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Time constraints and travel behaviour

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Abstract

Considerable observational evidence indicates that travel time, averaged across a population, is stable at about an hour a day. This implies both an upper and a lower bound to time that can be expended on travel. The upper bound explains the self-limiting nature of road traffic congestion, as well as the difficulty experienced in attempting mitigation: the prospect of delays deters some road users, who are attracted back following interventions aimed at relieving congestion. The lower bound implies that time savings cannot be the main economic benefit of transport investment, which means that conventional transport economic appraisal is misleading. In reality, the main benefit for users is increased access to desired destinations, made possible by faster travel, which is the origin of induced traffic. Access is subject to saturation, consistent with evidence of travel demand saturation. However, access is difficult to monetise for inclusion in cost-benefit analysis. Consequential uplift in real estate values may be a more practical way of estimating access benefits, which is relevant to the possibility of capturing part of such uplift to help fund transport investment that enhances such access.

Key words: travel time, time savings, induced traffic, access, land value, demand saturation

Introduction

There is considerable observational data indicating that travel time, averaged across a population, is stable at around an hour a day. Arguably, the significance of this phenomenon has been insufficiently recognised, in part because the concept of travel time savings has been so central to transport economic analysis. Yet the observed invariance of average travel time raises questions about the assumptions implicit in orthodox transport investment appraisal and modelling.

The purpose of this paper is to draw attention to the implications of travel time invariance for understanding travel behaviour. I first summarise the empirical data on travel time and consider the explanations for the observed invariance. I next suggest that travel time invariance implies both upper and lower bounds to the time individuals allocate to travel, which has explanatory power for the understanding of travel behaviour, notably the phenomenon of road traffic congestion. I then discuss the consequences of time invariance for economic analysis and transport modelling, as well as for policy interventions and investments aimed at fostering economic development and alleviating traffic congestion.

The argument of this paper is that travel time invariance is a phenomenon that should be recognised in transport analysis. The range of topics considered is wide, hence the literature cited is selective rather than comprehensive.

Observational evidence

The main evidence for the long run stability of average travel time comes from national travel surveys. The UK Department for Transport first commissioned a National Travel Survey (NTS) in 1965. The survey became a regular event starting in the early 1970s, and is now carried out annually, involving 16,000 representative individuals completing travel diaries with full details of their movements for seven days, thereby generating time series of travel data spanning 45 years in considerable detail. The NTS covers all modes of travel except international travel by air, so in effect it largely records the pattern of daily travel (NTS, 2018). Figure 1 shows outcomes per person for annual distance travelled, time spent travelling and number of journeys made, by all modes except international air travel. What is evident is that two aspects of individual travel have changed relatively little over 45 years: average travel time has remained close to 370 hours a year, or an hour a day, and the average number of trips has been about 1000 a year. There has been some small decline in annual trips in recent years - by 9 per cent between 2002 and 2017, almost all of which is due to a reduction in walking trips of less than one mile, mainly for shopping, personal business and visiting friends (Mitchell, 2018).

Figure 1. UK National Travel Survey. Source; Table NTS0101

The United States Department of Transportation is responsible for the National Household Travel Survey, which started in 1969 and takes place at intervals of five to eight years, most recently in 2017 when 130,000 households participated, individuals logging travel for one day of the week only. Average travel time is not recorded, but average time spent in a vehicle as driver or passenger has been close to an hour a day since 1995 (Figure 7 of NHTS, 2018).

Other national travel surveys vary in coverage, many not reporting average travel time, and in the availability of time series data. The Swedish National Travel Survey reports average travel time per day as 57±3 minutes for 2015-16, rather less than the 72 minutes found for 2012-13 (SNTS, 2017). The Netherlands Mobility Panel 2014 found an average travel time of 65 minutes (Olde Kalter, Hoogendoorn-Lanser and Geurs, 2014). Earlier data from the Netherlands National Travel Survey showed little change in an average travel time of about 72 minutes a day between 1985 and 1998 (van Wee, Rietveld and Meurs, 2006). The Danish National Travel Survey records average travel time in 2016 as 57 minutes (DNTS, 2016). The New Zealand Household Travel Survey reports average travel time of 5.8 hours per week in 2015-2018, or 50 min per day (NZHTS, 2018).

