Executive Summary

Recent trends in car usage in advanced economies – Slower growth ahead?

1. Introduction

Over the past 10 to 15 years, the growth of passenger vehicle travel volumes has decelerated in several high-income economies and, in some, growth has stopped or turned negative. Drawing from work presented to and discussions at the ITF Round Table on Long-run Trends in Travel Demand, held in November 2012, this paper presents evidence on known causes of this change in growth rates and discusses knowledge gaps, hypothetical explanations and policy implications.

The economic recession and relatively high fuel prices explain part of the decline in the growth of travel but not all of it. Slowing population growth, population ageing and increasing urbanisation contribute to the change in passenger vehicle use in several countries. There is evidence that car use growth has been reduced through policy intervention, particularly in urban areas and sometimes at the national level. Research also reveals remarkable changes in the intensity of car use within some socio-demographic subgroups. Notably, car use per capita among young adults (men in particular) has declined in several countries in recent years. It is as yet not entirely clear why this decline occurs, with competing – or complementary – potential explanations relating to attitudinal and lifestyle changes (e.g. starting a family at later age), to unfavourable economic conditions for increasing numbers of young adults (e.g. rising inequality and higher unemployment) and to increased availability of options other than car use to participate in activities (e.g. more ubiquitous public transport, internet shopping and socialising).

Understanding the determinants of aggregate volumes of passenger vehicle use, and particularly of changes in the weight or the nature of such determinants, is of interest to policymakers and to industry. Designing mobility policies, including but not limited to planning infrastructure development, requires forward-looking analysis of the demand for mobility. If it turns out that the drivers of demand are changing, projection methods need to be revised. The relevance of the issue is not limited to transport in a narrow sense. If car use is likely to grow more slowly than in the past, this may affect decisions on land use and on environmental and climate change policy.

Mobility choices, including car ownership and use, appear to be changing but it is not entirely clear why and explanations sometimes are place-specific. As a consequence, confidence in projections of mobility and car use volumes is undermined and simple, reduced-form approaches, based mainly on GDP and population, further lose their appeal. Rising uncertainty over mobility choices is exacerbated by rising uncertainty over the future development of factors like household income. The rising uncertainty in forward-looking analysis needs to be acknowledged and if some policies are more robust to uncertainty than others, such policies become relatively more appealing.

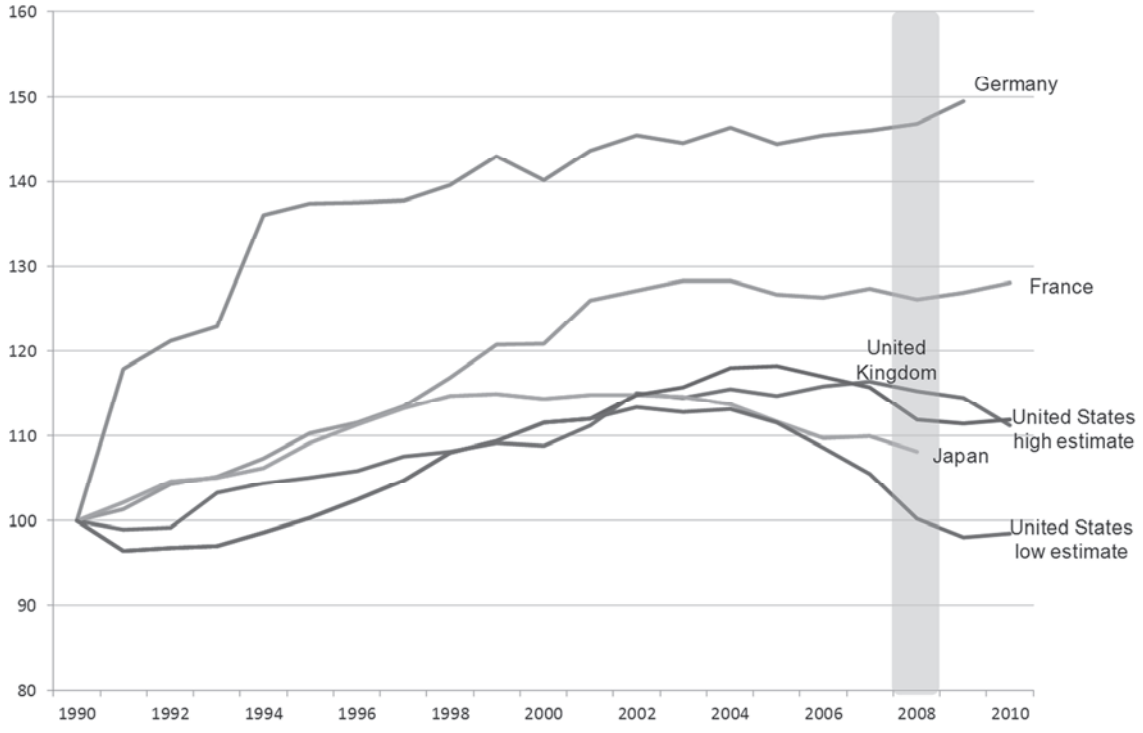
One emerging insight is that transport users are becoming more diverse, both in terms of preferences for lifestyles and mobility and in terms of budgets. Some groups choose less car-oriented lifestyles and the increased availability of other transport modes and online alternatives makes it easier for them to do this. However, in many (but not all[1]) cases such choices require a relatively high level of affluence, for example, because of the relatively high costs of living in urban centres and of choosing high-speed rail and air travel as substitutes for long-distance road travel. Other groups appear to adapt mobility patterns out of necessity. Rising inequality and unfavourable economic conditions, including low wages and high unemployment, restrain budgets for increasing numbers of households.

