeezed from both ends – by the flexibility of the car for short distances and by the speed of the airplane for long ones. The passenger rail life cycle in the United States took about 100 years to run its course. Rail now only enjoys a significant share of passenger traffic in the North East corridor and in commuting into New York and Chicago. A major reversal is highly unlikely under present circumstances, despite various attempts to develop high-speed routes, in imitation of Japan, Europe and China.

THE US LIGHT VEHICLE PARC REALLY TOOK OFF AFTER WORLD WAR II

The US light vehicle parc grew continuously for 100 years – see Figure 1.14 – with a slowdown caused by the Great Depression and World War II. The discontinuity in the chart reflects a reclassification that recognised that many light commercials (light trucks) were being used as alternatives to passenger cars. This was an unintended consequence of poorly thought out CAFE (Corporate Average Fuel Economy) rules instigated in the early 1980s, in response to the 1973 and 1979 oil price shocks. The parc

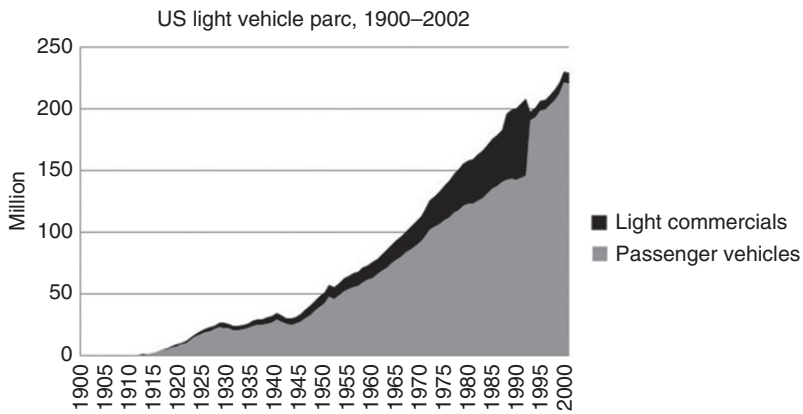

FIGURE 1.14 100 years of continuous growth
Data source: International Historical Statistics

has continued to grow since, more or less in line with population growth.

Passenger transport is thus dominated by the car in the large-area developed countries (the United States, Canada, Australia) and also in Europe, despite a much higher average density of population. Limits are really only encountered at very high densities, as in Japan. This is a possible harbinger of things to come, as more and more of the world's population moves into mega-cities.

MASS MOTORISATION TOOK PLACE IN MANY COUNTRIES BUT TO DIFFERENT DEGREES

Mass motorisation remains a phenomenon of the developed world, as shown in Figure 1.15. The low-population-density developed countries are most highly motorised, although the correlation with per

