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Peak Car and Beyond: The Fourth Era of Travel

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ABSTRACT *There is emerging evidence that personal daily travel, particularly by car, has ceased to grow in the developed economies. This can be attributed to saturation of demand, given high levels of access and choice now widely available, together with constraints on higher speeds. We are therefore at a time of transition from an era of growth of per capita travel to an era of stability, in which the future factors determining the growth of total travel demand are demographic — population growth, increasing longevity, and urbanisation. The peak car phenomenon, which marks this transition, is seen in successful cities that attract a growing population whose travel needs are increasingly met by investment in rail-based transport, the revival of which is a characteristic of the new era.*

> The future is already here — it's just not evenly distributed. (William Gibson)

Introduction

Mobility is central to human existence. Travel has been a key determinant of social and economic wellbeing since early modern humans walked out of Africa 60 000 years ago. In the first era of travel, humans as hunters–gatherers probably spent on average 3–4 h a day on the move, covering some 3000–4000 miles a year, as judged from behaviours in surviving Stone Age societies (Kelly, 1995). At the same time, they made longer journeys to find new habitats, thus populating all the inhabitable parts of the earth.

The second era of travel started with the Neolithic Revolution in the Middle East 10 000 years ago, based on cultivation of plants and domestication of animals. Farmers work hard because they can secure increasing returns from their efforts, unlike hunters–gatherers who are subject to diminishing returns as their wild food resources become scarcer. Once people lived in settled communities, the need to travel was much less and time for travel was at a premium, competing with time for working, eating, socialising, sleeping, and the rest, all

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between sunrise and sunset. It seems that, on average, people spent around an hour a day travelling. Evidence comes from modern low-income rural communities, and from the size of historic settlements, where it rarely took more than an hour to walk from the centre to the edge of the territory, whether the land holdings of the village or the boundaries of the city (Marchetti, 1994; Schafer & Victor, 2000). In an hour a day, at walking speed, the average distance travelled was about a thousand miles a year.

The third era began early in the nineteenth century with the invention of the railway. Harnessing the energy of fossil fuels, first coal and then oil, made higher speeds and mass mobility possible. Over the course of two centuries, the average annual distance travelled in Britain increased from 1000 to 7000 miles a year by surface modes, still utilising about 1 h a day of travel time, but permitting a huge increase in economic and social opportunities.

The purpose of this paper is to propose that we have now entered a new era of travel — the fourth — in which average per capita growth of daily travel has ceased. In the future, demographic considerations — population growth, ageing, and urbanisation — will be important for the overall amount and mode shares of travel, and technological developments will be influential. The phenomenon referred to as 'peak car' is a manifestation of the transition from the third to the fourth era of travel.

Cessation of Growth of Per Capita Travel Demand

Changing travel patterns in Britain has been followed over the past 40 years by the National Travel Survey (NTS), a household survey involving some 20 000 respondents annually, commissioned by the Department for Transport (DfT). This covers all modes of travel except international aviation, and accordingly accounts for daily personal travel. Detailed features of the NTS and relevant past developments have been discussed previously (Metz, 2008, 2010). Figure 1 shows per capita average data for annual trip rate, travel time, and distance travelled, up to 2011.

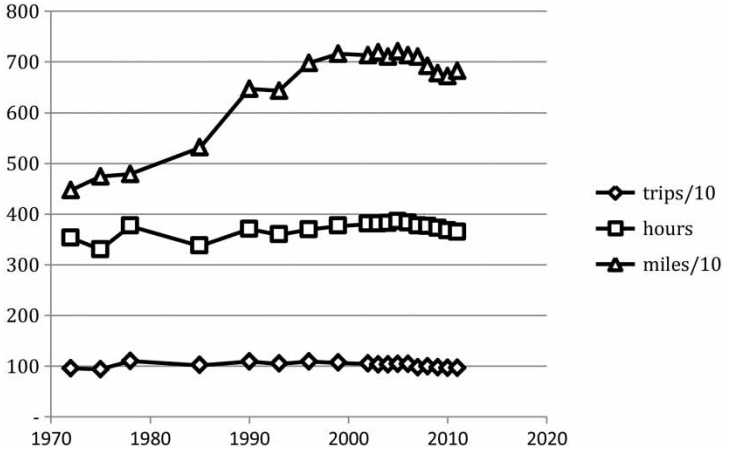

Figure 1. Average travel time (hours per person per year), distance (miles per person per year), and trips (miles per person per year).
Source: NTS (2011, Table NTS 0101).

The key features of the travel behaviour of the population as a whole that are generally observed are substantially invariant travel time (an hour a day on average) and trip rate (1000 trips a year). In contrast, annual distance travelled has increased from 4500 miles in the early 1970s (and from about 1000 miles in the early nineteenth century, as discussed above) to about 7000 miles in the mid-1990s at which point growth ceased (the recent downturn is probably due to the economic recession). To the extent that data are available, a similar pattern is seen for other countries (Metz, 2008). In particular, an average travel time of about an hour a day appears to be a general characteristic of populations of both developed and developing countries (Schafer & Victor, 2000).