The rising costs of getting a driving licence and of car insurance exacerbate these constraints, perhaps most for young adults. The affordability of mobility is a growing concern.

2. Indicators of change in aggregate car use volumes

Figure 1 shows an index of passenger-kilometre volumes by car (and by light trucks and/or vans where relevant) in five large, high-income economies, from 1990 through 2010.

Figure 1. **Passenger-kilometres by private car and light trucks, 1990-2010**
(index 1990=100)



Source: ITF statistics ; the high estimate for the USA assumes car occupancy rates remain at the level measured in 2001, and the low one that they decline as of 2001 to the level observed in the most recent household travel survey.

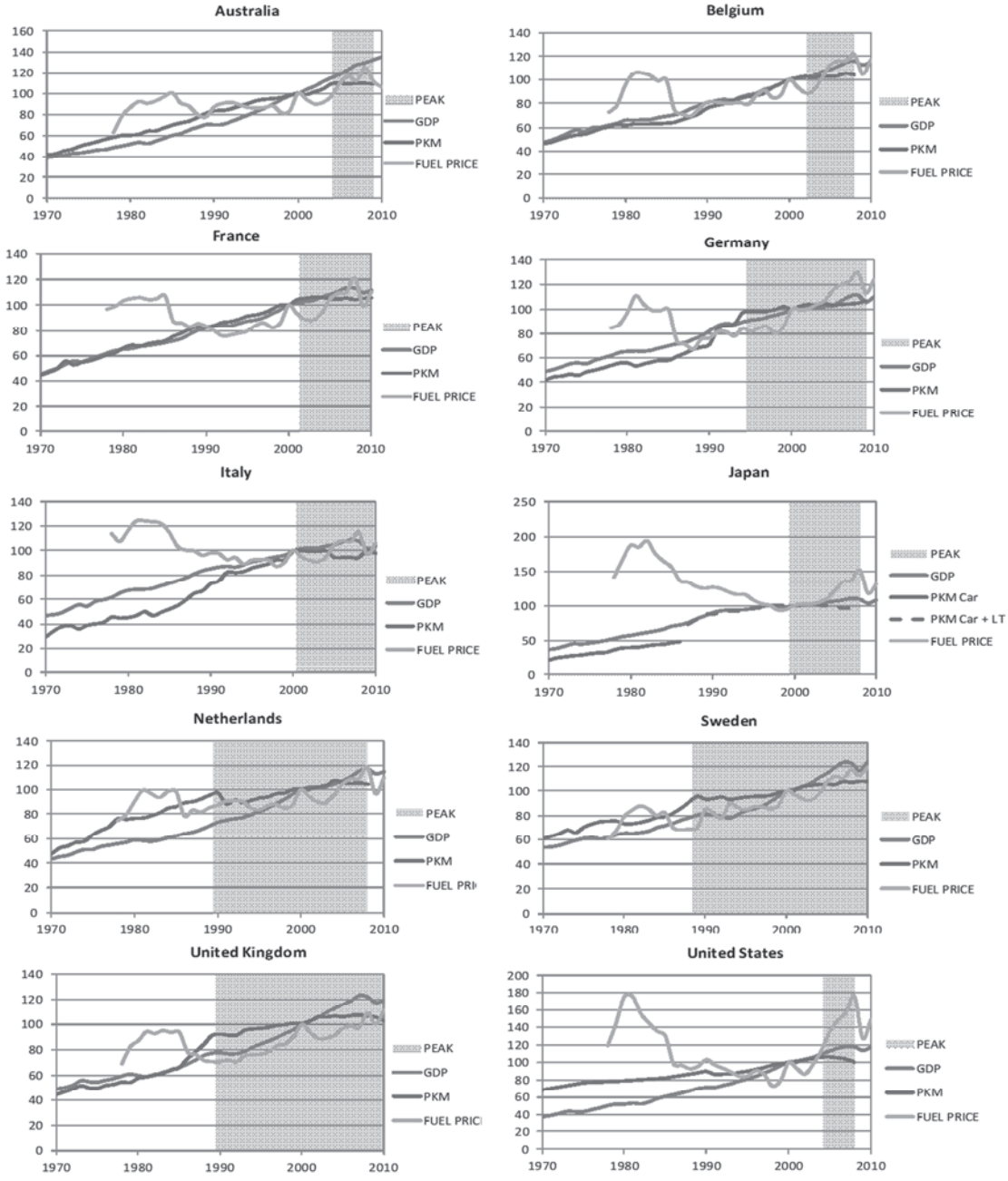
The slowdown in growth is clear in Germany. In France, car use is virtually unchanged since 2003. In Japan, car use has been declining since 1999. In the United Kingdom growth is negative since 2007 and it had slowed down considerably since 2003. The USA displays a decline since around 2005 or even earlier[2].

Figure 2 shows indexes of car use, GDP and fuel prices for ten high-income countries. Since the recession, economic growth has strongly declined in most of the countries shown, and this most definitely has negatively affected car use. However, the slowdown in car use volumes started before the recession, so other factors are at play too. Higher fuel prices have led to reduced car use but do not account for the entire change in the growth pattern either, as lower growth of car use preceded the strong rise in fuel prices in at least some countries. Lower overall growth and fuel prices contribute to lower car use, but do not explain it entirely.

In the countries shown in Figure 2, the rule of thumb that car use grows roughly as fast as GDP appears to be reasonable in the more distant past but it seems to break down in the recent past, with the timing of the change differing between countries.