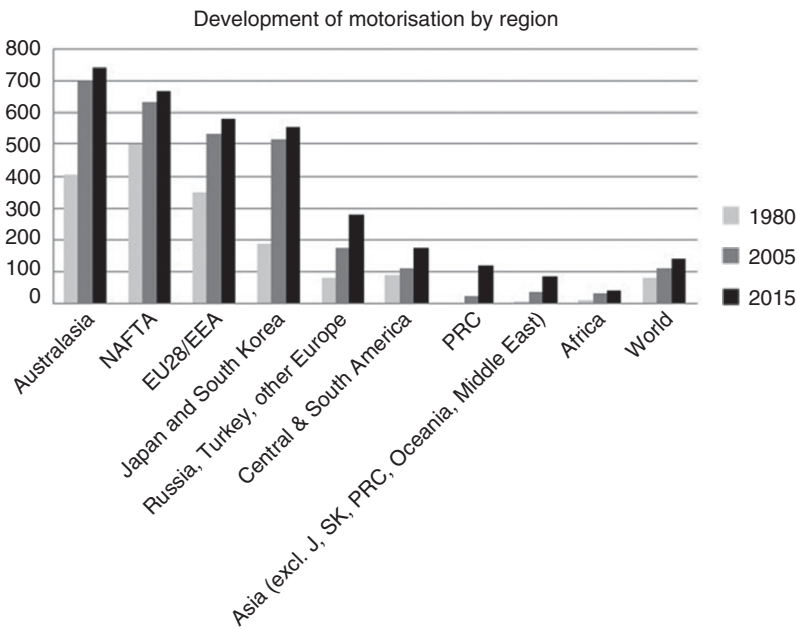

FIGURE 1.15 Still lots of space for growth?
Data source: MVMA 1982, OICA

capita GDP is not perfect – New Zealand had 819 vehicles in use per 1,000 population in 2015, sustained at low cost by having opened its market to massive imports of used cars. These mainly come from Japan, which also drives on the left, and has very stringent vehicle inspection standards, such that cars are retired from service unusually early. Japanese motorists also drive fewer kilometres per year than those in North America, Europe or Australasia, which further ensures a steady supply of good quality low-mileage used cars. Australia has always resisted this solution but keeps its cars in operation for a long time, aided by the dry climate. The US figure for 2015 was 821 cars (or car equivalents) per 1,000 population but the NAFTA average is pulled down a little by Canada and more so by Mexico. Rich but more densely settled regions, such as Europe and industrialised Asia (mainly Japan and South Korea) have slightly lower levels. All other regions remain considerably behind. The People's Republic of China has been motorising fast but still lags the OECD countries by a long way. The big question, of course, is whether it and other fast-developing Asian economies will follow the West along the road to mass motorisation. The automotive industry does, of course, wish this to be so. But will it really happen?

DESPITE APPEARANCES, THE GROWTH IS NOT ENDLESS

The number of vehicles in service throughout the world has indeed increased hugely, from very small beginnings, as shown in Figure 1.16. The difference between passenger cars (PCs) and all motor vehicles (MVs) is principally made up of non-PC light vehicles (LVs). These include not only light commercial vehicles (LCVs – notably pickup trucks, vans and 4x4s used for commercial purposes) but also many of these, including SUVs, used as substitutes for passenger cars, notably in North America but also increasingly so elsewhere. This seems to convey a picture of unending growth, heading for 2 billion vehicles in use or even more. But the story is more nuanced than that. Careful examination of the chart shows the beginnings of a change in the pace of growth in the later years.