The car is the dominant transport mode in most developed economies. There is growing evidence that the growth of car use per capita has ceased in such countries, as discussed in this issue and previously (Gargett, 2012; Kuhnimhof et al., 2012; Le Vine & Jones, 2012; Lucas & Jones, 2009; Metz, 2010; Millard-Ball & Schipper, 2011; Puentes & Tomer, 2008). This cessation of growth of car use is consistent with the proposition that per capita daily travel has substantially stabilised in the developed economies.

It is evident from Figure 1 that the consequence of the substantial investment in the transport system over the past 40 years has been that people take advantage of the higher speeds possible to make longer journeys in the same amount of time, on average (and for the same purposes, Metz, 2010). The benefit of investment has neither been taken in the form of more trips nor as time saved to permit more work or leisure activities. The central concept of conventional transport economics — that the benefit of investment can be valued on the basis of travel time saving — is therefore problematic (Metz, 2008). To the extent that time savings occur, they are transient. In the long run, the benefit has been taken in the form of more access, choice, and opportunities — which has always been the reason for improving the transport system.

Where people are constrained to travel at walking pace, access, choice, and opportunities are limited, whether historically in now developed economies, at present in rural villages of developing economies, or in rural areas of the developed world for those without use of a car or adequate public transport. Choice of jobs accessible from home, choice of homes accessible from place of employment, choice of shops, schools, and the rest, all are limited. The ability to travel faster than walking pace enlarges opportunities and increases choice.

Choice

The relationship between speed of travel and choice of given kinds of destination can be illuminated by analysis of accessibility statistics prepared by the UK DfT, intended to help local authorities develop strategies for improving access of their population to services and employment. Origin indicators look at the opportunities and choices available to a target population in a particular area.[1] The target population is the subset of the resident population relevant for the trip purpose; for instance, children 5–10 years old for primary schools. For each indicator there are two threshold travel times, for example 15 and 30 min. The lower represents the national median for that class of journey, while the upper, twice the lower, encompasses 80–90% of all such trips. Data for population origins derive from the national census. Spatially referenced destination data for location of services and employment are derived from a variety of sources;

in the case of general practitioners (GPs) (family doctors) considered below, locations of surgeries are known from National Health Services records. Travel times are estimated from public transport timetables and from the road network using representative speeds (reflecting daily averages) according to mode and type of road. A fuller account of the methodology and results will be presented elsewhere (Metz, 2013).

As an example, Figure 2 shows average access of all households to GPs, as a function of mode and time of travel, for the population of each local authority in England. For a 15-min journey by public transport and/or walking, there is a wide distribution of access and choice across the local authorities (least in rural areas), whereas for a 30-min journey by these modes the populations of a majority of local authorities have access to five or more GPs. It is noteworthy that the populations of nearly all local authorities have access to five GPs within 15 min by car, exemplifying the high level of choice available to those with use of a car (which accounts for nearly two-thirds of all trips). Access to hospitals and educational establishments show similar patterns, and likewise for employment generally and food stores.

The UK Competition Commission, in response to concerns about potential anti-competitive behaviour, adopted a similar approach to analysing access to food stores, focussing in this case on large supermarkets. The large retailers account for 85% of total grocery sales, with 60–70% of customers undertaking a major shopping trip once a week. The Commission has estimated that 80% of the urban population of Britain has access to three or more large stores, and 60% to four or more, within a 15-min drive (Competition Commission, 2008). This good level of choice has arisen in recent decades through investment to increase access — private investment in more cars, public investment in roads, and commercial investment in supermarkets.

A simple model postulates that access and choice increase with the square of the speed of travel, since what may be accessed in a given travel time is defined by the area of a circle whose radius is proportional to speed. Similarly, for a given speed, access and choice increase with the square of the travel time. This simple model assumes an ability to move radially in all directions to access destinations that

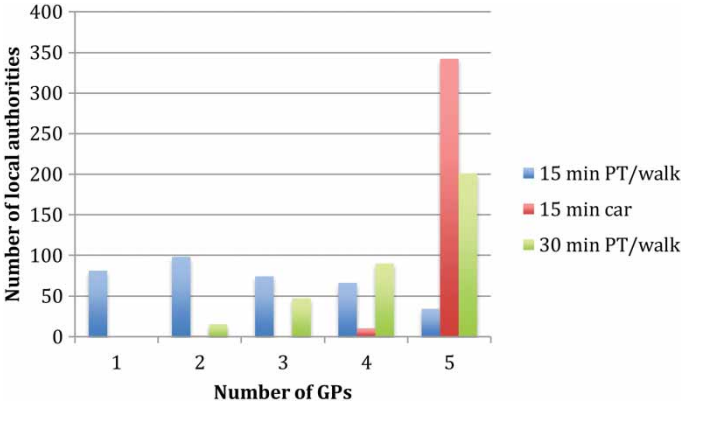

Figure 2. Access to GPs. Number of local authorities with access for households to average number of GPs as a function of mode and time of travel (PT = public transport).
Source: 2008 LA Core Accessibility Indicators: origin, data fields GPSO 10, 12, 13, 14.

are uniformly distributed, and hence defines an upper limit. In reality, movement is constrained by the pattern of roads and public transport services, and destinations are discretely distributed. At the lower limit, access to destinations distributed along a single road increases with speed or time to the power of one, subject to the lumpiness of location distribution.