A quick econometric exercise, see Box 1, supports the interpretation of a slightly weakening relation between GDP and driving, but not a strong decoupling. What other factors than GDP and fuel prices are driving the change in car use growth? Section 3 sets out to answer this question. As will become clear, a diverse set of factors is behind the aggregate slowdown in car use, and these factors are not well captured in a simple GDP – fuel prices – car use logic. Key factors, including population growth, ageing and labour force participation, are well understood but other factors are less tangible and less well described, while nevertheless potentially important.

Figure 2. **Index of GDP, fuel price and passenger-kilometres (PKM) in 10 high-income economies, 1970-2010 (base year 2000)**



Source: Passenger-kilometres are private car travel taken from ITF Statistics, USA data interpolated for missing data points before 1990, Japan data are without light trucks (full) and with light trucks (dotted); fuel price index is a volume-weighted average of gasoline and diesel prices taken from IEA Energy Prices and Taxes and volumes taken from the IEA MoMo database, for Japan only a gasoline price index is used;. GDP data is from OECD National Accounts and in constant 2005 PPP USD; shaded area denotes period when a structural change in private car travel is assumed in the regressions discussed in Box 1.

Box 1. Exploring the relation between GDP and passenger-kilometres travelled

Figure 2 suggests a changing relation between GDP and car travel volumes in several countries, with the change setting in at different points in time. We set up an econometric model to explore this suggestion of change further, using data for ten countries from 1980 through 2007. Results are summarised in Table B.1.

The data form a cross-sectional time series, and we use feasible generalised least squares (FGLS) to account for heteroskedasticity and panel-specific autoregression [AR(1)]. We add country dummies, or fixed effects, to account for unobserved differences between the countries. Year fixed effects can be included as well but make no meaningful difference to the results and are not included in the results shown in the table. Of the various specifications we tried, the following are shown:

- Equation 1: the basic "common sense" model, including a lagged dependent variable to account for inertia in responses to change in explanatory variables, per capita GDP, working age population, fuel price, country dummies (not shown in the table), and a country specific time dummy which is interacted with per capita GDP and equals one as of the year where pkm-growth appears to slow down permanently in that particular country (zero otherwise); we experimented with various definitions of the country-specific time dummy and retained the one for which its effects are strongest.
- Equation 2: extends equation 1 with adult population share in the total population and the share of urban population in each country; we also drop working age population as its effect cannot be separated from country fixed effects with our data (cf. the results of equation 1, for example; we also estimated models without country fixed effects where working age population gives expected results but which are not satisfactory otherwise).
- Equation 3: same specification as equation 2 except that the country specific time dummy is dropped and instead estimation is for 1980-2000;
- Equation 4: same as equation 3 but for 2001-2007.

Equations 3 and 4 are an alternative way to check for change in GDP effects, but cruder in the sense of imposing the same periods for all countries and with fewer data for both separate estimations.

Table B.1. **FGLS estimates with country fixed effects, heteroskedastic panels, panel-specific AR(1)**

dependent variable: pkm	equation 1 basic model		equation 2 additional controls		equation 3 years through 2000		equation 4 years after 2000	
	coefficient	z-stat	coefficient	z-stat	coefficient	z-stat	coefficient	z-stat
pkm lagged	0.905	53.74	0.880	46.76	0.872	35.66	0.423	6.08
gdp/capita	0.126	5.06	0.171	5.8	0.168	4.59	0.217	5.62
country specific time dummy	-0.006	-4.73	-0.005	-3.46				
population 15-64	-0.040	-1.05	-0.064	-1.56	-0.084	-1.37	0.308	3.9
fuel price	-0.041	-3.86	-0.044	-4.08	-0.059	-4.61	-0.109	-8.54
% adult population			0.341	1.73				
% urban population			-0.002	-2.33				
Elasticities	SR	LR	SR	LR	SR	LR	SR	LR
gdp/capita, time dummy = 0	0.126	1.326	0.171	1.425	0.168	1.313	0.217	0.376
gdp/capita, time dummy = 1	0.120	1.263	0.166	1.383				
fuel price	-0.041	-0.432	-0.044	-0.367	-0.059	-0.461	-0.109	-0.189

Note: bold for variables in logarithm, constant and country dummies not displayed.

The regression results are as follows:

- Taking account of autoregression is relevant as expected (see pkm lagged coefficients). Experiments with alternative estimation techniques show that the data allow distinguishing between auto-regression and autocorrelation, with the AR(1) coefficient around 0.11.

- The short-run elasticity and the lag are estimated with enough precision to obtain significant elasticity estimates, in all equations. GDP elasticities of pkm are well above 1 in the long run, for equations 1 and 2 (see lower half of table). In equation three ("early period"), the long-run elasticity is 1.313, and in the recent period it is 0.376. This suggests a strong decline in the income elasticity of pkm, in line with what visual inspection of Figure 2 suggests for at least some countries. However, this result comes about through the strongly reduced lagged effect, as the short-run elasticity estimate actually has increased.

- Equations 1 and 2 identify a significant change in the elasticity as well, through the country specific dummy. However, the change is economically small, as can be seen in the lower half of the table (e.g. in equation 2 the Long-run elasticity is 1.425 initially and 1.383 more recently).

- The long-run fuel price elasticity is -0.432 in equation 1 and -0.367 and is precisely estimated in both cases. The orders of magnitude are in line with literature, though perhaps on the high side. Equation 4 shows a much lower elasticity. It is possible that the role of fuel prices is not well identified in these equations and that this helps explain the differing role of income in them (e.g. the strong decline in income effects is really a fuel price effect).