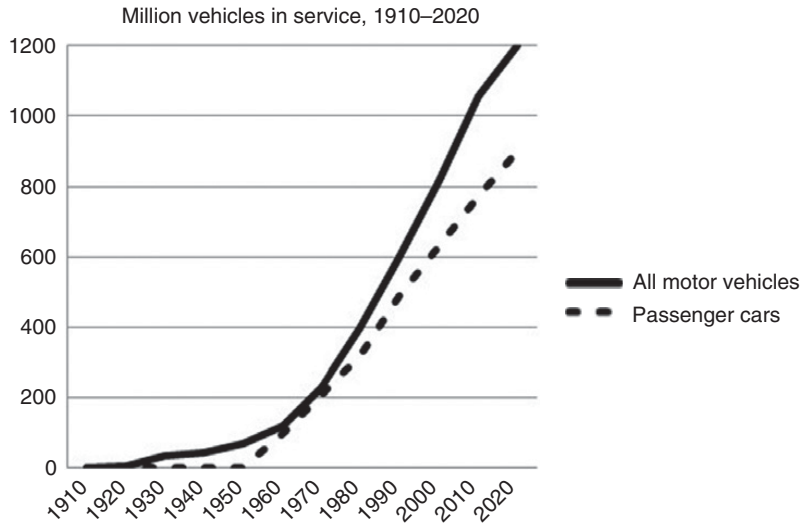

FIGURE 1.16 Seemingly endless growth
Data sources: OICA statistics, Autopolis

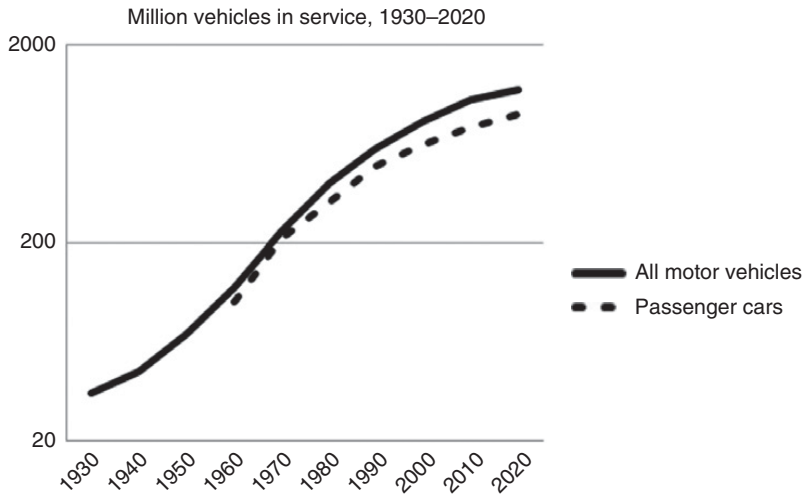

FIGURE 1.17 Growth apparently stalling
Data sources: OICA statistics, Autopolis

Figure 1.17 narrows the time frame, starting in 1930, by which time the industry was almost wholly operating on a mass production rather than a craft basis. The vertical axis is now a logarithmic one, emphasising growth rates rather than absolute numbers. The growth rate of vehicles in service (known as the parc) increased after World War II but began to slow again after 1980, which we would argue was the mid-point of the industry's life cycle and also marked the end of post-war reconstruction. But that would still leave it with another ninety-five years to go. The brake is simply market saturation: the mobility needs of people in the developed economies are now largely catered to. The expectation that newly emerging markets will take up the baton and race towards mass motorisation in the same way is, in fact, a false one, for a number of reasons. It is dangerous simply to extrapolate from past experience.

CHINA HAS RELAUNCHED MARKET GROWTH – BUT WILL NOT NECESSARILY FOLLOW THE SAME PATH

By 2005, the world vehicle market was no longer growing significantly. Figure 1.18 shows its development since then. The NAFTA region,

