Anticipating Urban Travel Transitions and New Mobility Behaviours

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Introduction

A good understanding of urban travel patterns is required to provide suitable transport infrastructure and services that serve the needs of society and the economy. Travel behaviours are a function of the wider socio-economic system, people's activity/travel preferences and the transport and telecommunications options available to them. Changes in each of these three domains and in the relationships between them will affect travel behaviours. This makes it difficult to anticipate future travel patterns. Typically, forecasts of future travel patterns are based on simple assumptions about future changes to the socio-economic system and transport system.

The digital age has dramatically changed modern life in the last 25 years (Lyons et al., 2018) and it is increasingly apparent that it is impossible to predict future developments with any confidence. It is suggested we are in a period of deep uncertainty about developments that affect travel behaviour in which there are divergent opinions amongst experts and stakeholders and a lack of empirical evidence (Lyons and Davidson, 2016). However, some form of anticipation is still necessary to be prepared for the future and to be resilient for what is to come. Our level of understanding of change, i.e. of cause and effect, determines the extent of our ability to anticipate future change (Walker et al., 2010). Furthermore, it is not merely a question of waiting for what lies ahead but seeking to positively influence it. This requires not only seeking to understand how the socio-economic system, transport and communications options and activity/travel preferences shape travel patterns but to steer the relationship in a beneficial way. The importance of understanding the relationship and how it is evolving is therefore paramount as the basis for considering how to address societal concerns such as productivity, inequality, quality of life and climate change.

There have been large discrepancies between forecasts of travel demand and outcomes in industrialised countries in the first two decades of the twenty-first century (Goodwin, 2012). Even where aggregate forecasts of demand have been reasonably accurate, there have been notable divergences in forecasts of underlying components of the demand. This compromises the ability for transport to be planned in a way that meets the needs of the population and responds to external challenges in a way that is accepted by the population. Some unexpected transitions in travel patterns have only been noticed some years after they occurred. At the same time, bold assertions are often made of an imminent transformation in how people will travel – usually by stakeholders with a vested interest.

Given doubts about the capabilities for accurate quantitative forecasting of travel demand, there is growing interest in alternative approaches which explicitly grapple with uncertainty and provide a basis for adaptive policy making and planning (Walker et al., 2010; Lyons and Davidson, 2016). With these new approaches, a key requirement is to develop capabilities of scanning for potential shifts in travel behaviours. This working paper takes travel demand in Great Britain (GB) as the basis for looking at the extent to which trend-breaks have been identified and understood in the last 20 years and identifying what we can learn from this for anticipating future urban travel transitions and new mobility behaviours.

Urban travel demand is the focus of this paper, as it is urban residents whose travel behaviour has changed the most in the last 20 years and it is urban areas where many of the most serious challenges that lie ahead

are faced. In the 2011 Census it was found that 35.1 million people in England (66% of the population) lived in local authorities defined as predominantly urban (DEFRA, 2017). Given the English population can be regarded as largely urban-living the paper considers both overall population travel trends in England, as well as trends for urban-living residents where they have been examined.

The paper aims to identify how we can better anticipate travel transitions to inform expectations about future travel demand and policy making and planning. It focuses both on how to become aware of transitions that are in the process of unfolding and how to anticipate transitions which might occur in the short to medium-term, recognising that transitions in the longer term are almost impossible to predict and to a large extent dependent on decisions that society makes in the interim.

In the next section the paper explains how breaks in longstanding travel trends in GB were not foreseen and how uncertainty in future trends is now being handled. It then considers how far studies have been able to explain the travel transitions that have taken place in the last 20 years in GB before discussing the significance of this for future efforts to anticipate travel demand and take this into account in transport planning and policy making. Ultimately, the paper addresses the fundamental question: "*What should we think about when we think about travel demand?*"

Aggregate travel trends and responses to uncertainty

Before looking at examples of travel transitions and new mobility behaviours, this section outlines how urban travel trends in England and GB[1] have differed from those expected in the last 30 years. It discusses how uncertainty in travel trends and factors that influence them is being handled currently by the UK Department for Transport (DfT hereafter). This is important context for clarifying what might be gained from studying breaks in travel trends and better understanding them - the focus of the following section.

Historical forecasts

National forecasts of road traffic growth have been made for GB since at least 1962 and have played an instrumental role in roads policy and investment (Chatterjee and Dudley, 2008, p19). After under-estimating traffic growth in 1984, forecasts in 1989 predicted total traffic would rise between 83 and 142 per cent by the year 2025 and in the same year the government introduced the 'Roads for Prosperity' programme which was stated to be the largest roads programme since the Romans. After a few years it became clear the 1989 forecasts had overestimated traffic growth and this, along with challenges to the roads policy from environmental groups and transport experts, led to the roads programme being scaled down and different policy directions being considered.