- The effect of the share of working age population and of urban dwellers is not precisely estimated in the second equation, but signs are as expected.

To conclude, if the results of equations 3 and 4 on the changing income effect were robust, the models of equations 1 and 2 should reproduce them more strongly than they in fact do, because the country-specific dummies allow more flexibility in changing GDP effects than the models of equations 3 and 4. Hence, we find evidence for a small decline in income elasticities, but not of the order of magnitude that a quick glance at Figure 2 would suggest.

We do not interpret this as conclusive regarding the absence of such a strong change. Instead, it seems to us that an aggregate model focusing on GDP effects and fuel prices is too crude to capture the diversity and various dynamics underlying aggregate car travel demand and how it changes – a conclusion that is strongly supported by the discussion in Sections 3 and 4.

3. Diagnosis

3.1 Potential explanatory factors and "stylised facts"

The growth rate of passenger vehicle travel (vehicle-kilometres) has declined in several rich countries, and has dropped to zero or turned negative in some. Aggregate passenger vehicle travel is the sum of car use in a large number of "markets for passenger vehicle travel", where in principle a market can be defined for every situation for which a sensible demand and cost relation is conceivable. For example, the market for morning peak hour commuting by car in a given city can be distinguished from the market for morning peak car use for other purposes, and from off-peak travel, and from car use in other cities and non-urban areas, etc. Analysing changes in demand (willingness to pay at given incomes) and costs (of access to a car, the costs of which are shared between markets, fuel and time) would establish why quantities demanded in these markets change. Combined with information on the size of the markets, the change in the aggregate outcome could then be reconstructed.

In practice, many studies implicitly apply the logic just outlined, but the resolution to which the analysis can be refined is limited by data availability. Aggregate travel is defined as the sum of travel by groups defined through a set of socio-demographic characteristics (age, gender, income, employment and education, urban or not, etc.). Data constraints impose the assumption that households or individuals in these groups are rather similar, even though the various characteristics are frequently considered separately rather than simultaneously, and even though recent work on travel choices suggests that unobserved heterogeneity is considerable even in the most sophisticated studies. Most analyses define individuals as the basic unit, and travel-per-capita as the basic measure, and then consider changes in travel patterns within the group. Changes in the sizes of groups to which individuals belong depend on the evolution of demographic, socio-demographic, and economic variables used to distinguish groups. These variables are exogenous to the analysis, which of course does not mean that their future path is necessarily known with a high degree of confidence.

The impact of socio-demographic characteristics on travel demand, and the change in that impact, can be described with a set of "stylised facts", which are generalisations and simplifications of empirical observations that are not valid for all specific cases but that are intended to capture average or modal regularities. It is important to distinguish stylised facts from hypothetical explanations, and case-specific analysis and policy development requires careful consideration of their applicability. Section 3.2 reviews case-specific work in more detail. The following stylised facts are mostly useful as starting points for detailed empirical analysis:

- Age: driving first rises and then declines with age. When people retire they significantly reduce their annual mileage, typically by about half, and annual mileage tends to decline as they age further. As a result, there are likely to be large reductions in vehicle travel as the Baby Boom generation ages. Although they drive more than past cohorts did in retirement (because licence-holding and car-oriented attitudes are more common in these cohorts and because they are on average healthier at higher age than older cohorts), they still significantly reduce their vehicle travel. Older adults now drive more than older adults in the past, but this effect is likely to phase out in the future. Conversely, the increase of driving at younger age is slower and smaller for younger cohorts, a phenomenon that is only partly understood.

- Gender: men on average drive more than women, but the difference is declining as car use in some cases declines among men, and rises among women. Furthermore, in some places the role models that partly determine mobility patterns are converging.
- Income: higher disposable incomes usually translate into more mobility and more car use[3], but the rate of increase declines at high incomes and apparently car use sometimes is lower for the most affluent than for lower income groups. Zero or negative growth at very high incomes can be the result of substitution towards faster transport modes, lower-mobility location choices (e.g. expensive downtown locations), of low or zero additional benefits from more mobility (saturation), or of the opportunity costs of spending more time in transport becoming very high[4].
- Saturation of aggregate vehicle ownership and travel: during the Twentieth Century, vehicle ownership and travel grew from virtually zero in 1900 to high levels which may be close to saturation levels in most developed countries by 2000. These levels vary from one geographic area to another (neighbourhood, urban region, country, etc.) due to factors including the quality of transport options, transport pricing and land-use development patterns.
- As affluence rises, proportionally more travel is for leisure purposes. Such travel may be more car-oriented than commuting because of stronger spatial dispersion of destinations and hence lower availability of public transport. Non-commuting travel also is more price-elastic, so may change strongly as time and money costs of using cars increase.
- Employment and education: working tends to involve commuting and often car use, whereas schooling is associated with lower car use. Rising female labour force participation has translated into increased car use, but the rate of the increase in participation declines, so this effect may diminish in the future. Increased take-up of opportunities for higher education has a negative effect on car use. This effect too can weaken as take-up of higher education grows more slowly.
- Access to cars: individuals can have access to one or several cars owned by the household they belong to, or to a company car, or via car sharing systems, and these accessibility conditions affect the intensity of use. Access to cars requires holding a driving licence, and licence-holding becomes more difficult with more stringent regulations and rising costs. Driving licence holding is declining among younger individuals in some countries, whereas it increases for older age groups. Access to company cars, and sometimes to cheap fuel, has risen in some advanced economies, presumably as a response to the high fiscal burden on labour. Since users are not directly confronted with marginal costs, this trend translates into higher car use. More recently, fiscal distress leads to partial dismantling of the favourable treatment of company cars and their use, with lower usage as a consequence.
- Location: car use is higher where density is lower and is particularly low in urban cores, because there are more destinations per unit distance and because alternatives to the car are more commonly provided.
- Access to alternative transport modes: as other modes become more ubiquitous and/or cheaper, car use declines. Urbanisation is associated with less car use because with higher density more destinations are accessible per unit of distance, which leads to shorter driving distances and makes other modes (public transport, walking and cycling) relatively more appealing. Furthermore, public transport availability is often higher in denser areas. Mobility policies in several urban areas are becoming less accommodating to car use, with appreciable reductions in road and parking space and increased support for alternative transport modes.