In general therefore, access and choice may be expected to increase with rather less than the square of the speed of travel. Choice, however, may be expected in general to exhibit the characteristics of declining marginal utility, in which, for instance, the benefits of additional choice from accessing the fourth supermarket by driving somewhat further are less than those from the third. This combination — of choice increasing with up to the square of the speed but being subject to diminishing returns — leads to the expectation that the growth of travel demand should slow and, in the limit, saturate.

Analysis of accessibility statistics allows the conclusion that high levels of access and choice of important kinds of opportunities and services are available to the generality of the population of England, particularly those able to take advantage of car-based mobility. The substantial increases in access achieved by car use at higher speeds and by longer journey times, compared with the base case (public transport and/or walking for the base case time), fit a simple saturation model. These observations are therefore consistent with the proposition that demand for personal daily travel has ceased to grow because needs for mobility-based access and choice have substantially been met (Metz, 2010).

As discussed previously, not all kinds of destination need be subject to travel demand saturation in the event of new transport provision becoming available (Metz, 2010). One likely exception is new housing on greenfield sites made newly accessible to centres of employment, attractive even in competition with an extensive existing housing stock. Another exception may be high-status employment offering salaries sufficient to cover the cost of long-distance commuting by new fast rail routes, thus avoiding the need to move house. In an economy with a mature transport system, additions to transport infrastructure are mostly modest, consistent with a collective judgement that high levels of access have generally been achieved. The occasional major project would have significant consequences for land use in its vicinity, but would not change the national outcome as shown in Figure 1.

Demand Saturation

Demand saturation occurs in other areas of the economy. A regular annual survey of household expenditure in the UK allows the ownership of consumer durables to be tracked over time (ONS, 2011). Household ownership of central heating, washing machines, fridge-freezers, and microwave ovens now exceeds 90%. Ownership of telephones, DVD players, digital television, and CD players exceeds 80%, and for home computers and Internet connection, ownership exceeds 70%. Car and van ownership has stabilised at 75% of households, probably reflecting substantial saturation of demand on the part of those able and wishing to drive (currently 72% of adults in Britain hold a driving licence). The markets for these products are therefore largely saturated, with sales mainly for replacement.

Uptake of new classes of product has been modelled in the technology adoption life cycle of Rogers (1964) in which successive adoption groups are designated

innovators, early adopters, early majority, late majority, and laggards. The cumulative uptake follows a logistic or sigmoid curve, representing market penetration and eventual saturation of demand for a new technology. The rate of market growth accelerates during the early phase of uptake, and then decelerates as saturation is approached. While this concept is well recognised, little further consideration of demand saturation is to be found in the business or economic literature. Osenton (2004) has discussed the implications of demand saturation for businesses. Aoki and Yoshikawa (2002, 2007, chapter 8) observe that in the standard macroeconomic literature, the fundamental factor restraining economic growth is diminishing returns to capital in production or in research and development. These authors offer a model in which the factor restraining growth is saturation of demand for individual consumption goods; the economy sustains growth through the introduction of new products and industries that sustain growth of demand and thus capital accumulation. Foellmi and Zweimuller (2008) note that when consumption evolves along a hierarchy of wants, consumers get increasingly satiated with existing products and new goods have to be continuously introduced to ensure that demand keeps pace with technical progress.

The significance of demand saturation as an observable phenomenon warrants further investigation to assess its potential contribution towards sustainability. While the saturation of ownership of consumer durables is to be expected, the saturation of demand for daily travel is less intuitive. There may be other examples awaiting discovery.

Population Growth

Per capital daily travel has ceased to grow in developed economies, as has car use, as discussed above. In the first instance, therefore, the emerging phenomenon may be designated 'plateau car'. Growing incomes no longer drive growth of travel demand. However, total travel demand is a function of demographic change — population growth, urbanisation, and population ageing.

Populations are growing in Britain and globally. The population of the UK is projected to increase from an estimated 62.3 million in 2010 to 73.2 million by 2035, mainly due to inward migration. Longer-term projections suggest the population will continue rising beyond 2035 reaching 89.3 million by 2085 (ONS, 2012). The implications for travel demand and the transport system of this substantial growth depend crucially on how the extra numbers are housed. The strategic issue is 'greenfield or brownfield'. This is not simply a matter of planning policy but also depends on where employment growth is located. Greenfield housing is associated with car use, would require more road capacity, and would result in more carbon emissions, all else equal. Housing on former industrial land (brownfield) within existing urban areas, as well as more intensive use of existing dwellings, is associated with public transport use since there is only limited scope for more car use on congested urban roads.