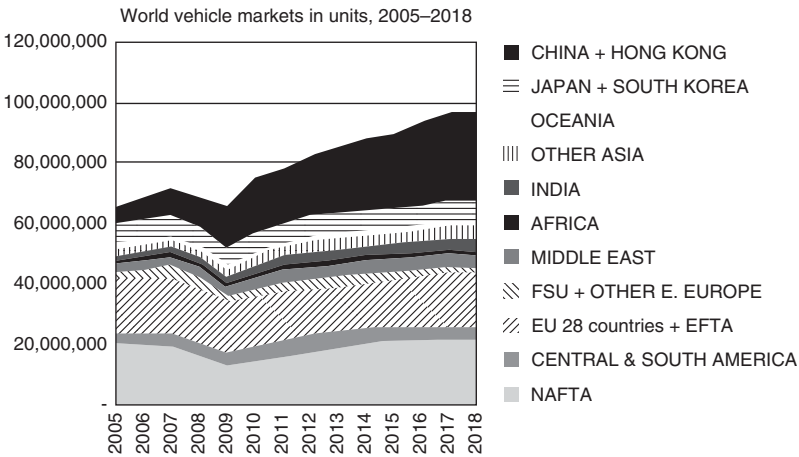

FIGURE 1.18 China shoulders the burden
Data source: OICA statistics

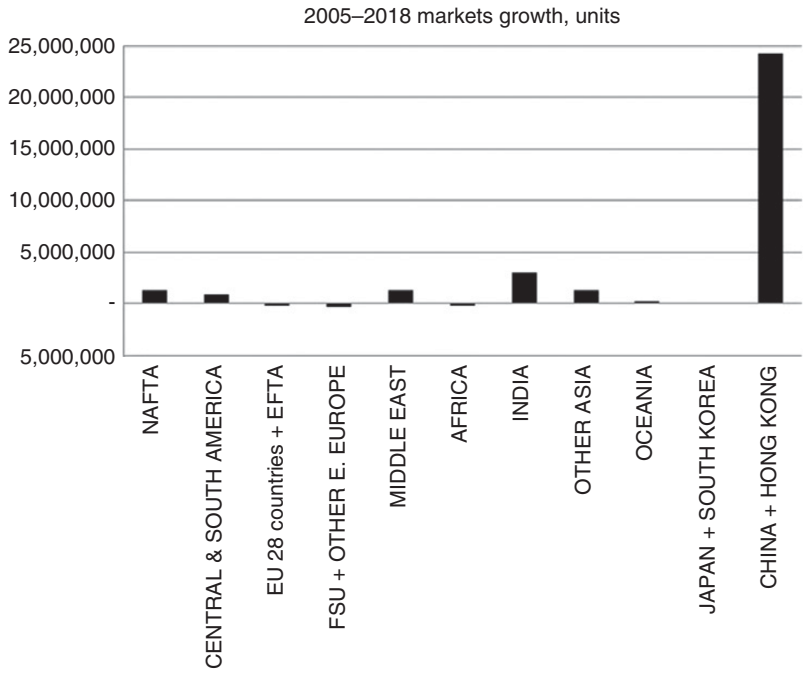

FIGURE 1.19 76% of recent growth has been in China
Data source: OICA statistics

dominated by the United States, took a bad knock from the Global Financial Crisis but has since recovered. Central and South America is small in comparison and suffers from the fluctuations of its largest market, Brazil, which continues to go through cycles of social and economic optimism followed by disappointment. The EU suffered less, largely thanks to government support schemes (scrappage incentives) and has also recovered. The market in the FSU (former Soviet Union) and neighbouring countries has been affected by the problems in Russia and is small. Everything else is also small, including India, with the huge exception of China, which has been responsible for the overwhelming majority of all the growth in the global vehicle market. These numbers, incidentally, are for all motor vehicles, as heavy and light commercial vehicles are irrationally lumped together in the statistics. This is

particularly problematical for North America, where large volumes of light trucks are used as substitutes for passenger cars. Heavy commercial vehicle volumes are small, however, so that the overall picture for light vehicles is not much distorted.

The point is reinforced by Figure 1.19: 97 per cent of all net market growth between 2005 and 2017 came from the emerging markets, and 76 per cent of it from China alone. The mature markets contributed very little at all. Will this growth continue at such a pace, particularly in China, until the emerging markets achieve mass motorisation as in the West, Japan and South Korea? There are serious reasons to doubt this.

FOUR FACTORS ARE NOW STARTING TO CONSTRAIN THE FURTHER GROWTH OF MOTORISATION

The answer is that headlong growth will most probably not continue, at least not for the automobile in its present form, although there is some growth yet to come. Events outside the automotive industry have overtaken it. Its environment has changed from favourable to increasingly hostile. There are four factors that will increasingly limit its future growth:

- The cost of fuel
- Urbanisation
- The environment
- The telecommunications revolution

First of all, the cost of fuels for cars will inexorably rise. The initial symbiosis between coal production and the steam engine was described earlier. The steam locomotive was superseded not only because of its inflexibility but also because of its hideously poor thermal efficiency (of the order of 4 per cent, compared to 30 per cent for a diesel engine). Coal production continued to grow enormously to feed the production of steel, cement and electricity. The cost of producing it, in fact, fell, in part through the mechanisation of deep mines but mostly through the large-scale development of open cast mining. World coal production is huge: 1 billion tonnes

per year in the United States, 3 billion in China, plus Australia, South Africa, etc. The vast growth in the use of road vehicles powered by petroleum-based fuels was the largest factor in the development of the oil industry.

CHEAP OIL NO LONGER HELPS DRIVE MASS MOTORISATION

Figure 1.20 shows the history of crude oil prices from 1861 to 2018. In the first years of production, oil was expensive to extract. As production built up and techniques of well drilling improved, the price fell by 80 per cent. For the first seventy years of automotive history, from 1900 to 1973, it remained remarkably low and stable. Since then, it has fluctuated wildly around a much higher level. Beyond the political events in the Middle East, which have brought actual or feared shortages, two factors are in play. First, the industry has considerable difficulty in adjusting to downturns, in large part because many of the producing countries are so economically reliant on oil production. Secondly, and underlying it all, are the huge disparities in production costs. Delivered to the refinery, oil from traditional fields such as those in Saudi Arabia,