- Immigration: increasing shares of foreign-born inhabitants lead to lower car mobility (controlling for income and predominantly urban location choice), perhaps partly because of habits, and because visiting friends and relatives in faraway places is less easily done by car (and more by plane or train); the changing geography of friendship and the associated mobility choices take place to a lesser extent outside immigrant communities as well.

3.2 Evidence and emerging explanations

Several studies report on similarities (but not simultaneity) in aggregate trends in car use in a number of high-income economies, see for example, Millard-Ball and Schipper (2011); ITF (2011), but systematic comparisons on a disaggregated level are scarce (see, however, Newman and Kenworthy, 2011). However, disaggregation is indispensable as aggregate outcomes are the result of change in opposite directions and not of an overriding common factor. Kuhnimhoff *et al*. (2012) provide a systematic comparison of six countries (France, Germany, Great Britain, Japan, Norway, USA) on the basis of travel survey data from around 1995 and 2005[5]. Their main findings are as follows:

- In itself, population ageing has a negative impact on car travel in all studied countries, and most strongly so in Japan and Germany.
- However, the negative effect of ageing is counteracted by the increase in car ownership at higher age in all studied countries except for the USA. In France, the UK and Japan, this compensating positive effect is larger than the negative effect of pure ageing, meaning that travel per capita rises. In Germany the two effects cancel out. The difference between the USA and the other countries probably is related to earlier mass motorisation, so that the rise in ownership at higher age took place earlier there, with as a consequence a smaller upward effect on driving now. Kuhnimhoff *et al*. (2012) hypothesise that this difference is key in explaining the larger drop of car use in the USA compared to the other countries studied. Dejoux *et al*. (2009) suggest that the USA pattern is general to North America and differs from the European one.
- Car ownership among young adults has declined in Norway, the UK, Germany, and the USA. It increased, by contrast, in Japan. In the middle age groups, there were declines in Germany and the USA and increases elsewhere.
- Reduced car use among young adults is key to explaining the aggregate pattern in Germany, the UK, and Norway, in the sense that without this change and all else equal there would have been no decline or even an increase in car travel in those countries. This conclusion does not apply to France, Japan.
- The effect of mode choice differs between countries. In Germany and the UK, modal shifts away from the car contribute strongly to reduced car use. In Japan the effect is small, and in France and Norway there was a shift in the reverse direction.

In short, these results emphasise the importance of compositional effects in explaining aggregate car use, they reveal heterogeneity among countries, and show the need for a better understanding of car use among young adults. We summarise findings from some country studies against this background.

Taking all modes together, distances travelled per person in Great Britain levelled off around 1998 and declined in 2007. Trip distances rose while the number of trips fell. Rail travel has increased

strongly. For car use, the number of trips, their length, and occupancy rates, were roughly constant from 1995 through 2007. A comparison of British travel survey data of 1995, 2000-02 and 2005-07 (Le Vine and Jones, 2012) reveals that the limited change in average car driving per capita over the period is the result of a strong decline in men's travel (reduced mileage among drivers, not fewer drivers) and an increase in women's licence-holding and travel (although car use for men remains about twice as high as for women)[6]. Travel declined most for the youngest men, was stable for men aged 50 to 59, and rose most for the oldest. For women aged 20 to 29, travel was stable and it increased most strongly for the oldest. There also is evidence that persons born outside the UK travel less than those born in the UK, although other characteristics (living in London, gender) explains part of that difference. The decline of car driving over time is visible in all income brackets except the lowest, and is stronger as income is higher. Nevertheless, higher incomes remain associated with more driving. The largest decline in car travel is for shopping and visiting friends and relatives, which some see suggestive of a change induced by choice (perhaps facilitated by the rising availability of online alternatives to travel) but which also could be the result of tighter budget constraints.

Remarkably, with the exception of men in their twenties, the decline in men's travel is largely explained by a drop in company car use, a phenomenon very likely caused by the less favourable fiscal treatment of fuel use for company cars. The decline of company car use can explain the entire levelling off of car driving since the 1990s. It is plausible that the company car effect is concentrated among higher incomes, so that the stronger decline in driving at higher incomes is at least partly the same company car effect. The largest reductions in company car use are among professionals and employers or managers. Car travel also fell in London.

Company car use and the London case apart, there has been no decline in travel among those aged 30 and above. The decline of car travel of men aged 20 to 29 is large – about 1 800m/year, and is mostly attributable to personal car use (the share of company cars in this age bracket is small). Half of the decline is due to fewer people driving, and half to reduced mileage by drivers. About one-third of the decline is for trips to visit friends and relatives. It is as yet unclear whether this decline reflects postponement of car use to a later age or whether lower car use will persist in this cohort.