Prior to 1997, forecasts could be interpreted as being of unconstrained traffic demand (*ibid*, p19). With the 1997 forecasts the capacity constraints of the road network were taken into account and forecasts became more sensitive to assumptions about policy. Nevertheless, forecasts have continued to over-

1 The main data source on personal travel for GB is the National Travel Survey (NTS) which has not historically collected data for Northern Ireland. The NTS has not collected data for Scotland and Wales since 2013, hence the latest trends can be considered only with respect to England.

predict traffic growth into the 2000s. For example, it was forecasted in 2000 that traffic would grow by 22% by 2010 when it only grew by 8% up to 2007 immediately before the great recession and was only 5% higher in 2010 than in 2000 (DfT, 2019a, TSGB0701[2]).

Looking at road traffic growth in GB in recent decades there was 59% growth in the 1980s, 15% growth in the 1990s, 6% growth in the 2000s and 6% growth in the nine years of the 2010s so far (DfT, 2019a, TSGB0701). Looking at car traffic, growth in the 2000s was even lower at 4% and has also been 4% from 2009-18. In fact when looking at average car distance travelled per person, rather than aggregate car traffic, it is found that this peaked at the turn of the millennium at about 5,800 miles per year (in 2002) and has steadily decreased year-on-year since then to 5,000 miles in 2018 (DfT, 2019b, NTS0303[3]). The slowing of traffic growth has been the subject of considerable interest in GB (and in other industrialised countries where it has been witnessed) with particular interest in what has happened to car use. The phenomenon has been dubbed as 'peak car' by some commentators (Goodwin, 2012).

Explaining differences in outcomes from forecasts

The DfT, along with other institutions, has conducted studies to investigate the unforeseen slowing of road traffic growth and reduction in per capita car travel (e.g. DfT, 2015a). As will be discussed in the next section, these have identified contrasting trends among different groups in the population and suggested a large number of potential factors contributing to the overall trend. However, they have concluded more evidence is needed to understand the role of these factors. In the meantime, they have emphasised the continued importance of factors traditionally assumed to determine travel behaviour (such as the distribution of population, income, and costs) (DfT, 2015b). The Department has explained its tendency to over-estimate future traffic growth on roads as "substantially attributable to over-forecasts in key inputs to the model rather than modelling error" (Marsden et al., 2018, p15).

In its 2018 forecasts, DfT looked at its road traffic forecasts between 2009 and 2015 and showed that they provided aggregate results close to out-turn, especially when they were adjusted for actual out-turn input values (for population, GDP, etc.) (DfT, 2018a). It did note, however, its forecasts have over-estimated traffic growth in London and under-estimated traffic growth on motorways (mostly carrying longer distance inter-urban traffic). It concluded that the latest version of its model is fit-for-purpose at an aggregate level, but "has difficulties replicating travel patterns at local levels where travel behaviour is substantially different from the national picture" (DfT, 2018a, p25).

National forecasting practice in GB

An overview of national forecasting practice in GB is helpful context for thinking about the value of better understanding travel transitions. Forecasts are made using the National Transport Model (NTM) which was established in 2000 (DfT, 2018a). The first part of the NTM is the National Trip End Model (NTEM) which takes exogenous demographic and socio-economic projections (for population, employment, housing supply, incomes and car sales and running costs) as input to its forecasts. It forecasts driving licence rates

2 Results from Transport Statistics Great Britain (TSGB) are referenced in terms of data table numbers such as TSGB0701. The data tables can be found at https://www.gov.uk/government/collections/transport-statistics-great-britain

3 Results from National Travel Survey are referenced in this paper in terms of data table numbers such as NTS0303. The data tables can be found at https://www.gov.uk/government/collections/national-travel-survey-statistics

based on historical rates for different birth-cohorts before forecasting car ownership rates and total number of trips (for 7,700 zones) based on the demographic and socio-economic projections.

The second stage is the 'Demand' model which predicts distances travelled and transport modes used for the trips forecasted by NTEM based on projected incomes and transport costs. The third stage assigns the trips from the 'Demand' model to the GB road network in the 'FORGE' model where allowance is made for congestion (via a feedback process). Separate models for light goods vehicles and heavy goods vehicles take historical data and economic projections to incorporate these in the FORGE model.

The NTM allows confirmed transport investment and policies to be incorporated into the forecasting process (through road capacity adjustments and fuel efficiency gains) and enables testing of alternative national policies or widely applied local policies by representing them as changes in prices and service quality. The forecasts from NTM are not only used to consider national transport policies but are also influential for local planning. Forecasts of trips generated by NTEM are often used in local scheme appraisals, especially if a suitable local transport model is not available.

