

Travel Transitions

How Transport Planners and Policy Makers Can Respond to Shifting Mobility Trends



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The International Transport Forum

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International Transport Forum
2 rue André Pascal
F-75775 Paris Cedex 16
contact@itf-oecd.org
www.itf-oecd.org

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The principal authors and section co-ordinators were:

- Kiron Chatterjee (University of the West of England, Bristol, United Kingdom): “Introduction” and “Trend breaks and travel transitions”
- Javier Burrieza Galán (Nommon Solutions and Technologies, Spain): “Looking back to look ahead”
- Glenn Lyons (University of the West of England, Bristol, United Kingdom): “Handling uncertainty in assessing travel transitions”
- Karolina Isaksson (National Road and Transport Research Institute, Sweden) and Greg Marsden (University of Leeds, United Kingdom): “Governance challenges and opportunities”.

Other contributors to the report include: Alexandra Millonig (Austrian Institute of Technology), Marcin Światała (Road and Bridge Research Institute, Poland), Mehmet Yazıcı (Ministry of Transport and Infrastructure, Turkey), and Peter Jorritsma (KiM, Netherlands Institute for Transport Policy Analysis).

Working Group participants were: Austria, Chile, France, Germany, Ireland, Latvia, Mexico, the Netherlands, New Zealand, Poland, Portugal, Spain, Sweden, Turkey, the United Kingdom, the United States and the European Commission.

The full list of participants at the Urban Travel Transition and New Mobility Behaviors in Light of Covid-19 Working Group Meeting held on 7-8 December 2020 appears in Annex A.

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Executive summary

What we did

This report considers why breaks in past travel trends and the emergence of new urban mobility behaviours were not foreseen. It assesses what has been learned about the causes of previous trend breaks and highlights how the future evolution of travel demand can be better anticipated. It reviews how transport planners and managers use projections of future movement of people and goods to guide decision making and identifies the limitations of established approaches for forecasting travel demand. The report considers the implications of deep uncertainty for strategic transport planning and suggests new ways of thinking and planning for more resilient investment decisions. It also considers the governance challenges to bring about change and the associated institutional implications.

What we found

Travel trends in industrialised, urbanised countries at the start of the 21st century have confounded expectations. Scientific studies have used theories of behaviour change and longitudinal data to analyse these travel trends. These studies have shed some light on travel transitions but have rarely fully answered why these transitions have occurred.

It is now clear that long-term travel trends are primarily influenced by changes to broader society and lifestyles rather than by internal changes to the transport system, although the interaction between these factors is important. The Covid-19 pandemic may cause further long-term changes to travel behaviour – be that due to people behaving differently during the pandemic and continuing these new behavioural patterns afterwards, or due to broader changes in society, which arise as a result of the pandemic (e.g. changes to working practices).

Public authorities have been slow to identify breaks in travel trends and to put effort into understanding these changes. Although efforts to track changes in travel patterns in response to transport investments have increased in the last 20 years, a more proactive approach should be taken to anticipate future travel transitions. Such analysis will need to look at changes in socio-economic systems, advances in transport and telecommunications, and changes in travel preferences and patterns.

The “predict and provide” paradigm, which has dominated transport planning since the mid-20th century, typically utilises one or more forecasting models to predict future demand. However, evidence on the performance of forecasting methods suggests two major limitations: a failure to capture the uncertain nature of travel demand and unsuitability for supporting new decision-making methods in transport planning. The deterministic travel demand forecasts widely applied under this paradigm were not intended to shape or limit mobility. However, the use of such forecasting methods often seems to have led to a cyclical reinforcement of undesirable trends.

The confluence of the motor age and the digital era has created a state of flux in transport and society generally, further exacerbated by the Covid-19 pandemic. This instability and change challenges the forecast-led paradigm's effectiveness in many contexts and suggests the need for a transition in transport planning and appraisal from “predict and provide” towards a “decide and provide” approach.

The decide-and-provide paradigm gives primacy to access, i.e. a combination of physical mobility, spatial proximity and digital connectivity. It is also vision-led rather than forecast-led, i.e. it sets out a preferred future and charts a course towards it that allows for uncertainty. This approach has been applied in the United Kingdom, where scenario-based representations of uncertainty have been used to test the resilience of policy interventions. Signs point to a change in thinking and practice in several other countries as well.

However, the formal and informal frameworks that condition the development and implementation of new approaches can hold back progress. The challenge is to develop and integrate target-oriented transformative governance processes, even in fragmented institutional contexts characterised by established norms and power relations.

What we recommend

Scan for emerging travel trends using a combination of traditional and new data sources

Big data sources (such as mobile phone records) can be used to rapidly detect changes in travel patterns at a high degree of spatial and temporal resolution. However, traditional travel surveys also remain essential for monitoring longer-term trends and relating these to socio-demographic and lifestyle factors. Detailed studies should be undertaken of outlier groups and areas exhibiting new mobility behaviours.

Measure the performance of the transport system with indicators that reflect how mobility contributes to societal objectives

Travel is not an end in itself and indicators of travel activity need to be helpful in assessing how mobility contributes to achieving societal goals. In this light, transport planners should reflect on whether the indicators for the travel activity they track are the most useful ones. Instead of focusing on total or average travel across a population, they should also look at the spread in values across the population to understand equity impacts.

Take a proactive approach to anticipating travel transitions by scanning developments inside and outside the transport sector

Transport planners should proactively scan developments inside and outside the transport sector in order to assess the implications of such developments for travel preferences and behaviours. This requires collaboration with scientists and researchers in other fields.

Account for uncertainty when making predictions and be explicit about the different sources of uncertainty

The level of uncertainty regarding future travel demand can vary from complete certainty to complete (or “deep”) uncertainty depending on the transport system and time horizon under consideration. The uncertainty in predictions stems from uncertainty in values of explanatory variables, assumed relationships and underlying processes. Uncertainty in transport often arises from the diverse stakeholders involved and their autonomy in decision making.

Shift from a “predict and provide” approach towards a “decide and provide” approach in the face of deep uncertainty

Determining what to do about deep uncertainty when making planning and investment decisions requires a new approach to strategic transport planning, as well as a new way of thinking about future trends. This shift entails moving from a purely predict and provide approach towards decide and provide – an approach that is vision-led rather than forecast-led and in which a preferred future is identified and a pathway towards that future is conceived that can negotiate uncertainty ahead. Decide and provide approaches should be part of the suite of methods used to assess the resilience of planning and investment decisions. Inherent to such an approach should be a move away from focusing only on mobility and a move towards recognising that the main purpose of transport – to enable access to opportunities – can also be achieved by spatial proximity and digital connectivity.

Change the mindset and enhance the skillset of the transport-planning workforce

Transport planners will need a different mindset and new skills to enable the sector to move to vision-based transport planning. For example, new notions and norms of analytical robustness are required in strategic transport planning which focus more on plausibility than precision – it is better to be approximately right than precisely wrong.

Foster a strengthening of international knowledge sharing and co-operation via a “learning by doing” approach

Learning from successful practical examples and building upon them will create the necessary confidence that new approaches to dealing with uncertainty are fit for purpose. Fostering international knowledge sharing and co-operation in a learning-by-doing context will help the transition to more effective planning approaches to gain momentum.

Adapt transport governance to better account for uncertainty in planning

The current situation of uncertainty and flux with respect to future travel demand is an opportunity to acknowledge the limitations of existing processes and transform transport governance. However, developing transformative capacity requires adaptation and adjustment to specific contexts, actor constellations and situations. Sweden offers an example of how this is possible. The Swedish Energy Agency led a commission to decarbonise the transport sector, demonstrating how target-oriented transformative governance processes can be developed and integrated, even in fragmented institutional contexts characterised by established norms and power relations.

Introduction

Travel trends in industrialised, urbanised countries around the world have confounded expectations at the start of the 21st century. Growth in motorised travel has slowed down and car travel per capita has decreased in some countries. Public transport use and cycling have increased in many cities. Many different factors appear to be at play in influencing people’s desires and needs for mobility – changes to socio-demographics, economies and lifestyles are occurring at the same time as fast-paced technological change. On top of this, the Covid-19 pandemic has arrived, without warning, to accentuate the sense of uncertainty about what the future holds for personal travel. Will the changes Covid-19 has brought about permanently alter the way people live now that societies have adapted to perform many essential activities without needing to travel, or will it make people appreciate travel more than ever and seek out greater travel opportunities?

This report is concerned with “travel transitions”, those changes that induce a break from existing and habitual patterns of behaviour and lead from one state or condition to another. The travel behaviour of urban residents is the focus of this paper, as it is urban residents whose travel behaviour has changed the most in the last 20 years in industrialised countries and urban areas that face many of the most serious challenges that lie ahead. However, trends are often reported at a broader level than just urban areas, so the report considers travel at a variety of levels, from local to national.

Although growth in travel has decreased in industrialised countries, the need to anticipate future demand for travel and make plans to accommodate or influence these developments has never been more important. A good understanding of travel activity is required to provide transport infrastructure and services that serve the needs of all in society and to support economies. It is important to understand and account for travel transitions in infrastructure provision, transport and land-use planning and the regulation of mobility services. For those world regions still experiencing rising motorised travel, the travel transitions in industrialised countries may indicate a need to re-evaluate perceived wisdom regarding appropriate transport policy design and deployment.

Transport has a key role to play in tackling existential threats to society such as climate change, air pollution and inactive lifestyles. Hence, there is a need for public authorities to be proactive in shaping the future of transport and demand for travel in order to meet societal imperatives. Prior to the pandemic, transport authorities in industrialised countries could be seen as largely reactive to external developments and struggling to understand the implications of changes taking place both externally and within the transport sector (such as the introduction of new mobility services).

This report explains why it is no longer reasonable to make confident predictions about future travel activity given the diverse set of factors that influence mobility and the complex inter-relationships between them. The report argues, based on the experience of the last two decades, that the analytical and decision-making methods of the past are no longer fit-for-purpose and a change is required, not only in methodology but also in the ways of thinking about the future. There is a need to directly engage with uncertainty in a way that recognises that there are multiple possible futures and to acknowledge that actions taken today will influence the future and can help chart a course towards desirable outcomes. The

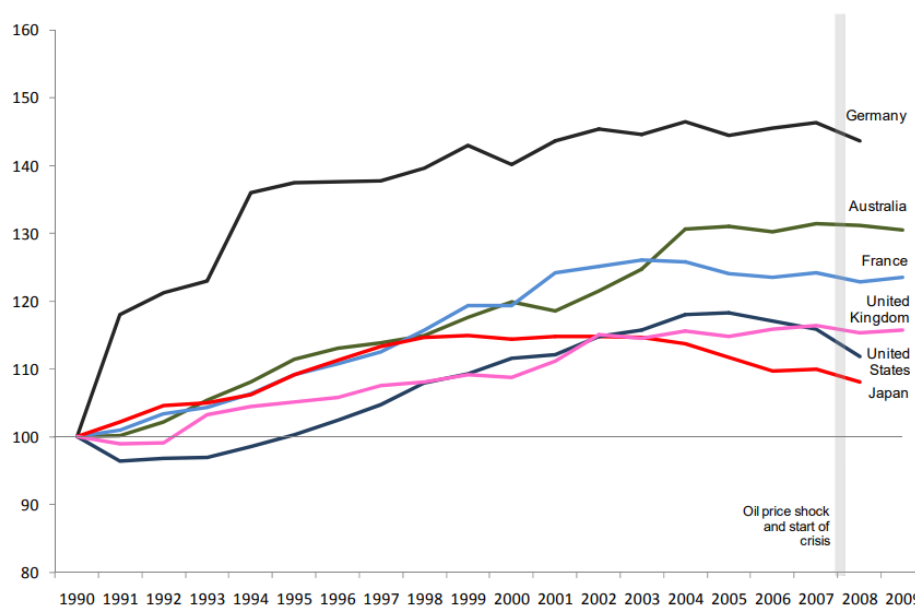
report also considers the governance challenges in bringing about the necessary changes in perspectives and approaches to transport planning and what these mean for institutional arrangements.

The remainder of this introduction provides further background to the report and explains why a change in perspective is needed by public authorities in order to anticipate future transport developments and make strategies and plans which are resilient and address the major challenges that they face.

Unexpected trend breaks

Growth in travel has not developed as expected in urban, industrialised economies in the last two decades. This was observed as long ago as 2011, when an ITF report highlighted the lack of growth in car travel in six advanced economies (Australia, France, Germany, Japan, the United Kingdom and the United States) in the first ten years of the 21st century (see Figure 1), in contrast to the strong growth that had been seen in preceding decades (ITF, 2011).

Figure 1. Growth in passenger-kilometres by private car and light vans in six advanced economies, 1990-2009 (indexed to 1990 = 100)



Source: ITF (2011).

Following these observations, there has been widespread discussion of whether “peak car usage” has been reached and what the future holds for car travel and the use of alternative methods of transport (Goodwin, 2012).

It has proven difficult to explain why car use has stopped growing in these and other countries experiencing similar trends. It is clear that the previously observed strong link between economic growth and travel growth has weakened (Millard-Ball and Schipper, 2011). Suggestions have been made that a saturation point has been reached where citizens cannot benefit from more travel (Metz, 2013). This is particularly argued for cities, as illustrated by Newman and Kenworthy (2011), who showed that growth in car use in cities in Australia, Canada, Europe and the United States has been slowing down in each decade since 1960. In summarising the search for explanations, Goodwin and van Dender (2013) concluded that: “New

econometric work suggests that an aggregate model focusing on gross domestic product (GDP) effects and fuel prices is too crude to capture the diversity and various dynamics underlying aggregate car travel demand and how it changes”.

Researchers have therefore focused their attention on different groups of the population. For example, in the United Kingdom there have been: decreases in car driving among men, but little change in driving among women; decreases in car driving by young adults, but increases in driving by older adults; and decreases in driving in cities with little change in driving in smaller urban areas and rural areas (DfT, 2015).

BMW’s Institute for Mobility Research commissioned an international comparative study in 2010 which assessed how the Generation Y cohort (defined as being born between the early 1980s and early 1990s) differed from previous cohorts in their travel behaviour (IFMO, 2013). It compared trends in France, Germany, Great Britain, Japan, Norway and the United States. It found a similar trend of decreased distance travelled by car in all six countries, although noted differences between countries in trends such as public transport use (for example, increasing strongly in Germany, but unchanged in the United States). The study found that one-half of the decrease in car ownership in Germany could be explained by socio-economic changes (such as decreasing real incomes, an increase in the proportion of urbanites and a higher average age for starting a family), but the other half could not be explained by those factors. For Great Britain, only one-third of the decrease of car ownership could be explained by socio-economic factors.

An in-depth study commissioned by the UK Department for Transport (DfT) sought to understand the reasons why young people in Great Britain are driving less than previous generations (Chatterjee et al., 2018). It assessed the role of 22 possible contributory factors and concluded that there are multiple inter-connected reasons for the changes in transport use. They include changes in the socio-economic, living and family situations of young people, as well as changes in transport costs and the relative importance attached to driving in the digital age.

An important point to note is that travel patterns and trends can vary enormously, even within a country or city. A comparison of the travel trends in six city regions (Atlanta, Brisbane, London, Melbourne, New York and the combined English metropolitan areas of Greater Manchester, Merseyside, West Midlands and Tyne and Wear) found “markedly different trends in young adult travel behaviour that are unlikely to be explained by economic differences alone” and suggested that “changes to the transport systems in these cities are likely to be playing an under-recognised role in shaping travel behaviour” (Delbosch et al., 2019).

In the Discussion Paper prepared for this working group, Chatterjee identified ten different travel transitions which have occurred in the last 20 years in Great Britain (Chatterjee, 2020). Most of these transitions are connected to the broader trend break in car travel which has seen per capita car use decrease since 2002. Nearly all of the travel transitions can be traced back to the 1990s, or earlier, and therefore have been in existence for 20 years or more. However, it has taken a long time for the transitions to be recognised as the subject of significant studies, and when studies have been carried out, they have not been able to fully ascertain why transitions have occurred.

Realisation that existing practices are inadequate for future transport planning

There have been large discrepancies between forecasts and actual outcomes of travel demand in industrialised countries in the first two decades of the 21st century. For example, it was forecast in 2000

that traffic would grow by 22% by 2010 in Great Britain, but 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). The DfT has explained its tendency to overestimate 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: 15).

Up to 2015, the national forecasts for Great Britain included a central, most likely forecast along with low and high forecasts. In the 2015 and 2018 forecasts, the approach changed, with forecasts given for a set of equally plausible scenarios, without any one of them identified as most likely. 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) for seven different scenarios (DfT, 2018a). 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).

Lyons and Marsden (2019) provide a critique of DfT’s treatment of uncertainty in national forecasting and 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, that this is then “closed down” when it comes to using forecasts for scheme appraisals and policy decisions where “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 National Transport Model (NTM)”. Sensitivity testing is carried out around this with high and low growth scenarios, but it is noted that “the choice of which scenario is used to bound assessment of uncertainty, among 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”.

Even where aggregate forecasts of demand have been reasonably accurate, there have been notable divergences for underlying components of travel demand. Furthermore, 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 – and this can have a disproportionate impact on transport policy decisions.

The mismatch between aggregate forecasts at the national scale, even when they are accurate, and the need to account for disruptive and outlying changes in travel behaviour at the local and regional scale causes tensions going forward. At the national level, there has generally been a focus on projecting future travel demand in order to adapt to it (e.g. by providing sufficient infrastructure). Local and regional authorities, on the other hand, have generally shown more appetite to positively influence what lies ahead, rather than just waiting for and adapting to change.

There is a further mismatch between what can be gathered from aggregate forecasts and insights into outlying behaviours among segments of the population that may spread to other sectors and indicate the emergence of a “new normal”. Against all of this background, the emerging short-, mid- and long-term impacts of the Covid-19 pandemic further add to the challenge of forward planning and policy in transport. Given doubts about the capabilities for accurate quantitative forecasting of travel demand, there is growing interest in alternative approaches that explicitly grapple with both uncertainty and disaggregate but important changes in behaviour at different spatial scales and among certain sectors of the population.

Transport planning as a “wicked problem”

The digital age has dramatically changed modern life over 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 has been suggested that this is a period of deep uncertainty for developments that affect travel behaviour, with

divergent opinions among experts and stakeholders and a lack of empirical evidence (Lyons and Davidson, 2016).

Lyons and Marsden (2019) have suggested that the extent of uncertainty in the transport sector means that decision makers are dealing with a “wicked problem”. Kolko (2012) states that a wicked problem is a social or cultural problem that is difficult or impossible to solve for four reasons:

- incomplete or contradictory knowledge
- number of people and opinions involved
- large economic burden
- interconnected nature of these problems with other problems.

The uncertainty over developments in transport and future demand for travel, the number of parties with an interest, the significance of transport for modern economies and the role of transport in tackling wider societal problems confirms that transport planning in this period of deep uncertainty can be seen as a wicked problem.

Reader’s guide to this report

What the previous discussion has indicated is the need to take stock of the approaches used to forecast travel demand and plan transport systems. The next section, “Trend breaks and travel transitions”, discusses what is known about the causes of travel transitions and new mobility behaviours and asks whether it is possible to learn enough about drivers of travel behaviour change processes to be able to anticipate future trends. It makes suggestions for how to more quickly identify counter-trends. The following section, “Looking back to look ahead”, provides a critical assessment of current capabilities in transport planning and considers data, theory, models and assessment frameworks and their varied applications. It covers long-established approaches which continue to be used today, as well as examples of novel approaches currently in practice.

The section “Handling uncertainty in assessing travel transitions” considers the challenge of how to deal with uncertainty, especially deep uncertainty, in strategic transport planning. It considers how policy makers and other transport sector stakeholders can, and are, making sense of this feeling of deep uncertainty and responding to it. It introduces ways to embrace this uncertainty such that planning and investment decisions can be taken that are more resilient in the face of it. The final section, “Governance challenges and opportunities”, considers challenges and opportunities to govern a transformation towards a regime of transport planning with a higher capacity to face transformation and uncertainty.

Trend breaks and travel transitions

The unexpected discontinuity of past travel trends and the emergence of new urban mobility behaviours prompt reflection on how transport planning is undertaken. It is important to consider why these trend breaks were not foreseen. This requires consideration of the processes which can lead to counter-trends and transitions in travel behaviour and the contributions made to these processes by different drivers of change. This section looks at the role of different types of drivers of change in travel behaviour, what is known about their influence and what gaps in knowledge exist. Recent studies have provided welcome illumination on travel transitions, but have usually needed to acknowledge they have not been able to fully establish why transitions have occurred. The experience from the Covid-19 pandemic is used to consider how effectively it has been possible to monitor and understand the rapid changes in travel behaviour that have occurred during the pandemic and the lessons from this for future travel monitoring and detection of trend breaks.

The final part of the section looks at promising avenues for monitoring travel and detecting trend breaks and discusses how these might be used to support transport authorities in their anticipatory work. It is suggested that pro-active monitoring of developments external to transport and within transport can enable quicker identification of counter-trends and support adaptive responses to emerging phenomena. 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. 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 focused studies of outlier groups and areas will be invaluable for examining the plausibility of different future trends for wider society.

Travel behaviour, habits and change

How can changes in travel patterns over time be explained? Travel patterns in a neighbourhood, city, region or country are comprised of thousands or millions of individual decisions, a large proportion of which at any time are habitual decisions. Over time, individuals change their travel behaviour, sometimes because their travel needs change (e.g. when their workplace changes), sometimes because their transport options change (e.g. when public transport services are modified) and sometimes for reasons that are hard to grasp (e.g. when wanting to do something different). As time passes, the population itself changes as people move into or out of an area. Aggregate change in travel patterns is the net effect of all these underlying changes.

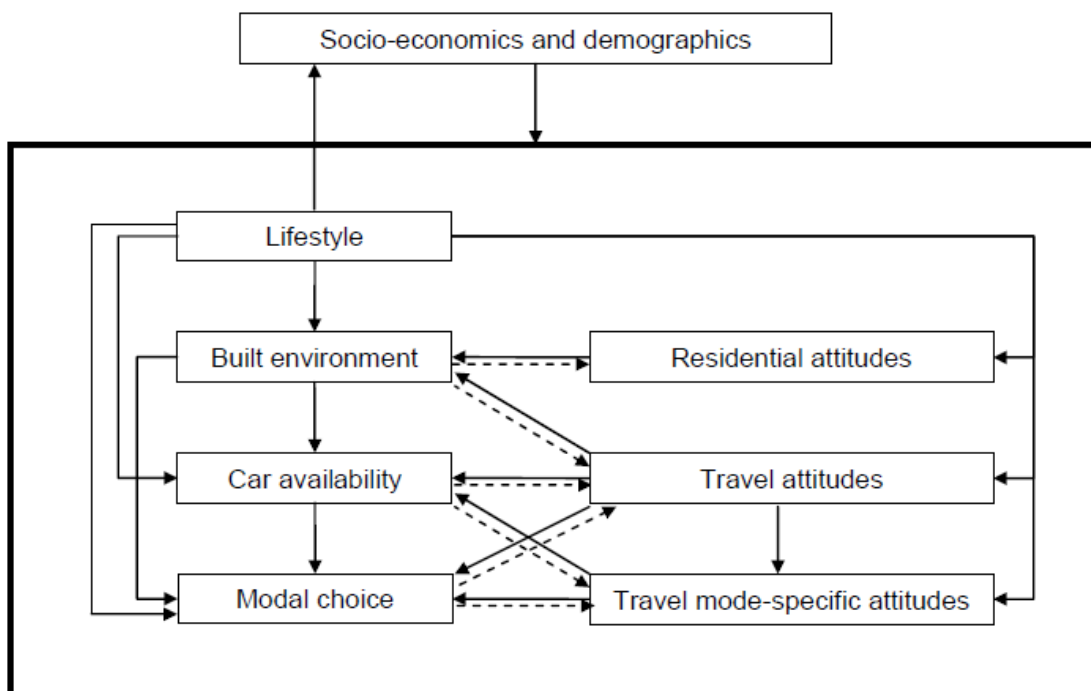
If there is stability at the aggregate level it is because underlying changes are balancing each other out. For example, observations one year apart for a representative sample of 19 545 English households showed the same percentage of households increased the number of cars owned (9%) as decreased the number of cars owned (9%) (Clark, Chatterjee and Melia, 2016). Aggregate change (either a continuation of a past trend or a reversal) arises when there is an imbalance in the underlying changes. This has been referred to

as “asymmetric churn” because the change in one direction is different in size to the change in the opposite direction. For example, a panel study undertaken in the United Kingdom during the Covid-19 pandemic showed 15% of the panel increased the frequency they drove a car between June/July 2020 (when restrictions had been eased after a first national lockdown) and November/December 2020 (when a second lockdown was in place), while 22% decreased the frequency of car driving and 63% reported unchanged car driving frequency between these periods (Marshall, Bizgan and Gottfried, 2021). While the second lockdown appeared to have had contrasting effects on different members of the population, there was a net decrease in car driving.

Individual-based theories

Various theories have been used to understand travel behaviour, some focusing on the behaviours of individuals and others on the behaviours prevalent in society more generally. Perhaps the most commonly employed basis for understanding travel behaviour is rational choice theory, which assumes travel entails disutility (notably time and cost) and that travellers seek to minimise disutility to reach destinations. Rational choice theory helps illustrate how supply-side factors related to transport provision (such as travel times and costs) influence travel choices.

Figure 2. Hierarchical structure of decisions



Source: Van Acker, Mokhtarian and Witlox (2011).