In the Netherlands, total car-kilometres by drivers levelled off starting in 2005, and car-kilometres by passengers declined. Car ownership kept rising and so did licence-holding except for 25-29 year olds. Van der Waard *et al*. (2012) suggest this points to very weak signs of saturation at best. Mobility among young adults fell, notably for 18-29 year olds (as of 1995) and more moderately for 30-39 year olds (as of 2005). This is both because of group size and because of changes in group behaviour. Across modes, men aged 18-29 travelled 16% less in 2009 than in 1995, while women travelled 6% more (but their travel as car passengers declined). These changes appear to be linked to strong reurbanisation and to a rising share of students and declining share of workers in this age bracket. In the Netherlands, public transport is very cheap for students, and this group represents a third of public transport patronage. Change in this policy, which is contemplated for 2015, might have a substantial effect on students' travel choices. The status of car ownership remains high among young adults but it is not known if it nevertheless fell compared to earlier cohorts. There is no evidence of a shift in preferences for cars towards smartphones or tablet computers. The Dutch do travel more abroad, particularly by plane, but the share of international travel in total travel is too small for this to explain the decline in national mobility.

For the USA, Davis *et al*. (2012) emphasise the role of young adult's travel choices in explaining the observation that per capita car travel started declining in 2004, and is now 6% below its highest historical level. Household travel survey data show that per capita car travel in the age group 16 to 34 fell by 23% between 2001 and 2009, with the number of trips per driver declining by 15% and the average trip distance by 6%. The share of 14 to 34 year olds without a licence increased from 21% to

26% over the same period. Increased use of other modes (walking, cycling, and public transport) suggests a degree of substitution, and this substitution is facilitated by increased urban living. However, substitution by other modes is not very strong, so that the reduction in travel by young adults is strong. Furthermore, travel at higher age is not growing very strongly anymore in the USA (as travel-intensive habits permeated earlier in the USA than elsewhere). In the aggregate, the result is particularly strong decline in car travel growth compared to other countries.

Survey evidence supports the view that technology and social media are seen as substitutes for physical travel, particularly among the young. Barriers to driving, including high gas prices and tougher licensing laws, matter too. Lower incomes explain part of the decline as well, but likely not enough to expect a turnaround in travel choices if and when income growth picks up. In short, Davis *et al*. (2012) and Puentes (2012) see sufficient evidence to hypothesise that there is an enduring trend toward lower car use. Puentes (2012) argues that the economic development model in the USA is transitioning from a consumption-oriented approach to one that relies more on production and exports. Growth is increasingly concentrated in metropolitan areas, and within these areas real estate development and land-use patterns are changing, with less urban fringe and car-oriented development. This contributes to slower growth in car use (but perhaps stronger growth in freight traffic).

For France, Madre *et al*. (2012) emphasise contrasting developments between large urban areas and less dense regions. In large urban areas, fewer car trips were made per head in 2008 than in 1994 and they were of shorter duration. The transition from a double to a single commute per workday appears to explain a considerable part of that change. Car ownership declined, and there was a slight decline in licence-holding among young adults (at least partly because of the abolition of compulsory military service). These changes took place irrespective of income levels. Fuel prices increases around 2000 play a role in explaining the declining growth rate, although in greater Paris the decline started well before 2000, and earlier at higher income levels. In lower density regions, there are more cars and they are used for longer trips. The slowdown to zero of car use growth is expected in these regions too, but car use will remain higher. Currently, data do not allow distinguishing between a "delayed rise car use among younger adults" and "permanent reductions of car use among currently young cohorts".

Distances travelled in Japan by air, rail, and car started a gradual decline in 2004, see Hyodo (2012). Car-kilometres fell as of 1999, as a result of shorter trips and despite an increase in the number of trips and of passengers. Low growth, translating particularly into rising numbers of low income households, and high gas prices drive part of this evolution. Other changes, including later age of marriage, smaller households, and of course population ageing and a decline of the total population (since 2009) work in the same direction. There are relatively fewer younger drivers in more recent years, and the relative decline of younger female drivers is particularly pronounced. Travel in the Tokyo conurbation is still on the rise, partly driven by a larger population.

To summarise, the decline in growth rates of passenger car use is the result of group size effects and within group changes. The relative importance and sometimes the direction of the effects differ between countries, and country-specific effects matter. There are similarities between countries, but they are not strong enough to generate simultaneity. Furthermore, strong disparities occur within countries, notably between the largest cities, other cities, and rural regions. Population ageing and low or negative population growth have negative effects on mobility growth, although growing car access and use among older cohorts puts a brake on this effect up to now, except in the USA. Access to cars and car use among young adults declines in several countries [among the six countries analysed by Kuhnimhoff *et al*. (2012), France and Japan are the only countries where young adults do not contribute to declining car use], and it is not clear to what extent this is a transitory or a permanent change. Apart from the USA, where it was high to begin with, there are no strong indications that the

status of the car has waned. Gender differences in car use and broader mobility patterns appear to be declining.

Urbanisation has a negative effect on car use in several countries, and contrasts in mobility patterns between large metropolitan areas and less dense cities and rural areas appears to be sharpening. Increasing participation in higher education plausibly leads to – at least – a delay in taking-up car-intensive mobility habits. Correspondingly, if this increase phases out, the downward effect on car use declines. More generally, car-intensive lifestyles appear to occur later in life more often, which would mean that lower car use at younger age is partly a persistent effect to the extent that the lifestyle change is persistent. Higher incomes lead to more car use, although at high incomes the effect appears to be weaker and may even turn negative. However, the causes of this declining income effect are unclear: rising opportunity costs of spending time in transport may matter; there can be substitution to other (faster and more expensive) modes; but there can also be confounding with high-density location choices and the reduced appeal of company cars.