NTM is a multi-modal model which considers travellers' choices between walking, cycling, rail, bus and car. It aims to satisfactorily represent the relative attractiveness of these modes in response to changing costs, levels of congestion or policy changes, but is not designed to accurately predict the amount of usage of these modes at a local level (DfT, 2018a, p14).

For the 2018 forecasts, the NTM was updated to account for recent traffic and travel trends, including those examined in studies that DfT and others has conducted (Le Vine and Jones, 2012; DfT, 2015a; Headicar and Stokes, 2016). This included updates of behavioural parameters in the NTEM and Demand models. Probably the most significant development was to update the trip rate models used in NTEM based on National Travel Survey (NTS) data. This was motivated by the observation that trip rates had decreased over time for a number of travel purposes (commuting, shopping, visiting family and relatives and personal business). The trip rate models have been re-estimated based on NTS data for 2002-2012 based on a larger number of socio-demographic variables found to influence trip rates (AECOM/Imperial, 2017). However, it was found that these variables could not provide much explanation for the observed decrease in trip rates and it was recommended that further research is needed to explain this. Year dummies are included in the NTEM trip rate models to reflect the decreasing trend but trip rate declines are only enabled until 2016 in forecasting carried out using the NTM after which they are assumed to stay constant (to reflect the uncertainty that exists about future trip rates).

Handling uncertainty in national forecasts

The 2018 national forecasts for Great Britain have a range of predictions of future traffic growth (between 17% and 51% for total traffic by 2050, between 11% and 43% for car traffic) for seven different scenarios (DfT, 2018a). It is stated that the traffic growth is largely driven by population growth and reduced fuel costs (p48). The reduced fuel costs are largely a consequence of the assumed increasing penetration of electric fuel vehicles over time (with no imposition of tax charges on electricity to match the current fuel duty on petrol and diesel). Traffic growth is forecast to be similar across regions of England and Wales (p60), despite recent lower growth in London and it is acknowledged that the forecasts do not take into account local conditions with respect to public transport networks and congestion (p61).

Up to 2015, the national forecasts included a central (most likely) forecast along with low and high forecasts (based on a set of assumptions for population growth, GDP growth and fuel prices). In the 2015 and 2018 forecasts the approach changed with DfT presenting forecasts for a set of equally plausible

scenarios without any one of them identified as most likely. In 2018, there were seven scenarios based on variations in GDP growth, fuel costs, migration rate, the income-car ownership relationship, trip rates, young adult driving licensing and zero emissions vehicle penetration (p29). Despite all seven scenarios being described as plausible, one scenario is identified as a reference scenario (entailing a 35% growth in road traffic to 2050). Another scenario pays particular attention to the trends of decreasing trip rates across the population and decreasing driving licence rates amongst young adults and assumes these trends will continue. This scenario produces the lowest forecast of traffic growth of 17% in 2050.

Lyons and Marsden (2019) provide a critique of DfT's treatment of uncertainty in national forecasting. They are positive regarding the increasing recognition of uncertainty, especially the abolishment of a central forecast with sensitivity tests around it. They suggest this has 'opened out' the degree of consideration of uncertainty in forecasts. They note, however, this is then 'closed down' when it comes to using forecasts for scheme appraisals and policy decisions. They note for local scheme appraisals that "DfT guidance requires the modelling of a core scenario that is based on central projection data from the National Trip End Model (NTEM) that forms part of the NTM". Sensitivity testing is carried out around this with high and low growth scenarios but it is commented "The choice of which scenario is used to bound assessment of uncertainty, amongst a set of (equally) plausible options, matters hugely to what levels of demand are considered in closing down and which scenarios are included or excluded as a result of that".

Lyons and Marsden discuss how to avoid the trap of looking at uncertainty through sensitivity approaches around a reference scenario by embracing approaches which identify a wide range of plausible scenarios and assessing policy scenarios against all of them to identify policy scenarios that perform well overall. They suggest that better treatment of uncertainty in decision making requires a better understanding of a changing world. They write: "The plausibility of different combinations of social change, transport technology change and behavioural adaptation (to both) is not well-understood. A deeper understanding of the extent to which different futures could unfold, given existing land-uses, cohort effects, technology transition periods and evidence of pace of change to date should be developed".

Need for swift detection of transitions

The need for swift detection of trend-breaks has been noted. After identifying a number of travel transitions which explain the slowing of car traffic growth, a DfT report suggested that scenarios applying recent trends can be investigated but, without knowing reasons for these trends, this is of limited value and therefore developing an understanding of these trends is essential for anticipating future travel patterns (DfT, 2015, p86).