More advanced theories focus on the context for people making journeys. The activity-based approach to travel behaviour considers how people organise their travel in the context of the activities they wish to pursue and constraints of time and place (McNally and Rindt, 2007). This approach helps illustrate how household needs and organisational factors influence travel choices. Socio-psychological theories move away from the assumption that people are rational decision makers (seeking to minimise travel disutility) and consider how subjective factors, such as attitudes and social norms, influence travel behaviour. They

help describe how people perceive the options available to them and are motivated to perform particular behaviours.

Combining the above theoretical perspectives, van Acker, Mokhtarian and Witlox (2011) proposed a conceptual framework (see Figure 2) which suggests travel behaviour decisions are part of an extended choice hierarchy with lifestyle choices at the top level of the hierarchy, representing the long-term view of “what life should be like” and manifested in decisions on family, employment and leisure. Medium-term decisions, such as residential location and car ownership and short-term decisions such as choice of destination and mode of transport are made in line with lifestyle choices and attitudes. The framework also recognises that lifestyle preferences and travel decisions are influenced by the wider social-economic and demographic context.

Turning to theories of behavioural change, habit theory hypothesises that behaviour when first initiated is the product of rational decision making, but becomes automatic when repeated in a stable context. In particular, the habit-discontinuity hypothesis posits that habits may become weakened when they are interrupted by a contextual change (Verplanken et al., 2008). This has led to interest about the nature of events which bring about a reconsideration of behaviour. Events can be at the micro-level (relating to the life of an individual and their immediate social network), or at the macro-level (relating to the wider social system, including the transport system) (Chatterjee and Scheiner, 2015).

The life course perspective is a multidisciplinary paradigm for the study of people’s lives, structural contexts and social change. It is helpful in considering why travel behaviour changes during the course of people’s lives. There are four primary analytic themes of the life course perspective (Elder, 1998):

1. Historical time and place – the life course of individuals is embedded in and shaped by the times and places they experience over their lifetime. This signals the importance of cohort effects, where distinctive formative experiences are shared at the same point in the life course by birth cohorts.
2. Timing of lives – the impact of life transitions or events is contingent on when they occur in a person’s life.
3. Linked lives – lives are lived interdependently, and social and historical influences are expressed through this network of shared relationships. The family has been the prime focus of life course research in this respect, but social relationships can be considered in a wider sense.
4. Human agency – individuals make their own decisions and construct their own life course through the choices and actions they take, within the opportunities and constraints of their history and social circumstances.

The life course perspective has been applied to travel behaviour through the concept of mobility biographies. Lanzendorf (2003) proposed that mobility biographies consist of lifestyle, accessibility and mobility domains, and that these three domains are interlinked, with events in one domain affecting the others. The emphasis in mobility biographies research has been to study how events in the course of life influence a change in travel habits. Studies have highlighted the importance of changes in household composition, driving licence availability, residential and workplace location (Chatterjee and Scheiner, 2015).

While researchers have given much attention to behavioural change induced by disruptive events (whether micro or macro events), there are theories that suggest that change is a more gradual process and occurs in stages. The transtheoretical model of change (Prochaska and Di Clemente, 1983) assumes that individuals progress through stages of change over time, ranging from not contemplating change through to contemplating and preparing for change, enacting change and maintaining changes. At each

stage, there is a “decisional balance” of pros and cons for change. Learning theories, such as social learning theory (Bandura, 1977), are helpful in highlighting that behavioural change occurs through a combination of trial and error and in observing what others do. It is suggested that “learning is more likely to happen when there is a change in the situational context (or behavioural goal), when deliberation is prompted by information or when the situation is uncertain” (Sunitiyoso, Avineri and Chatterjee, 2013: 259).

Systems theories

The theories highlighted above emphasise individual agency in travel decision making, but there are sociological theories that argue that individual behaviour is determined by societal structures. Instead of placing attention on individual behaviour, social practice theory focuses on collective practices and looks at the elements that are needed to maintain these practices (Shove, Pantzar and Watson, 2012). Elements are categorised under the headings of materials, competencies and meanings and can be interpreted for transport as access (physical access to transport services), ability (know how to use a transport mode) and ambition (willingness to use a mode of transport) (Millionig, 2021). While efforts are being made to reduce physical and financial limitations restricting access to car alternatives, there are still few solutions for overcoming competence deficits and emotional barriers. Although access is an essential prerequisite for behaviour change, simply ensuring access is, of itself, insufficient to drive behavioural change. More comprehensive efforts are required to address barriers related to ability and ambition in order to achieve greater levels of behavioural change. This explains, from a systems perspective, why travel behaviour change is a slow and gradual process at the aggregate level, even if change is faster and more substantial among certain individuals and cohorts.

One application of social practice investigated the elements that help to maintain car-based commuting practices in the United Kingdom and what might destabilise these practices (Cass and Faulconbridge, 2016). It concluded that structural barriers to bus and cycling use need to be addressed, (such as the frequency of bus services, the availability of cycling equipment, knowing how to navigate bus timetables or ride a bike safely and appreciation of exercise gained through cycling or relaxation when using the bus), as well as the re-organisation of linked social practices (such as working hours) that hinder bus-based and cycling-based commuting practices.

Everett Rogers proposed the diffusion of innovations theory to explain how new ideas and technologies spread in a population and is helpful in considering how large-scale system change occurs. The theory states that the diffusion of an innovation (or a new practice) depends on its relative advantage over previous practices, its compatibility with the needs, habits or values of those who will potentially adopt the practice, its complexity (or ease of use) and its potential for trialling (Rogers, 2003). Some people are more likely to adopt a new practice than others with five groups identified: innovators, early adopters, early majority, late majority and laggards. While diffusion of innovations theory has often successfully been applied to profile users of new transport technologies, it is less well suited to understand how broader travel behaviours will evolve over time.

A more expansive theory of system change is the multi-level perspective (MLP), which adopts a socio-technical approach to the study of transitions and assumes “that transitions are non-linear processes that result from the interplay of multiple developments at three analytical levels: niches (the locus for radical innovations), socio-technical regimes (the locus of established practices and associated rules), and an exogenous socio-technical landscape” (Geels and Kemp, 2012: 53). Niche actors work on radical innovations that deviate from existing regimes and hope that their promising novelties are eventually used in the regime or even replace it. However, the existing regime is stabilised by many lock-in mechanisms. For example, a car-based transport system is stabilised by “sunk investments (in road infrastructures,

plants, skills), user patterns and lifestyles oriented around the car, favourable regulations, cultural values (such as speed, freedom, individuality, identity), resistance from vested interests (industry, car lobby, road-building lobby)” (Geels and Kemp, 2012: 58). These lock-in mechanisms are persistent and pervasive and amount to what Mattioli et al. call a “system of provision” for car-based transport that generates significant friction to change by niche or other actors (Mattioli et al., 2021).

When it comes to considering timescales of change, Tilley (2017) has proposed a dynamic framework for understanding the multi-level forces stimulating changes in travel behaviours. This framework identifies three types of multi-level forces that influence change in travel behaviour over time:

- period effects – shorter-term effects that apply to whole populations, 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 the resulting processes of suburbanisation and counter-urbanisation
- deep structure effects – cultural changes occurring at an almost imperceptible rate of change and which contribute to the development of socially constructed norms regarding mobility, which in turn influence travel patterns.

This is a helpful basis from which to think about the rate 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.

Empirical studies of travel trends

Having introduced the above theories, it is now shown how empirical analysis can apply these theories to help analyse and interpret travel trends. When looking at longer-term change in travel trends, the most easily obtained data is time-series data of aggregate travel, such as annual observations of vehicle-kilometres travelled. Econometric analysis is often conducted with such data to explore how socio-economic conditions influence travel trends over time with the underlying assumption of rationality, such that travel increases with more income and decreases with higher transport costs.

A good example of an econometric analysis of time-series data is that of Bastian, Börjesson and Eliasson (2016), who estimated multiple regression models of log vehicle-kilometres travelled per capita against log gross domestic product (GDP) per capita and log gasoline price for six countries (Australia, France, Germany, Sweden, the United Kingdom and the United States) based on 1980-2014 time-series data. They found the models explained the observed trends very well through the full period. They also found that GDP per capita elasticities have decreased over time, whereas gasoline price elasticities have increased, which indicates saturation of car ownership and use among higher-income groups and increased sensitivity to fuel prices when they are at high levels. The authors “conclude that economic variables are sufficient to explain the aggregate trends in car use” but “do not rule out the existence of alternative explanations”.

While the regression models estimated by Bastian, Börjesson and Eliasson accurately reproduced the time series of observations from which they were estimated, this does not guarantee their accuracy for future predictions. Even if trend breaks have been driven by macroeconomic factors, the adaptations that arise (e.g. investment in car alternatives or take-up of alternative lifestyles) may exert longer-term influence, as implied by the decreasing GDP elasticities. It is, therefore, still important to look at other influences alongside economic factors and to study different socio-economic groups. While analysis of this kind can assess the extent to which population-wide aggregate travel trends are explained by socio-economic

variables, it is not able to explain why differing trends might be taking place within the population. For example, the analysis could not explain the significant reduction in car travel by young adults.

Where disaggregate, longitudinal data is available from repeated cross-sectional surveys (such as annually conducted national travel surveys), more sophisticated analysis can be performed and a greater understanding gained of reasons for change in travel behaviour. In 2013, IFMO reported on the use of a trend decomposition technique to analyse national travel survey data for France, Germany, Great Britain, Japan, Norway and the United States. This data was used to look at changes in travel behaviour by age group and assess the impact of population aging on the levelling off or reduction in car distance travelled observed in these countries. For example, in Great Britain between 1996 and 2005 increased car ownership and use among older people (aged 60 or above) contributed to greater overall distance travelled by car, however, decreased total travel and car mode share of young people (aged 20-39) counteracted this. However, this study could not explain why total travel and car mode share had reduced for young people.

Cohort analysis is a powerful approach to understanding trends. Before analysis, a data set is broken down into related groups, where these groups or cohorts share common characteristics or experiences within a defined time span. Cohort analysis is often applied to distinguish between three types of time-related variation:

- age effects – variations associated with age that remain more or less stable over time
- period effects – variations over time that affect everyone simultaneously, irrespective of their age
- cohort effects – changes across groups of individuals who experience an initial event together, such as their birth year.

When seeking to understand changes over time, cohort analysis is potentially highly illuminating at identifying whether changes can be attributed to explanatory factors, such as socio-demographics or transport provision, or whether unexplained change applies to the whole population or particular cohorts.

McDonald (2015) used United States National Household Travel Survey data for 1995, 2001 and 2009 to compare daily car mileage of the Generation X cohort (those born in the late 1960s to the late 1970s) and the millennial cohort (those born in the last two decades of the 20th century). McDonald noted that car trips and mileage decreased between 1995 and 2001 for 19-30 year-olds, suggesting “a long-term decrease in automobility that started in the late 1990s with younger members of Gen X and has continued with the millennial generation”. McDonald went on to note that there was only a very modest increase in the use of public transport, walking and cycling over the period in which car use decreased.

McDonald (ibid.) used multiple regression modelling to quantify socio-demographic, age-specific, period-specific and cohort-specific effects on car trips and mileage of 19-42 year-olds. A decomposition of the different contributors to changes in car mileage showed that lifestyle-related socio-demographic changes accounted for 10-25% of the reduction in car mileage from 1995 to 2009. Changes over time specific to millennials and younger members of Generation X accounted for 35-50% of the reduction and general dampening of car mileage travel that applied across all age groups accounted for the remaining 40% reduction. McDonald interprets the 35-50% reduction specific to younger Generation X and millennials as “Millennial-specific factors such as changing attitudes and use of virtual mobility (online shopping, social media)”. It is not possible to conclude further from this study to what extent “millennial-specific factors” comprise structural factors untested in the analysis or changes to values, attitudes or social practices.

Panel data which tracks the same individuals over time can be used to analyse the dynamics of behaviour and understand processes of change. For example, analysis of panel data from the UK Household

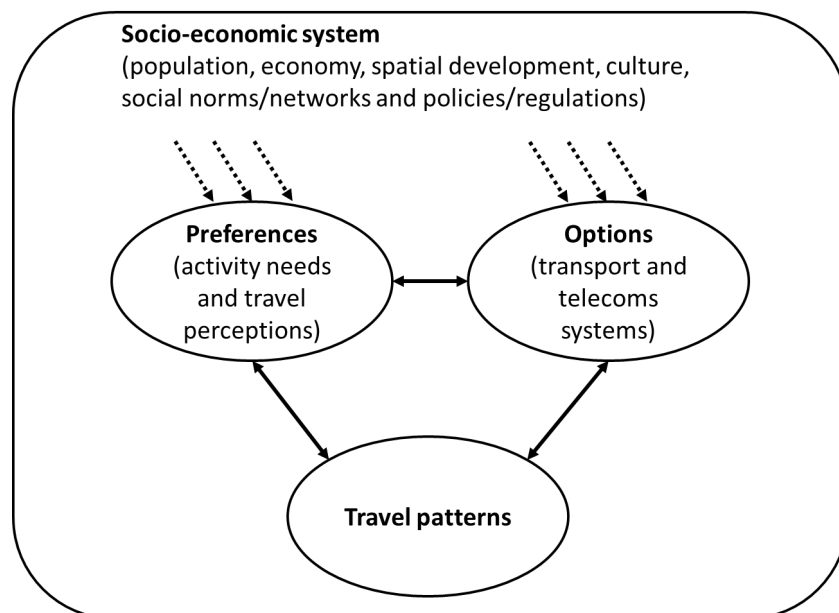
Longitudinal Study has revealed the circumstances in which households are more likely to change car ownership (Clark, Chatterjee and Melia, 2016). Events associated with a transition to adulthood (e.g. acquiring a driving licence, entering employment, partnership formation or having a child) increase the likelihood of becoming a car-owning household. If these events are postponed or foregone altogether, then reduced car ownership is to be expected. Additionally, the panel data showed that the volatility of young people’s living and socio-economic circumstances leads to instability in car ownership and this is likely to have increased in recent years given more unstable employment.

It is clear that to understand travel behaviour change it is necessary to gather longitudinal data. Time-series data at an aggregate level will support analysis of overall dynamics, while periodically collected observations of individual behaviour will enable understanding of the underlying components of change. Meanwhile, panel data can shed light on the process of behavioural change experienced by individuals, which can help with the interpretation of aggregate trends.

Drivers of change in travel behaviour

Travel can be predictable at an aggregate level when the drivers of travel demand are stable but rarely, if ever, is this the case. Drivers of change can apply to the whole population or certain groups within the population, but either way can bring about fundamental change. Taking a high-level systems perspective that draws upon the theories previously introduced, travel patterns can be considered to be a function of three domains: the wider socio-economic system; people’s activity or travel preferences; and the transport and telecommunications options available (see Figure 3). 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 assumed to remain constant over time.

Figure 3. Conceptual framework for influences on travel patterns



Source: Chatterjee (2020).

The conceptual framework above highlights that to understand what is causing changing travel patterns, it is necessary to look beyond the transport system and changing population characteristics. Consideration needs to be given to broad changes in the socio-economic system and how they influence the preferences of the population and the provision of transport and telecommunications. It is also necessary to regularly challenge the understanding of how activity and travel preferences are resolved subject to the available transport and telecommunications systems.

This section will look at the role of demand-side drivers of change (such as economic change and cultural shifts), supply-side drivers of change (such as new technologies within transport and telecommunications) and, finally, new behaviours and practices. These drivers of change will be evaluated based on experiences in the ITF member countries that participated in this working group.

Social and economic change

The socio-economic system is complex in nature, but traditionally only certain key characteristics are considered when predicting future travel demand. This raises questions: How fully do the socio-economic factors considered in transport models explain travel behaviours and how travel behaviours change over time? How important are the socio-economic factors that are not considered in transport models?

In the Discussion Paper for this working group (Chatterjee, 2020), these questions were considered with respect to national road traffic forecasting in Great Britain. The UK Department for Transport (DfT) evaluated the performance of its road traffic forecasts carried out between 2009 and 2015, with a view to understanding why its forecasts had overestimated traffic growth (DfT, 2018a: 18-25). It wanted to know to what extent differences between forecasts and outcomes between 2010 and 2017 could be explained by the changing relationships between travel and its key drivers (including the emergence of new drivers) or by input over- and under-forecasting for key drivers such as GDP, population and fuel costs. The forecasting methodology was found to provide aggregate results close to outcomes when adjustments were made for actual values for GDP, population, etc.

This is similar to the conclusion of Bastian, Börjesson and Eliasson (2016) who, as mentioned earlier in this section, found that national trends in vehicle-kilometres between 1980 and 2014 in six highly industrialised countries were well explained by changes in GDP and gasoline prices. The DfT did note, however, that forecasts overestimated traffic growth in London and underestimated traffic growth on longer distance inter-urban roads. 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: 25).

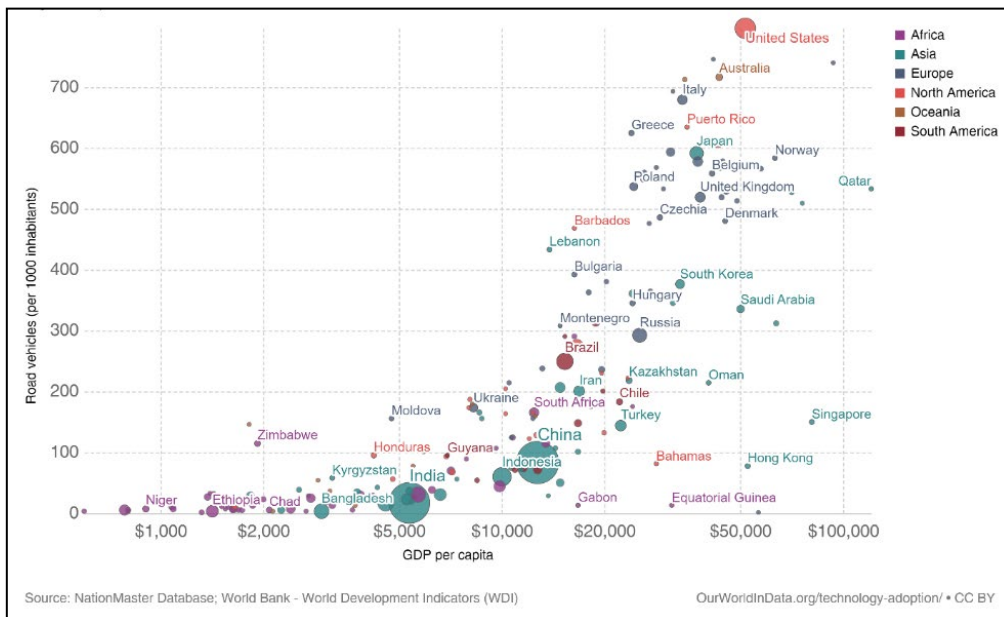
As well as doubts as to whether national-scale forecasting can be informative for anticipating travel trends at sub-national scales, the experience from the last 20 years in Great Britain suggests there are also doubts about how well forecasts are able to anticipate travel trends for different socio-demographic groups. An in-depth study that sought to understand the large reduction in driver licence rates and car travel by young people in Great Britain since the 1990s, concluded that changes in demographics, socio-economics and living circumstances only provide a partial explanation, with changes in travel attitudes and substitution of travel by online communication also likely to be important factors (Chatterjee et al., 2018).

The DfT has been undertaking work to improve its forecasting system to account for the latest evidence on travel behaviour and its determinants. Driving licence rates, car ownership, trip rates and usage of different transport modes are predicted in the National Transport Model based on exogenous demographic and socio-economic projections for population, employment, housing supply, income and transport costs. For the latest 2018 forecasts, the National Transport Model was updated to account for

recent travel trends. One of the most significant developments was updating the trip rate models 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 observed decreases in trip rates in the last two decades. This further highlights that socio-economic factors traditionally included in transport models have not been especially useful in explaining breaks in past travel trends in the last 20 years.

This is further supported by an analysis by the DfT of National Travel Survey data for England for 1995-2012, which looks at demographic and socio-economic determinants of having a driving licence, car access and car mileage over time (DfT, 2018b). This analysis found age, gender, household composition, employment status, job type, education, personal income, type of residential area and access to public transport to all be influential factors. However, it found that the positive association between personal income and licence holding, and car mileage weakened over the period. It also found that household composition made less difference over time, while employment status became more important. After accounting for demographic and socio-economic factors, it found increases in driving licence holding across the population over the period (linked to people with driving licences growing older and eventually replacing the generation above) and decreases in car use over the period. However, it also found more recent cohorts had a lower probability of licence holding and car access than previous cohorts (after accounting for other factors) and had lower car mileage. These results show that there are travel trends over time, which vary between generations, which are unexplained by the demographic or socio-economic characteristics of the population.

Figure 4. Number of motor vehicles per 1 000 inhabitants versus GDP per capita, 2014



Source: Our World Data (2014).

The observations above suggest that it may be possible to make reasonable forecasts of short-term aggregate (national-level) travel trends based on demographic and economic projections, where these projections are reliable. However, these are unlikely to be informative for sub-national travel trends or for the travel trends of specific socio-demographic groups which require their own, bespoke analysis, and are

likely to be subject to influence by social and economic change which is not easily captured in traditional forecasting methodologies.

In highly motorised countries, the widely observed phenomenon that the relationship between income and car use has weakened lends support to the argument that saturation has occurred of car ownership and use among higher-income groups. Studies show that employment status and job type remain important discriminators of car use, which suggests that attention needs to be given to changes to labour-force composition when looking at future travel demand. The locations where people live have been shown to be of increasing significance, with increasingly low levels of car use in large cities, but continued high car use in less populated areas, which suggests it is vital to pay close attention to the future spatial distribution of the population. Furthermore, it is clearly necessary to pay attention to attitudinal and lifestyle factors that are reshaping travel behaviours among different groups in society.

When looking across a range of countries with different levels of industrialisation it can be seen that there is a positive association between road vehicle ownership and GDP per capita (see Figure 4). This would suggest that economic growth measured in this way will continue to play an important role for travel trends in industrialising countries. However, it should be recognised that there are large variations in vehicle ownership rates between countries with high GDP per capita with, for example, Australia, Italy and the United States having much higher rates than Denmark, Korea and Saudi Arabia.

Technological change

It was clear, even before the Covid-19 pandemic, that the digital age has been having fundamental effects on people's lifestyles and everyday lives. There has been much speculation on whether information and communication technology (ICT) is 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, Guillot and Rallet, 2012: 667).

Studies that have investigated the relationship between ICT use and travel have generally 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 how useful cross-sectional data used in such studies is for highlighting the effect of digitisation over time, as it cannot control for other factors (such as socio-economic status) which explain both higher levels of ICT use and travel. Longitudinal data tracking of individuals' ICT use and travel over time would be more helpful in assessing this relationship. The potential impacts of ICTs in reducing the number of trips for different activities are considered below.

Teleworking

Taking the example of the United Kingdom, working from home was becoming more common prior to the Covid-19 pandemic, both occasionally and on a regular basis, and there had been a decline in the number of commute trips made by workers in England from 7.1 journeys per worker per week in 1988-92 to 5.7 in 2013/14, with a similar trend observed in the United States (DfT, 2017). It has also been shown that over time a greater proportion of the English working population has either spatially variable working patterns or are infrequent commuters (Crawford, 2020).

Analysis of the Swiss Mobility and Transport Microcensus suggests teleworking increases travel due to teleworkers living further away from the workplace than other workers and replacing commuting trips

with journeys for other purposes (Ravalet and Rérat, 2019). However, an analysis of data from the Netherlands for 2000-16 concludes that different types of flexible working, including teleworking, have contributed to a 2% reduction in car-kilometres on working days and a 7% reduction in traffic during peak hours on all roads (van der Loop, Haaijer and Willigers, 2019).

In the future, job profiles are expected to change fundamentally in many sectors. The main drivers of a new world of work and mobility are advancing digitalisation and connectivity, artificial intelligence and autonomous driving. Flexible working hours, desk sharing and teleworking will, in all likelihood, play a greater role in this future working world than they do today (Wipperman, 2018). During the Covid-19 pandemic, the acceptance of teleworking among employees and employers has increased and much experience has been gained. What is uncertain now is whether sustained increases in teleworking will lead to corresponding decreases in traffic volumes, moves away from urban areas to locations where greater travel distances are required to meet daily needs, and whether workers will compensate for decreased time spent commuting with more leisure travel.

Distance learning

Distance learning refers to the replacement or partial replacement of school attendance by the provision of digital learning content. While this form of education had been quite rare before the Covid-19 pandemic, it dramatically increased during 2020. However, the drawbacks of distance learning for young people also became quickly apparent (see, for example, OECD, 2020). These include more limited access to learning resources for socio-economically disadvantaged students, additional care obligations for working parents, potential isolation of students, insufficient development or decline in social skills and less physical activity for home learners. Thus, even if distance learning concepts are maintained to some extent in the future, it is unlikely that this will contribute to a significant reduction in traffic volume.

E-commerce

Prior to the pandemic, online shopping was growing at around 10-12% per year in the United Kingdom and represented almost 17% of total retail sales (Marsden et al., 2018). At the same time, there was a long-term trend of decreasing personal trips and distance travelled for shopping. In 2019, 4.4 million Austrians used online shopping, which is approximately half of the total population, according to the Austrian Trade Association (2019). Around 10% of consumer spending flows into internet retail. However, domestic retailers only benefit from the growing market to a limited extent, as more than half of people order items from abroad, thus exacerbating the outflow of purchasing power and potentially increasing global transport. In the second-quarter of 2020, at the height of official Covid-19 movement restrictions in Central Europe, turnover in German mail order and online trade increased by 29% compared to the same period the previous year, and turnover in the e-food sector rose by 90% (KPMG, 2020). With regard to transport impacts, several studies conclude that no significant carbon emissions savings can be expected once it is understood that reduced personal car travel is offset by increased goods vehicle movements, missed deliveries and collections of returned items (Lengauer et al., 2015). There is, however, some transport saving potential regarding online shopping when orders do not result in the physical delivery of goods. Examples include 3D printing (although material for printing has to be delivered) and downloads of e-books, music, movies, games or software.