Schafer and Victor (2000) compiled earlier data from over 60 national and city travel surveys for single time points, finding an average travel time of approximately 1.1 hours per person per day, not varying across a wide range of incomes, geography and cultures, although travel time was higher in congested cities. Mokhtarian and Chen (2004) reviewed a number of previous surveys of travel, time use and activities, finding that at aggregate level travel time expenditures appeared to have some stability. Stopher, Ahmed and Liu (2017) employed GPS monitoring to follow the travel behavior of individual participants in panel studies over eight years, confirming an average expenditure of travel time of about an hour a day, with no trend and with a majority of individuals showing no significant variations over the period. A recent analysis of a number of US time use surveys found travel time to increase by about 20 per cent between 1975 and 1993, but decreased thereafter such that by 2013 average travel was similar to that in the 1960s and 1970s; the earlier increase is attributed in part to demographic changes, the latter decline to a shift from work to leisure (Song and Wei, 2018).

Taken as a whole, the empirical evidence is consistent with an average travel time of about an hour a day being a general characteristic of settled populations, with no consistent trend for this parameter to increase or decrease over the years, and with no evidence of variation with average income.

On the other hand, within populations there are variations in average travel time for sub-groups. Data from the UK National Travel Survey show people in mid-life spent some 60 per cent more time travelling than children and older people, while people in the highest income quintile spent 70 per cent more time on the move than those in the lowest, a reflection of more active lifestyles; in contrast, there was relatively little variation of travel time according to geographic location, except for those living in London who spent 16 per cent more time travelling than the national average (Metz, 2005). Similar variations with age are found in the Swedish and New Zealand surveys cited above. Mokhtarian and Chen (2004), reviewing earlier studies, identified more that found a significant effect of age on travel time expenditure than those that found it insignificant, and more generally found travel time to vary according to individual and household characteristics.

Implications of travel time invariance

The observed invariance of average travel time has prompted consideration of the concept of a ‘travel time budget’, implying that individuals have a certain amount of time they are willing to spend on travel and that they will minimize departures from that budget. The relevant literature has been reviewed by Mokhtarian and Chen (2004) and by Ahmed and Stopher (2014). As the latter authors point out, a travel time budget is not directly observable, unlike travel time expenditure, which is measurable. The observed variation of travel time expenditure as a function of age and income imply that individuals are making choices of activities that involve the expenditure of time, just as they make choices about the expenditure of money. Daily expenditure of time is constrained by the 24 hours available to all, whereas money expenditure varies with income that is unequally distributed and changes across the life course. As with money, there is an opportunity cost to time spent travelling, time that cannot be used for other desired activities, which sets an upper bound. On the other hand, reducing daily travel time tends to lessen access to opportunities that are spatially separated, as well as to intrinsic benefits of mobility (Mokhtarian, Salomon and Singer, 2015).

The notion of a travel time budget to be attributed to individuals seems not to be particularly useful for practical purposes. However, the observed invariance of average travel time implies both upper and lower bounds to time that can be expended on travel, considerations that can inform our understanding of travel behaviour and are central to decisions on transport investment and policy. The growth of average distance travelled, as for instance seen in Figure 1, is necessarily the result of faster travel in unchanged travel time, a consequence of investment, very largely private investment in more and better road vehicles and public investment in roads, as recognised by Metz (2008) and Ahmed and Stopher (2014).

The ability of the population at large to travel faster than walking pace was made possible by harnessing the energy of fossil fuels, initially coal on the railway and subsequently oil-based fuels for road transport. Since the first passenger railway opened in 1830, there has been almost two centuries during which the availability of modern forms of transport have become ever more widespread, allowing the average speed of travel to increase. Individuals have taken advantage of faster travel to venture further, to gain more access to destinations and more opportunities to benefit from a wider choice of employment and services.

However, the scope for traveling yet faster on roads is now quite limited, as indicated by the cessation of growth of distance travelled since the turn of the century, as for example shown in Figure 1. This is the consequence of high levels of car ownership in developed economies, road traffic congestion in and near densely populated areas, and safety concerns that limit the speed of travel on uncongested roads. While new high-speed rail routes offer faster travel, rail is responsible for a minority of trips, and high-speed rail therefore for a minority of a minority, with little impact of new routes on the average speed of travel. There are a variety of new transport technologies under development with the prospect of general deployment, in particular electric vehicles and autonomous vehicles, but these seem unlikely to permit faster travel. Other new technologies, such as electric aircraft in urban airspace, could provide faster travel but are likely to be confined to niche markets (Metz, 2019).