The available evidence provides insight into characteristics that are correlated with car use, and on how the role of these characteristics changes over time and is place-specific. But insight into cause and effect remains limited, because characteristics are often considered in isolation whereas they ideally should be considered simultaneously (e.g. income and location, company car access and income). Also, characteristics may be related with underlying variables rather than being explanatory in themselves. For example, reduced car use among young adults can be the consequence of changing attitudes and/or of declining disposable income among subgroups of young adults. It is, in other words, not entirely clear to what extent the change in travel is mostly the result of choices or of constraints. Both likely play a role, and rising heterogeneity within the young adult population may mean that for some subgroups constraints dominate and for others choice is the main driving factor.

The impact of IT applications on car and other travel remains unclear. Several effects, in different directions, are plausible: a shift away from cars as other modes allow online activity more easily, lower travel demand following the emergence of IT-enabled alternatives to traditional vehicle ownership (e.g. car-sharing), a reduction in travel demand as some activities no longer necessarily require physical travel, increased availability of cars for other purposes as telecommuting rises, rising average trip distances as location farther away from physical travel destinations now is less costly, etc. The net effect on travel is unclear in principle, and available evidence is inconclusive. It was pointed out that much of the evidence appears outdated, and updating it is of considerable interest, not least because newer IT-induced innovations likely have qualitatively different effects from earlier ones. The earlier generation of research focused on home-based personal computing, whereas the dominant recent trend is for multi-instrumental portable mobile internet access, which changes usage patterns and potentially interactions with mode-choice. Also, changing choice sets do not necessarily lead to changing choices, but do create larger scope for change if behavioural incentives (e.g. prices of car use) change and if preferences change (e.g., the distribution of family relations and friendships has become more geographically dispersed, partly because of immigration, and this affects what social connectivity models are chosen).

Another example concerns the impact of urban living on car use. To what extent is the negative effect on car use the result of self-selection? If individuals or households that prefer high-density and low car-use lifestyles are disproportionally present in urban areas, then measured effects of urban living should not be expected to be equally large if other individuals or households, with different preferences, move to urban areas (see, for example, Golob and Brownstone, 2009, and Kim and Brownstone, 2010). Furthermore, transport choices in urban areas are affected by policies. Increasing numbers of cities are adopting less car-oriented transport policies, and this discourages car use. The point here is not to evaluate the merits of such policies, but simply to acknowledge that car-use

choices are contingent on policies, not just on drivers' characteristics and preferences. Data limitations make it difficult and often impossible to evaluate the relative importance of such competing or complementary explanations, and this in turn means that projections on the basis of current observations of decline are subject to high uncertainty – uncertainty that needs to be acknowledged.

4. Lessons for policy and projections

Aggregate car use is the result of location and travel choices made by a diverse set of (potential) car users. These choices depend on preferences, incomes, and prices of various transport options and alternatives to travel. Preferences are subject to change, and there are signs that car use is less of a priority in groups preferring urban lifestyles and more reliant on online networks. Income growth is now less self-evident, with rising inequality and weaker growth prospects in many OECD economies. Prices are partly determined in markets and partly depend on transport policies broadly defined, where the latter now often are less favourable to car use than before. Together with ageing and saturation of access to cars, these changes contribute to slower growth of car use. They also reflect increasing heterogeneity among potential car users. Whereas car ownership and use was a common aspiration for most, and an aspiration that was satisfied for increasingly many, it has become a somewhat less universal goal, and perhaps one that is more difficult to reach for some.

Aggregate car travel is a variable of some policy interest, as it is roughly indicative of a country's resource needs for car transport (including road and parking infrastructure, energy, etc.), of environmental and climate change impacts, and of the sector's tax revenue generating capacity. Aggregate travel is particularly relevant for gauging investment needs when transport and economic growth are high and networks are under development, as it provides an indication of overall resource needs. In more mature economies, decisions on where and how to invest in infrastructure or are driven less by overall growth than by specific needs in the network. It is, for example, anything but obvious that slower growth in aggregate car use changes the case for relieving current bottlenecks.

The relevance of the analysis discussed above then is more in the message that disaggregation is needed to understand change, and that local patterns can diverge from the aggregate trend. The priority is not to establish with maximal confidence whether aggregate travel will grow, stagnate, or decline, but to understand drivers of growth better. The keywords here are rising heterogeneity and rising uncertainty. Rising heterogeneity means that travel choices are less well predicted by basic socioeconomic characteristics. Since choices are harder to predict, projections are subject to rising uncertainty. Deciding on policy is more difficult in a more uncertain environment. Policies that are robust to uncertainty, i.e. that make sense in the widest possible set of possible outcomes, gain in appeal, and identifying such policies is of key interest.

Goodwin (2012) argues that the broad class of "smart" and less car-oriented mobility policies fares better than standard policies that can be characterised as accommodating towards car usage aspirations. At any rate, the need to select policies that consider overall benefits ("balanced mobility policies") rather than focussing on direct user benefits is strengthened by the rise in uncertainty. Appraisal, in the form of comprehensive cost-benefit analysis of policy strategies rather than just projects, is instrumental to such a policy approach. Of course, the case for such policies is not contingent on any particular pattern of development of car use, but on the need to align individual

travel aspirations and choices with their social costs and benefits. This does not mean that the observed changes are irrelevant to the debate. First, to the extent that user preferences diverge less from what is socially beneficial, as is the case according to some readings of the observed change in aggregate car travel, implementing balanced mobility policies will meet with less resistance. Second, there are several indications that, apart from a possible change in preferences, behavioural change now is easier given the changing nature of travel (a larger share of non-work trips, for which own- and cross-price elasticities may be larger) and the increased availability of alternatives (more public transport, more cheap air travel, more online activities, etc.)[7]. Such changes may translate into more flexibility in travel choices, so that higher prices for car travel result in larger declines of that travel. This suggests that pricing reforms (more efficient road, parking, fuel and insurance pricing, and less favourable company car policies) can be more effective at reducing vehicle travel and encouraging use of alternative modes, and road tolls will generate less revenue than assumed in many travel models (see, for example, Williams-Derry, 2011). It was noted that in an ageing population the demand for travel changes, but also the weight of the elderly in decision-making rises, and this may lead to mobility policies that align more with their needs and preferences.