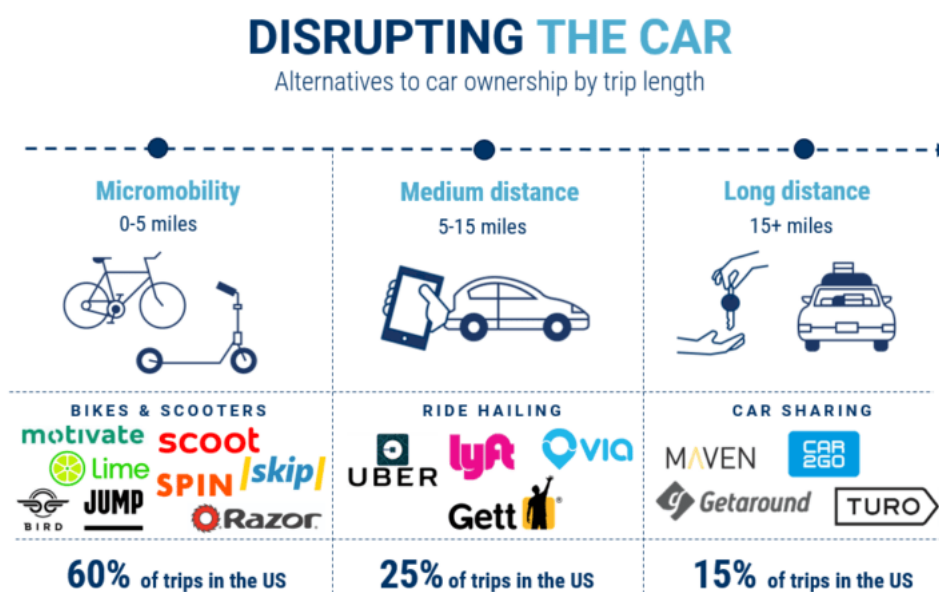
New transport options

There are said to be three transport revolutions occurring concurrently: electrification of the vehicle fleet, automation of driving and adoption of shared mobility (Marsden et al., 2018). The autonomous vehicle has been heralded as a transformative technology which will drive significant social change. By reframing

the terms of accessibility – through changes in attitudes to the time people are willing to spend on travel, speed of travel and transportation costs – the autonomous vehicle is likely to change lifestyles in many ways, with important consequences for various aspects of daily and long-distance mobility practices (especially frequency, average distances and modal choice). Anticipating these changes and preparing for them (Bali, Capano and Ramesh, 2019) is of critical importance in regulating the deployment of autonomous vehicles in order to limit the negative environmental and social impacts and to promote the benefits of this kind of transport (Harb et al., 2021; Narayanan, Chaniotakis and Antoniou, 2020). The medium- and long-term decisions concern innovation policies, but also planning policies, such as infrastructure investments and land-use policies. Anticipating these changes is nonetheless a considerable scientific challenge since, on the one hand, the technology is not mature and, on the other hand, lifestyles are the result of complex, interdependent decisions involving many factors and different temporalities.

Shared mobility services offer a range of alternatives to accessing mobility through personal ownership of vehicles or using public transport and, currently, are perhaps the most notable development which could influence future travel behaviour. Figure 5 shows different shared mobility services which could meet the needs for travel over different distances.

Figure 5. Shared mobility service options by trip length



Source: NHTS (2018).

In France, 80 million trips were made by shared mobility services in 2020 and station-based bike services accounted for 73% of these trips (Fluctuo, 2021). Turkish carsharing service provider, MOOV by Garenta, announced that it has had 2 million rentals, with more than 100 000 active users within two years and that 69% of the trips made during the Covid-19 pandemic were for commuting, implying they were being used as a substitute for public transport (Dunya, 2020).

Looking at the United Kingdom, it has been noted there have been increasing numbers of shared mobility users since 1998 when services emerged, but users remain concentrated in London and among younger, higher-income residents. The number of carshare members has increased from 32 000 in 2007 to nearly 250 000 in 2017 in the United Kingdom, while the equivalent growth in Germany has been from 100 000

to 1.7 million (Marsden et al., 2018, p30). However, it is generally not possible to quantify the share of the travel market carved out by these services since use of shared mobility services is not distinguished from personal vehicles in most travel surveys. A study on carsharing in the Netherlands estimated that 1% of the population has used carsharing and that carsharing accounts for 0.02% of the total car journeys in the Netherlands (KiM, 2015).

New behaviours and practices

The different societal and technological trends described previously have the potential to give rise to new mobility behaviours. The European Transport and Mobility Forum identified, among others, the following trends that are expected to create new patterns of behaviour (Mobility4EU, 2016):

- Digitalisation and personalisation – the wealth of data collected about mobility service customers is giving rise to increasingly customised products and services. This will lead to more individualised and flexible behaviour patterns.
- Climate change and resource efficiency – in view of the impending consequences of climate change, measures to reduce CO₂ emissions will become increasingly important, which will also lead to stricter regulations and stronger pricing mechanisms. More sustainable behaviours need to be enforced, which can be driven, to some extent, through the use of incentives.
- Sharing instead of owning – new concepts of resource efficiency also lead to new ownership models, such as the sharing economy and collaborative consumption, which allow for a more flexible use of different mobility offers. This is further supported by digital services.

The trends described above are already evident in the behaviour patterns of younger, urban travellers. Many of these behaviour patterns are closely related to the use of digital information in the context of mobility. Within the framework of a study conducted in Austria, for example, six different mobility types were identified, which differ in their behaviour patterns and information habits (Markvica et al., 2020).

Three of these mobility types are particularly prevalent in the younger age groups. One such type is called “highly-informed sustainability” (17%). People belonging to this group proactively search for or receive transport- or mobility-related information. They deal with current issues and topics in detail and are characterised by their effort to organise their own daily routine in a sustainable and environmentally friendly way with a fundamental interest in new things, such as new developments and innovations in the field of mobility.

The type “Spontaneous – on the go” (6%) is not yet common, but will become more significant in the future. This group is characterised by the speed and spontaneity with which they expect, absorb and process information. Due to a mobile, flexible and non-routine lifestyle, this group is dependent on a lot of information on a daily basis. This type is very mobile and uses many different means of transport for their travel needs. They do not stick to one means of transport and are, in principle, open to all transport options.

In contrast, the “Efficiency-oriented” type (16%), is only interested in the information that it needs to fulfil a certain goal. Characteristic of this type is a commitment to one means of transport and more resistance to changes in behaviour than the two previous types. Owning a car is important; they see the car as something very personal. However, they also use sharing services, often as a supplement to their own car. All three of these mobility types use digital and mobile information to organise their mobility and will benefit from increasing digitalisation and personalisation. The remaining three types, “Interested-Conservative” (35%), “Low Demand” (16%) and “Digital Illiterates” (10%) will decline over time as younger

generations come of age in the population. However, these less digitally reliant behavioural types will be prevalent for longer outside of cities, which is why there may be even more divergence between urban and rural mobility patterns.

The impact of the Covid-19 pandemic

The Covid-19 pandemic had an extraordinary impact on the way people live, work and travel. There is a wealth of information available on how the pandemic has affected the transport sector (see, for example, ITF's *Covid-19 insights: The Compendium* [ITF, 2021]). Of particular interest for this report are the travel behaviour changes that have taken place and how these have been measured using existing and new monitoring approaches. Given that the pandemic is still placing restrictions on the activities of citizens in most parts of the world, now is not the right time to judge whether there are enduring shifts in travel patterns compared to pre-2020. However, comments can be made on what monitoring approaches will be valuable in the future to assess ongoing trends in travel behaviour.

Established approaches for collecting travel data, such as road traffic counting systems, public transport passenger counting systems and national travel surveys have generally continued during the pandemic, even if they have had to adapt in response to health protection measures. These surveys are contributing to understanding the impacts of the pandemic and will play a particularly important role in assessing longer-term implications. As an example, the Union of Municipalities of Turkey collated information for 30 cities in Turkey and found decreases in public transport use of 34% to 87% during the first wave of the Covid-19 pandemic in Turkey, between March and June 2020, when social restrictions were in place (UoM, 2021). There is often a considerable time lag between data being collected and results being published, due to the time needed for processing and analysing the data. For example, in England, results from the National Travel Survey¹ are published in July for data collected during the previous calendar year, hence results for 2020 are not currently available at the time this report is being written.

Global information technology companies have helped to provide up-to-date data on travel activity during the pandemic. Apple has published daily “Mobility Trends Reports” since 13 January 2020 on the levels of driving, walking and public transport in different countries, regions and cities, based on the number of requests for navigation by transport mode (Apple, 2021). Similarly, Google has published daily “Covid-19 Community Mobility Reports” since 15 February 2020 on visits to different types of destinations (e.g. retail and recreation, public transport hubs, etc.) based on anonymised data collected from Google apps on mobile devices (Google, 2021). These two data sources provide an indication of changes in aggregate travel activity over time, but they do not provide information about the characteristics of those making trips and only limited categorisation of the type of trips made. Hence, it is not possible to analyse trends for different population groups and types of travel.

Given the limitations during the pandemic of obtaining sources of data to monitor travel behaviour, countries have been interested in collecting data to enable rapid reporting of travel behaviour and to provide illumination on specific issues of interest or concern during the pandemic. Table 1 provides details of three major travel behaviour studies commissioned and organised at short notice to obtain an in-depth understanding of travel behaviour impacts of the pandemic.

Table 1. Travel behaviour studies during the Covid-19 pandemic

Country/study	Data collected	Impact of pandemic on travel behaviour	Longer-term implications
Netherlands Institute for Transport Policy Analysis (KiM). Special survey of Netherlands Mobility Panel (MPN) participants (de Haas, Hamersma and Faber, 2020).	2 000 panel members asked to keep a 3-day travel diary in March-April 2020, and complete a questionnaire. The questionnaire was designed to identify the causes of any changes in travel behaviour, related perceptions and experiences, and expectations for the future.	44% of workers started to work from home or worked more from home. Number of trips decreased by 55% and the total distance travelled decreased 68%. Increased modal share for walking and decreased modal share for all other types of transport.	27% of home workers expect to work from home more after the pandemic than before. 20% think they will walk and cycle more and around 20% say they will fly less.
Switzerland Institute for Transport Planning and Systems (IVT) at ETH Zurich and the Faculty of Business and Economics (WWZ) at the University of Basel. MOBIS-Covid19 sample recruited from participants of the 2019 MOBIS (MOBility Behaviour in Switzerland) study (Molloy et al., 2021).	App-based (GPS) tracking of travel behaviour of 1 439 Swiss residents supplemented with occasional online questionnaires to collect personal details. Data weighted to be representative of 22 000 respondents to MOBIS introductory survey.	Large reductions initially in distance travelled by all modes, except cycling which increased. Cycling distance remained 100% higher in August 2020 compared to the baseline, while walking and use of cars returned to pre-pandemic levels and public transport was still 50% lower. The proportion of active (mobile) days decreased from around 90% pre-pandemic to 70% at start of first wave and 80% in August 20.	Not directly investigated, but the tracking study continues as of May 2021.
UK Department for Transport (DfT). New survey “All change?” (Marshall, Bizgan and Gottfried, 2021).	Online longitudinal survey repeated three times (May-June 2020, June-July 2020, November-December 2020) with one further wave planned for Spring 2021. 4 059 adults aged 16-75 took part in wave 1. Waves 1 and 2 had 2 782 participants and waves 2 and 3 had 2 847 participants. Data weighted to be representative of United Kingdom. Main topics covered: frequency of travel by mode, purposes of travel undertaken, future expectations of travel.	Travelled by car as a driver once a week or more often during previous four weeks: 63% in January-March (pre-pandemic), 47% in May-June 2020, 60% in November-December 2020. Used a bus once a week or more often during previous four weeks: 30% in January-March 2020 (pre-pandemic), 6% in May-June 2020, 14% in November-December 2020. Walking and cycling at similar rates during the pandemic as pre-pandemic. Frequency of travel changed more during pandemic than mode switching.	Outlook for longer-term behaviours to be considered with last wave of data.

The value of longer-term ongoing studies is shown with these examples. The Netherlands Institute for Transport Policy Analysis (KiM) runs the Netherlands Mobility Panel (MPN)² which collects travel behaviour data on an annual basis for a fixed group of individuals from around 2 000 households. The special survey in March-April 2020 enabled a direct comparison to be made between travel behaviour during the first wave of the pandemic to pre-pandemic baseline travel behaviour already reported in the main survey (de

Haas, Hamersma and Faber, 2020). Like most countries, the United Kingdom does not have a mobility panel, but the DfT saw the value in commissioning a longitudinal panel to specifically capture travel behaviour data during the pandemic (Marshall, Bizgan and Gottfried, 2021). Because there was no equivalent study of travel behaviour prior to the pandemic, participants were instead asked to think back to the January-March 2020 period and, retrospectively, report their pre-pandemic travel behaviour with this serving as a baseline.

The MOBIS-Covid19 study in Switzerland was made possible by the 2019 MOBIS study. Although the original MOBIS study had finished collecting data via the tracking app in November 2019, 300 participants were still using the app March 2020 and around 1 600 participants responded positively to the invitation to reactivate their app (Molloy et al., 2021). As with the Netherlands Mobility Panel, the availability of pre-pandemic data for the study participants enabled accurate comparisons to be made of travel behaviour. Also, in this case, the tracking app has enabled data to be collected continuously throughout the pandemic and this data collection can potentially be continued afterwards (from participants willing to continue and some refreshment of the participant sample).

Around the world, researchers have also taken the initiative to carry out smaller-scale studies. One notable example, which responded very quickly to the developing situation, was an initiative of researchers based in Istanbul (Turkey), Leeds (United Kingdom) and Sydney (Australia) who organised a panel survey of residents in Istanbul and collected data in January-February 2020, February-March 2020 and March-April 2020 (Shakibaei et al., 2020). A snowball technique was used to recruit participants given the lack of immediate access to a market research firm or online platform. Analysis of data from 144 people participating at each of the three waves showed minimal change in travel activity between the first two waves, but large changes in travel to work and travel for social, recreational or leisure activities between the second and third waves when social restrictions were introduced. Although such smaller-scale studies cannot provide robust estimates of population-wide travel behaviour trends, they can identify interesting phenomena worthy of more detailed investigation.

Public authorities have needed to respond to the pandemic and make alterations to the transport system to accommodate modified demand for different modes of transport and to protect health. Many of the measures introduced were expected to be temporary, but in some cases, there has been an eye to the future with the possibility of the measures being maintained in the longer term if they are beneficial. In either case, it is helpful to monitor the impacts and see what changes in travel behaviour occur over time.

In the United Kingdom, the DfT introduced the Active Travel Fund to make cycling and walking safer and to facilitate more trips via active transport modes at a time when public transport capacity is reduced due to social distancing, pavements may not be wide enough to provide sufficient space for pedestrians and roads are at risk of congestion if significant numbers of people switch their commuting mode from public transport to cars (DfT, 2021a). It initially invited applications from local authorities in June 2020 for the installation of temporary projects. It then invited applications in November 2020 for the creation of longer-term projects. The second phase schemes have been rolled out without time to organise monitoring activities for the first phase. In July 2020, the DfT legislated to enable 12-month e-scooter trials to take place in England and invited local authorities to come forward with proposals. Trials are taking place in 32 areas as of 19 April 2021 (DfT, 2021b). It has commissioned a national monitoring and evaluation study to assess the outcomes of these trials on travel behaviour.

It seems likely from the account above that the disruptive event of the Covid-19 pandemic will bring about long-term changes to travel behaviour due to people doing things differently during the pandemic and continuing these behavioural changes afterwards, or due to broader changes to society which arise as a

result of the pandemic (e.g. changes to working practices). For all these reasons, it is important to monitor changes and seek to understand them.

Lessons from past travel transitions

As mentioned in the Introduction, the Discussion Paper for this working group (Chatterjee, 2020) reviewed studies of ten different travel transitions, which have occurred in Great Britain since the 1990s and drew a number of lessons from the findings of these studies. These are now summarised.

Nearly all the transitions could be traced back to the 1990s or earlier, but it took a long time for the transitions to become the subject of significant investigations. It takes years (usually at least two) for a break in a trend to be identified as a persistent change, rather than a short-term “blip”, but a delay of ten years or more for studies to be carried out is noteworthy. It can be speculated that the delays in instigating studies occurred because the transitions were not expected, hence it took longer for them to be recognised as genuine breaks in trends.

For most of the studies, no prior hypotheses were put forward to explain the transition and an array of potential contributing factors were examined. In some cases, there was strong belief in the importance of a particular factor, but evidence only supported this playing a modest role. It was generally not 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) was either not available or, where available, it did not include factors thought to have played a role. Instead, qualitative judgement has been needed in order to explain transitions. This is exemplified by the assessment of 22 putative factors contributing to reduced car driving by 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 of the relationship between that factor and the travel indicator of interest in order to make a judgement whether the factor had contributed to the trend.

The studies provided welcome illumination on the travel transitions by allowing better characterisations of the nature of the transitions and identifying which population groups were the main contributors to these changes (for example, see a study on a decline in bus use by Le Vine and White, 2020). Such studies have usually needed to acknowledge that they have not been able to fully answer why the transition has occurred (for example, studies on the 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 specific groups of interest and 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 this could be investigated further 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 learned about the transitions, it will be possible for forecasting models to account for them. 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 in models. For some transitions, travel behaviour and travel behaviour change vary significantly across the population. However, 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.

Indicators of change

Forecasts generally assume that the indicators of travel activity that are important to measure and track over time have already been identified. Examples include the number of cars per capita, trip rates and vehicle-kilometres travelled. However, it must be considered whether the most important and useful indicators are in fact being measured and consider whether it is enough to obtain overall or average measures for these indicators or whether it is necessary to know the spread in values across the population. For example, it is useful to know the trend in the average daily trip rate, but it is also important to know what proportion of the population is mobile on any day and what proportion is immobile. Immobility should also be considered for different groups. An increase in immobility among workers might reflect voluntary working from home, while an increase among retired people might represent difficulty accessing transport.

While this working group has a primary focus on the daily mobility of urban citizens, it is important to recognise the role of long-distance travel (whether conducted by car, bus, coach, rail or air). Although urban residents make long-distance trips less often than short-distance urban trips, these longer trips contribute substantially to total personal travel mileage and emissions. Furthermore, there are large differences in the amount of long-distance travel undertaken by different groups within the population. Monitoring of personal travel activity should therefore also capture long-distance travel.

Taking a broader view, travel activity is not an end in itself but is part of the broader socio-economic system and travel needs to play its role in contributing to societal goals. It is therefore important to obtain indicators of travel activity that are useful in assessing the achievement of wider societal goals. In the Horizon 2020 LEVITATE project, quantified policy goals were defined to identify desirable urban visions as a starting point for a backcasting approach to identify policies and measures which enable a path to be taken towards the vision. Indicators were defined that allow measurement and monitoring of progress over time towards these goals. The main objective of the exercise was to understand transport as a means to achieve broader societal goals and therefore focused on four target dimensions to which transport contributes: society, environment, economy and safety. In co-operation with cities and stakeholders, specific policy goals within the goal dimensions were defined based on the UN Sustainable Development Goals and Sustainable Urban Mobility Indicators (SUMI), which were then assessed in terms of their measurability. The following table provides an overview of the resulting target areas and indicators.

In the list of indicators selected in this stakeholder process, it is noticeable that traditional aggregate transport indicators no longer play a major role, but that much greater importance is attached to person-based travel and access indicators. It is also striking that for many of these indicators there are not yet sufficient or standardised measurement methods. Accordingly, a paradigm shift in transport planning also requires that appropriate measurement methods are developed and harmonised.

Progress is being made in this direction in the Netherlands, with the development of an Integrated Mobility Analysis (IMA) which includes accessibility indicators (the number of destinations that can be reached from a specific location within a given travel time for different modes), as well as traditional transport indicators. The IMA will be used for decision making concerning future investments in transport infrastructure.

Table 2. LEVITATE goals and indicators

Dimension	Goal	Indicator	Measurability
Safety	Protection of human life	Number of people injured in traffic per million inhabitants (per year)	+++ (already measured)
		Number of fatalities per million inhabitants (per year)	+++ (already measured)
	Perceived safety	Standardised survey: subjective rating of (overall) safety	++ (already measured)
	Cyber security	Number of successful attacks per million trips	? (measurability unclear)
		Number of vulnerabilities found (fixed?) (per year)	? (measurability unclear)
Society	Reachability	Average travel time per day (dispersion, goal, equal distribution)	+
		Number of opportunities per 30 minutes per mode of transport	? (precise definition required)
	Use of public space	Lane space per person	+
		Pedestrian/cycling space per person	+
	Inclusion	Distance to nearest publicly accessible transport stop (including Mobility as a Service [MaaS])	+
		Affordability/discounts: the degree to which transport services are used by low-income groups	+
		Barrier free accessibility: the degree to which transport services are used by socially disadvantaged and vulnerable groups, including people with disabilities	+
		Quality of access restrictions/scoring	+(qualitative ind.)
	Satisfaction	Satisfaction with active transport infrastructure in the neighbourhood (walking and/or cycling)	+
		Satisfaction with public transport in the neighbourhood	+
Environment	Low noise levels	Standardised survey: subjective rating of main sources of disturbing noise	+
	Clean air	Emissions directly measurable: SO ₂ , PM _{2.5} , PM ₁₀ , NO ₂ , NO, NO _x , CO, O ₃	+++
	Efficient settlement structures	Building volume per square kilometre (total and per built-up area)	+
		Population density (Eurostat)	+++
	Sustainable behaviour	Rate of energy consumption per person (total)	+++
Rate of energy consumption per person (transport related)		+	
Economy	Prosperity	Taxable income in relation to purchasing power	+++
	Fair distribution	GINI index	+++

Source: Zach, Millonig and Rudloff (2019: 36).

New data opportunities for monitoring travel trends

Personal travel data has traditionally been collected through travel surveys. A number of individuals or households are selected to report their travel behaviour, which is later expanded to the total population. This approach has several limitations, particularly if it is assumed that the patterns to be described are rapidly evolving and increasingly variable from one individual to another. First, high-quality travel surveys are costly. This implies that they are hardly ever conceived as a longitudinal source but rather as a cross-sectional picture of travel patterns. The exception to this are continuous travel surveys (usually carried out at a national or regional level) which are repeated at regular time intervals (annually, for example) and enable trends to be investigated and tracked.

Most of the focus in travel surveys is on the reproduction of an “average day”. This falls short if the goal is also to accurately describe intra-week and seasonal variations, which are crucial elements for understanding flows beyond home-work trips. Second, revealed preference surveys will be always subject to response biases. The comparison with passively collected data sources shows that a consequence of this may be a systematic under-reporting of discretionary trips (e.g. social or leisure trips) which are also the type of trips that are subject to greater variability and therefore more challenging to estimate accurately. Third, surveys are time-consuming and cannot provide answers for short-term tactical decision making. Leaving these limitations aside, travel surveys have been successfully used in combination with other measurements (e.g. traffic counts) in identifying shifts in travel over time and in developing transport models across the globe.

A number of alternative data sources (referred to loosely as big data sources) are emerging in the transport sector, such as mobile phone records, GPS tracking, Wi-Fi and Bluetooth beacons, accelerometer sensors, etc. The pervasive use of mobile phones among citizens and the increasing sensorisation of vehicle fleets generate large data sets based on geolocated registers. Once properly anonymised, these can be highly suitable for analysing travel patterns. However, three important elements must be taken into account when exploiting these sources:

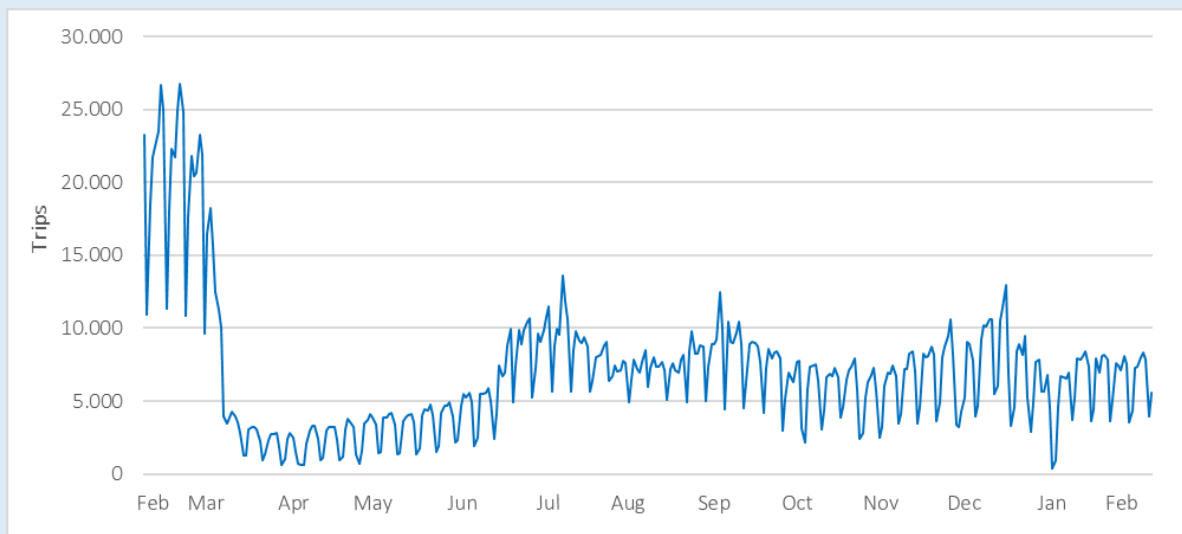
- Each new big data source has its own potentialities and limitations. These are usually framed in trade-offs between the different characteristics of the sources. For instance, location tracking by mobile apps can have a remarkable spatial precision that potentially covers the door-to-door details of a trip. However, most of the available data sets achieve a very limited sample size in comparison to other sources, such as mobile network data (with lower spatial resolution) or public transport smart card data (with no information about the door-to-door trip).
- The same raw data can lead to different values for the measured indicators. Passively collected data sources are usually generated for other purposes beyond travel monitoring. Hence, complex algorithms must be applied to compute target indicator values, for example, to identify activities and trips from a mobile network data sample. This highlights the relevance of algorithm validation and comparison with alternative sources.
- These kinds of big data sources can accurately describe how people travel, but they cannot address all the behavioural factors that explain why people travel in the way they do. Travel surveys are still a valuable source of information for characterising detailed trip purposes (beyond those that can be inferred through trip frequencies or land use) or assessing some of the individual constraints of the trip, e.g. car ownership and availability, parking availability, rigid schedules, etc. Indeed, a current research priority is to use artificial intelligence techniques to infer some of these attributes by merging big data with traditional survey data.