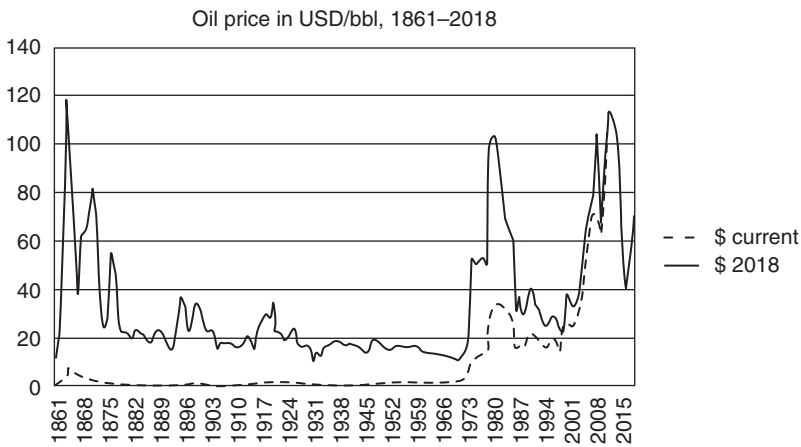

FIGURE 1.20 Oil gets expensive
Data sources: Oil industry, Autopolis

Iraq or Iran, costs about $10 per bbl to produce. That from deep-sea fields can cost over $50 per bbl. This is a source of short-term pricing instability. But, more fundamentally, as the lower-cost fields become exhausted, oil has to be found from ever-more-difficult and costly sources, notably deep-sea fields, such as those off Brazil. The risk of accidents that are very damaging to the environment and very costly is all too real – witness BP's 2010 Deepwater Horizon 'spill', which almost broke the company and caused huge damage to the US Gulf Coast. Road transport – dominated by passenger vehicles – is the largest and one of the fastest-growing consumers of oil. Fuelling cars will, on trend, continue to become more and more expensive, reducing their relative attractiveness.

THE GROWTH OF URBANISATION MAKES DRIVING CARS LESS ATTRACTIVE THAN BEFORE

Second, urbanisation is an inexorable global trend. Car use in cities is declining while urbanisation continues. It is well known that the ownership and use of private cars in the centres of large metropolitan areas is well below average. Look at Tokyo, Manhattan, London or Paris. The share of journeys made by car in more densely populated metropolitan areas has been falling – 30 per cent down from its peak in London, for example. Car use in German cities started to decline twenty years ago. The larger the city, the smaller the role of the private car. Increased traffic congestion and the rising cost of motoring are one factor in this. An increasing number of cities are restricting access to city centres for private cars, often imposing entry tolls and making parking very expensive. Many city and town centres have already been made car-free. As a result, there is increasing recourse to other modes of transportation, from walking and cycling to taxis and car sharing and to buses, light rail and heavy rail. Access to and the convenience of using alternative transport modes has been greatly increased through IT, notably apps on smartphones. The free use of individually owned cars will be increasingly inhibited. Driving – not only in cities – is subject to

increasing congestion and constraints. It's simply not the fun or convenience that it used to be. The day is not far off when we shall have to file a journey plan and book a slot, just as has long been the case in aviation.

GLOBAL WARMING POSES AN EXISTENTIAL THREAT TO AUTOMOBILES IN THEIR PRESENT FORM

Third, the environment. This has been the subject of so much writing and discussion that it need not be repeated in detail here. The scientific consensus is clear: if we do not cut greenhouse gas emissions deeply and rapidly, we risk catastrophe. The urgency and the measures required are starkly presented in a recent book:[9] one measure is to ration car use to 3,000 km per year, one-third of today's average in Europe, let alone the United States. Road transport is one of the largest sources of toxic emissions and of CO_2, and the fastest growing. It is clear that the world cannot afford for the emerging markets to motorise en masse, as did the OECD countries. Allowing them to achieve a sufficient level of mobility as they develop economically, and sustaining one in the already developed countries is impossible with the present pattern of road vehicle use and the technologies employed. We are not going to see 2 billion vehicles or more of today's type of cars on the world's roads. Simply electrifying existing types of vehicles provides no real solution either, while most electricity is generated from fossil primary energy sources. This ultimately has to mean the end of the automobile and of the automotive industry, as we know it today. We return to this in Chapter 2. The public is in general unaware of how deep and rapid the cuts need to be. There is much resistance, for example, to attempts by governments to restrict motoring directly or indirectly via increased taxes. The Gilets Jaunes protest movement in France against increased taxes on motor fuels, particularly diesel, and supported by 78 per cent of those questioned in attitude surveys is a case in point. Universal road tolling, with rates varied by time of day

[9] *Change! Warum wir eine radikale Wende brauchen*, Graeme Maxton, Komplett VEDA, 2018.

and journey, is already technically feasible but politically very hard to implement. Change will have to come but socially and politically it will be very difficult to achieve. But this is no excuse for inaction. Nor is it enough to load the whole responsibility onto the supply side, i.e., the automotive industry and the vehicles it delivers. As an admirably lucid former CEO of PSA Peugeot Citroën put it some years ago, if people want less pollution from their cars, they have will to drive them less. So much for the untrammelled freedom afforded by the automobile.