Goodwin (2012) explains that, when contemplating the direction of the future trend for car use, the essential need is to identify "a 'trend-break' or discontinuity, while it is still happening" and this requires looking out for trend-setters, whose behaviour differs from everybody else, and for leading indicators of change which signal, for example, the direction of future travel behaviour. Lyons (2015), in arguing that we are seeing a gradual transition from the motor age into the digital age, recommends looking at overall lifestyles attitudes and behaviours both between people and within people's life course (p17) and to "seek out and examine 'case study microcosms' of emergent regime change (either amongst particular social groups or particular geographic locations) to better inform wider examination of the plausibility of different future states for wider society and in turn different configurations of land use and transport systems".

Studies of 21st century travel transitions

General approach taken

The break in the trend of increasing car travel in GB led to a number of studies which sought to better understand what was happening. The first major study commissioned by the RAC Foundation, the Office of Rail Regulation, the Independent Transport Commission and Transport Scotland sought to make sense of car and train travel trends in GB (Le Vine and Jones, 2012). It started by presenting aggregate trends across the population and then looked at disaggregated trends for different groups in the population, but it acknowledged its inability "to go further and seek to uncover the causes of these behavioural changes". It speculated on reasons for the observed trends and concluded "… very little of the observed aggregate change in car and rail travel is accounted for by the ongoing changes in the proportions of the population that fall in each age group, or that live in different types of area; most are due to changes in travel behaviour within groups, caused by external factors" (Le Vine and Jones, 2012, pxi). The inability to explain changes in travel behaviour within constituent population groups is a reoccurring theme in many of the subsequent studies that have investigated travel transitions.

The typical sequence of investigation in these studies has been to first examine whether the aggregate trend applies to selected geographic areas/population groups or to the whole population. It then involves looking within selected areas/groups to find sub-areas/sub-groups which exemplify the trend-break. Identifying areas/groups within the population which most strongly exemplify the phenomenon of interest is helpful for starting to explain what is causing it. Information can be gathered on the prevailing circumstances and characteristics of those areas/groups and whether these differed from the rest of the population. However, in many cases it has been found that trend-breaks apply similarly across different areas/groups and it would have been desirable to have access to detailed, longitudinal data that captured changing circumstances and behaviour over a lengthy period of time from before the trend-break was evident. This luxury is rarely available.

Ten studies of travel transitions

I identified published studies of ten different travel transitions, most of which are connected to the broader trend-break in car travel which has seen per capita car use decrease since 2002. Most of them relate to a change in direction of popularity of a method of travel observed across the British population (company car use, van use, bus use, rail use, shared mobility use, walking). One transition is broader than this and concerns a general reduction in trip making. One concerns a modal shift in one geographic area (London). Two transitions concern distinctive transitions amongst a subset of the population (young adults, those with high-income). A summary of findings from the studies is presented in Table 1.

Table 1: Summary of Findings from Studying Travel Transitions in Great Britain

Travel transition/study	Nature of transition	Explanation provided by the study	Lessons for future work
Reduction in company car use (Le Vine and Jones, 2012; Headicar and Stokes, 2016)	Large reduction in company car access and use occurred between mid-1990s and mid-2000s (contributing to overall reduction in car distance travelled by men).	This transition can be directly attributed to change in tax treatment of company cars and change in employment structure.	Reinforces importance of obtaining data on the characteristics of vehicles used for personal travel (as collected by National Travel Survey (NTS)).
Modal shift in London (TfL, 2014; TfL, 2019)	Large modal shift in London from car to public transport and cycling from 1999 to present.	Modal shift linked to changes in transport supply and demographics/economics. Travel behaviour of some groups (young, migrants, high-income) not fully explained.	Comprehensive data collection in London (including London Travel Demand Survey (LTDS)) enabled rapid detection of modal shift and full investigation of causes. Focussed studies of population groups required to further increase understanding.
Lower trip rates (AECOM/Imperial, 2017)	Decreases in trips per person for commuting, shopping, visiting friends and relatives and personal business between mid-1990s and early-2010s which has slowed/stabilised since.	Trend is largely unexplained.	NTS data has not been able to explain trend. Social research (e.g. repeated time use surveys) is needed to understand changes in people's activities.
Growth in van travel (Braithwaite, 2017; WSP, 2018)	Light goods vehicle use has been growing faster than any other vehicle type in the last 30 years.	Different explanations put forward (e.g. just-in-time deliveries, more perishable deliveries, internet shopping, express parcels and outsourcing of services) but evidence weak on role of these.	Lack of data on use of vans has compromised explanation of trend (in particular, NTS does not distinguish between use of cars and light vans for personal travel).
Declining car driving of young adults (Chatterjee et al., 2018)	Decline in driving licence acquisition and car driving amongst young adults from early 1990s to early 2010s (for those born in late 1970s/80s/90s), now manifested in lower driving amongst these cohorts as they get into their 30s/40s.	Change in demographics, socioeconomics and living circumstances provide partial explanation with changes in travel attitudes and substitution of travel by online communication also thought to be important.	Travel surveys insufficient to explain generational change in travel behaviour. Also need longitudinal (panel) data on individual's lives and qualitative research (interviews, ethnography).
Weakening of income-car use association (Headicar and Stokes, 2016; DfT, 2018b))	Positive association between income growth and car travel growth no longer apparent in England since 1997.	Cross-sectional income relationship with car travel has decreased over time but reasons unknown.	Focussed studies of different income groups required to gain understanding.