Big data sources are already being used to improve knowledge and awareness of travel trends (see Box 1). It is likely that surveys will be better designed thanks to big data sources and although they will likely be less frequently deployed, they will still play an important role in monitoring travel trends.

Box 1. Monitoring travel demand in Spain through mobile network data during the Covid-19 pandemic

The Covid-19 pandemic has accelerated the use of new big data sources among transport practitioners as many public bodies have had to rapidly monitor evolving mobility patterns. The pressure to deliver this information with the minimum possible delay has fostered the optimisation of data processing methods. *Nommon Solutions and Technologies Ltd.*³ is working with the Spanish Ministry of Transport and other local and regional institutions to provide origin-destination matrices extracted from anonymised mobile network data. The information is delivered with 3-4 days of delay, which enables up to date analysis of the current impact of mobility restrictions. This has become particularly relevant in the latter stages of the pandemic, when measures applied in different regions and cities have differed and their efficacy and impacts have needed to be assessed quickly. The Spanish Ministry of Transport publishes the information every day on its website⁴. This authority already had experience with the use of mobile network data, after a national mobility study in 2018.⁵ Those who had previously worked with this type of data managed to quickly arrange projects to obtain this information.

Figure 6. Daily trips between Madrid and Barcelona, 14 February 2020 to 14 February 2021



Note: Analysis of mobility in Spain using big data technology enabled transport authorities to monitor rapid changes in travel demand flows between Spanish metropolitan areas during the Covid-19 pandemic. As the figure illustrates, the number of trips between Madrid and Barcelona decreased by 90% during the first lockdown. Demand levels in this origin-destination pair were still 70% below pre-pandemic levels in February 2021.

Source: Author's elaboration based on open data from Spanish Ministry of Transport (2021).

Recommendations on scanning for emerging trends

Public authorities have been slow to identify and put effort into understanding trend breaks in transport activity. In fact, greater efforts have been made in the last 20 years in 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 citywide cycling investment (Aldred, Croft and Goodman, 2019). These studies have largely found that interventions have succeeded in achieving their objectives, although impacts are often not of a scale that spreads to wider regional populations.

A more proactive approach should be 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 mainly influenced by changes to wider society, rather than by internal changes to the transport system. However, it is important to recognise the interaction between these factors.

By scanning changes to the socio-economic, transport and telecommunications systems it is possible to identify potentially significant developments which merit exploration for their likely 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. Suitable data and research methods and a long-term, process-based perspective are needed to examine hypotheses on how changes to the socio-economic, transport and telecommunications systems are influencing travel.

The following data and analysis methods will be instrumental in establishing better evidence of causality for travel trend breaks:

- Repeated cross-sectional data to analyse changing relationships over time for different population sub-groups and the extent to which these changes can be explained by different variables.
- Longitudinal (panel) data on the lives of individuals (including their travel habits) to analyse how their travel behaviour responds to changing circumstances.
- Tracking data from digital devices (e.g. smartphones) to analyse differences in lifestyles and activity participation across the population and how these change over time.
- Qualitative research (interviews, ethnography) to find out how particular groups of interest (e.g. “trend-setters”) have changed their travel behaviour in response to changing circumstances.
- Participatory methods (scenario planning, gamification) with prospective adopters of new mobility behaviours exploring possible future behaviours.

Population-representative data sets will continue to be crucial in assessing the prevalence of travel transitions and new mobility behaviours in the general population, but focused studies of outlier groups and areas (“case study microcosms” in the words of Lyons, [2015]) will be invaluable for examining the plausibility of different future trends for wider society. Such studies should be conducted by researchers who do not have a vested interest in the commercial success of a transport “product”, so that an objective outlook can be determined for the transition or new behaviour reaching beyond the outlier group or area.

Looking back to look ahead

Looking ahead is a very natural thing to do. It is human nature to picture ourselves in the future and it is this vision of the future that helps drive the decisions that we make today. Transport does not escape this reality. Even day-to-day mobility choices at the individual level are guided by some sort of anticipation. Sometimes this is almost imperceptible, as is the case when choosing an alternative route based on past experiences with traffic congestion. In other cases, considerable time may be spent evaluating travel options, for instance, when deciding whether to book a rail connection depending on the available time for transferring between two services. As much as this holds true at the individual level, it is similarly evident that stakeholders who plan and manage transport systems also strive to evaluate how people and goods will be moving in the future.

This section reviews why transport decision makers seek to anticipate the future state of travel demand patterns. The variety of actions that mobility planning entails leads to a wide range of questions, spatial scales and temporal horizons when looking ahead. Each of these perspectives is described in order to provide a comprehensive picture of how transport stakeholders think about the future. There then follows a review of the methods used since the mid-20th century for forecasting travel demand. These techniques are framed under the “predict and provide” paradigm that has dominated orthodox transport planning. The section collects the available evidence on the performance of well-established forecasting techniques and suggests two salient limitations of these methods: the failure to embrace the uncertain nature of travel demand and the unsuitability for supporting new paradigms in transport decision making. Finally, the section reflects upon how uncertainty affects travel demand futures, examining the different degrees and sources of uncertainty that transport decision makers face when evaluating their actions.

Multiple reasons to look ahead

The transport futures that come to our mind are prompted by the answer to several basic questions: What do we want to know about the future? How do anticipated futures influence our present decisions? What is the spatial scope of these futures? When do they take place?

Anticipation at the heart of transport planning

There is a natural correlation between futures studies and planning. Planners need to anticipate as accurately as possible the effects of their decisions in the systems they manage. As Cole (2001: 372) states: “many futurists wish that their dreams could be implemented, and many planners dream that their work could be less short-sighted and parochial”. This demand for anticipation comes from a commitment to the “precautionary principle” which guides any planning initiative that can result in any harm to society (Walker et al., 2003) and underscores the need to perform *ex-ante* evaluations of possible actions.

It is clear that transport planning is not the only sector where this principle and its consequential demand for anticipation operates. However, transport stakeholders often deal with decisions that can have decisive positive and/or adverse effects, as the link between transport and long-term environmental impacts

demonstrates. As a result, transport planning has been a fertile ground for exploring different ways to think about the future. Even if much of the reflections on the future of transport have not been explicitly grounded in the body of knowledge provided by futures studies, transport planning has demonstrated the usefulness of scenarios. The concept of scenarios is a contested term: sometimes it is only associated with the idea of depicting a set of alternative futures, excluding analysis such as trend extrapolation or deterministic forecasting (e.g. Masser, Svidén and Wegener, 1992). However, it can be generally understood as any description of a future state and its development (e.g. Börjeson et al., 2006), conveniently covering any kind of future projection.

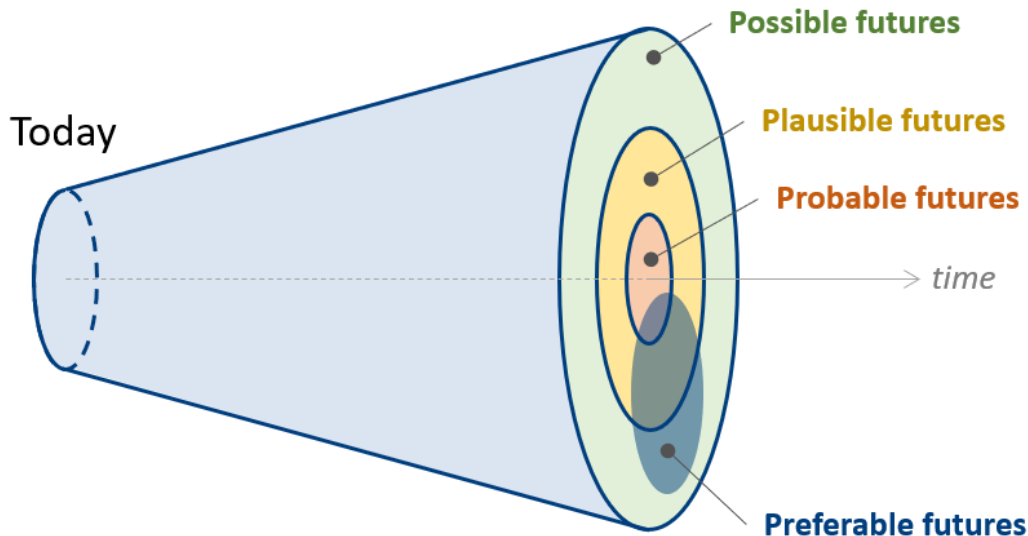
Futures from different perspectives

Potential futures can be approached through different and complementary questions, which lead to separate perspectives. The seminal work of Börjeson et al. (2006) identified three main approaches to scenario making:

1. **Predictive questions:** this perspective emerges when trying to establish what will actually happen in the future. Predictive questions assume that it is possible to anticipate future developments with some degree of certainty, given the extent of prior knowledge of the systems under study. The most obvious form of predictive analysis is forecasts, which provide the most likely picture of the future state of affairs given the expected behaviour of the processes leading up to it. Another common way to think about the future from a predictive perspective is the development of “what-if” scenarios, which usually provide a set of forecasts, each of them describing the most likely outcome if an alternative probable event takes place in the near future. Typical travel demand forecasts associated with infrastructure investments are examples of predictive questions.
2. **Explorative questions:** this approach is used when trying to anticipate the range of possible developments, assuming that it is not possible to determine which is the most probable. Organisations and individuals often think about external explorative scenarios, which provide a set of alternative futures depending on how an external factor develops, however strategic explorative scenarios can also be used to grasp the range of possible outcomes derived from a decision. Climate change research has adopted this approach on many occasions, analysing how different mitigation and adaptation strategies can have an impact on emissions.
3. **Normative questions:** this mode of thinking inverts the chronological dimension since it starts from a desirable image of the future and works backwards to understand how this future can be reached. Some of these exercises look at what adjustments are required to the current situation to achieve the desired targets in the future (preserving normative scenarios). Furthermore, this perspective allows us to think about which structural changes are required in current practices to accomplish our goals. This type of approach can be called “transforming normative scenarios”, although more commonly known as “backcasting” processes. Some sustainable mobility planning initiatives follow this approach.

These categories are similar to the ones depicted in the “futures cone” (Figure 7), which also makes a distinction between explorative questions addressing plausible futures (what realistically could happen) and those linked to possible futures (what conceivably might happen).

Figure 7. The futures cone



Source: based on Hancock and Bezold (1994).

Futures for different decisions

As mentioned above, future reflections on travel demand are motivated by the need to anticipate the effects of a decision. Two characteristics of the decision at stake can be identified as highly influential for how future mobility scenarios are developed.

First, there is a notable distinction between the evaluation of public and private investments. The transport appraisal processes carried out by public authorities incorporate travel demand projections as one of their inputs. These processes seek to prioritise and select which investments should receive funding in the upcoming years. Their actions do not pursue a profit for investors, but rather cover a set of societal needs according to predefined goals. As a consequence, the evaluation is inherently multidimensional: it has to address several possible returns on economic, social and environmental dimensions. Cost-benefit analysis (CBA) and multi-criteria analysis (MCA) are the most common techniques for conducting these studies, and a key element of these studies is travel demand futures. CBA and MCA confront the costs that society faces to deploy and operate an infrastructure or service with all the benefits that will be leveraged from its expected use, providing cost-benefit ratios or investment scores that support the appraisal process (Tudela, Akiki and Cisternas, 2006; Annema, Mouter and Razaei, 2015). A well-known example of a framework that integrates these techniques is the United Kingdom's "transport business case" approach, which evaluates five dimensions of investments: strategic, economic, commercial, financial and management areas (Mackie, Worsley and Eliasson, 2014). The broad nature of transport appraisal processes from a public perspective expands the scope of the future reflections made in this context.

Private transport investors focus on the revenues that their infrastructure or service will generate to cover the capital and operating costs. Wherever users are charged for using the provided asset, travel demand forecasting becomes the basis for revenue projections and it is usually framed as "demand risk management" (Roumboutsos, Temeljotov-Salaj and Karousos, 2020). Indicators such as the return-on-equity or the net present value are generated in order to synthesise the profitability of the project and

guide the decisions of creditors and investors. As can be seen, private investments are often associated with predictive questions seeking the most probable values for a single intervention, indicating the need for accurate forecasts (Willumsen, 2014). This requirement is less crucial in public investments, where prioritisation between different alternatives is usually the aim.

Second, the reversibility of the decision under analysis also influences scenario generation. Regulatory frameworks and policies are often much more easily reversed than physical interventions. Although public authorities usually carry out studies trying to anticipate the effects of such policies, there is more room for trial and error, even taking into account the associated political costs of ill-suited decisions. Nevertheless, many transport initiatives are related to the provision of infrastructure. These actions are often not easy to reverse, even where the final impacts of the infrastructure are not as desired. Even small adaptations can be costly and time-consuming. Here the precautionary principle becomes crucial and travel demand forecasts are key in these assessments. It is not surprising that there is a trend in search of more flexible physical interventions, in order to reduce the dependence on accurate forecasts (Ramjerdi and Fearnley, 2014). A recent example linked to the rapid transitions noted in the previous section is the reversible active mobility infrastructure deployed in many cities during the Covid-19 pandemic. This flexibility can also be applied to non-reversible infrastructure, following a real options approach that adapts initial project aims to plausible future needs beyond the immediate functionalities of the infrastructure (Martins, Marques and Cruz, 2015). For instance, rail bridges and tunnels can be oversized to facilitate the future addition of tracks, minimising the adaptation costs of increased travel demand.

Futures at different scales

Interventions in the transport systems are grounded in a territorial and spatial context. The scale of each of these activities is a prominent part of its nature and defines much of what is needed in terms of future projections. As any part of the territory works as an open system, it is common to find blurring spatial boundaries in transport scenario-making initiatives. However, the following discernible layers emerge from the local level upwards:

1. Local futures – any town or neighbourhood has to provide a basic mobility supply for its citizens, and most are committed to doing this in a way that improves citizens' quality of life. Even small-scale actions, such as the (re)design of a street intersection, require some level of understanding of future mobility needs. Even though local futures address fewer people than other layers given their limited scale, the alternative chosen for each local measure can determine future travel demand patterns in the area. Jane Jacobs already described in 1961 how the attractiveness of walking can be influenced by the vitality of a single street in a network (Jacobs, 1961).
2. Metropolitan futures – most of the trips people make take place in cities. In many cases, citizens travel beyond their local neighbourhoods to perform activities in different parts of the metropolis. Even in those contexts where suburbs are growing fast to the detriment of urban centres, metropolitan areas are still conceptualised as an open, but autonomous system, with their own futures. Citywide planning initiatives in the 1950s pursued the adoption of rigorous modelling techniques to anticipate future travel demand patterns for the first time (Deutsch, 2013). Far from losing its relevance, increasing urbanisation rates mean that metropolitan scale planning is a decisive level for analysing how people will move in the future.
3. Regional and national futures – modern states and their associated regional authorities have naturally assumed the responsibility for interurban transport. They must anticipate how travel demand between different areas will evolve, as well as the consequences of their actions to manage this demand. This involves scenario-making processes leading to regional or national

transport strategies (e.g. Tapio and Hietanen, 2002) or project-centred futures associated with investments in interurban transport supply, such as high-speed railways. In addition, in many countries national and regional stakeholders still preserve some degree of influence over how metropolitan transport futures are shaped.

4. Global futures – globalisation and worldwide challenges, such as climate change, have motivated several attempts to foresee future scenarios for how global transport will, may or needs to evolve. The influence of these scenarios is expected to grow steadily in the coming years, likely determining local, metropolitan, regional and national futures in more explicit ways than today.

The scale used in simulation tools and techniques for generating future projections is also a relevant consideration. This unit of analysis is the most basic element of the system whose behaviour is modelled. The scale differentiates microsimulation, which often focuses on each person or vehicle in the system, from macrosimulation, which works with aggregated demand flows. Sometimes an intermediate approach is added to the scale: mesosimulation, which combines properties of both simulation frameworks, usually reducing the level of detail concerning the interaction between individual entities (Liebermann and Rathi, 1997).

Futures at different horizons

Any scenario has its own position in the future timeline. The nature of a transport decision usually suggests the time horizon where travel demand anticipation is most useful: for instance, operational management decisions call for short-term anticipation, while strategic interventions require longer time spans. Interestingly, the results of the assessment of a single action may significantly change from one horizon to another. Future transport projections can be grouped according to these criteria as follows:

1. Near real-time analysis (e.g. in the next hour) has been particularly used for traffic management, e.g. as an input for routing recommendations (Ben-Akiva et al., 2001). Very short-term demand anticipation is spreading from traffic-oriented applications to other modes, thanks to the increasing sensorisation (sensors recording or transmitting data) in transport infrastructure and vehicles. This enables continuous data collection and early trend identification. The availability of real-time information about the immediate incoming demand opens the door to automated decision making with very short timescales. This becomes crucial for the efficient operation of emerging on-demand transport systems, such as ridesharing (Zhang, Du and J. Yang, 2020).
2. Short-term analysis (e.g. next day) of demand levels can optimise the way transport operators provide their supply and thus significantly increase the efficiency of transport systems. Once again, the availability of longitudinal data sets about travel demand is crucial for enabling this kind of analysis, especially given that this can be exploited by artificial intelligence techniques to unveil recurrent patterns and interdependence with other variables. Predictive scenario-making for this horizon can still be very useful, as long as quality data is available, as state-of-the-art models have proven to significantly reduce uncertainty about short-term travel demand evolution (e.g. Cheng et al., 2016). The operation of scheduled public transport services can be significantly improved thanks to these capabilities.
3. Long-term (e.g. next year) – many transport decisions fall between day-to-day operation and strategic assessments. Transport operators and authorities can benefit from anticipating the travel demand evolution in the next months in order to establish baseline supply levels and adjust their transport strategy plans. The dependence of travel demand on cyclical factors, such as weather or labour and school calendars, facilitates the reproduction of future intra-year patterns. However,

other factors are driven by particular events, introducing several uncertainties that differentiate this horizon from the short-term analysis.

4. Very long-term (e.g. next decades) – most transport infrastructure is intended to have long lifespans, so transport stakeholders making decisions about these interventions often assess how demand will change over the course of time that the infrastructure is being operated. In addition, many of the desirable futures sought by the transport sector require long-term transitions that unavoidably take several years. It is clear that predictive questions are difficult to answer in this type of scenario-making exercise: exploratory and normative standpoints become very useful at this point. The next section, “Handling uncertainty in assessing travel transitions”, which focuses on long-term strategic planning, provides examples of explorative and normative approaches.

Established approaches to travel demand futures

Nowadays, the planning and management of transport systems are based on the systematic development of future projections for travel demand. The principles and overall workflows for developing travel demand forecasts were consolidated in the mid-20th century. Most practitioners have followed these approaches with little deviation, even if some key limitations have been identified regarding their application.

A brief history of travel demand forecasting

The 1950s marked a tipping point in the conceptualisation of transport planning as a field that required scenario-making techniques to achieve better results. Two drivers fuelled this trend. First, car ownership levels in the United States had just started to climb in the mid-1940s, without any foreseen limits. The provision of transport supply had to take into account this rapid evolution. Second, the computation capacity required to perform large-scale travel demand modelling also began growing exponentially.

Box 2. The evolution of Finnish national transport futures studies

Four Finnish strategic documents unveil different approaches to travel demand futures:

1. Traffic and automobile stock forecast, 1989-2010: predictive scenarios with some alternative outcomes depending on gross domestic product (GDP) forecasts.
2. Traffic and automobile forecast, 1995-2020: an evolution towards explorative strategic perspectives, with three alternative futures – “business as usual”, “market-driven” and “sustainable growth”.
3. The visionary process, 1997-2020: an increasing emphasis on possible futures and the capacity to shape the evolution of travel demand.
4. Traffic scenarios, 1999-2025: a focus on desirable futures, complementing mathematical modelling with other methodologies aimed at defining what society finds desirable.

Source: Tapio and Hietanen (2002).

In this context, social scientists and engineers started to develop the theoretical grounds for travel demand modelling (Deutsch, 2013). The daily number of trips made by each household, known as trip generation

rates, were correlated with individual and zonal attributes, such as income or land use (Carroll, 1952; Mitchell and Rapkin, 1954). The application of gravity models to travel demand flows provided a basis for trip distribution modelling (Zipf, 1946). The development of shortest path algorithms (e.g. Dijkstra, 1959) and equilibrium principles for road networks (Wardrop, 1952) enabled the assignment of demand flows to each link in order to anticipate congestion. After the initial focus on car traffic modelling, mode choice models were largely developed during the 1960s (Barff, Mackay and Olshavsky, 1982). At the same time, early practitioners started to collect travel demand data through the first generation of mobility surveys (e.g. Detroit 1942 and San Juan 1948). Transport authorities adopted the new modelling techniques to exploit the data they were collecting in order to estimate travel demand growth and provide infrastructure that was capable of accommodating such demand.

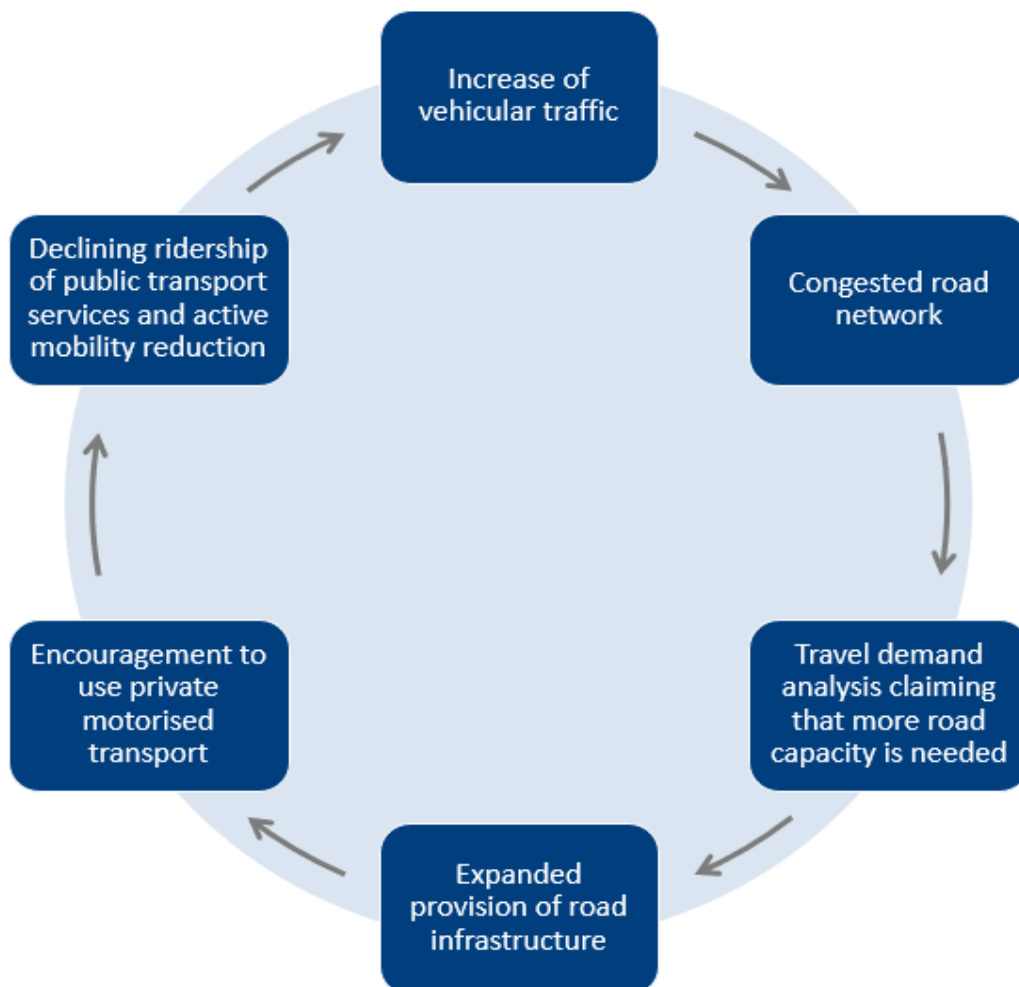
Predictive questions dominated early studies of future travel demand. However, alternative voices started to emerge from the very beginning. For instance, the influential “Traffic in Towns” report (UK Ministry of Transport, 1963), also known as the “Buchanan report”, already questioned the trend-following strategies embedded in these initial scenario-making exercises, highlighting the problems that car dependency could bring to cities. The limitations observed for producing deterministic estimates of future demand, together with the efforts to influence car dependency rather than simply surrendering to it, have led to alternative approaches. These frameworks generally focus on achieving desirable futures rather than predicting unstoppable consequences and are sometimes known as “Travel Demand Management”. Even if this approach is well valued among practitioners, the “predict and provide” paradigm is still influential (Vigar, 2017). As Box 2 shows for the case of Finland, the scenario-making methodologies suffer from path-dependent trends that are hard to bend. The ongoing evolutionary nature of transport futures studies and the concern with vision-led and robust decision making in the face of uncertainty are further addressed in the next section.