HAVING SUBSTITUTED FOR RAIL, THE AUTOMOBILE IS ITSELF STARTING TO BE SUBSTITUTED BY VIRTUAL MEANS

Fourth, a fundamental factor working against the growth of the automobile has been the enormous expansion in data and telecommunications services of every variety, at steeply declining real costs. In hindsight, the start of this trend was already evident in 2000. Figure 1.21 illustrates how

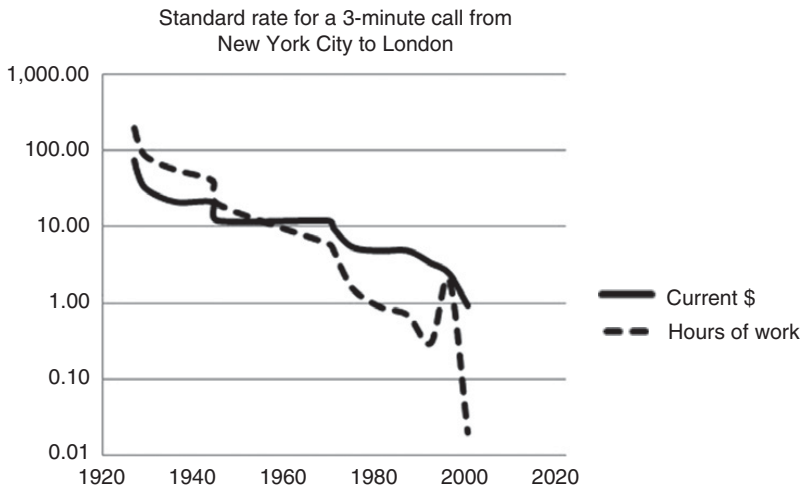

FIGURE 1.21 A staggering decrease in telecoms prices
Data source: Internet Pricing and the History of Communications
Andrew Odlyzko, AT&T Labs Research, 2001

the cost of a telephone call went into steep decline with the advent of fibre optics and satellite communications, plus digital switchgear. Much more was to follow, as we now know, but this was one of the precursors. The explosion in digital electronics has been literally life changing. One hundred years ago, the great majority of those who emigrated across the oceans could not expect to see their original homes and families again. Cheap airfares then made an occasional visit affordable for most. Now a virtual visit can be made as often as desired, at virtually no cost. It is a real revolution, of the most fundamental kind. We are only just beginning to appreciate its scope and impact. This is a clear and spectacular example of a substitutional life cycle effect. Lower-cost water transport by canal wiped out the cart-and-horse haulier. The railway wiped out the stagecoach and the post chaise, and also water transport for freight, except for bulk commodities. The car and the truck wiped out the railway, except in specific market segments. Now telecommunications is wiping out the car (but not the truck), or at least improving the efficiency of their use, except in specific demand segments. In every case, it's a matter of faster, cheaper, more convenient – and, today, less environmentally damaging. And this is an effect on the demand side of the equation, which causes a reduction in the need and desire for physical mobility, a market-driven natural response to innovation, unlike retroactive restrictive constraints placed on physical mobility.

THE AUTOMOBILE IS NOW NO LONGER THE ICON THAT IT ONCE WAS

The consequence of all these increasing pressures is that the private car is no longer the icon of growth and personal fulfilment that it once was. A deeply threatening trend for the automotive industry is the loss of interest in driving and owning cars on the part of millennials. This represents a fall in demand, rather than a regulatory constraint, whether on driving or on the specific fuel consumption of cars. US Department of Transportation statistics for driving licences show that only half of teens now drive. This is a huge change from the past, when every American kid wanted a car as soon as possible. The car has lost its

prime social role among the young. No more cruising up and down Main Street in the evening. A 2014 survey by Schoettle and Sivak of the University of Michigan examined why a substantial percentage of young adults currently do not have a driver's licence and the future plans of this group concerning obtaining a licence.[10] The top eight reasons for not having a driver's licence were as follows: (1) too busy or not enough time to get a driver's licence (determined by personal priorities), (2) owning and maintaining a vehicle is too expensive, (3) able to get transportation from others, (4) prefer to bike or walk, (5) prefer to use public transportation, (6) concerned about how driving impacts the environment, (7) able to communicate and/or conduct business online instead and (8) disability/medical/vision problems. Of the respondents, 22 per cent indicated that they plan never to obtain a driver's licence. On the other hand, 69 per cent expect to get a driver's licence within the next five years. It's rather different once you have a job, a family and a house in the suburbs. But 69 per cent is still a historically low figure. It may all seem rather anodyne and modest but in fact it reflects a profound change in attitude towards individual motorised mobility.