London is an example of a city that has experienced two decades of population growth, accommodated at higher density within the existing urban area. Road capacity has not been expanded so that there has been no growth of car trips, which have remained at about 10 million a day since 1993 (and car traffic has held steady at about 15 billion vehicle-miles a year). Because the population has been growing, this represents a declining share of total trips. Car trips have declined from 50% of all journeys in 1993, when the data series commences, to

38% currently, with further decline projected as the population grows (Metz, 2012; TfL, 2012). Public transport use has increased correspondingly, as shown in Figure 3. During the second half of the twentieth century car ownership grew nationally, and car use in London would have grown in parallel. This implies that 'peak car' occurred in London prior to 1993, if car trips are expressed as a share of the total. In absolute terms, car use in London has reached a plateau.

Travel data for London are collected by Transport for London in support of its comprehensive responsibilities for managing travel by all modes within London. There are no equivalent bodies for the other British conurbations and hence less travel information is available for these. Nevertheless, some relevant data are available for Birmingham and Manchester, the second and third largest cities, which suggest that a similar modal shift is occurring.

Figure 4 shows inbound trips into Birmingham City Centre at morning peak (0730–0930 h) over the period 1995–2009 (Birmingham, 2010). Total trips changed little, but there was a substantial decline in car journeys, a corresponding increase in rail plus metro, with bus trips remaining broadly steady. Over the period 2001–2011, the population of the city as a whole grew by 9%. As for London, car trips into the centre would have increased in the previous decades as car ownership grew, implying 'peak car' prior to 1995, in this case in absolute terms.

Figure 5 shows inbound trips into Manchester City Centre at morning peak since 2002 (HFAS, 2012). Again, a decline in car trips and a rise in rail, metro, and walking trips are evident. Total trips grew by 6%. Over the period 2001–2011 the population of the city as a whole increased by 19%. In this case, 'peak car' occurred in 2006.

A recent study has shown that a number of other English cities display significant declines in inbound vehicle numbers at the morning peak over the period 1999–2007, including Nottingham, Leicester, Bristol, Sheffield, and Liverpool, where there is evidence for a shift to rail-based modes and to walking and cycling (WSP, 2010). The conclusion drawn is that the observed reductions in

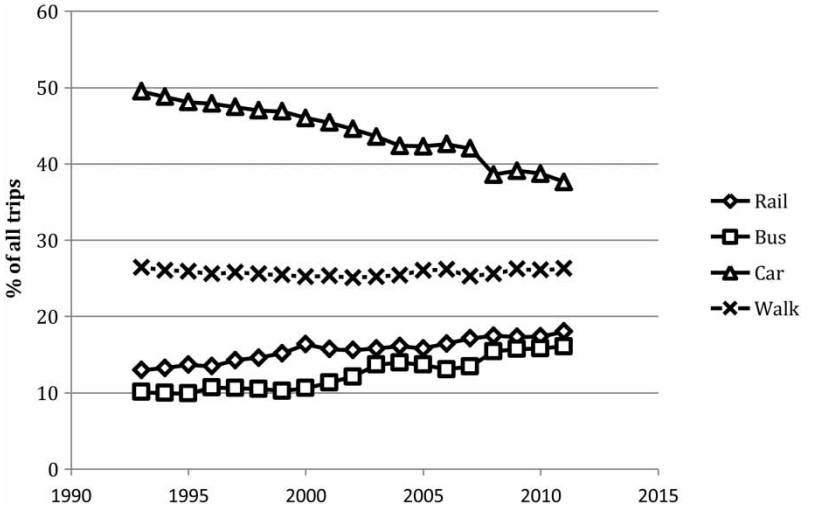

Figure 3. Travel in London: trip-based mode share.
Source: TfL (2012).

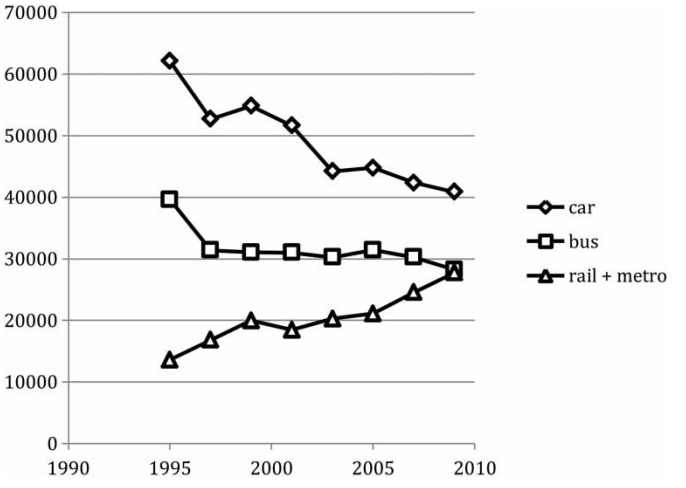

Figure 4. Birmingham City Centre inbound person trips per day, 0730–0930 h.
Source: Birmingham (2010).

car travel in these cities are not due to reductions in employment or resident labour force and that the urban renaissance should lead to a relative reduction in national car travel demand. A further study of six English regional cities relates the growth in demand for regional rail travel to economic growth and more central activity arising from a move from manufacturing to service sector employment and strong growth of shopping and entertainment, together with road congestion, limited parking provision, and increased parking costs (Crockett, Mason, Segal, Whelan, & Condry, 2010).