Road traffic congestion

Traffic congestion is an important constraint on the speed of travel on the road network. The upper bound to the availability of travel time is a key factor that both regulates the level of congestion and make its mitigation difficult. Congestion arises in or near densely populated urban areas where car ownership is high. There are more trips that could be made by car at times of peak usage than can be accommodated by the capacity of the network, such that some potential road users are deterred by the prospect of unacceptable delays. They may decide to use a different mode of travel where available, travel at a time when there is less traffic, or to a different destination where there are such options (shopping, for instance), or not to travel at all (such as shopping on line). The suppression of potential road use by the expectation of excessive delays is responsible for the self-regulating nature of congestion, in that if traffic grows and delays increase, more users are deterred. Hence the experience that in well managed cities with alternative modes of travel available, gridlock is rare and generally arises from unexpected events (Litman, 2019).

The existence of suppressed trips is the reason why attempts to reduce congestion prove difficult. Adding road capacity reduces delays and encourages previously suppressed trips to be made, adding to traffic and restoring congestion to what it had been, hence the maxim that you can’t build your way out of congestion (Downs, 1962; Ladd, 2012). Such ‘desuppressed’ trips are one source of induced traffic, the traffic long recognised as arising from additional road capacity (SACTRA, 1994; Goodwin, 1996; Noland and Lem, 2002; Duranton and Turner, 2011; Handy and Borneat, 2014; WSP, 2018).

Interventions that seek to divert car users to other means of travel - such as public transport or the active modes of walking and cycling - free up carriageway for previously suppressed trips. Charging for use of road space under congested conditions is ineffective for the same reason (Metz, 2018).

The prospects for a direct solution to the ubiquitous problem of road traffic congestions seem poor. One means to mitigate its impact is to provide alternative modes of travel that are not impeded by general traffic – rail and bus rapid transit. Another approach is made possible by digital navigation devices that offer optimal routes through congested road networks and provide an estimate of expected time of arrival, which mitigates journey time uncertainty, an important adverse impact of congestion for road users.

While a direct attack on congestion cannot be expected to be fruitful, it is possible to influence the volume and composition of traffic. Adding capacity allows more trips to be made, while subtracting carriageway for private vehicles can make more space available to buses, cyclists and pedestrians, an approach adopted by many successful cities.

Transport economic analysis

The observed invariance of average travel time is problematic for orthodox transport economic analysis, for which a central concept is that investment that allows faster travel results in the saving of travel time that can be valued. Monetised values of time savings are the largest element of user benefit in conventional transport cost-benefit analysis. There are many questions about the appropriateness of transport cost-benefit analysis, as reviewed recently by Vickerman (2017) and by Hickman and Dean (2018). The particular question for the present discussion is the appropriateness of time savings as the main user benefit.

Small (2012) states that it is difficult to name a concept more widely used in transportation analysis than the value of travel time. Considerable effort has been made to establish monetary values of travel time, largely by means of stated preference techniques. The benefit of a transport investment that permits faster travel is then the estimated time savings per person, multiplied by the number of persons benefiting per year, multiplied by the appropriate monetary value of time, with future years’ values discounted using a suitable discount rate.

For individual transport investments, time savings per person per trip are generally quite small, typically a few minutes. There has been debate about the significance of such small time savings (Daly, Tsang and Rohr, 2014). On the one hand, it is argued that these are too insignificant to change travel behaviour and so should be ignored. On the other, the view that has prevailed is that the accumulation of such small time savings from a succession of investments can have a substantial impact on behaviour and so in logic the components should not be disregarded. There is also a question of whether the value of time varies as a function of short-term versus long-term decisions, for instance for different routes for a single trip versus decisions about a change of workplace location. Beck et al (2017) have presented evidence for higher values in the long term than in the short term.