The predict and provide paradigm

As noted above, the predict and provide paradigm has dominated the development and use of future scenarios for travel demand from the 1950s. Under this approach, transport stakeholders seek to forecast future travel demand in order to provide the infrastructure required to serve it (Owens 1995, Goulden Ryley and Dingwall, 2014). The paradigm implicitly assumes that travel demand is an external phenomenon that cannot, or should not, be modified by proactive measures.

It has been assumed that travel demand is largely coupled with economic growth. As societies pursue the latter, travel demand is assumed to grow. This turns the predict and provide paradigm into a cyclical process, where transport authorities have to provide more and more supply to keep up with demand growth, as can be seen in Figure 8. Hence, this approach inadvertently influences travel demand. As the next section will show, the coupling between road traffic and economic activity has been weakening in recent years and a new paradigm, “decide and provide”, is emerging.

Figure 8. Predict and provide cyclical process



Source: TUMI (2019).

Available data and tools

Transport stakeholders have resorted to two kinds of inputs when forecasting travel demand: (i) data on current travel patterns; and (ii) simulation frameworks that support the creation of plausible scenarios. Data is required to enable a diagnosis of baseline mobility patterns, a useful starting point, not only for predictive or trend extrapolation scenarios but also for developing desirable futures by improving the current situation. The degree of sophistication of these travel demand diagnoses can vary significantly. Much depends upon the availability of human and economic resources, as well as on the role of baseline data in the construction of scenarios. In any case, this involves measurements aimed at quantifying and characterising travel demand. Travel surveys, traffic counts and other methods are deployed to generate data for this baseline diagnosis. Moreover, if travel demand is explained through stimulating and motivating factors, such as land use, labour force, etc., then there is also a need for data collection about these factors.

The dominant travel demand modelling framework is the Four Step Model (FSM). It combines the sub-models for trip generation-attraction, trip distribution, mode choice and route choice that were developed in the mid-20th century, by establishing an equilibrium between demand flows and the capacity provided by the available transport supply options. A long-standing alternative to this approach is the “activity-based” framework, which uses activities as the unit of analysis (instead of trips or tours as FSM does) in order to include location and schedule in the system equilibrium loop. Advocates of activity-based modelling highlight the behavioural realism of this approach, as activities are the events generating travel demand, in contrast to the “statistically-oriented” nature of the FSM (Bhat and Koppelman, 1999). FSM and activity-based modelling paradigms usually deal with a fixed built environment.

Land Use Transport Interaction (LUTI) models have been developed to combine the effects of transport and real estate markets in the decisions made by citizens and businesses about the location of their activities, including home location, and how this shapes urban development. The inclusion of the time dimension in all the aforementioned paradigms has been challenging. Static approaches have been outperformed by dynamic approaches, such as Dynamic Traffic Assignment models, which are able to simulate congestion effects. Moreover, the role of equilibrium in the modelling of travel demand has also been under scrutiny. The system dynamics approach is claimed to be suitable for complex areas where multiple stakeholders may have competing interests and lagged responses are usual, as is the case for transportation (Shepherd, 2014). These models combine qualitative assessment of relations through causal loops and quantitative stock-flow equations, moving from equilibrium-based modelling. It has to be noted that these models focus more on unveiling the links between system processes, rather than on producing forecasts.

Performance of current methods

Although more and more stakeholders are using models to anticipate future travel demand levels, concerns over the accuracy of travel demand forecasts are rising, as outlined earlier in this report. The performance of the methods developed under the predict and provide paradigm has been analysed from two different perspectives. The first approach does not really question the validity of the predict and provide paradigm, focusing instead on analysing the deviations of expected demand from actual demand once the forecast time horizon has been reached. The second perspective questions the effectiveness of predictive approaches as the sole method for envisioning travel demand futures and considers if explorative or normative scenarios provide a more solid basis for decision making. The next section presents alternative methods that have been developed to address this concern.

Much of the transport infrastructure built during the last 70 years has had associated travel demand forecasts. The passage of time has allowed researchers to conduct meta-studies that review the performance of these forecasts, analysing the actual versus forecast demand ratios of different projects and exploring features that can explain the regularities observed in the deviations. Table 3 shows some of the most well-known extensive meta-studies. The performance analyses of forecasts produced by strategic transport models that are not associated with a single project are less common, with notable exceptions from the United Kingdom, as discussed in the Introduction, and Sweden (Andersson, Brundell-Freij and Eliasson, 2016). The conclusions that stem from the studies covering project-related forecasts are notably that:

- Actual demand levels usually deviate significantly from forecasts, regardless of the impact of “black swans”, such as the Covid-19 pandemic.

- Toll roads usually suffer from systematic overestimations in traffic and revenues, with some remarkable exceptions, e.g. the Norway case according to Odeck and Welde (2017). The same kind of overestimations have been reported for rail projects (Nicolaisen and Driscoll, 2014).
- Overestimations have been related to a perverse incentive problem, namely that there is a demand for optimistic forecasts among those commissioning the studies (Flyvbjerg, Glenting and Rønne, 2004). Optimism bias is particularly problematic for stakeholders taking demand risks when financing infrastructures, as a systematic overestimation of travel demand across their portfolio does not allow them to compensate the limited revenues of certain concessions with potentially underestimated revenues from other projects (Welde and Odeck, 2011).

It is worth noting that most researchers involved in meta-studies have reported major difficulties in accessing data and there is a lack of a common methodology for conducting these meta-studies (Nicolaisen and Driscoll, 2014). This makes it difficult to make overall conclusions and suggests that more transparent forecasting could facilitate further improvements in the techniques used.

Table 3. An overview of meta-studies on project-based travel demand forecasting performance

Study	Sample	Results
JP Morgan (1997)	14 toll roads (United States)	93% of the forecasts overestimated toll road usage, 29% of them over +30%
Bain and Polakovic (2005)	104 toll roads (international)	Actual vs. Forecast demand = 0.77
Flyvbjerg, Holm and Buhl (2005)	183 toll-free roads (international)	50% of the toll roads with $\pm 20\%$ deviation
Næss, Nicolaisen and Strand (2012)	63 toll-free roads (international)	Actual vs. Forecast demand = 1.11
Button et al. (2010)	44 transit projects (United States)	Actual vs. Forecast demand = 0.79
Baeza and Vasallo (2012)	15 toll-free roads (Spain)	Actual vs. Forecast demand = 0.79
Schmitt (2016)	61 transit projects (United States)	Actual vs. Forecast demand = 0.63
Odeck and Welde (2017)	68 toll roads (Norway)	Actual vs. Forecast demand = 1.04
Hoque et al. (2021)	1 291 toll-free roads (United States)	Actual vs. Forecast demand = 0.94

As the next section details, the performance of travel demand models will always be limited by the uncertain nature of mobility futures. Deviations will remain, even if deterministic forecasts gain accuracy thanks to advanced systems knowledge and where potential optimism bias is avoided. This does not imply that quantitative approaches to travel demand futures are worthless. It has to be taken into account that CBA methods, which are usually based on demand forecasts, have been proven to outperform a random selection of policy alternatives, even in uncertain contexts (Asplund and Eliasson, 2016). As is discussed in the next section, the models developed under the predict and provide paradigm can be adapted and integrated in to broader methodologies that embrace uncertainty in a more explicit way.

The uncertain nature of travel demand futures

The previous section indicates how transport practitioners have made considerable efforts to anticipate travel demand trends. However, it seems necessary to dwell on an undeniable truth: it will never be possible to fully anticipate how society will move in the future. Travel demand futures are subject to uncertainty, which can be understood as a “deviation from the unachievable ideal of completely deterministic knowledge” of how mobility patterns will evolve (Walker et al., 2003: 5). Past initiatives for unveiling travel demand futures show that this realisation not always been obvious. As a consequence, the new approaches that are presented in the “Governance challenges and opportunities” section generally point to the need to manage uncertainty, rather than denying its existence. A better understanding of uncertainty in the context of transport futures will help facilitate the development and application of alternatives to the predict and provide paradigm. Acknowledging the dominant natures, levels and sources of uncertainty can help transport stakeholders to improve their foresight initiatives.

Uncertainty of future values versus uncertainty of future processes and trends

Even if most current transport studies insist on producing forecasts of future travel demand levels, there is a welcome trend of acknowledging uncertainty in future values. The proliferation of confidence intervals in travel demand forecasts means that substituting narrow deterministic values provides a more realistic representation of future travel demand (Lyons and Marsden, 2019). However, the discussion about uncertainty in this context goes beyond future values: what is uncertain is not only the value itself but also the processes and trends leading to a given value.

The alternative approaches to the predict and provide paradigm that are presented in the next section are generally aimed at aligning future travel demand patterns with a higher quality of life rather than interpreting them as fixed expectations. Therefore, the future extrapolated value loses importance as it is not necessarily determining our actions: what is crucial to comprehend are the processes within which transport policies have to operate in order to align mobility patterns with broader societal goals. Instead of assuming that the explanatory mechanisms behind demand levels will hold in the future, as current approaches to transport modelling do now (Rowe, 1994), the focus should be on harnessing how actions may shape and influence the processes behind travel behaviour.

Natures of uncertainty: Mobility futures or broader societal futures?

The notion of transport as a derived demand of socio-economic activity makes transport futures an interdisciplinary question, adding complexity to the analysis of the transport phenomena. Any future reflection about the evolution of travel demand incorporates assumptions and hypotheses that go beyond what is generally understood to be the scope of transport sciences. A first step towards uncertainty acknowledgement may be to embrace this multidimensional condition and assume that this includes broader societal futures. As the Introduction discusses, this makes transport planning a clear example of a “wicked problem”.

Walker et al. (2003) distinguish two complementary uncertainty “natures”, and it is clear how the multifaceted scope of transport planning has implications for both of these. First, the multidimensional nature of transport planning multiplies what is known as “epistemic uncertainty”: what we do not know about the future because we have not been able (yet) to understand the system dynamics behind it. Following on from this, in order to improve transport models, we should improve our knowledge of systems outside of the transport sector. Simply put: any improvement in the knowledge of socio-economic processes can be leveraged to improve transport models. However, the interdisciplinary condition of

transport planning also arguably multiplies “ontological uncertainty”, as it makes travel demand futures partially dependent on phenomena that are perceived to hold a high degree of random variability.

Levels of uncertainty in transport planning

Not all projections of future travel demand are equally uncertain. Even if uncertainty is not directly quantifiable, there are some frameworks that help to analyse the degree of uncertainty that should be assumed in a given scenario-making initiative.

Walker levels: from complete certainty to total ignorance

Walker et al. (2003) provide a useful scale that encompasses all the situations that are likely to arise when thinking about future travel demand (Table 4). The extreme positions of the scale (complete certainty and total ignorance) are hypothetical situations that allow comparison of each actual context with these ideals. It is interesting to see how this classification covers both uncertainty on values and uncertainty on processes, which, as claimed above, are both crucial when looking at foresight studies of travel demand.

Table 4. Walker uncertainty levels

Level	Description	Examples
(1) Determinism or complete certainty	This is an unattainable level where everything would be known with full precision.	It is hard to think of a single action that leads to a completely determined impact on travel demand.
(2) Statistical uncertainty	At this level it is possible to “describe [the uncertainty] adequately in statistical terms”.	Demand data collection methods based on representative samples allow us to compute the sampling errors. Most variables used for inferring travel demand at short timescales (e.g. weather) are also associated with probabilities of occurrence.
(3) Scenario uncertainty	At this level “there is a range of possible outcomes, but the mechanisms leading to these outcomes are not well understood and it is, therefore, not possible to formulate the probability of any one particular outcome”.	Many factors that have an influence on travel demand fall under this range, for instance, a reasonable range for future socio-economic variables are known, but it is hard to untangle the probability distribution of their future values.
(4) Recognised ignorance	At this level it is not possible to describe “the functional relationships nor the statistical properties” so “the scientific basis for developing scenarios is weak.” This can be partly alleviated through research reducing epistemic uncertainty, but this is partly indeterminate by nature.	The emergence of new technologies and business models in the transport sector have situated travel demand futures at this point in recent times (e.g. shared mobility). This will continue to happen in the future, for example with vehicle automation.
(5) Total ignorance	At this level “we do not even know what we do not know” and “we have no way of knowing the full extent of our ignorance.”	We can assume that the nature of transport as a derived demand is a discernible principle that will hold in the future.

Source: Walker et al. (2003).

Control, influence and no-influence

Part of the inherent complexity of the transport sector is caused by the multiplicity of stakeholders, as the governance challenges described in the final section “Governance challenges and opportunities” demonstrate. This implies a close relationship between the degrees of uncertainty experienced in each

situation and the sense of control that each stakeholder has over the situation. Interestingly, this is revealed through two complementary perspectives. On the one hand, travel demand itself is an “aggregate of a myriad of individual decisions” (Owens, 1995: 44). On the other hand, many different agents are able to make collective decisions with influence on individual travel patterns. Covey (2004) provides a useful description of the degrees of control for general management that can be applied to transport governance. He postulates three concentric circles (Table 5) that directly shed light on the uncertainties about the processes leading to travel demand flows.

Table 5. Covey circles

Level	Description	Examples
(1) Circle of control	This includes all the decisions that are based on the agent’s sovereign choices. Obviously, it is likely that all decisions are somehow influenced by the context, but it is clear that some decisions still depend significantly on the willingness of a single decision maker.	Some transport operators have a high degree of control over the supply levels they provide: this is the case for publicly owned transport operators, but also some loosely regulated services, such as ride hailing schemes.
(2) Circle of influence	This includes all the areas where the agent actively participates in the decision-making processes.	Most travel demand management strategies operate at this degree of control: they incentivise travellers to adopt certain options over other alternatives to reduce the externalities of their movements, e.g. by facilitating cycling and walking.
(3) Circle of concern	This includes all the areas that have a clear impact on the interests of the agent, but where the agent does not have significant influence.	Demographics shape a very significant part of travel demand patterns. However, transport stakeholders neither have control nor influence over demographic trends.

Source: Covey (2004).

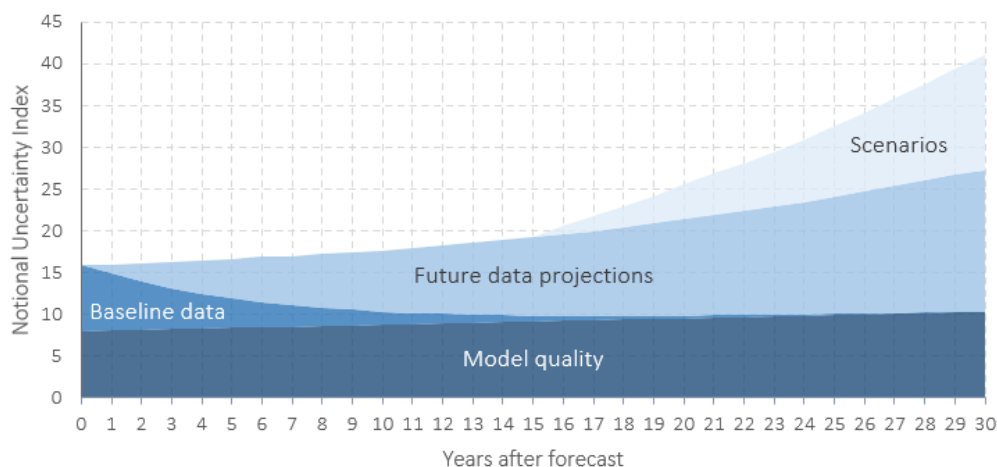
Sources of uncertainty in transport planning

Another way to discern the ability to anticipate travel demand futures is to identify the different sources of uncertainty operating in a scenario-making process. Walker et al. (2003) present this as the “locations” of uncertainty, complementing the two aforementioned dimensions: “natures” and “levels”. Willumsen (2014) identifies four main sources that support the affirmation of Walker et al. (2003: 9) that: “uncertainty can prevail in situations where a lot of information is available”. As Figure 9 shows, Willumsen suggested how the relevance of each source evolves depending on the time horizon of the forecast.

Model quality

The purpose of travel demand modelling is to reproduce the drivers of mobility patterns in a controlled environment so that alternative scenarios can be tested. This requires the ability to select the required drivers and properly define the interactions between them. The “model specification” problem is a frequent source of uncertainty, as it is very unlikely that a model can capture all the minutiae of decisions that precede a trip (Manzo, Nielsen and Prato, 2014). For instance, many FSM models have been criticised for ignoring trip chaining behaviours, i.e. performing intermediate activities between two main activities, such as shopping after work on the way home (Bhat and Koppelman, 1999). Another frequent example is the omission of induced demand, which has contributed to the continuing prevalence of the predict and provide paradigm (Næss, Nicolaisen and Strand, 2012). In any case, simplifications are often needed for the sake of practicality, as adding variables without any limitation reduces flexibility and increases the uncertainty stemming from baseline and future data projections (Walker et al., 2003).

Figure 9. Sources of uncertainty



Source: Willumsen (2014).

Baseline data

The measurement of current travel demand conditions is subject to error and bias. These flaws are transferred to the models at the moment of their calibration, when testing if the model accurately reproduces the current state of travel demand. Sampling error is well noted, as most data collection methods work with samples and not the whole population (Manzo, Nielsen and Prato, 2014). However, this type of error is at least controllable. The key challenge is to collect valuable data about all the relevant decisions that individuals make before and during a trip. It is widely accepted that a good combination of different data sources contributes to better knowledge about the relevant processes, but there is usually a trade-off between the level of detail achieved and the frequency of data collection. For instance, household travel surveys investigate most of the variables that shape travel behaviour, but they usually focus on a limited number of days and cannot be frequently updated due to high costs.

Future data projections

As travel demand depends on other socio-technical factors, scenario-making exercises often require future data projections for economic or demographic variables in order to reproduce future travel demand as an outcome of these factors. However, exogenous variables to mobility patterns are part of other complex systems with their own uncertainties (Manzo, Nielsen and Prato, 2014) and are also subject to different monitoring approaches or frequencies.

Range of plausible scenarios

Even those scenario-making initiatives that fully embrace the exploratory approach face difficulties in identifying the full range of plausible scenarios that may take place in the future. These scenarios come from future disruptions, as the Covid-19 pandemic has reiterated, but also from more subtle trends such as digitalisation. To some extent this uncertainty may be solved through better knowledge (e.g. considering the future opening of an alternative highway when forecasting the demand for an existing highway), but others largely pertain to ontological uncertainty: no realistic improvement in system knowledge will serve to reduce the indeterminacy (e.g. the precise timing of natural disruptive events). In this context, it is important to balance creativity and pragmatism throughout the scenario-making process, in order to consider all plausible relevant futures.

A certainty: Looking ahead always influences future pathways

This section has examined how transport planning has responded to the need to anticipate travel demand patterns. The variety of perspectives, scales, horizons and methods deployed point to a salient conclusion. The deterministic travel demand forecasts widely applied under the predict and provide paradigm were not intended to shape, nor bind, travel demand futures. However, the consequence of their use seems to be a cyclical reinforcement of trends that may be undesirable. Transport policies that were thought to accommodate travel behaviour have, in turn, durably influenced this same travel behaviour and this fact should not be neglected in policy design. How to achieve this, and account for inherent uncertainty regarding the future, is the focus of the next section.

Handling uncertainty in assessing travel transitions

As noted previously, there has been a sense of stability and familiarity with how transport in society is evolving and with the approach to transport planning supporting this evolution. However, deep uncertainty has become much more prominent in recent years and there is both an individual and collective feeling about the future, in which stability and familiarity are diminished. This section considers how policy makers and other transport sector stakeholders can, and are, making sense and responding to this feeling of deep uncertainty. Deep uncertainty makes people uncomfortable. It can be tempting to suppress this discomfort and conceal the uncertainty. However, it is necessary to find ways of embracing the uncertainty such that planning and investment decisions can be taken that are more resilient in the face of this inherent uncertainty. Such uncertainty can also be interpreted as an opportunity to shape the future in the absence of a predictable or inevitable route ahead.

Determining what to do about deep uncertainty when making planning and investment decisions requires a new way of thinking, as well as a new way of carrying out strategic transport planning. This section highlights the state of flux in transport and society brought about by a collision and merging of the motor age and digital age. This state of flux has been exacerbated by the Covid-19 pandemic, bringing further into question whether the forecast-led paradigm of transport planning is able to cope in the face of significant technological innovation and behaviour change, in a world facing a climate emergency. The section addresses the need for a transition in transport planning and appraisal which involves a move away from predict and provide towards an approach of decide and provide.

Decide and provide centres upon the primacy of access in society (a combination of physical mobility, spatial proximity and digital connectivity) and is vision-led rather than forecast-led. By determining a preferred future, there is a need to chart a course towards that future that can negotiate the uncertainties ahead. Using a case-study focus on the United Kingdom, this section highlights how thinking and practice in transport foresight are changing. Particular attention is given to scenario planning and how scenario-based representations of uncertainty can be used to test the resilience of policy interventions. The section reflects on how a number of other countries are also considering such matters and calls for an internationally collaborative “learning by doing” approach to address the challenges of planning for the future of mobility.

Transition and deepening uncertainty

The future has always been uncertain. It is widely accepted that a distinguishing feature of most if not all forecasts, when it comes to traffic and travel, is that they will be wrong. The previous section “Looking back to look ahead” gives a series of examples of retrospective performance assessment of travel demand forecasting, pointing to problems of overestimation and bias. The models themselves that are used to produce the forecasts can contribute to these inaccuracies, but input values to the model can also be wildly flawed for variables such as future population, economic growth and fuel price. That these values were wrong can only be discovered in the future, after the fact. Models use past data for their calibration,

for establishing cause and effect relationships that are then played forwards into the future. However, suppose that such relationships do not hold true in future, adding to the uncertainty over the “correct” input values for the models – what then? Models may still be useful as explorative tools (as highlighted in the previous section), provided that their limitations are understood. It should also be recognised that there may be questions over the relevance of output measures of a model compared to the priorities of the future (i.e. motorised road traffic, and especially car traffic measured in vehicle distance travelled, has tended to predominate, but this may not be the case in the future).

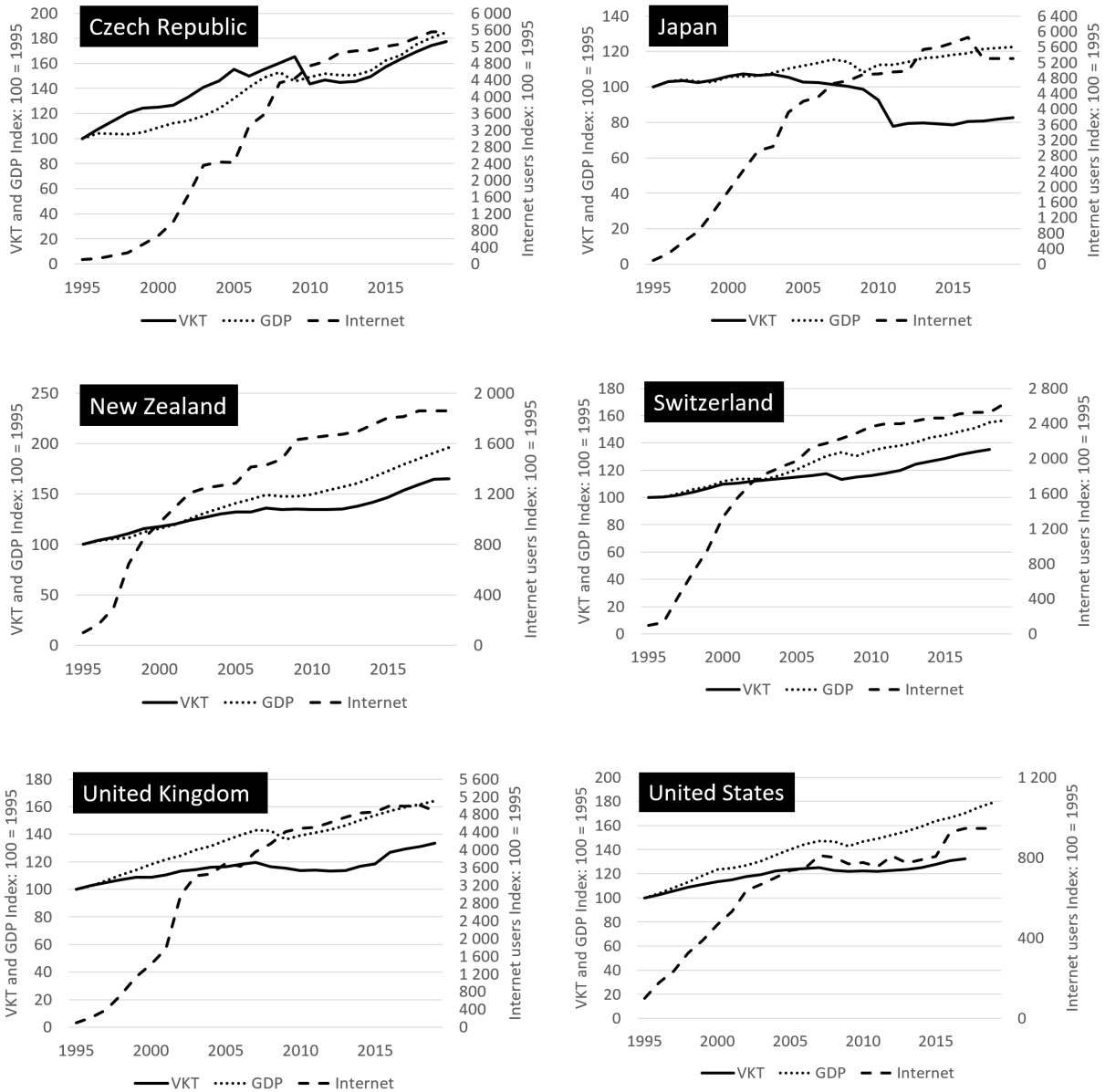
A state of flux for the transport sector

The multi-level perspective (MLP) approach introduced in “Trend breaks and travel transitions” is a systems-based theory that addresses transitions (Geels, 2012) and helps to interpret the broad, globally observed trends, that have been taking place in the transport sector in recent years. In essence, the MLP suggests that a system of interest can exist in a state of broad stability known as a “regime” (the way of the world as we know it). Such a regime may continue to evolve, but retains defining characteristics. Meanwhile, niche developments can begin to take place, and once they gain momentum and begin coalescing, they can start to disrupt the regime and precipitate a regime transition. Regime transitions can take decades to unfold. They create a state of flux. Historical examples include transitioning from sailing ships to steam ships and from horse-drawn to motorised transport. The MLP recognises the complex socio-technical nature of transport and wider society and considers the “co-evolution and multi-dimensional interactions between industry, technology, markets, policy, culture and civil society” (Geels, 2012: 471).