More generally, there has been a marked trend towards provision of new housing on brownfield land in England, reaching as much as 80%, as shown in Figure 6 (DCLG, 2010). This is a consequence of a government target of 60% for brownfield housing, local resistance to green field development, and the response of housebuilders to a market in which there has been demand for one- or two-bedroom properties, most of which are flats (up from fewer than 20% of new

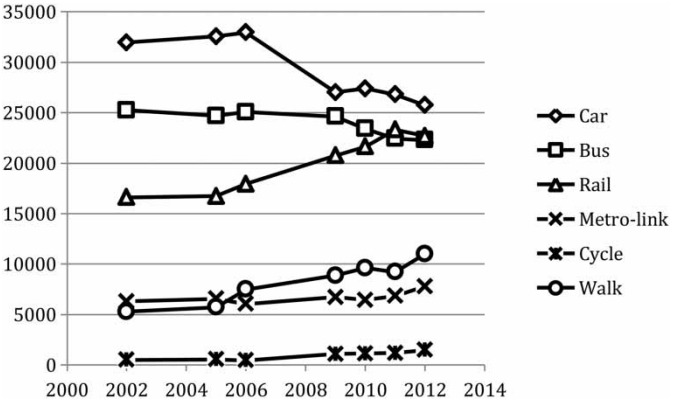

Figure 5. Manchester City Centre inbound trips per day, 0730–0930 h.
Source: HFAS (2012).

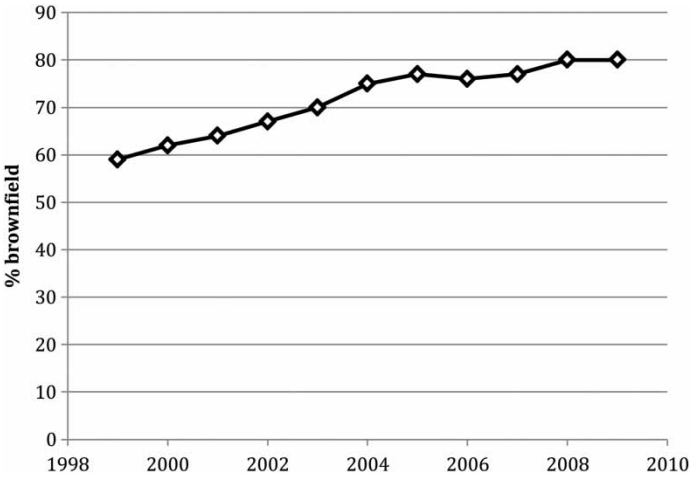

Figure 6. New dwellings on brownfield land.
Source: DCLG (2010, Table 11.1).

build completions in 1999–2000 to almost 50% by 2009–2010). Demand for smaller dwellings reflects both smaller household sizes and the high cost of property. Recent changes in government policy towards greenfield development may, however, reverse the trend to brownfield housing (Headicar, 2013).

The findings from London, Birmingham, Manchester, and the other cities are consistent with the proposition that car use in cities can decline from a peak as population density increases where effective public transport provision provides an alternative means of travel that is speedy and reliable. A good illustration is Canary Wharf, the new financial district in London's Docklands, where approaching 100 000 well-remunerated employees rely very largely on rail to get to work.

Population Ageing

National populations are ageing as longevity increases. In Britain and some other developed countries there is the additional impact of the ageing of the large post-war 'baby boom' cohort, adding to the numbers of older people. The impact of this trend on overall travel demand is as yet unclear, in part because increasing longevity means that the characteristics of particular age cohorts change. Thus over time more older women hold driving licences, while frailty and loss of independent mobility tend to occur later in a longer life course. Stokes (2013) has explored possible future levels of car use, taking account of the variation in car travel by age cohort and assuming some degree of behavioural inertia.

Population ageing is having the greater impact on travel demand at an earlier phase of the life course. Increased life expectancy allows the young to defer the transition to traditional adult life. More young people enter higher and further education, located mainly in urban centres. They continue in the urban lifestyle for employment and social life, facilitated by modern mobile technology — not cars but Internet and phones. Cars are expensive for young people to own, particularly the cost of insurance, parking is constrained, and do-it-yourself servicing difficult with modern vehicle technology. Driving licence holding by those in their 20s is in decline (Metz, 2012; Stokes, 2013). Cycling is fashionable amongst

professionals. Young people who do not drive take the train, contributing to the buoyancy of rail travel. Starting families is put off. In England the mean age of mothers having their first child has increased from 25.5 years of age in 1990 to 28.0 in 2011 and half of all babies are now born to mothers over 30 years (ONS, 2013).