Growth in rail use (Williams and Jahanshahi, 2018)	Growth in rail use has doubled since 1995 without this being predicted by model forecasts.	Changes in employment composition and in population/employment distribution are key contributors but this does not provide full explanation.	Greater segmentation of the population (by employment type, residential location) is required in rail forecasting models.
Growth in shared mobility users (Marsden et al., 2019)	Increasing numbers of shared mobility users since 1998 when services emerged but users remain concentrated in London and among younger, higher income residents.	Without greater policy support, shared mobility is likely to remain niche.	Use of shared mobility vehicles is not distinguished from personal vehicles in NTS and other travel surveys. Need good quality evaluations on the impacts of shared mobility services on travel behaviour.
Increase in walking (DfT, 2019b)	After a long-term decline in the average number of walking journeys made in England, an increase has been noted of 20% (from NTS) in the last three years (2015 to 2018). The increase has occurred across geographic areas and population groups.	As yet, no explanation has been confidently been put forward for this trend with tentative suggestions it has been influenced by health promotion and apps that make navigating streets easier.	Attitude surveys could help understand trend. Qualitative research could reveal motivations to walk more.
Declining bus use (Le Vine and White, 2020)	Significant decline in bus use outside London of 15% between 2008/09 and 2018/19 after previous period of stability.	Particularly large reductions in bus users from traditional segments of the market (such as students and those on low income) and in struggling economic areas.	A data limitation is that NTS does not capture details of the types of bus service being used. Focussed studies of areas/groups where reductions in bus use are greatest required to increase understanding.

The first notable point to make about the transitions is that nearly all of them can be traced back to the 1990s or earlier and hence they have been in existence for 20 years or more. It has taken a long time for the transitions to be the subject of significant investigations. This cannot be explained by delays in data availability. Indicators are collected on an annual basis by official data collection sources for most of the transitions. Of course, it takes a number of years (at least two usually) for a break in trend to be identified as a persistent change, rather than a short-term 'blip', but a delay of 10 years or more for studies to be carried out is noteworthy. It can be speculated that the delays occurred because the transitions were not expected or planned for, hence it took longer for them to be recognised as genuine breaks in trends.

One of the transitions is more recent – the increase in walking observed between 2015 and 2018. The same delay in investigating this should be avoided. It represents a reversal of a longstanding downward trend and a potentially fruitful opportunity to take advantage of greater public willingness to walk and therefore address various policy goals. Some of the transitions appear to have ended for reasons easily explained (for example, a reduction in company car use occurred almost immediately after changes in the tax treatment of company cars), but for other transitions explanations for their duration are not apparent (for example, trip rates decreased between mid-1990s and early-2010s and have since stabilised).

For most of the studies, no prior hypotheses are put forward to explain the transition and an array of potential contributing factors are examined. In some cases there is strong belief in the importance of a particular factor but evidence only supports this playing a modest role. It has generally not been possible to use statistical analysis to quantify the relative contribution of different factors in explaining transitions. Suitable time-series data (in particular, repeated cross-sectional data) has either not been available or, where available, it has not included factors thought to have played a role. Instead qualitative judgement has been needed in considering heterogenous data/information and making informed assessments. This is exemplified by the assessment of 22 putative factors contributing to the reduced car driving of young people in Chatterjee et al. (2018). This involved looking at the trend direction over time for each potentially influential factor and using the most up-to-date knowledge for the relationship between that factor and the travel indicator of interest to make a judgement whether the factor has contributed to the trend.