It can be suggested that transport and society have been in such a state of flux for some time now, as a consequence, in part, of the digital age colliding and merging with the motor age (Lyons, 2015). Figure 10 (below) illustrates this contention for several OECD countries. Characteristic of the motor age has been an observed “coupling” between economic growth and road traffic growth – they appeared to go hand-in-hand and this has highly influenced transport planning and policy making (Banister and Berechman, 2001), as noted in “Trend breaks and travel transitions”. However, Figure 10 shows that from around the turn of the millennium (somewhat later for the Czech Republic), this coupling has turned to “decoupling” – the so-called traffic intensity of the economy has been reducing. The timing of this change corresponds with digital progress, notably: the invention of the World Wide Web in 1989 and its increasing popularity from the 1990s onwards; the subsequent rapid penetration of Internet access into many countries; an onwards intensification of the speed of Internet access; and an ever-growing array of online services and forms of communication. This has brought about disruption to how people access jobs, social contact, goods, services and opportunities in society. The relative role of transport in these wider phenomena is undergoing structural change, compounded now by a need to address climate change.

It may indeed be the case that a regime transition has been ongoing for the last two decades. This helps explain the deep uncertainty felt about the future. The state of flux has been further exaggerated and distorted by the Covid-19 pandemic. However, such uncertainty and state of flux is also an opportunity to shape how the transport sector emerges from this transition.

Figure 10. Time series data for selected OECD countries depicting potential signs of regime transition, 1995-2015



Source: VKT (total motor vehicle traffic in vehicle-kilometres) from OECD and ITF, although note that United States data for VKT (converted from vehicle-miles travelled) from Vehicle Technologies Office (2018); GDP (constant 2010 USD) and Internet users (individuals using the internet as a percentage of population) from The World Bank (2021).

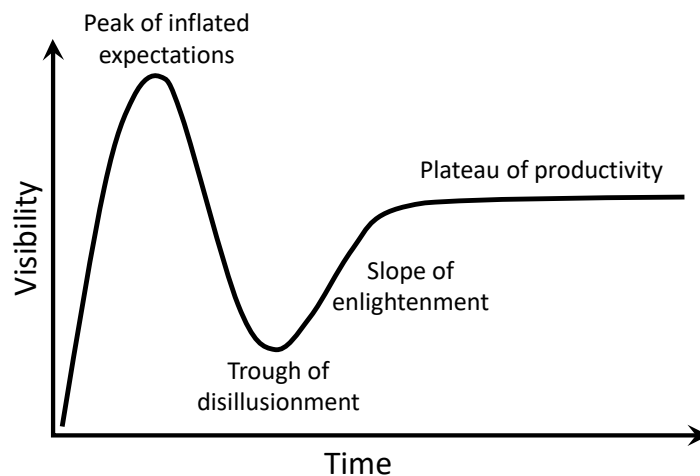
Making sense of change

The transport sector is no stranger to technology. Within the transition, as the digital age and motor age merge, significant technological innovations or technology-enabled innovation prospects have arisen as part of the state of flux. These include: new forms of propulsion (battery-electric and hydrogen fuel cell electric vehicles, e-bikes, e-scooters); new forms of control (semi-autonomous vehicles, fully-autonomous

vehicles, unmanned aerial vehicles); new forms of transport ecosystem (shared vehicle ownership, shared vehicle use, Mobility as a Service); and new forms of infrastructure (green hydrogen production and distribution, inductive vehicle charging, low-resistance vacuum tubes). There has recently been a popularised notion of a future of Autonomous-Connected-Electric-Shared (ACES). This creates a sense of a “knowable” future ahead, a future that must be planned and facilitated into reality.

However, the hype cycle (Figure 11) developed by Gartner⁶, is a reminder that there is an all-too-familiar pattern to the emergence of new and exciting possibilities (Dedehayir and Steinert, 2016), related to the adage that “we tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run”. Media interest in “proof of concept designs” or prototypes increases the visibility and expectation surrounding new technology. This can be a seductive phase for stakeholders, including policy makers in the public sector. However, this reaches a peak of inflated expectation before ongoing attempts to deliver often fail or encounter unanticipated problems. Interest subsides to a low point, the “trough of disillusionment”. If a particular technology and associated stakeholders survive this period, then a crystallisation of insight and capability begins to deliver a more measured progression up a “slope of enlightenment” towards a “plateau of productivity” where mainstream adoption begins to take off.

Figure 11. Hype cycle depicting a path for emergent technologies



Source: reproduced from https://en.wikipedia.org/wiki/Hype_cycle.

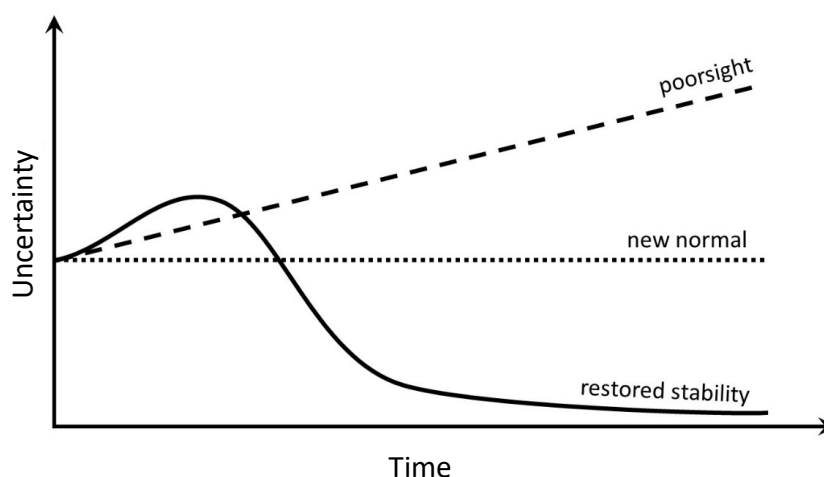
Anticipating whether, when and how a technological innovation will mature and diffuse into society – moving from the innovators to early adopters, to early majority, to late majority and finally to laggards (as per the stages set out in Rogers’ diffusion of innovations theory, see Karakaya, Hidalgo and Nuur, 2014) – is far from straightforward. Such developments do not unfold in an otherwise steady-state environment where all else is held equal. Multiple developments are happening concurrently within the overall state of flux of the system. Progression involves inter-dependencies (e.g. vehicle technology, infrastructure, consumer demand). One of the issues that needs wider recognition in the transport sector is that many of the strategic problems being addressed are “wicked” as opposed to “tame” (Rittel and Webber, 1973). The Introduction emphasised that the extent of uncertainty in the transport sector means that decision makers are dealing with wicked problems. Wicked problems are “marked by value divergence, knowledge gaps and uncertainties, and complex relationships to other problems” (Head, 2010: 21) as well as by changing conditions. Notable examples include poverty, obesity and climate change; and within transport might include congestion, car dependence and transport-related social exclusion. Such problems are not

soluble (there is neither agreement on the problem itself nor the solution) but they need to be managed, which calls for a collaborative and participatory approach bringing together multiple perspectives.

Uncertainty about uncertainty

The degree of uncertainty about the future can change over time and is itself uncertain. There has been talk of a “new normal” beyond the Covid-19 pandemic. This idea risks giving the impression that a new steady state of the system is on the horizon and that such a horizon is in the near term. However, with the pandemic seen as a shock to a global system that was already in transition, the prospects ahead may be much less clear. Figure 12 offers a contemplation of plausible uncertainty trajectories. The “restored stability” trajectory suggests uncertainty about the future may deepen further over time (greater ignorance) before subsiding as the system emerges from its transition towards a new stable regime (greater determinism). This may take decades to unfold. The “new normal” trajectory suggests that the sense of deep uncertainty felt before, or even the increased level felt during the pandemic, may endure into the longer term. The “poorsight” trajectory suggests the sense of uncertainty about the future could progressively deepen over time in the face of multiple developments and drivers of change (ever greater ignorance). The onward evolution of strategic transport planning needs to be able to accommodate such, as yet, unknown future contexts for policy and investment decisions.

Figure 12. Plausible uncertainty trajectories



Acknowledgement of uncertainty

Policy documents do not necessarily acknowledge uncertainty. For example, the recently published Government Policy Statement on Land Transport 2021/22-2030/31 from the New Zealand Government refers to uncertainty only once (NZ MoT, 2020), whereas the European Union’s Sustainable and Smart Mobility Strategy (EC, 2020) and the U.S. Department of Transportation 2018-2022 Strategic Plan do not mention the term at all (US DoT, 2018).

However, when it comes to the decision-making process and underlying analysis and advice, examples of acknowledgement can be seen. High levels of uncertainty “surround the decisions that need to be taken over the next thirty years” according to the UK’s National Infrastructure Commission (NIC, 2017: 34). In its latest road traffic forecasting exercise in 2018, the UK Department for Transport (DfT) acknowledged that “[w]hile uncertainty in road traffic demand has always existed, it is perhaps now more uncertain than ever”

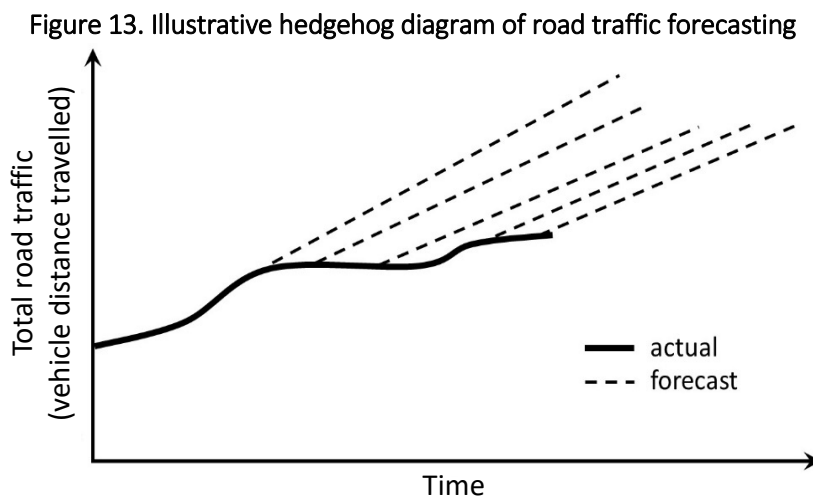
(DfT, 2018a: 27). In their paper for the World Bank, Kalra et al. note that “deep uncertainty about the future exacerbates the challenge of sound decision making” (2014: 3) and they highlight the need for those party to decisions to stress-test options against multiple plausible futures to help improve the robustness of decisions (a theme returned to later in this section).

The need for a transition in transport planning and appraisal

The circumstances above point to significant and indeed substantial challenges facing strategic transport planning. There would appear to be mounting concern that the orthodox approach is struggling to cope. As with transport and society, the system of strategic transport planning can be considered through the lens of transition theory: perhaps the established regime is destabilising with early signs emerging of a transition being underway, or at least signs of recognition of the need for change away from the established regime.

Misplaced confidence in forecasting and inadequate strategic thinking

Road traffic forecasts have, in recent years, given rise to what have been called hedgehog diagrams, as illustrated in Figure 13 (after Goodwin, 2019). An online collection of these diagrams (for Anglo-Saxon countries) is available.⁷ These depict a persistent overprediction of future road traffic levels (as also discussed in the “Looking back to look ahead” section). Such overprediction may be attributed to input values to the model (predictions about the future) being incorrect (input uncertainty). It has been argued that if only such values were known, the model may be able to perform rather well. Yet given that future values are not known, or are at least not known with confidence (especially currently, in light of the pandemic), what should be done? It should also be noted that in the demand-led paradigm of predict and provide, such forecasting can be considered a form of second-order chaos (Harari, 2014). The forecast itself influences policy making and investment which, in turn, influences transport system supply and demand and hence actual traffic levels. This has been referred to as a self-fulfilling prophecy. (This can be contrasted with first-order chaos, such as weather forecasting, where the forecast itself does not bring about an influence on the future of the weather.)



Source: based on empirical graphs in Goodwin (2019).

Transport appraisal has relied upon travel demand forecasting. Indeed, there has been much reliance placed upon a “most likely” central projection of road traffic demand, bounded by a limited sensitivity analysis to account for uncertainty (Lyons and Marsden, 2019). This is not reflective of the level of confidence currently possible in how the future is being shaped.

Compounding the inability to point with confidence to a most likely future is the attention, or lack thereof, being paid to strategic direction in the appraisal process. There appears, at least in the United Kingdom, to be an appraisal culture in which many proposals have a weak strategic case that risks undermining the longlisting of options for delivering the proposal’s objectives. With a lack of strategic direction, the result is an unhealthy reliance upon the benefit-cost ratio in judging the merits of a proposal. This is according to the UK Treasury’s recent review of the appraisal process – a process which it notes is intended to support maximising “the delivery of economic, social and environmental returns for UK society for every pound of public funds spent” (HM Treasury, 2020: 2). The benefit-cost ratio in transport appraisal is dependent upon modelled future consequences, which have traditionally taken the form of the forecasts referred to above. There is, potentially, therefore a structural problem in the forecast-led paradigm of transport planning and appraisal and it can be argued that something needs to change.

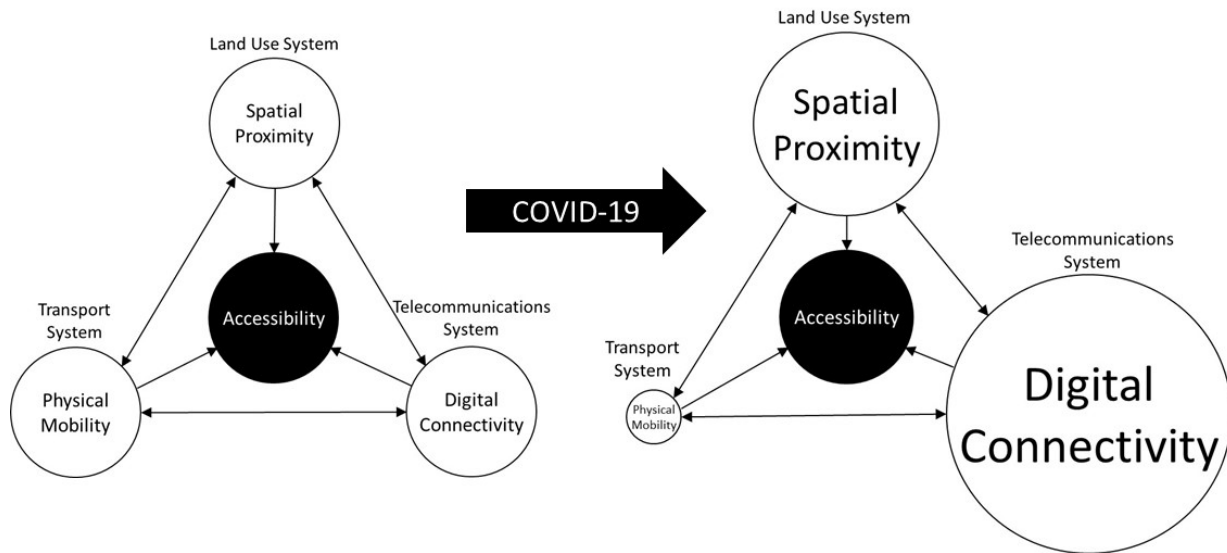
A shift in focus from mobility to access

The forecast-led paradigm of predict and provide can be characterised as forecasting a most likely mobility future (within sensitivity-tested bounds of uncertainty, as noted above) and providing a means to accommodate projected demand. This reliance on forecasting is problematic, particularly when looking at decarbonising the transport sector where evidence and policy goals point to reducing traffic levels rather than continuing to let levels increase (see the later reference to a recently declared national reduction target for car traffic). This method is also potentially problematic since it is focused heavily, or even exclusively, on mobility goals.

Travel is a derived demand – derived from a need to access people, jobs, goods, services and opportunities. Access is what supports economic prosperity and social well-being. The transport system can provide access through physical mobility. However, the land-use system can provide access through spatial proximity. One explanation for the decoupling of traffic and economic activity (shown in Figure 10) is that the rapidly maturing telecommunications system is increasingly capable of providing access through digital connectivity. This tripartite means of access has been referred to as the Triple Access System (TAS) (Lyons and Davidson, 2016), see Figure 14 below for a more detailed illustration.

While experiences have varied within and across different societies during the Covid-19 pandemic, increased collective reliance upon the TAS has become apparent. Social distancing has seen restricted use of the transport system, with much greater reliance upon the telecommunications system for access alongside spatial proximity, embracing the notion of “living local and acting global”. The TAS has provided society with significant access resilience and society has shown its collective ability (if not necessarily desire) to adapt in the face of changing circumstances. The International Labour Organization (ILO) estimates that nearly one in five workers globally may have been working from home following the arrival of Covid-19. ILO observes that “[a] few labour force surveys were already equipped with adequate questions on home work and telework, but most were not and have struggled to uncover what has been going on in the world of work during the pandemic” (ILO, 2021: 30). Understanding change in the TAS has not yet become a mainstream priority of governments. In looking forwards, individuals will continue to increasingly live, work and play within the TAS. Accordingly, it has been suggested that strategic planning should broaden its purview beyond its traditionally narrower preoccupation with transport (Lyons, 2021).

Figure 14. The adaptability of the Triple Access System and its use during the Covid-19 pandemic



Source: reproduced and elaborated conceptualisation from Lyons and Davidson (2016).

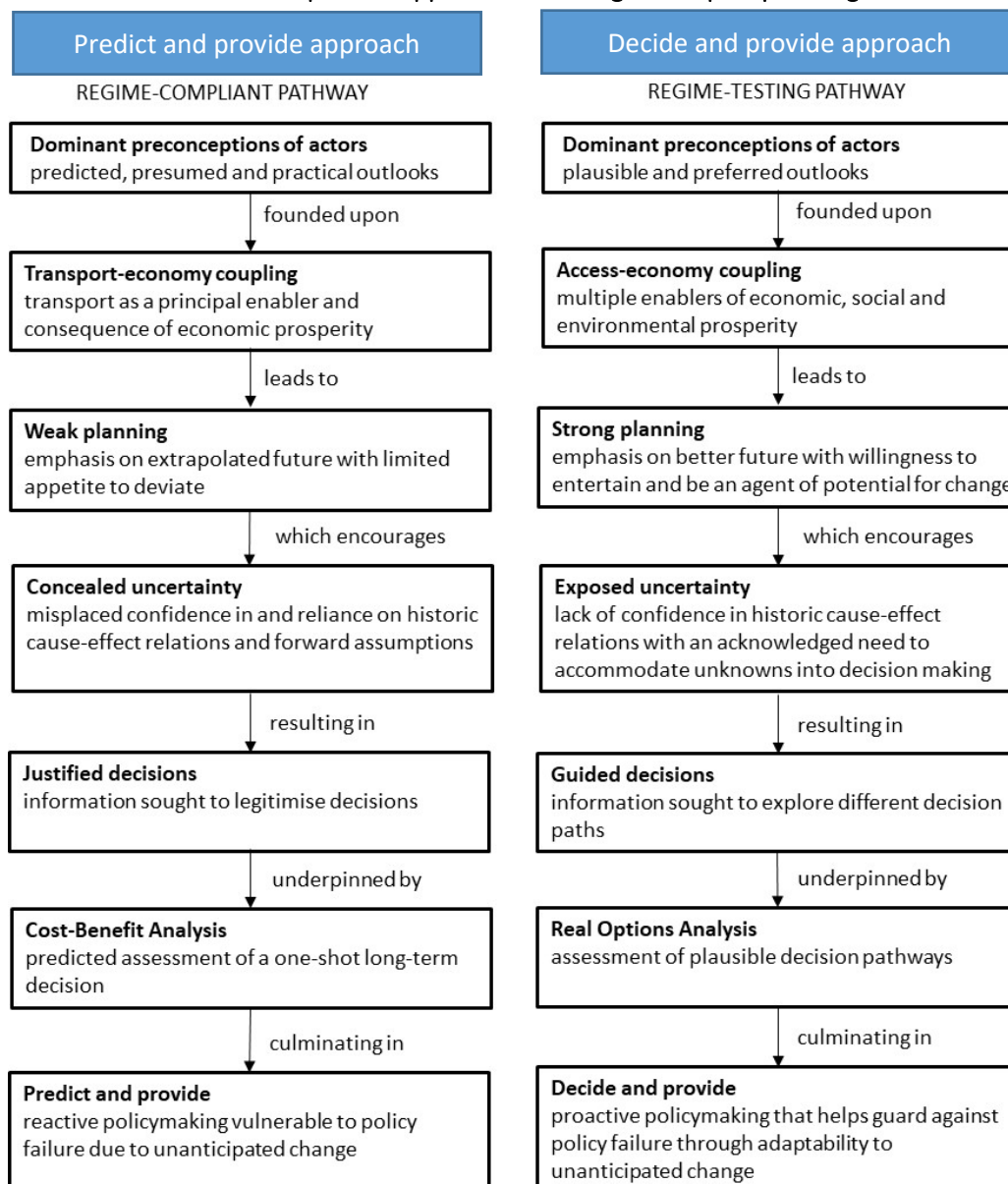
Enthusiasm and reluctance to change: A paradigm shift towards “decide and provide”

If there is a need to transition away from the orthodox approach to strategic transport planning, what direction should this transition take? Work by the New Zealand Ministry of Transport examined uncertainty in the future demand for car travel and led to the identification of two contrasting policy-making pathways relating to strategic transport planning (Lyons and Davidson, 2016). The two pathways are portrayed in Figure 15, although the figure is purely illustrative it is a useful learning aid.

One pathway suggests elements that would, when put together, reflect an approach to decision making that would be compliant with the current regime (in which adherence to trends and efforts to continue with the world as we know it steers policy). In this approach, there is a tendency to have a misplaced confidence in a predictable future that aligns with past experience and which is predicated upon the primacy of a link between transport activity and economic activity. This amounts to weak planning with a deterministic outlook that supports a justification of decisions founded upon a “one-shot” assessment of costs and benefits. This predict and provide approach risks vulnerability to policy failure due to unanticipated change (see also the previous section).

Meanwhile, the alternative, regime testing pathway, brings into question the nature of the world as we know it and it is visions of the future that inform policy decisions. In this approach, there is an open-mindedness to the possibility of significantly different futures and an appetite to shape a preferred future, predicated on recognition of the primacy of access (in different forms) supporting society and realisation of goals. This amounts to strong planning which recognises a need to expose and accommodate uncertainty. Analysis aims to inform decision making and look beyond a one-shot assessment of costs and benefits, appreciating the scope and need for future adaptation. Such a “decide and provide” approach helps guard against policy failure.

Figure 15. Contrasting a predict and provide approach with a decide and provide approach to strategic transport planning



Source: reproduced from Lyons and Davidson (2016: Figure 3).

A study undertaken in 2016 engaged with over 200 transport professionals across the United Kingdom to understand their views regarding strategic transport planning in the face of deep uncertainty (Lyons, 2016). The study used the work detailed above, including the learning aid in Figure 15. Overwhelmingly, individuals said they were able to contemplate radically different plausible futures (in some cases very different to those considered in official national road traffic forecasts). There was almost unanimous recognition of the prevailing dominance of the predict and provide paradigm. The vast majority of professionals felt there was a need to move away from this paradigm towards decide and provide. These are clear signs of appetite for change.

Nevertheless, what was referred to as “professional impotence” was recognised as a barrier to change (which links to matters of governance discussed in the following section “Governance challenges and opportunities”). Individuals can see a need for change but are in a system within which norms and expectations associated with orthodox practice are strongly engrained. There may also be limited skills (in nature and capacity) to readily migrate to a new paradigm, coupled with vested interests in preserving the established paradigm creating forces of inertia.

Such observations are characteristic of the notion of regime transition referred to earlier: systemic change is a process, it is messy, and can take time to unfold. So, what of niche developments that may be taking place, gaining visibility and traction, and which may point to an evolution (if not yet a transition) taking place in strategic transport planning?