A similar pattern is seen in the other countries of Western Europe, consistent with the idea of a prolonged period of career and personal development before 'settling down', possible because we are living longer — with average life expectancy increasing by two years every decade. Billari and Liefbroer (2010) have suggested that a new European pattern of the transition to adulthood is emerging that can be characterised as 'late, protracted, and complex', compared with the recent past. Most events are postponed, with the exception of leaving home. As a result, the transition to adulthood occurs both later and becomes more protracted. In addition, the increased popularity of living on one's own, unmarried cohabitation, and childbirth outside marriage makes the transition more complex. Thus, the move to the suburbs and car-dependent lifestyles come later in a longer life course and we see a decline in car travel by young adults, particularly men, in developed economies, as documented by Kuhnimhof et al. (2012).

The urban lifestyle of younger people is an important contributor to urbanisation generally. Globally, half the population of the planet currently lives in urban areas, a proportion expected to increase to 70% by mid-century, driven by the access, opportunities, and choice available at high densities. Cities of increasing size and population density cannot function effectively through reliance on road transport. White collar employees can be attracted out of their cars onto speedy and reliable rail transport for work-related journeys (Metz, 2012); buses are generally less attractive, being slower, less reliable, and used by school children and poorer people. Cities without extensive rail services thus suffer from traffic congestion, often severe. Cities that are successful, economically and culturally, are characterised by growing populations, the result of inward migration, and good rail transport. In such circumstances, car use in central areas tends to decline, allowing better use to be made of road space by pedestrians, trams, buses, taxis, freight, and emergency vehicles.

Technology

Life has been transformed over the past two centuries through harnessing the energy of fossils fuels. In the transport sector, this energy has enabled us to travel faster through a succession of innovative technologies and their incremental improvement. However, the impetus to ever-faster travel has now lost momentum, inhibited by energy requirements, carbon emissions, safety, and cost.

The main energy required to propel a vehicle — to accelerate and brake and to overcome air resistance — increases with the third power of the velocity (MacKay, 2008). Oil as a fuel is non-renewable and its price seems on an upward trend long term. Vehicle carbon emissions are subject to increasingly stringent regulatory limits. These considerations, together with safety concerns, militate against any significant increase of vehicle speeds on uncongested roads. Cutting traffic congestion could increase speeds, but road widening allows people to make longer trips such that the traffic thus induced offsets the initial reduction in congestion. Road pricing can reduce congestion but at the cost of displacing lower-income drivers whose access is reduced.

There is more scope for faster travel with high-speed rail (up to 200 mph), but rail represents a minority of all trips, and high-speed rail a minority of a minority, hence the overall impact must be limited. Magnetic levitation allows trains to go faster but the technology is demanding and costly.

Therefore, a contributing factor to the cessation of growth of per capital daily travel in recent years has been the difficulty of travelling faster. However, while transport modes are reaching technological limits, information and telecommunications technologies have been leaping ahead, digitising, miniaturising, and disseminating. As yet the consequences for travel remain unclear. Telecommunications can substitute for travel, but can also facilitate it, both by making the journey planning and execution easier and by enlarging the network of people felt to be worth visiting. Use of broadband Internet allows activities remote from traditional locations, whether online shopping, home working, etc. However, if the historic hour a day of travel continues to apply, less of one kind of travel would mean more of another.

Generally, transport seems remarkably resistant to change, whether under the influence of digital technologies or other innovations. The modern mass production motorcar has not changed fundamentally in the century since the introduction of the Model T Ford, although its performance and reliability have improved vastly. There are a few new transport concepts with promise, for instance the Ultra Personal Rapid Transit now operational at Heathrow Airport, but at present it is hard to judge their long-term impact.

Aviation

The NTS data on which much of the above discussion has been based are concerned with personal travel within Britain by all modes except international travel by air. Figure 7 shows the growth of terminal passengers through UK airports. It is generally supposed that the recent downturn is due to the economic recession and that the long-run prospects for the growth of demand for air travel are strong (see for instance DfT, 2013; Schafer & Victor, 2000). Nevertheless, it is possible that demand for air travel by UK residents may be nearing maturity and that a cessation of growth of air travel is developing, as seen for daily travel (Figure 1). Daily travel is limited by time to about an hour a day on average, given

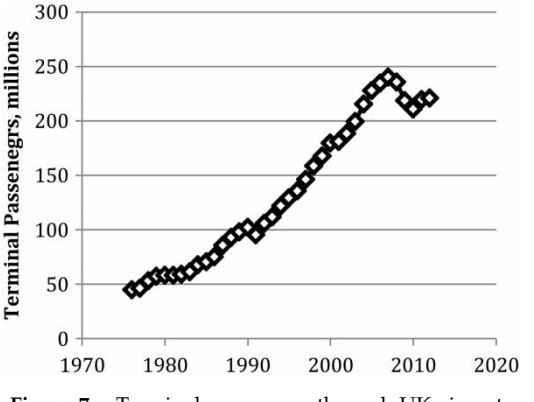

Figure 7. Terminal passengers through UK airports.
Source: CAA (2013, Table 02 1).

the other activities that have to be carried out. Air travel is different as regards both frequency — UK residents make rather less than one round trip a year on average — and time constraints, where it is the time that can be spent away from home or work that is limiting.