Revenues needed for maintaining the integrity and quality of current road networks, let alone of upgrading them, do not diminish in proportion to slower growth of network usage. If transport infrastructure is to be funded from user charges, slower or zero traffic growth will need to be accompanied by increasing charges (especially if user charges are mainly fuel taxes and fuel economy improves, as is clear from the current experience in the USA). If funding is from general revenue, transport tax revenues will grow more slowly or stagnate, unless rates are raised and/or new taxes introduced. In either case, the possibility of prolonged slow growth of car use volumes adds to the already considerable set of arguments for reforming the funding basis for transport infrastructure.

The discussion up to now has focused on high-income economies. In developing economies, the rule of thumb that mobility and in particular car use will develop in line with GDP as long as policies do not point strongly in the opposite direction, remains broadly applicable. Furthermore, strong natural population growth and rural migration to cities where motorisation is often twice that of rural areas due to higher incomes, will induce pressure towards higher motorisation. Possibly, attitudinal changes related to availability of online activities could curb growth at an earlier stage than in high income economies, and faster urbanisation leading to congestion can reduce growth in car use. However, this curbing effect will not necessarily materialise in the absence of policies that disincentivise car use. Balanced mobility policies conceivably could induce levelling off of car use at lower per capita car use volumes than are observed in currently high income economies (see also Litman, 2012b). Providing public transport is not enough for this – car use itself needs to be regulated through appropriate prices, and land-use policy. And even when car use is inconvenient because of high congestion and high purchase prices, the preference for personal mobility may lead users to turn to two-wheelers (motorcycles, in particular), as currently is the case in Asian and Latin-American cities. We may observe a downward tendency of car use due to ageing but not before 20 or 25 years (Madre and Bussière, 2012).

Linking back to Section 2, the disaggregate analysis shows that the change in aggregate levels of car use is the result of various changes, in different directions. This suggests that aggregate projections on the basis of GDP and fuel prices may be misleading, as they do not capture these underlying changes. It could be argued that the aggregate fuel price elasticities are the result of the changes observed and therefore are a reasonable shortcut for forward looking analysis, but our reading of the evidence is not in line with such an interpretation. It is difficult to see how the range of explanatory variables considered could all be captured in a single fuel-price elasticity.

5. Conclusion

In past decades, the aggregate demand for passenger travel has developed roughly in line with per capita GDP and population growth but there are strong signs that this close connection is weakening in advanced economies. In particular, *car* travel volumes in some countries stopped growing in the recent past or have declined despite continued growth in GDP. This paper considered evidence that helps us understand why this is so. We find a range of explanations that are understood, and some hypothetical explanations that are plausible. A combination of factors explains the aggregate trend but some are likely to be more persistent than others. Policy interventions also make a difference. While some explanatory factors are fairly well understood (e.g. ageing and cohort effects), others are more uncertain (e.g. the role of information and communication technology). The relative importance of different factors also differs between countries and between places within countries (e.g. urban and rural regions). Separating out the various factors is important for making useful projections of travel demand and for examining specific issues of transport policy (emissions mitigation, congestion management, etc.). Is the phenomenon transitory or is it permanent? This holds for economies where the demand for car travel has levelled off recently, but potentially also for developing economies. The latter may experience some of the changes apparent in high income markets at lower levels of incomes (e.g. because of more rapid urbanisation and policy intervention), although for the coming decades rapid increases in motorisation are expected.

Notes

1. For example, incomes in many US city cores are relatively low, and more generally the sum of commuting and housing costs in urban centres may not differ strongly from that in suburbs.

2. Two lines are shown for the USA, with the upper one assuming that car occupancy rates remain at the level measured in 2001, and the lower one assuming they decline as of 2001 to the level observed in the most recent household travel survey. The true path is most likely in between those two bounds.

3. Mobility and car use are "normal goods", in economic parlance. Note that cross-sectional and time-series income effects can differ, so that evidence on differing effects in a cross-section do not necessarily apply when analysing income growth over time.

4. An extreme case would be that there is a maximum to the time individuals are prepared to spend in transport. Evidence for such a maximum is weak on the disaggregated level (Mokhtarian and Chen, 2004), and the more general case of rising opportunity costs is sufficient to explain declining income effects.

5. Although not apparent from this review, establishing comparability between the national travel surveys of the six countries is a major contribution of the study.

6. Le Vine and Jones (2012) note that most road traffic growth since the 1990s comes from greater van traffic, an observation for which the causes merit further exploration.

7. Elasticities are not constant over time, although data limitations often lead to time-independent estimates. Over the long run, some studies (e.g. Small and Van Dender, 2007) found a declining elasticity of mileage with respect to the fuel price. More recent evidence suggests a renewed increase (e.g. Litman, 2012a), a finding consistent with a framework in which elasticities rise with higher fuel prices and decline with higher income, but also with arguments discussed in this paper regarding changing habits and the rising availability of alternatives.

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