Ways of exploring the future to inform strategic planning

If minds are open to the need for a new way of thinking and doing, then tools and methods are available that can be brought into the repertoire of the strategic transport planning process and tailored to the needs of the sector. The challenge for strategic transport planning lies less with the availability of new tools and methods but with familiarity and expertise in utilising these tools. Strategic transport planning has tended to preoccupy itself with approaches suited to lower levels of uncertainty, where the uncertainty is taken to be stochastic or arise from a lack of information (Walker, Marchau and Swanson, 2010). There is now a need to consider approaches that are better suited to the higher levels of uncertainty e.g. deep uncertainty.

Case study: Overview of the United Kingdom evolutionary approach

The United Kingdom has a long and well-documented history of transport policy and appraisal, with economic appraisal reaching back to the early-1960s (OECD, 2011). Recent developments serve to provide a useful case study examination of changes to established thinking and practice, against which other countries will be able to draw comparisons.

The DfT has been evolving its approach to road traffic forecasting. Significantly, for its 2015 forecasting, and even more notably for its 2018 National Road Traffic Forecasts (DfT, 2018a), there has been a move away from a focus upon a central projection (most likely future) and associated sensitivity testing, towards an approach involving a set of plausible scenarios which more strongly acknowledges deep uncertainty. This is reflective of the DfT’s observation (as noted earlier) that “[w]hile uncertainty in road traffic demand has always existed, it is perhaps now more uncertain than ever given the changes that are currently being experienced in the system and the changes that could lie ahead” (DfT, 2018a: 27).

In its 2019 Appraisal and Modelling Strategy, the DfT identifies “reflecting uncertainty over the future of travel” as one of its key themes. The consultation on the strategy “found strong support for considering uncertainty in appraisals more thoroughly than we currently collectively do. Decision-makers and the wide variety of stakeholders impacted by transport investment are indeed calling for better storytelling on how investments might perform in a range of different potential futures” (DfT, 2019b: 28). Pursuing its strategy in relation to the economic case in appraisal, the DfT is addressing the use of scenarios including: How to ensure proportionate assessment? How to provide support for those needing to apply scenarios to handle uncertainty? How to present uncertainty to decision makers? In May 2021, the DfT published the Uncertainty Toolkit (DfT, 2021c) that seeks to address such matters. This includes a set of six “off-the-

shelf” common analytical scenarios, all of which are cross-modal and against which there is an expectation that high impact schemes, in particular, will now be assessed.

The Appraisal and Modelling Strategy and the resulting Uncertainty Toolkit have been informed, in part, by an investigation into how current appraisal and modelling methods account for uncertainty (Batley, 2018). There is a distinction to be made between risk and uncertainty (although a “lack of consistency/agreement on concepts and terminology” is apparent in existing guidance [Batley, 2018: 28]). Risk reflects events or future states subject to a known or assumed probability distribution, whereas uncertainty reflects events or future states whose probabilities cannot be numerically specified (see LeRoy and Singell, 1987). In terms of modelling, a distinction is made (as noted earlier) between input uncertainty (where values of exogenous variables are unknown) and model uncertainty (where there is a model specification error). Propagation error results when input uncertainty passes through the model to produce output uncertainty.

Methods for quantifying risk and deeper uncertainty include “sensitivity analysis, switching values, scenario analysis, Monte Carlo simulation, jack-knife/bootstrapping tests, and/or risk analysis... Monte Carlo analysis would yield insight into the full distribution of appraisal outcomes, whereas sensitivity analysis would effectively reveal only discrete points along the distribution” (Batley, 2018: 31). Monte Carlo analysis was used for risk analysis in the economic case for high-speed rail in the United Kingdom, whereby thousands of repeated simulations examined the impact of different combinations of key variables on the key output measure – the benefit-cost ratio. “A large number of simulations are required to build a reliable distribution of possible outcomes. In order to achieve this, the model that is used to predict the outcome must be capable of running quickly and automatically” (HS2 Ltd, 2016: 2).

Box 3. A six-stage approach to applying decide and provide

- Gearing up – opening minds to the rationale and underlying philosophy of a decide and provide approach to help stakeholders in their readiness to engage.
- Preferred futures – co-creating with stakeholders an expression of what characterises the preferred future.
- Opening out – developing a set of plausible (narrative) scenarios to help expose and embrace uncertainty about the future.
- Options – generating options (ways) to deliver the preferred future (vision) with cognisance of the uncertainty.
- Closing down – stress testing options for their ability to negotiate uncertainty and remain aligned with achieving preferred outcomes.
- Review – monitoring, reviewing and adapting how the strategy (comprised of selected options) is performing when implemented in an ever-changing world.

Source: Mott MacDonald (2019).

Meanwhile, the DfT’s Office for Science has been pursuing a Transport Futures programme to add resilience to decision making in strategic planning in the face of uncertainty by applying the publicly available Futures Toolkit published by the Government Office for Science (GOS, 2017). The toolkit is a cross-sector “set of tools and techniques to help government officials use long-term strategic thinking in

policy making”. The toolkit includes: (i) tools for gathering intelligence about the future (horizon scanning, interviewing to elicit key issues, Delphi consultation); (ii) tools for exploring the dynamics of change (driver mapping, axes of uncertainty); (iii) tools for describing what the future might look like (scenarios, visioning, SWOT analysis); and (iv) tools for developing and testing policy and strategy (policy stress-testing, backcasting, roadmapping). The Transport Futures programme is supported by Mott MacDonald and its partners. Emulating the Futures Toolkit, Mott MacDonald in partnership with the University of the West of England, has developed a publicly available six-stage approach (see Box 3) for vision-led strategy planning for an uncertain world called FUTURES (Future Uncertainty Toolkit for Understanding and Responding to an Evolving Society).⁸ This is tailored to strategic transport planning based upon the decide and provide paradigm.

As with orthodox analysis techniques in transport planning, there are multiple methods and variations of approach to planning for an uncertain future, allowing a tailoring to the case in question. Visioning and backcasting represent a complementary methodology (e.g. Hickman and Banister, 2007). This involves identifying a future state, and then, in turn, examining the content and sequencing of policies and investments that are needed to transition from the present state to the desired future state (see also the previous section). A particularly effective futures approach is called “Three Horizons” (Curry and Hodgson, 2008: 3). This allows an examination of what is involved in moving from the present to a plausible or preferred future state. The first horizon refers to the dominant world of today, which, in the face of transition would diminish in dominance moving into the future. The third horizon reflects how a future world emerges, from glimpses of the future as seen from the present to gradually becoming a new dominant trend in the future. The second horizon is “an intermediate space in which the first and third horizons collide...a space of transition which is typically unstable” (Curry and Hodgson, 2008: 3). The method encourages consideration of the obstacles, risks and opportunities faced in the medium term.

As has been seen earlier, the strategic case is an important precursor to the economic case being made for a transport scheme or proposal. The economic case points to a need for quantitative methods to be able to weigh up costs and benefits and to judge risk. The strategic case, meanwhile, involves a need for a more participatory approach involving qualitative methods. Qualitative and quantitative methods can be used in combination.

A more detailed explanation is offered below of how, in support of strategy development, scenarios can be created and then used in an explorative way to build confidence in determining a way forward that is resilient to the unknown. This more detailed insight is not intended to imply other approaches should not be considered; rather, it seeks to give an insight into one way that new thinking in transport planning can be turned into practice.

Scenarios

A scenario can be considered as a future state – determined or characterised by how relevant variables have changed over time (see the previous section for distinctions between predictive, explorative and normative scenarios). A scenario may be a preferred future state (vision) or a plausible future state (reflective of exogenous change). Scenarios can be narrative- or numbers-based, or a combination of both.

For strategic transport planning against a backdrop of deep uncertainty, an important role for scenarios is as a means to explore this uncertainty. Simply put, scenarios make you think. Typically, generating scenarios (which tends to be participatory and involving key actors who stand to benefit from the co-production process) involves the following steps:

1. Identifying the focal question – an expression of the focus or purpose that the scenarios are intended to help address.
2. Identifying drivers of change – variables (nouns) that could influence the future and are pertinent to the focal question. Drivers are identified using the PESTLE approach across the following categories: political, economic, social, technological, legal and environmental.
3. Mapping the drivers of change – drivers are considered and sorted according to their relative importance to the focal question (policy area) and relative uncertainty of their future projection.
4. Selecting critical uncertainties – based upon the driver mapping, the most important and most uncertain variables (which may be proxies for one or more drivers) are identified. Variable selection should be mindful of avoiding highly correlated (overlapping) variables and should favour those which are more orthogonal (statistically independent) from one another.
5. Selecting scenario wireframes – each critical uncertainty is assigned two or more future projections (e.g. high, medium or low). Consistency analysis examines the credibility of different combinations of projections coexisting. Within the subset of credible combinations, a small number of combinations of projections for the set of critical uncertainties are selected. Each combination constitutes an outline depiction of a scenario. It is typical to identify three to five combinations – sufficient in number to expose uncertainty and depict divergent plausible future states, but few enough to avoid cognitive overload in their subsequent use (although higher numbers of scenarios can be considered, as described later for Transport Scotland).
6. Developing scenario narratives – using each wireframe as a basis, a storyline is developed (potentially also using other drivers of change) which paints a picture of the future in question and helps assure its sense of plausibility. The aim is to bring the scenario to life in a way that helps those using the scenarios to strongly engage in thinking about the future in relation to the policy area of concern. Each scenario is also given a short, distinctive and memorable name to aid recall and engagement.

Stress testing

A set of narrative scenarios can be used to improve the resilience of decision making by considering how different policies may perform in terms of yield (achieving effects aligned to the vision) versus risk (the possibility that uncertain future circumstances could cause a policy to fail or produce effects that are misaligned with the vision). The process of stress-testing should ideally be participatory, involving key policy-making actors. It is an important opportunity to probe each candidate policy, and thereby inform the wider policy-making process. While the exercise is not intended to be reduced to numerical scoring and ranking, the stress-testing is framed by rating a policy on a three-point (-1, 0, +1) or five-point (-2, -1, 0, +1, +2) scale in terms of its alignment or misalignment (see Figure 16). How a policy option is scored across scenarios helps provide an indication of how to proceed, for example:

- Positive in all scenarios – proceed as planned (policy option A in Figure 16).
- Positive in more scenarios than not – proceed, but monitor and develop options for potentially opting out (policy option D in Figure 16).
- Negative in more scenarios than not – do not proceed initially, but monitor ensuring means for opting in have been identified (policy option B in Figure 16).
- Negative in all scenarios – rethink the option (policy option C in Figure 16).

Figure 16. Stress-testing policy options against uncertainty

		plausible future scenarios				
		1	2	3	4	5
candidate policy option	A	✓	✓	✓	✓	?
	B	✗	✗	?	✓	✗
	C	✗	✗	✗	?	?
	D	✓	?	✓	✓	✗

- ✓ good alignment
- ? possible/partial alignment
- ✗ poor alignment

Source: based on Lyons et al. (2018).

Reflective of this approach, the UK DfT (see case study above) has developed its own set of common analytical scenarios – quantitative scenarios (do-nothing or do the minimum), against which a (major) scheme proposal (do something) can be tested to determine whether, and to what extent, the value for money of an investment changes in terms of the economic case.

State of practice in handling uncertainty

Strategic transport planning has been evolving for decades both nationally and internationally, and this continues to be the case. If such evolution is becoming more strongly characterised as transition, what can be said of the state of practice among different countries? What sorts of niche developments are taking place that may symbolise a destabilising of the incumbent predict and provide regime? How widespread are such niche developments? There are unprecedented global circumstances, notwithstanding that different countries have different backdrops in terms of their economies, transport systems and societies. The need to tackle climate change is becoming paramount and the digital age continues to evolve and influence the functioning of societies. The Covid-19 pandemic has provided a global shock in which norms of behaviour have been interrupted and potentially irrevocably altered. Such circumstances might strongly suggest a mounting need for a transition in strategic transport planning, but change is likely to involve a diffusion of new thinking and new practice. Indeed, inspired by diffusion of innovations theory it might be prudent to ask if innovators are being followed by early adopters, and in turn the early majority, late majority and laggards.

Niche developments in the United Kingdom

Building upon the earlier case-study focus, there are indications of change in transport planning at a national, regional and local level in the United Kingdom. Three examples are given below.

Transport Scotland is the national transport agency responsible for delivering the Scottish Government's vision for transport. Following a comprehensive review of its 2006 National Transport Strategy, in February 2020 it published its new National Transport Strategy (Transport Scotland, 2020a). Inspired by the work in

New Zealand described earlier, a scenario planning tool and process were developed to help ensure that the vision-led strategy was created in a way that would be able to accommodate deep uncertainty (Lyons et al., 2018; Ruscoe et al., 2019). The tool draws upon national transport and land-use models while providing significantly shorter run times. It consists of an elasticity-based spreadsheet model able to examine different combinations of input variables and produce over 40 different output metrics relating to the outcomes-focus of the strategy development. A shortlisted set of eight scenarios were identified and used, both in narrative and numerical form, to examine how different policy options could play out in terms of their effect on output metrics and specified outcomes. The model inputs were used to represent the eight “do nothing” scenarios (plausible future inputs) and in turn adjusted to reflect “do something” scenarios with the introduction of policy options (enabler inputs). Having decided on preferred future outcomes, Transport Scotland’s delivery plan for its strategy (Transport Scotland, 2020b) maps out commitments and actions it will be taking to work towards achieving its outcomes. It has, for example, made a pledge to “work across government to develop a coordinated package of policy interventions to reduce car kilometres [compared to pre-pandemic levels] by 20% by 2030” (Transport Scotland, 2020b: 11).

At a regional level, Transport for the North (TfN) is the United Kingdom’s first sub-national transport body, bringing together 20 local transport authorities, other transport agencies and businesses across the North of England. It has adopted a decide and provide approach to its strategic transport planning (TfN, 2020), in which scenario planning is being used to address uncertainty and improve the resilience of its decision making and investment plans to deliver its vision for the future. “Our new Future Travel Scenarios represent strategic factors that are external to our direct control and are used as “reference case” scenarios to test the performance of different strategies and policies against our objectives” (TfN, 2020: 6). Mention of control is significant, and a distinction between control, influence and concern in shaping the future is made in both the previous section and (as it relates to matters of governance) in the next section. TfN has identified that the four scenarios for 2050 will be used to: communicate the approach to uncertainty being taken; test plans under TfN’s investment programme; help refine the vision of TfN and its partners; and help improve understanding of policy interactions. As with Transport Scotland, TfN is making use of scenarios in both narrative and numerical forms to support its strategic transport planning and business case development.

In the United Kingdom, transport assessments are prepared for proposed new developments and scrutinised at a local level. A transport assessment sets out in detail the transport implications of the development concerned. TRICS is an evidence base containing over 7 000 transport surveys spanning some 30 years and covering different types of development sites and is “an integral and essential part of the Transport Assessment process”.⁹ The way TRICS has been used by practitioners to date fits with the predict and provide paradigm. Historic data on trip rates (especially car trips) for similar types of development to the one being proposed have strongly dictated the determination of the projected trip rate for the new development (with little or no account taken of the influence on trip rate of settlement design). However, in February 2021, a new guidance note was published setting out how TRICS can be used to take a decide and provide approach to development planning and the assessment of transport implications (TRICS, 2021). In this approach, the TRICS database is examined to identify changes over time in trip rates for settlements of the type being proposed. This trend insight is combined with insight from national transport scenarios to depict how car trip rates could change in the future. The intended effects of settlement design on access to and from the site are then also considered in producing a vision-based (supply-led) projection of future car trip rate as part of the transport assessment. However, TRICS is a historic database depicting the past not the future. Either approach using TRICS is subjective – the past and the future can be interpreted differently. Any attempt to project future trip rates is a matter of

judgement. Although the decide and provide approach may be subject to challenge, it casts doubt over the veracity and suitability of the predict and provide approach and can be seen as the preferable approach moving forwards.

Signs of change internationally

In preparation for this publication, ITF country representatives were invited to respond to a question regarding the state of thinking and practice in their country's strategic transport planning in the face of uncertainty and changing travel trends (see Box 4). It is unreasonable to expect clear-cut answers to such a question. However, the purpose of posing the question was to encourage reflection and invite elaborated feedback to help assess the state of play. Eight countries provided responses and these are considered below.

Box 4. Question posed to International Transport Forum country representatives

Which of the following best reflects the current situation in your country regarding strategic transport planning in the face of uncertainty and changing travel trends?

1. Business as usual – there is little or no recognised need to change from long-established practices (e.g. forecasting with a central projection and sensitivity analysis).
2. Awareness – there is some awareness of change and deep uncertainty and the implications for established practices.
3. Need for change – there is significant or growing awareness of change and deep uncertainty and the need to change practices.
4. Changing practice – awareness of change and deep uncertainty is resulting in changes taking place to long-established practices.

Detail of the United Kingdom's response is largely reflected in the preceding part of this section. There is mixed awareness of the need to change transport planning practice. Some areas of the United Kingdom transport planning community are already changing practice with, for example, widening use of scenarios in the way described earlier. For larger scheme proposals the need to move away from a reliance on forecasting with a central projection is being embraced. There is recognition of a need to take a proportionate approach – smaller schemes may not warrant such close scrutiny in terms of uncertainty analysis. The UK DfT intends to maintain and update the evidence base on changing travel trends over time, and continue its social research into understanding changing travel behaviour and wider trends.

Chile is experiencing recognition of the need for change in strategic transport planning practice. Only with major infrastructure projects is the need for change starting to translate into changing practice (prompted especially by changes in travel trends associated with the Covid-19 pandemic). Consideration is being given to rethinking assumptions about future trajectories of change. However, the implication of more analysis associated with explorative rather than predictive questions is a concern for planning agencies with limited budgets.

With regard to Germany, recognition is needed of the heterogeneity of thinking and approach within a federal system. Overall, it is suggested that need for change best describes the state of thinking and practice. Some cities and their authorities may remain in a mode of "business as usual" while others are confronting the need to address the climate crisis by shaping the future – being vision-led and then

backcasting to identify steps towards realising these visions. There is a sense that attitudes are shifting ever more towards changing practice, especially in recent times.

Mexico, as with other countries, is experiencing the consequences of social distancing, which include public transport becoming less attractive relative to private transport, and which is at odds with urban development goals. A need for change is recognised when planning for the future. Sweden, likewise, is experiencing a sense of deep uncertainty with a recognised need for change. This is also true for Poland, where there is recognition of the (growing) importance of qualitative insight in the face of the limitations of quantitative modelling in dealing with changing trends. This, to some extent, aligns with the current emphasis on Polish sustainable urban mobility plans (SUMP) which represent a shift from forecast-led planning to vision-led planning with citizens placed at the heart of the plans.

Strategic transport planning in Turkey, meanwhile, is seen to rest somewhere between an awareness of change and uncertainty in travel trends, and a need for change in transport planning practice. The Turkish government is, nevertheless, in the process of changing its national-level transport planning approach in light of the Covid-19 pandemic and is being prompted to consider potential future shocks.

The Netherlands noted that need for change and change itself rather depend upon the “business as usual” position against which these situations are considered, alongside a need to appreciate differences according to geography and scale (from national to regional to local). Accordingly, the current state of play for the Netherlands in relation to the question in Box 4 is hard to establish. Using time horizons of 2030 and 2050, the Netherlands’ approach is to have a high and low scenario (in relation to economic growth) against which to consider policy interventions.

A substantial challenge is faced currently in all nations. There is, or may be, a recognised need for change in transport planning practice, and indeed this need has been heightened by the pandemic. However, a deeper examination of this need and the onward effort required to bring about change require time and resources at a point when many countries are struggling to cope with the immediate crisis of Covid-19. Of those countries responding above, there are nevertheless signs of a change in thinking and (at least an intention to address) change in practice (see also the summary of change that has taken place in Finland in the previous section). The responses also illustrate the environment in which change will need to take place, involving different spatial scales and jurisdictions and in turn matters of governance (addressed in the following section). Knowledge sharing between and even within countries may be important, but where change in attitudes or practice is taking place, this is not necessarily captured in a more widely accessible form, either because of the language of published material or because the nature of work in progress means that written accounts are unavailable. Such challenges may be best addressed by furtherance of the dialogue generated by the working group behind this report with a widened participation.

Looking to the future

This section has highlighted how change in transport and society (as discussed in more detail in “Trend breaks and travel transitions”) may amount to a fundamental regime transition taking place and is creating a sense of deep uncertainty about the future. It has been shown how this is proving problematic to orthodox strategic transport planning. A mounting case for a significant evolution, or even regime transition, in the paradigm of strategic transport planning and the tools and techniques of analysis employed to support decision makers has been outlined. Insights into such tools and techniques – in particular scenario planning and stress-testing – have been provided. Examples have been given of how a new decide and provide approach to strategic transport planning is emerging, which is both vision-led and

able to better account for deep uncertainty. There are signs of changes in thinking and, in some cases, changes in practice across several countries, suggestive of a process of change (and maybe even a transition) being underway. In relation to an access rather than a mobility focus to strategic transport planning, a new three-year pan-European practice-facing research project (led by the University of the West of England) began in May 2021 called “Triple Access Planning for Uncertain Futures”.¹⁰ This case-study based project will be seeking to advance guidance on urban mobility planning to better account for deep uncertainty and take more consideration of the tripartite nature of access in society.

This section has highlighted the significant uncertainty in strategic transport planning that decision makers will face in the years ahead. If there is to be confidence in dealing with uncertainty going forwards, then it will be necessary to learn from and build upon the practical examples currently emerging of how a new approach to strategic transport planning can be undertaken.

It is advisable to foster a strengthening of international knowledge sharing and co-operation in a “learning by doing” approach to handling uncertainty and developing more resilient, and ultimately more effective, decision making. This is not an easy path to tread, as has already been shown and as will be further considered in the next section. A new way of thinking is called for and new skills will need to be developed within, or brought into, the transport sector to help take advantage of, and tailor, the sorts of methods that are available and already being used successfully in other sectors. At a more detailed level, it is necessary to reinterpret notions and norms of analytical robustness within strategic transport planning. It can be said that it is better to be approximately right than precisely wrong. We make light of deep uncertainty, and the opportunity it invites to more strongly shape the future, at our potential peril.

Governance challenges and opportunities

The current state of deep uncertainty and climate emergency puts pressure on existing transport governance to evolve. This section is inspired by an institutional understanding of transport governance. In general terms, governance is defined as “practices through which societies are governed” (Lange et al., 2013: 406). Consequently, transport governance relates to societal efforts to steer and co-ordinate the transport sector. Organisations are the bodies through which decisions are enacted and institutions are the social structures, rules, processes and practices which explain how things work in practice and how governance processes are carried out (Scott, 2008).

This section discusses key challenges and opportunities facing contemporary transport governance and provides ideas on how practices could be developed to become better equipped to face and accommodate transformation and uncertainty. The section is based upon a review of some of the most well-known challenges related to transport governance, and this is used as a starting point for discussing key insights from previous research on ways to overcome these challenges. Specific attention is given to the concept of transformative capacity as a way to identify and explore different types of actions and ways of working that can strengthen the capacity of governance actors to initiate and steer systemic change. The final part of the section brings together insights from a case study on building transformative capacity in practice. The section closes with a discussion on the key issues for the further development of transport governance in a changing world.

Key challenges for contemporary transport governance

It is first necessary to establish the key challenges facing contemporary transport governance. Let’s start by considering some of the key features of transport and travel behaviour developments. The “Trend breaks and travel transitions” section introduced travel behaviour as an outcome of a complex set of factors, such as the wider socio-economic system, people’s attitudes and lifestyle choices, activities, habits, practices and preferences, as well as the transport and telecommunications options available to them. The Triple Access System (TAS) (Lyons and Davidson, 2016) introduced in the previous section also illustrates how mobility and access is influenced by land use and digital connectivity. In other words, the current uncertainty regarding travel trends and mobility behaviour is also deeply linked to changes in other sectors (ITF, 2020).

In most countries, there are specific organisations clearly tasked to govern or steer transport per se, for instance with responsibility for planning and maintaining transport infrastructure, keeping track of transport developments, managing issues related to road safety, cycling, walking, etc. However, the multiple outside influences on travel behaviour strongly suggest that transport governance needs to go beyond transport-oriented organisations and include, for instance, other organisations tasked with land-use planning, economic development, housing, digital infrastructures and the organisation of education and work. In practice, this has proven difficult. In most countries, governments are structured so that there are specific organisations with clearly designated tasks to govern transport, with specialisms relating to

the distinct engineering, regulatory, market and social issues historically linked with different modes of transport (Gudmundsson et al., 2016). Integration across modes within the transport sector can sometimes be challenging and even more so when looking outside of the traditional narrow field of transport (Stead, 2008).

Multi-tiered transport governance with several modes in focus

When it comes to specific governance arrangements, there are variations among different countries, but also some generic characteristics which can be considered. The first of these relates to the number of levels of government which are significantly involved with transport. Looking into transport governance in different countries around the world there is a recurring structure of three broad tiers from national, through state or regional to local government (Barfod et al., 2018; Halpern and Le Galès, 2016; Low et al., 2003; Tønnesen et al., 2019; Ramani et al., 2018; Prasad et al., 2021). The importance of each level depends on constitutional traditions, but generally speaking democratically elected bodies with tax-raising powers have the most influence on spending and subsidy in the transport sector. These same bodies are therefore more likely to be involved in shaping the rules for how transport planning and decision making are conducted. There are also important questions of co-ordination across different scales that can dictate where the balance of decision-making powers sit; for example, international aviation, ports policy and long-distance networks are often steered by national or international actors. The national policy level is, in many cases, also responsible for traffic regulations and standards for traffic safety and road quality, where divergence would create operational challenges.