The NTS collects information on the number of flights abroad made by residents in the past year: over half made no flights. This suggests that demand for air travel has plenty of scope for further growth if these 'infrequent flyers' constitute a reservoir of potential demand. Frequency of air travel increases from lower to higher socio-economic status group, is higher with younger people, and rises with income. Nevertheless, around a quarter of those in the top social group or in the highest income quintile took no flights in the previous year. The prospects for the growth of demand for air travel depend importantly on whether these 'infrequent flyers' are likely to change their habits in the future. A further uncertainty is the scope for more trips being made by those who do fly, given the time constraints that apply. An ageing population may mean more leisure time for the retired, but the worsening prospects for pension income may inhibit the growth of leisure travel.

As with the surface modes, there seems little scope for faster travel by air that is economically viable and sustainable. The supersonic Concorde was environmentally problematic and expensive to operate. Generally, there has been no increase in aircraft speed since the introduction of the Boeing 707 in 1958. However, better fuel economy has allowed increases in range, lessening the need for refuelling stops on long-haul flights and so reducing travel time.

Forecasts

The reality or otherwise of demand saturation and 'peak car' is evidently important for the accuracy of forecasts of travel demand prepared for policy and investment purposes. Consider, for instance, the national road traffic forecasts that are an output of the UK DfT's National Transport Model (NTM) (DfT, 2012). The most recent forecast projects an increase of 36% in car traffic in London by 2035. This is shown in Figure 8 in relation to actual traffic in recent years, which peaked in 1998 and has since declined slightly to about 15 billion car miles a year.

Although London's population is growing and incomes are increasing, the observation that car traffic is not rising implies a capacity constraint for the road network, which is not surprising since new roads are not being built and controls on on-road parking in working hours in the inner suburbs are generally stringent. It is therefore very hard to see how the Department's projected increase in car traffic could arise without some major road capacity increase, which few are proposing. It seems therefore that the NTM is mis-specified for London's road capacity, and quite likely also for that of other conurbations.

It is also noteworthy that the increase in both London and national car traffic projected by the Department is about twice that of projected population growth, implying continuing growth in per capita car travel. The modellers explicitly reject the proposition that an individual's car travel demand has saturated and expect that, as the economy recovers, car demand will begin to grow once again.

The econometric modelling approach used in the NTM and similar models is essentially backward looking in that it employs historic relationships between the determinants of travel demand, such as gross domestic product, oil prices, and fuel efficiency, and projects forward on the basis of assumptions about the

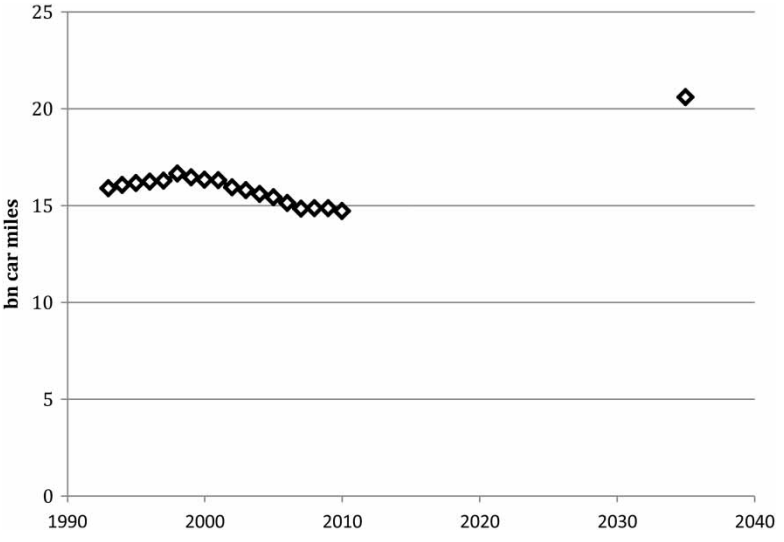

Figure 8. Car traffic in London, billion car miles.
Source: Table TRA8902a, DfT Statistics.; for 2035 datum see DfT (2012).

behaviour of these parameters in the future. What is difficult to take into account in such an approach are changes in relationships of the kind discussed in this paper which result in inflexion in historic trends. Accordingly, rather than generate a central case projection with low and high variants, it would be preferable to address a wider range of possible outcomes by means of scenarios, one of which might be a business-as-usual case based on continuation of past trends, another a lower demand case based on per capita demand saturation. Policies and investments would be tested against these and other scenarios for their robustness.

Conclusions

In the first era of human travel, our hunter–gatherer ancestors walked out of Africa and populated the earth. In the second era, they settled in agricultural communities and towns, where travel was generally limited to about an hour a day on foot. The third era began early in the nineteenth century with the coming of the railways, when the energy of fossil fuels could be harnessed to achieve faster travel through a succession of technological innovations, culminating in mass mobility made possible by the motorcar. There is now emerging evidence that growth of personal daily travel has ceased, so that we are entering a fourth era in which, on average, travel time, trip rate, and distance travelled hold steady. The 'peak car' phenomenon, whereby car mode share in cities like London reached a peak and has subsequently declined, marks the transition from the third to the fourth era.