The studies have provided welcome illumination on the transitions and enabled better characterisations of the nature of the transitions and which parts of the population have been the main contributors to them (for example, see study on decline in bus use by Le Vine and White, 2020). They have usually needed to acknowledge they have not been able to fully answer why the transition has occurred (for example, studies on income-car travel relationship have not been able to explain why those with high incomes are using cars less than before).

A common issue is that studies have not had longitudinal data on individuals belonging to groups of particular interest which can help to explain their travel behaviour histories. This is a key evidence gap. These groups may represent trend-setters from whom it can be learned whether the transition might be expected to transfer across to other groups. For example, the profile of early adopters of shared mobility services is distinctive and there are doubts whether other groups in the population will follow them as users, but we could develop a better idea on this by finding out more about the motivations of early adopters of these services.

The question is often asked in these studies whether, from what has been learnt about the transitions, it will be possible for forecasting models to account of this. There have been mixed conclusions on this. In some cases, there is inadequate data available on the travel behaviour of interest (e.g. shared mobility use) which means the behaviour cannot be well represented at all in models. For some transitions, it has been found travel behaviour and travel behaviour change vary significantly across the population but models are not set up to include sufficient segmentation of the population. For some transitions, changes

in travel behaviour have not been explained by variables that can be included in models but have simply shifted over time (e.g. lower trip rates) – any explanation lies beyond the specification of models and different approaches will be required to consider their future significance.

The way forward for anticipating travel transitions and new mobility behaviours

This section draws upon what was found from the studies of ten travel transitions to make suggestions on what can be done to anticipate travel transitions and new mobility behaviours.

Conceptualising the determinants of travel patterns

The first question to ask is whether we have an adequate conceptualisation of urban travel to understand why travel transitions occur.

The studies reported in the previous section have not been explicit in how they identified factors that had potentially impacted upon travel and arrived at very different sets of factors. Some studies built on existing quantified conceptions of the determinants of travel. They sought to find out the extent to which transitions are explained by inputs and relationships previously used to explain travel behaviour (DfTb, 2018), or built upon these to include additional inputs and re-estimate relationships (AECOM/Imperial, 2017). Other studies took a broader view and considered the relevance of a wide range of factors across different domains, whether they could be quantified or not (Chatterjee et al., 2018).

In considering factors influencing long-term modal shift in London, TfL (2014) differentiated supply factors (transport options available in London), demand factors (economic trends) and structural factors (redistribution of population). TfL did not explicitly identify changes in 'ways of doing things' but did acknowledge decreasing driving licence holding amongst young Londoners as a structural factor without attempting to explain it.

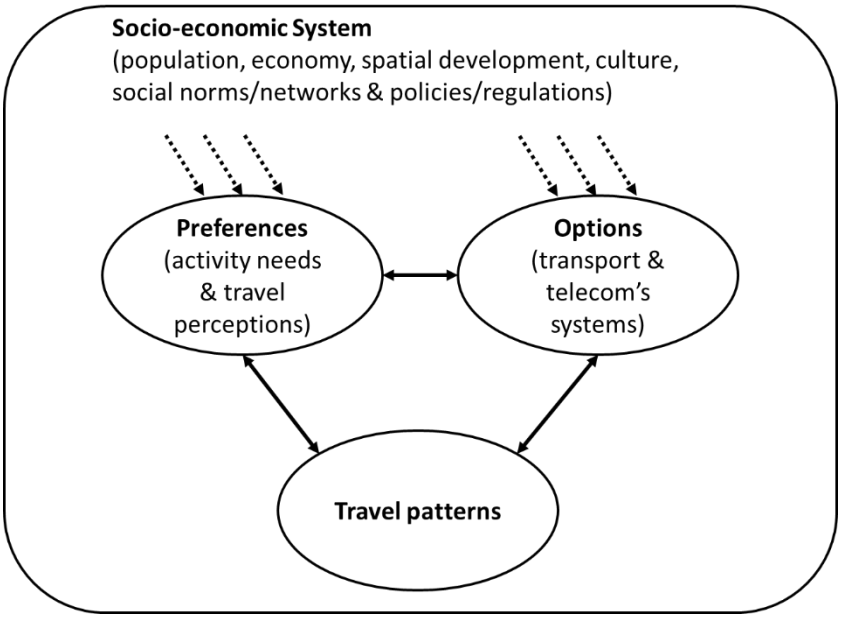
In seeking to understand the large growth in rail travel in Britain in the last 20 years, Williams and Jahanshahi (2018) noted that growth in rail could stem from two contributions:

- Differences/changes in the incidence of groups within this population; and
- Differences/changes in the behaviour of groups within this population.

Taking a general view, travel patterns can be considered to be a function of three domains - the wider socio-economic system, people's activity/travel preferences and the transport and telecommunications[4] options available for them (see Figure 1).