A 2011 study by the same authors examined the recent changes in the percentage of persons with a driver's licence in fifteen countries as a function of age. The countries included were Canada, Finland, Germany, Great Britain, Israel, Japan, Latvia, the Netherlands, Norway, Poland, South Korea, Spain, Sweden, Switzerland and the United States. The results indicate two patterns of change over time. In one pattern (observed for eight countries), there was a decrease in the percentage of young people with a driver's licence, and an increase in the percentage of older people with a driver's licence. In the other pattern (observed for the other seven countries), there was an increase in the percentage of people with a driver's licence in all age categories. A regression analysis was performed on the data for young drivers in

[10] *A survey of public opinion about autonomous and self-driving vehicles in the U.S., the U.K., and Australia*, Brandon Schoettle & Michael Sivak, University of Michigan Ann Arbor, Transportation Research Institute, 2014.

the fifteen countries to explore the relationship between licensing and a variety of societal parameters. Of particular note was the finding that a higher proportion of Internet users was associated with a lower licensure rate. The results of the analysis are consistent with the hypothesis that access to virtual contact reduces the need for actual contact among young people. A smartphone matters to them more than a car. They can do more with it, at much less effort and cost.

Car brands – volume ones at least – have also fallen far behind other product brands in the esteem of consumers. An analysis of the 2017 Forbes ranking of brand values is revealing in this respect. Only eleven automobile manufacturer brands made it into the top 100: Toyota #8, Mercedes-Benz #17, BMW #21, Honda #26, Audi #37, Ford #39, Chevrolet #57, Porsche #60, Nissan #67, Hyundai #68, Caterpillar #82. Note the preponderance of German up-line and Asian brands. The automotive cohort in the top 100 achieves half the brand value relative to brand revenue of the non-automotive brands, despite spending 30 per cent more on advertising as a proportion of revenue, and gets less than half the brand value per advertising dollar. This is a sinister development for an industry that relies so much on branding and advertising its products in order to achieve differentiation and hopefully increased sales. We return to the industry's failing business model in Chapter 3.

IN SUMMARY, THE AUTOMOBILE IS SUBJECT TO ITS OWN LIFE CYCLE PHENOMENON

The railways were the great transportation innovation of the first half of the nineteenth century, an unprecedented and epoch-making upheaval in human lives. They rapidly became the dominant, indeed near-universal mode of passenger transport. They did not disappear with the arrival of the automobile but were relegated to specific niches within the overall market. They often hold on to these only with the help of government subsidies. It is the tail end of a long life cycle. The same will hold for the automobile, even if its life cycle ends up spanning more than two centuries. Already, the overwhelming mass of

person-to-person contacts is enabled by telecommunications and electronic media. Physical mobility will never wholly disappear but it will be reduced in scale and achieved by different means. But it will be a very long and difficult disentanglement, given how much the automobile is imbedded in developed and developing societies. Until now, everything has been done to encourage and facilitate an increase in physical mobility, and the automobile has been the greatest ever instrument of that. We need to understand that from now on the trend has to reverse, with physical mobility reduced or accomplished in ways that are less damaging to the planet. There are no silver bullets for this. Technological fixes to automobiles won't do it and it is unreasonable to expect the automotive industry (the supply side) to solve the problems on its own. The initiative has to come from the demand side. Individual consumers generally have neither the immediate motivation nor the means to do so. This is the role of government, through the political process. It will be neither quick nor easy. They will be bitterly resisted and progress may be fatally slowed.[11] This massive industry has a great depth of sunk investment in highly developed existing products, technologies and processes, along with very strong internal disciplines and a great deal of pride. Unless some environmental catastrophe forces a change of heart and very possibly panic measures, it will continue to struggle with replacing these with something else, in all likelihood less attractive to consumers and more expensive.

[11] The Gilets Jaunes movement in France in 2018 is a case in point, supposedly triggered by the reduction of the national speed limit from 90 to 80 km/hour.