At the same time, the local and regional planning levels are important from the perspective of long-term transport developments. Stakeholders at these levels control land-use developments including regional and local transport infrastructure, are responsible for planning and procuring public transport, manage road networks and parking, and are in immediate contact with residents, local and regional industry and other employers. A further important distinction between national and local government is that while national governments tend to organise policy production around departmental and modal siloes, this is less true in local and regional bodies. While policy siloes do still exist, local areas are the point at which the actions of siloes manifest themselves and the benefits of integration are realised. Local bodies tend to be more acclimatised to cross-silo and partnership working to tackle complex issues (Holman, 2013).

Organisational structures and institutional traditions are important for how travel demand is incorporated in governance practices. Each level of government and each organisation or modal interest group within it may have a different view on the future of travel demand, informed by its own traditions and markets (e.g. aviation forecasting and road traffic forecasting are very different). The purposes of making demand forecasts or more explorative types of foresight might be different, for example, to motivate the allocation of scarce funding, to make the case for greater funding for growth or to manage the additional costs incurred in working towards climate goals. Public authorities at different administrative levels might also want to use future scenarios in different ways – at the national level, this might be with the aim of identifying average trends, while local authorities might be more interested in exploring and testing emerging trends locally (ITF, 2020). Uncertainty will be important for all of the different examples of forecasting and foresight, but the purpose and manner of recognising uncertainty and the use made of the outcomes will vary, even within a given national policy system.

While it is important to acknowledge these differences as part of any case for change, it is typically the case that transport modelling, economic appraisal and sustainability assessments are key responsibilities for national transport organisations and that these practices cascade down through other tiers. In relation to economic appraisal, there are also many similarities across countries. As an example, an international

comparison of transport appraisal practice by Mackie and Worsley (2013) concluded that the economic welfare framework of cost-benefit analysis (CBA) is today the most common appraisal method in Australia, England, Germany, the Netherlands, New Zealand, Sweden and the United States. The results of the comparison concluded that there are some variations in the values, emphasis and context of transport appraisal policy in different countries, but altogether they find the similarities to outweigh the differences (ibid.).

The multifaceted character and the level of fragmentation and split responsibilities highlighted in this section place high demands on collaboration and co-ordination among different types of organisations (Gudmundsson et al., 2016; Hrelja et al., 2017). These various forms of fragmentation constitute challenges for acting and responding to travel transitions and uncertainty. For instance, even though issues of changing travel behaviour and demand management may be recognised within specific organisations, sector-specific responsibilities or modal divisions may inhibit the integrated understanding of societal change. Moreover, even though individuals or individual organisations may acquire new knowledge and identify the need for change, when it comes to strategic transport governance, they cannot change the system as a whole, nor the agency of other organisations. It has long been recognised that more highly technical disciplines, such as transport, prove especially resistant to changing practices (Hall, 1993; Geels, 2011) and so the challenge of implementing new solutions or perspectives requires consideration, not just of what needs to be changed, but how processes will be done differently.

Norms, knowledge perspectives and incentive structures

Other challenges relate to normative and cultural-cognitive elements that permeate and impact the structure of transport governance. Previous research has highlighted how different actors and organisations involved in transport governance and planning hold different norms and knowledge perspectives (Hull, 2008; Thoresson, 2011; Vigar, 2017). Specifically, national transport governance is commonly characterised by perspectives from economics and engineering, predominantly based upon ideas of technical and economic rationality, relying on conventional modelling and traffic forecasts (Lyons and Marsden, 2019; Thoresson, 2011; Witzell, 2021) and in essence supporting and reproducing the established regime of transport planning (Lyons and Davidson, 2016). There is often an awareness at the national level of other possible ways to analyse future demand, for instance by using different kinds of scenario techniques that encourage a more integrated approach to uncertainty (Witzell 2019, c.f. Lyons and Marsden, 2019), however, these have only had limited influence in practice (Marsden and McDonald, 2019; Witzell, 2020). While it is well known that conventional transport models and forecasts have several limitations, they still have a powerful position as the “standard approach” for assessing future developments (Lyons and Marsden, 2019; Witzell, 2020).

At the same time, local and regional transport governance is often characterised by a more multi-faceted understanding of links and relations between land use, activity patterns and travel behaviour (Hull, 2008). There is also evidence that local policy and planning often have direct experience of disruptive events that could be used as an input to strategic transport governance (Marsden et al., 2020). However, the differences in knowledge perspectives, professional cultures and working methods among different organisations and administrative levels often generate tensions that hamper the development of a more integrated and comprehensive approach to transport governance. In practice, the strong reliance on conventional transport models and the (false) perceptions of the precision they generate tend to prevent other, more transformative or explorative approaches from being developed and applied (Witzell, 2020; 2021).

These types of challenges are related to a theme that has already been discussed in research on environmental policy integration, namely the resistance or lack of incentives to develop new approaches and ways of working within an established institutional context (Storbjörk and Isaksson, 2013). In practice, there may be professional norms and incentive structures (for instance, related to career pathways) that make it less attractive or feasible to develop and integrate new perspectives, new knowledge and different ways of working.

Power relations and conflicting goals

Another significant challenge for transport governance relates to established power structures in the transport sector and the controversial political issues that often surround transport transformations. Previous studies have discussed how transport policy and planning treat car-based mobility as the natural state of affairs and this makes it more difficult to challenge. Part of the explanation relates to prevailing assumptions regarding the link between transport infrastructure and economic development (Mattioli et al., 2020). As illustrated in Figure 10 in the previous section, there is evidence of a gradual decoupling of this relationship, which has been underway for a number of years; however, policies and strategies for sustainable mobility are still understood as counteracting ambitions for economic growth (Marsden et al., 2014; Hrelja et al., 2015). Previous studies have discussed how such goals and strategies are therefore often added on as another layer to existing policies, plans and frameworks, but without changing the underlying assumptions of ever-increasing transport demand (Hrelja et al., 2015; Isaksson, Antonson and Eriksson, 2017). As stated by Marsden and McDonald (2019), imagining different demand futures is challenging in political environments where new infrastructure is understood to be “an essential part of future productivity growth” (p. 1 085). Along similar lines, Bertolini (2020) discusses difficulties in implementing policies for sustainable mobility in practice and concludes that there is a need to question the underlying relationships between economic growth and mobility growth, and to explore other possible mobility futures by means of more “radical” imagination and experimentation (Bertolini, 2020; c.f. Isaksson, 2014).

While such arguments remain difficult, or even controversial for governments, it is important to observe that different countries and cities have achieved economic growth with very different levels of reliance on motorised traffic growth. As demonstrated by Rode et al. (2014), cities where the built environment and the transport system together provide efficient access, and where services and goods are available without having to travel long distances, often experience economic benefits through economies of scale and agglomeration effects. Embracing uncertainty necessitates an open attitude to different pathways of development emerging.

Making transport governance more transformative

Clearly, there are several challenges that need to be considered when developing transport governance to accommodate uncertainty while also contributing to the transformation of transport systems towards sustainability goals. Several of these challenges are deeply embedded in formal and informal social structures which permeate contemporary transport planning. A key question is therefore how barriers to change can be overcome – is it even possible, within the framework of an existing system of transport governance? In this section, it is argued that there are possibilities to develop existing transport governance by increasing the capacity to accommodate uncertainty and transformation.

The need to move from recognition to action

Factors culminating in resistance to change are well recognised throughout society and institutions, both within and beyond the transport sector. The challenges listed in the section above are not new – problems related to fragmentation, silo thinking, resistance to ambitions regarding climate and environmental policy integration have been discussed in international literature for more than three decades. Many studies have pointed out the need for more integrated approaches with closer links between land use and transport planning (May, 1991; May and Roberts, 1995; Geerlings and Stead, 2002; Tornberg, 2011) and a closer consideration of, for instance, how the built environment, including access to sustainable transport and local services, affects travel demand (Ewing and Cervero, 2010). Research initiatives and other forms of development projects have tried to bridge existing gaps between different organisations and create more integrated ways of thinking and working in transport governance (Hull, 2005; 2008). When it comes to the need to consider climate, the environment and other sustainability issues in transport planning (and other plans and programmes), new environmental regulations have been put in place within OECD contexts (Fundingsland Tetlow and Hanusch, 2012). Notwithstanding this, the basic rationale of transport planning and decision making, the conventional approach, has remained strong in practice (Tennøy, 2010; Rye, 2020; Witzell, 2021), and the regime transition that this report focuses on remains to be deployed in any significant manner. However, it should also be recognised that there are some clear signs of change. The responses to the ITF survey that were presented in the previous section are one such sign, indicating an awareness of the need to change, and in some cases, evidence of initial steps taken to initiate transition.

It then becomes a question of how to move beyond simply recognising that there is greater uncertainty and a need to transform planning practice, to actually incorporating that uncertainty into contemporary transport planning? As this report suggests, the point has been reached whereby adjustment of existing analytical processes is no longer sufficient to provide decision makers with a robust basis on which to base decisions. Therefore, as well as focusing on the need for improved tools and assessment practices, the focus should also be on creating capacities to change.

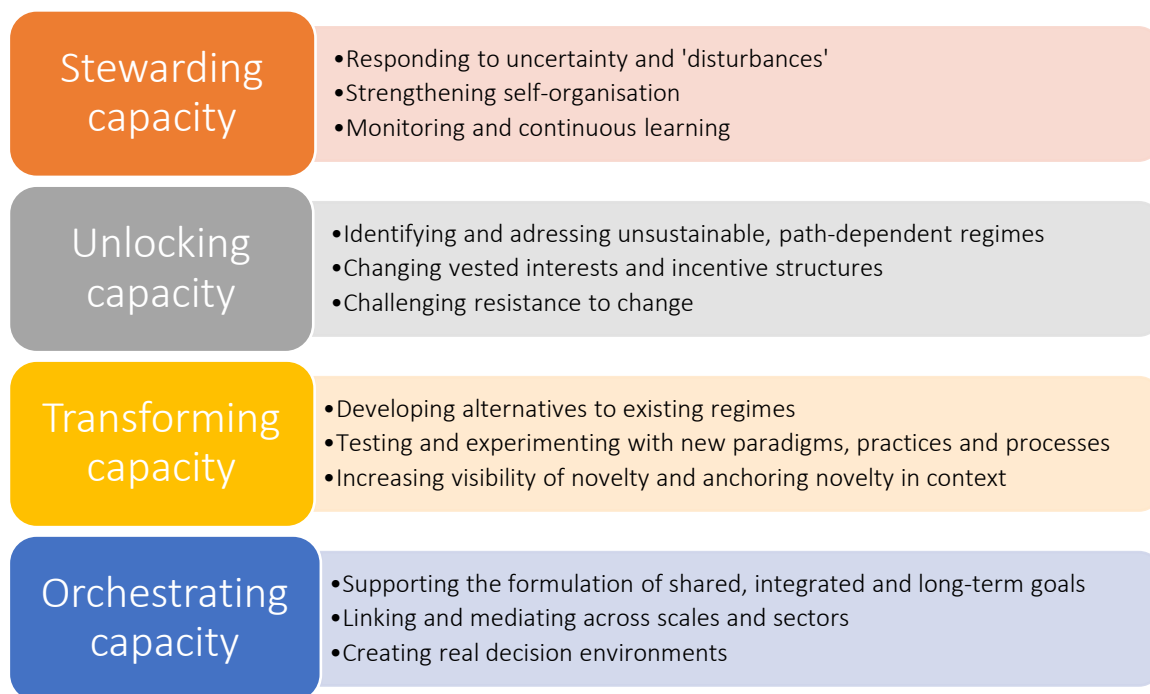
Capacities to transform

The types of governance challenges that characterise strategic transport planning are not unique to this sector of society. Research on sustainability transitions and urban climate governance has, over the past five to ten years, drawn attention to similar types of challenges in other sectors as well. This has generated an emerging field of research that discusses the need to make governance more targeted at transformative action and at initiating and supporting regime shifts. The concept of “transformative capacity” (Wolfram, 2016), has evolved into a framework for identifying and analysing actions and ways of working. This can include specific qualities, such as creating an open atmosphere with spaces for learning and collaboration that can improve the capability of governance actors to initiate and steer systemic change towards sustainable development, even under conditions of political contestation and uncertainty (Hölscher, Frantzeskaki and Loorbach, 2019, Broto et al., 2019). Researchers within this field have reviewed previous research on urban climate governance, transition management, sustainability transitions, meta-governance and other related fields, and suggest the following four different types of capacity necessary to address transformation dynamics: 1) stewarding capacity; 2) unlocking capacity; 3) transformative capacity; and 4) orchestrating capacity (Hölscher, Frantzeskaki and Loorbach, 2019; Hölscher et al., 2019). Transferred into the context of transport governance, these capacities, which are illustrated further in Figure 17, can be understood as:

1. Stewarding capacity is the capacity to anticipate and actively respond to uncertainty and “disturbances” in the existing transport planning regime while exploiting relevant opportunities

for transforming towards a more sustainable development path. This capacity builds on strengthened self-organisation, monitoring and continuous learning to adapt existing norms of how things should be understood and assessed. This includes the integration of different forms or sources of knowledge, identifying and communicating sources of uncertainty, as well as ensuring inclusive dialogue (Hölscher, Frantzeskaki and Loorbach, 2019). For transport governance, this would mean acting on the recommendations put forward in this report, namely focusing more on the current state of flux in the transport sector, seeking to understand how things might unfold in the future and doing so in a way which allows several actors with different perspectives to contribute. This would be an expansion of existing practice with a greater focus on income, costs and user preferences as reasons and drivers of change.

2. Unlocking capacity is related to the active destabilisation of unsustainable, path-dependent regimes. This capacity builds on the ability to recognise and undermine vested interests and incentive structures, for instance by breaking up existing networks of actors and addressing resistance to change (ibid.). This might mean reversing long-held fossil fuel-related subsidies, or questioning the norms, perspectives and institutional frameworks that reproduce land-use patterns promoting car dependence. In the context of transport governance, this is of specific importance because any change to decision-making processes will impact on streams of investment and where funds are ultimately spent. Changes will also affect established norms, perspectives, networks and hierarchies within planning organisations.
3. Transformative capacity builds on the acknowledgement that efforts to overcome unsustainable trajectories will require the development of radical alternatives to the current method of operating (ibid., with reference to others e.g. Kivimaa et al., 2017). This includes developing, testing and experimenting with new paradigms, practices and processes, while supporting and creating informal and heterogeneous (shadow) networks. Another key condition relates to increasing visibility of novelty and anchoring novelty in context (Hölscher, Frantzeskaki and Loorbach, 2019). This means building real assessment tools that treat uncertainty as central to the process of decision making and not just as a sensitivity test to the existing paradigm, as well as developing policy processes with specific focus on reaching sustainable development and climate mitigation goals.
4. Orchestrating capacity refers to the ability to co-ordinate multi-actor processes, in addition to fostering synergies across scales and among different sectors and actors. This requires the definition of a shared, long-term and integrative strategic direction, as well as a sense of a stronger ownership over strategic directions, for instance by engaging heterogeneous networks. This also depends on the creation of opportunity contexts, for instance by linking strategic direction to ongoing processes within existing governance and planning practice (ibid.). The implications for transport governance may well vary between countries, the specific institutional arrangements and policy conditions at hand. However, to truly make progress decision makers must not conflate uncertainty with ignorance, but rather work together to build a consensus to try to understand uncertainty and to take decisions that incorporate a wider range of interested and relevant stakeholders.

Figure 17. The transformative capacity framework

Source: adapted from Hölscher et al. (2019: 846).

The capacity framework offers a helpful way of looking at the well-known challenges in contemporary transport governance. There is significant inertia in changing transport governance, not only in relation to the formal structures that exist but also with regard to the norms, perspectives and professional practices that underpin transport planning in practice. There are substantial vested interests in maintaining the status quo. So, while this report has made the case for incorporating uncertainty into the decision-making process in new ways, this does not necessarily mean this will happen in practice nor gain momentum in every organisation. For transport planning to transform there are several elements of professional and political practice that need to change and develop, and which are addressed by the four capacities above. In other words, there is a need for transport governance with a stronger emphasis on explicitly managing and supporting change as a process and which addresses these issues head on, otherwise despite current efforts, transport governance may well revert to the status quo, as has happened after so many other calls for change.

Transformative capacity in practice

There are already examples of innovative governance initiatives and other types of change in strategic transport planning occurring in various settings. In this section, consideration is given to a recent case study of strategic transport planning that involves such strategic and innovative responses, and which demonstrates how the capacities can play out in practice. The case study selected is the Swedish government commission for a transformation to a fossil-free transport system, which was carried out between 2016 and 2020.

The Swedish government commission for a transformation to a fossil-free transport system

In December 2015, the Swedish government gave an instruction to Energimyndigheten (the Swedish Energy Agency [SEA]) to initiate and lead a four-year commission to co-ordinate a transformation of the transport sector to become fossil-free (Swedish Government, 2015). The background to the governments' instruction was a new situation of uncertainty where new, stricter, climate policy goals for the Swedish transport sector were set. These goals were expected to have a large impact on transport policy and planning, and Swedish policy actors saw the need for a focused report to establish ways in which these goals could be met.

According to the governments' instruction, five additional public agencies with mandates related to the development of the transport system should assist the SEA in the work, including Boverket (the National Board of Housing and Planning) and Naturvårdsverket (the Swedish Environmental Protection Agency). The instruction stressed the importance of carrying out dialogues with relevant actors, preparing a strategic plan, co-ordinating activities and striving for synergies with other relevant processes. Beyond that, however, the task was formulated openly and allowed the SEA to design the process in a flexible way, as they deemed appropriate. This is a clear example of orchestrating capacity by the Swedish government.

The government's commission to the SEA has been analysed in detail by Witzell et al. (n.d.), with a focus on transformative capacity. Witzell et al. (n.d.) conclude that the government instruction to the SEA should be understood as an act of stewarding, i.e. an active response to the uncertainty that was anticipated to follow from the stricter climate targets introduced for the transport sector. Stewarding was also seen in the way in which the SEA responded to the task, not the least the way in which they designed an inclusive process where several actors and sector perspectives were encouraged to collaborate and learn from each other. Of specific importance was that neither the government nor the SEA project leadership team set any restrictions or attempts to narrow the scope of the work at the initial stage (ibid.).

This process also showed evidence of unlocking capacity, i.e. the active destabilisation of a path-dependent regime. For instance, the organisations involved started their work by carrying out a joint analysis of the current state of the transport system and transport policy, including an in-depth discussion of key barriers to transformation. Another aspect of unlocking was the way in which the organisations came to agree on key principles for the transformative process; for instance, they agreed not to allow measures that risked counteracting climate goals (ibid.).

Transformative capacity was also seen in this case study, most notably in the way in which the process led to an acknowledgement among the organisations involved that conventional CBA is not suitable for analysing broad societal transformations and is thus not suitable for the identification and selection of measures for reducing travel. The commission developed a novel approach with an emphasis on "impact chains" (instead of trying to define isolated effects), and an analytical approach with a focus on sustained monitoring and evaluation of the direction of development, instead of aiming for very precisely measured impact targets. The commission also discussed the need for a broader set of future scenarios to guide the continued work.

Overall, there were many signs of transformation in this process. However, as with other experiences, the commission did not develop into a fully transformative trajectory. Witzell et al. (n.d.) note that while the process opened up more pragmatic assessment practices and a stronger emphasis on uncertainty and transformative agendas, conventional path dependencies were still at play. When the commission presented the final results of their work to the government in April 2020, the government did not follow up with a clear idea of the continued direction for the initiative, nor did they use the results as an input to

other long-term planning commissions, for instance the long-term strategic infrastructure planning process that started just a few months later. It should not, however, be concluded that this was a failed process. Instead, the process illustrates the transformative potential that can be brought forward by encouraging existing actors to explore change and uncertainty and bring together knowledge perspectives from several areas in a long-term and goal-oriented process. Thus, the main lesson to take away from this study relates to the transformative potential that can be created – quite rapidly – when starting to change the way that governments look at problems. However, the approach needs to permeate other processes, rather than existing separately and stand-alone from them; otherwise, the pre-existing routines and practices for decision making will continue to carry on, particularly given the huge inertia that exists in the face of such change.

Transport governance for a changing world

This section began with a review of challenges characterising contemporary transport governance, but the watchword for this final section is opportunity. Indeed, the current situation of uncertainty and flux is an opportunity to actively identify the cracks in the existing regime and actively develop transport governance for a changing world. To make this happen, it will be important to continue to identify and reflect upon the problems and limitations of the conventional methods and techniques for transport modelling, forecasting and evaluation, which were discussed in the previous sections of this report. If these methods and approaches no longer provide a sufficiently adequate and robust basis for long-term plans and decisions, then they need to be changed and complemented or replaced with other methods. It is therefore important to continue to engage and learn about other models, tools and techniques that are more suited to the current state of flux, and especially in relation to the urgent need to transform the transport system in line with long-term goals of climate mitigation and sustainable development.

The ideas and experiences summarised in the “Handling uncertainty in assessing travel transitions” section are intended to provide inspiration for more countries, regions and cities to try new ways of thinking and working in strategic transport planning. However, even though there are opportunities to think and act in new ways, the formal and informal institutional frameworks that condition the development and implementation of new approaches and working methods can restrict progress, at least to some extent. However, the framework of transformative capacity that was introduced in this final section has shown that there can be opportunities to instigate transformation, even within existing institutional contexts. The capacities framework forces attention on how to develop and integrate target-oriented transformative governance processes, even in fragmented institutional contexts which are characterised by established norms and power relations. It is worth noting, however, that the capacities framework is not a ready-made recipe for enacting change. The development of transformative capacity requires adaptation and adjustment to specific contexts, actor constellations and situations at hand, which is also illustrated by the Swedish case study presented in this section.

It is hoped that this report can inspire decision makers, planners, experts and others active in transport governance to continue to reflect upon the planning and decision-making situations they might be involved in or may have the chance to positively influence. It is, therefore, appropriate to end this final section with a call to every reader of this report to think of the first key steps that could be taken, within the specific context in which they are working, to instigate change and develop spaces for transformation and learning. The opportunity to transform transport governance is not determined by having the perfect institutional arrangements, as such a position could never exist. It is, to a large extent, about the willingness and openness to reflect, reconsider, explore and challenge established processes and standard ways of thinking and doing. In line with the suggestions in the previous section, it is important to stress the need

to foster a spirit of “learning by doing” and promote processes of knowledge sharing internationally, as well as in national contexts. A key task for transport governance in a changing world, therefore, is to actively stimulate the development of transformative arenas and processes within existing institutional frameworks. This should be supported with perspectives, methods and ways of working that acknowledge uncertainty and the need for transformation, and which can help decision makers to see that there is not just one but several possible ways forward.

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Annex A. Working Group participants list

Working Group participant affiliations were provided at the time the Urban Travel Transition and New Mobility Behaviors in Light of Covid-19 Working Group meetings took place in December 2020.

Kiron CHATTERJEE (Chair), University of the West of England, Bristol, United Kingdom

Anne AGUILERA, IFSTTAR – LVMT, France

İbrahim AKIN ERBAS, Union of Municipalities of Turkey

Ernest ALBUQUERQUE, New Zealand Transport Agency

Jillian ANABLE, University of Leeds, United Kingdom

Jo BACON, Department for Transport, United Kingdom

Javier BIRRIEZA GALÀN, Nommon Solutions and Technologies, Spain

Bastian CHLOND, University of Karlsruhe, Germany

Barry COLLEARY, National Transport Authority, Ireland

Rodrigo CONTRERAS, Ministry of Transport, Chile

Philippe CRIST, International Transport Forum (ITF),

Ombline DE SAINT LÉON LANGLÈS, ITF

Brittany FARRANT-SMITH, Ministry of Transport, New Zealand

Sandy FONG, Ministry of Transport, New Zealand

Phil GOODWIN, University of the West of England, Bristol / UCL, United Kingdom

Philipp HEINRIGS, OECD

Rodrigo HENRÌQUEZ, Ministry of Transport, Chile

Karolina ISAKSSON, Swedish National Road and Transport Research Institute

Asuka ITO, ITF

Peter JORRITSMA, Kim Netherlands Institute

Rahmi KAMIL GAYDA, Turkish State Railways

Layla KHALAF, ITF

Nicholas KLEIN, Cornell University, United States

Scott LE VINE, State University of New York at New Paltz, United States

Martin LEES, OECD

Iuliana LUPU, European Commission

Glenn LYONS, University of the West of England, Bristol, United Kingdom

Vincent MARCHAU, Radboud Univeristy/STT, Netherlands

Greg MARSDEN, University of Leeds, United Kingdom

Alexandra MILLONING, Centre for Mobility Change, Austria

Stephen PERKINS, ITF

Niccolò PIERI, European Commission

Sofia PIRES BENTO, Mobility and Transport Institute, Portugal

Abel SCHUMMAN, OECD

Marcin ŚWITALA, Road and Bridge Research Institute, Poland

Claire WORDSALL, Department for Transport, United Kingdom

Mehmet YAZICI, Ministry of Transport and Infrastructure, Turkey

Sintija ZIEDONE, Ministry of Transport, Latvia

Koffi ZOUGBEDE, OECD

Travel Transitions

How Transport Planners and Policy Makers Can Respond to Shifting Mobility Trends

Travel behaviour has evolved in unexpected ways in urbanised areas in the early 21st century. This report examines how significant breaks with past trends happened - and why these shifts were not foreseen. The Covid-19 pandemic adds to uncertainty about future demand to travel. Forecast-led transport planning is not well equipped to handle uncertainty. The report presents new approaches which explicitly address uncertainty, are vision-led and enable the development of resilient plans. It also considers how governance and institutions can be adapted to support such a paradigm shift.

International Transport Forum

2 rue André Pascal
F-75775 Paris Cedex 16
+33 (0)1 73 31 25 00
contact@itf-oecd.org
www.itf-oecd.org