It is proposed that the main reasons for cessation of growth of personal daily travel are abatements in both demand and supply, reflecting the high levels of access and choice now available to those with use of a car or good public transport, together with the difficulty of attaining increased speed. The adoption of mobile telecommunication technologies by younger people appears to be contributing

to a reduction in car ownership and use by them, and also to the buoyancy of demand for rail travel (passenger journeys in Britain have doubled since the low point in 1994). Revival of urban living leads to a decline in car use in city centres. Cessation of growth starting in the mid-1990s indicates that factors such as the current economic recession or high oil prices are secondary in importance.

The detailed analysis of recent trends in car and rail travel in Britain by Le Vine and Jones (2012) identifies the main contributing factors to the cessation of growth of car use: reduced use of company cars by men, some shift of business travel to rail, less use of cars by men in their twenties, less car use in London. These trends to reduced car travel have been offset by increased car use by women, which reflects a catching up with men in respect of licence holding and car ownership. Less car use by young men and by Londoners, on the other hand, could reflect a longer-term trend to urban living, consistent with an era in which overall average travel demand has ceased to grow and car use in densely populated city centres is in decline. Reduced use of company cars arises from changes in taxation aimed at reducing carbon emissions, which could intensify in the future, depending on achievements in cutting greenhouse gas emissions across the economy.

What are the likely characteristics of the fourth era of travel? Road, rail, the slow modes, and air will continue to meet our transport needs. The road network is open to all and therefore tends to be congested in or near population centres at times of peak usage. Road pricing can be used to limit demand but is only feasible where an alternative is available for those priced off; this may be public transport in urban areas or the secondary road network elsewhere. Some priority can be given to buses by means of traffic management methods. The scope for reducing congestion by building more carriageways is limited by the tendency for road users to take advantage of the improvement to make longer journeys between work and home. Some shifting of demand away from times of peak usage is feasible by means of predictive traffic information that allows those with flexibility to adjust their travel plans. Travel by car will probably always be attractive beyond the inner suburbs of cities, but its popularity may have reached its peak.

Rail is not subject to congestion in the same sense as roads, although route capacity is limited by safe operational headways and carriages with uncontrolled entry can be very overcrowded. There is scope for improvement by means of longer trains, better signalling, and new track. Conventional rail is best seen as part of a wider system, which includes urban rail (under- and over-ground metros) as well as trams, Bus Rapid Transit (BRT), and Personal Rapid Transit. All these can offer travel that is speedy, reliable, productive, safe, and also sustainable, when, as is largely the case, electric traction is employed, and when, in time, the electricity supply system is decarbonised. There is scope for enhancing the attractions of rail by offering seamless travel through integration of timetables, ticketing, and information. Implementation of the concept of 'integrated transport' is feasible for the wider rail system.

There are prospects for a considerable revival of rail travel, particularly in countries where there is an existing network that can be developed. Population growth and urbanisation result in larger, denser cities whose travel needs cannot be met by road transport. Cities are where agglomeration spurs creativity and innovation, economic dynamism, and cultural vibrancy. Cities attracting inward migration cannot expand road capacity to match. To be successful they

must invest in rail-based transport. Increased urban rail use reduces the need for car ownership and use, resulting in increased demand for inter-urban rail travel.

The slow modes of walking and cycling are favoured in high-density urban environments where catchment areas are smaller and distances to services shorter (a consideration which also favours electric vehicles). A number of successful cities have high levels of cycling, which in other cities can be encouraged by cycle hire schemes and by adapting carriageways. Improving the urban environment both attracts pedestrians and improves quality of life.

Some growing cities in the developed economies are experiencing a decline in car use from a peak reached a couple of decades ago. For growing cities in developing economies, with relatively low car mode share at present, there is the possibility of an alternative trajectory which avoids this peak but reaches the same kind of balance between public and private modes as will be achieved in developed cities. The key policy measures would be to provide BRT or rail-based travel for work-related journeys and to regulate central parking to ensure the flow of buses, taxis, road freight, and emergency vehicles.

Travel demand saturation, as well as increased use of rail and the slow modes, is helpful as regards concerns about sustainability and carbon emissions. Aviation remains a worry in this respect, particularly given projections of substantial growth of demand, with the concomitant needs for additional airport capacity. However, as for daily travel, time availability constrains travel by air, and it is possible that demand saturation by UK residents is nearer than is generally supposed.

The future pattern of travel, however, will depend as much on factors outside the transport system as within it, in particular demographic changes and society's response to population growth and ageing. Policy measures can reinforce market forces that respond to a tendency for young adults to prefer vibrant urban living without a car. Other variants of urban living may increasingly meet the needs of older adults who are getting to the point at which multiple minor disabilities incline them to give up driving, when an inclusively designed environment will be important. Transport policy therefore needs to be seen as one element of the wider response to demographic, societal, economic, and environmental developments.

Note

1. http://www.dft.gov.uk/statistics/releases/accessibility-statistics-2011/

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