4 Note that the options available to meet people's preferences are assumed to include online options (e.g. video-conferencing), as well as physical options (spatial proximity, physical mobility) (as per the triple access system advocated by Lyons and Davidson (2016)).

Figure 1. Conceptual framework for influences on travel patterns



Changes in each of these three domains and in the relationships between them will affect travel patterns. This makes it difficult to anticipate future travel patterns. Typically, forecasts of future travel patterns are based on simple assumptions about future changes to the socio-economic system and the transport system with relationships between them assumed to remain the same as previously seen.

The conceptual framework above highlights that to understand what is causing changing travel patterns we need to look beyond the transport system and changing population characteristics. We need to look at broad changes to the socio-economic system and how they influence the preferences of the population and the provision of transport and telecommunications. We also need to continually review our understanding of how activity/travel preferences are resolved subject to the available transport and telecommunications systems.

When it comes to considering the timescale of change, Tilley (2007) has proposed a dynamic framework for understanding the multi-level forces stimulating changes in travel behaviours. She identifies three types of multi-level forces that influence change of mobility over time:

- Period effects – shorter-term effects that apply to whole population such as macroeconomic processes of growth and recession;
- Mid-structural effects - structural changes operating at a moderate rate of change such as post-war planning and resulting processes of suburbanisation and counter-urbanisation; and
- Deep structure effects - cultural changes occurring at an almost imperceptible rate of change which contribute to the development of socially constructed norms regarding mobility, which in turn influence travel patterns.

This is a helpful basis to think about the speed of change of travel patterns and whether a transition might represent a swift adjustment to a time-limited event or a long-term, gradual evolution of behaviour in response to structural effects.

Swift detection and analysis of transitions

In the last section it was observed that we have been slow in the transport sector to identify trend-breaks and put effort into understanding them. In fact, greater efforts have been made in the last 20 years into identifying changes in travel patterns in response to transport investments implemented in specific geographical areas such as public transport systems (Ingvardson and Nielsen, 2018) or city-wide cycling investment (Aldred et al., 2019). These studies have largely been found to demonstrate that interventions have succeeded in their objectives, although their impacts are not of a scale that they spread to wider regional populations.

It is recommended a more pro-active approach is taken to anticipating travel transitions by scanning changes in the socio-economic system and in transport and telecommunications, as well as in travel preferences and patterns. It is now clear that long-term travel trends are influenced more by changes to wider society than by internal changes to the transport system, although it is important to not neglect the interactive effect of these.

The scanning of changes in the socio-economic system in GB can be supported by a variety of social statistics sources, in particular the plethora of information available at the Office for National Statistics (ONS) website (https://www.ons.gov.uk). For forty years up to 2010, the ONS published an annual review of *Social Trends* which reported on "topics ranging from educational attainment, income distribution, population health, prison conditions and hours of TV watching" (Financial Times, 2019). This review was very helpful at collecting together a diverse set of information on social trends and it would be helpful to regularly produce something similar again but tailored for the transport sector.

The scanning of changes to the socio-economic system and to transport and telecommunications can be used to identify potentially significant developments which merit exploration for their possible effects on travel preferences and behaviour. Collaboration will be needed with social scientists in other fields (such as those in science and technology studies) to ensure well-informed hypotheses are put forward.

A cautionary example is offered on our experience of understanding the impact of social trends on travel behaviour. There has been much speculation and research on whether ICTs are substituting, stimulating, supplementing or redistributing travel (Lyons, 2015). Research has been inconclusive, however, and it is suggested that instead of directly asking this question there is a need to recognise that changes are taking place gradually to our lifestyles and there is a need to focus attention on "how mobile ICTs are transforming many aspects of our daily lives and especially how they are helping to reshape the temporal and spatial organization of everyday activities" (Aguiléra et al. 2012, p667). Studies which have investigated the direct relationship between ICT use and travel have found that those who use ICTs more also travel more (e.g. Kroesen and Handy, 2015), leading to the conclusion that the digitisation of society is not a contributor to reduced travel. However, it is questionable whether cross-sectional data used to make this claim is useful for informing us on the effect of digitisation over time which requires longitudinal data on both ICT use and travel over time.

The review of declining car driving of young adults (Chatterjee et al., 2018) found evidence of young adults in England spending more time at home between 1995 and 2014 and travelling less which it "tentatively put forward to support the claims of a move towards greater ICT use in place of travel. Even if other factors were the initial causes of reduced car use, spending more time at home is likely to lead to a change in what people do and where they go. This could mean that people continue to use cars less even if the original causes of a fall in car use are no longer prevalent" (p50). This highlights that suitable data and research methods and a long-term, process-based perspective are needed to examine hypotheses for how changes

to the socio-economic system and to transport and telecommunications are influencing travel. The following data/methods will be needed to enable better evidence for causality.

- Repeated cross-sectional data to analyse changing relationships over time for different population sub-groups and the extent to which this can explained by available variables (this data is already available for England in the form of NTS and for London in the form of London Travel Demand Survey (LTDS), but only limited analyses have been carried out exploring dynamics of travel behaviour, an exception is DfT, 2018b).
- Longitudinal (panel) data on individual's lives (including their travel) to analyse how their travel behaviour responds to changing circumstances.
- Tracking data from digital devices (e.g. smart phones) to analyse differences in lifestyles/activity participation across the population and changes over time.
- Qualitative research (interviews, ethnography) to find out how particular groups of interest ('trend-setters') have changed their travel behaviour in response to changing circumstances.
- Participatory methods (scenario planning, gamification) with prospective adopters of new mobility behaviour to explore future behaviours.

Population-representative data sets will continue to be crucial for assessing the prevalence of travel transitions and new mobility behaviours in the general population, but focussed studies of outlier groups/areas ("case study microcosms" in the words of Lyons (2015)) will be invaluable for examining the plausibility of different future states for wider society. It is essential that such studies are conducted by researchers without a vested interest in the commercial success of a transport 'product' so that an objective as possible outlook can be determined for the transition or new behaviour reaching beyond the outlier group/area.

Accounting for transitions in policy making and analysis

There are two main ways that scanning for travel transitions can help with policy development. First, it can be used to review existing policies, plans and investments to check they remain appropriate. Second, it can be used to refresh policy making by incorporating intelligence on transitions into future expectations of travel demand, whether this is through quantitative estimates of demand or qualitative judgements.

A good example of where this has been employed is in Transport for London's latest annual travel report (TfL, 2019). In this report, TfL has revisited the understanding gained from their 2014 review of drivers for demand for travel in London (TfL, 2014) to assess the most recent effects of those drivers for the period 2011-2018 and how each has contributed to the Mayor's Transport Strategy of a travel mode share of 80 per cent for active, efficient and sustainable transport modes by 2041. The report also includes the results of an exercise to envision future 'big picture' scenarios for how London might change by 2014 based on the Oxford Scenario Planning Approach. Three divergent scenarios (Innovating London, Rebalancing London and Accelerating London) were developed with stakeholders and are presented alongside a modelled core scenario. It will be monitored whether travel trends in London develop more in line with one of these scenarios or the core scenario.

An advanced approach to adaptive planning, which accounts for deep uncertainty, is being taken forward in the Netherlands by Rijkwaterstaat (Marsden et al., 2018, p43). It involves using scenario planning to ensure investment plans are robust to different futures and identifying thresholds which trigger the need for additional investments if they become necessary. As part of this, one task is "Collecting and evaluating

evidence on rapidly emerging trends and developments to inform planning assumptions and to trigger, amend or cancel further additional investments". Details are not currently available on how this is pursued but it sets a promising agenda for anticipating travel transitions and responding accordingly.

Conclusions

Marsden et al. (2018) noted there is a need to look back to understand why we did not anticipate changes and to see what this tells us about how to understand demand. This has been achieved in this paper by reviewing studies of 10 travel transitions. The studies have provided welcome illumination on the transitions and enabled better characterisations of the nature of the transitions and which parts of the population have been the main contributors to them, but they have usually needed to acknowledge they have not been able to fully answer why the transition has occurred.

It is apparent from the travel transitions reviewed in this paper that the evolution of travel patterns is the product of a highly complex, dynamic system that to be understood requires looking at wider changes to the socio-economic system and to transport and telecommunications, as well as looking at trends in travel preferences and patterns. It is recommended that scanning exercises are employed looking at either 'end of the telescope'.

- Vigilantly monitoring trends in travel preferences and patterns and investigating trend-breaks even where they only show up for a short, sustained period.
- Scanning social developments (including those in transport and telecommunications options) and constructing hypotheses for how they may affect travel preferences and behaviour which can be investigated in carefully designed research studies.

Without being able to be confident on future directions of travel demand there is a need to place greater emphasis on monitoring trends in travel, as well as developments in the socio-economic system and transport and telecommunications systems. This is not just a case of being responsive to external developments – a better appreciation of responsiveness of travel patterns to the 'wider system' will also give important clues as to how top-level policy goals can be achieved by bringing in policies that 'go with the grain'. Anticipating urban travel transitions and new mobility behaviours will support vision-led policy making to address the challenges of the age.

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