The observed long-term invariance of average travel time seems inconsistent with an investment appraisal methodology that emphasises time savings. Such invariance does not preclude the existence of travel time savings but does imply that these must be short term, and that in the long term time initially saved must be expended to travel further, to gain a different kind of benefit. Given the long-lived characteristic of transport investments, we should be concerned about the nature and value of such long term benefits.

It is generally recognised that a change in the transport system leads to changes in accessibility, which in turn may lead to new development that contributes to changes in the real economy (Mackie, Batley and Worsley, 2018). The worth of such development may be observed in increases in values of land and property (real estate) made more accessible as a result of the transport investment. However, increases in real estate values are generally disregarded in conventional economic analysis to avoid double counting benefits assumed to be included in cost reduction (mainly time costs) experienced by users of the transport system.

Orthodox economic analysis is focused on time savings that, for road investments, are assumed, not observed. In principle, travel time savings could be observed empirically using travel diary techniques to monitor the changes in behaviour of a panel of users as they responded to the improvement to the transport system. However, no such systematic study appears to have been carried out. Available evidence from the evaluation of road improvements is generally limited to information on volumes and speeds of traffic, and sometimes data on journey time reliability.

For railway investments that allow faster travel, the time saving for the journey can be read from the new timetable. This would be a measure to the benefit to users if trip origins and destination remained unaltered, which was the original simplifying assumption of the standard approach transport modelling that provided the time saving inputs to economic analysis. It was subsequently recognised that origins and estimations would change if the cost of travel were reduced, which led to a requirement for variable demand modelling. However, such modelling is based on short run elasticities and does not recognise the increase in demand implicit in the invariance of average travel time.

The limited evidence available is consistent with a behavioural response of users to a transport investment that takes place in three phases: initially time savings available for more work or leisure activities; fairly soon some of this time is used to make optional trips that are longer than previously made, for instance to access a more distant but superior shopping destination; and subsequently, as individuals change employment or move house, they are able to gain access to a wider choice of such opportunities, within travel time constraints that they find acceptable. These longer trips are an important source of induced traffic.

The SACTRA (1994) study (para. 4.70) suggested a short-term elasticity of demand with respect to travel time of the order of about -0.5, and a long-term elasticity of the order -1.0, implying that most time saved would be used for additional travel in the long run. More generally, the observed scale of such induced traffic would depend on the time elapsed after scheme opening, increasing over time. Induced traffic increases the detriments associated with vehicle distance travelled, including noxious pollutants, carbon emissions, noise, crash-related injuries, all of which are underestimated in conventional economic analysis based on time saving. Induced traffic also adds to congestion, reducing travel time savings. But the additional trips made increase the access of users to desired destinations, which is in reality the main user benefit of transport investment.

Access

As noted by the International Transport Forum (ITF, 2017), ‘Appraisal of transport projects has traditionally focused on travel time savings and congestion relief. However, there is a growing understanding that this misses the ultimate purpose of the transport system, which is to provide access to employment, goods, services and other opportunities.’

The concepts of access and accessibility have received considerable attention, with a variety of methodologies identified for quantifying improvements. Geurs and van Wee (2004) adopted the term ‘access’ when considering a person’s perspective, and ‘accessibility’ for a location’s perspective. Both depend on the pattern of land use and on transport provision, and reflect the needs of individuals and the time constraints under which they operate. Guers and van Wee identified four approaches to quantifying accessibility: measures of performance of the transport system, such as speed on a road network; measures that reflect access at particular locations, such as the number of jobs within 30 min travel time from origin locations; person-based measures, reflecting the activities in which an individual can participate in a given time; and utility-based measures that reflect the economic benefits gained by individuals from access to spatially distributed activities.

Utility-based measures of accessibility are in principle appropriate for the appraisal of proposed transport investments, but the theory is relatively complex and in consequence this approach had not been generally employed in practice. However, as Guers and van Wee (2004) note, utility-based measures show diminishing returns, consistent with the evidence for travel demand saturation (discussed below), and contrast to travel time savings, for which diminishing returns are not assumed. Venter (2016) reviewed utility-based measures of accessibility, identifying only a few examples of their use in practice (for example Geurs et al, 2010). He attributed this to their dependence on complex destination/mode choice models in combination with integrated land use/transport models, neither in common use – a challenge in respect of both cost and communication to decision-makers. Silva et al (2017) investigated why accessibility instruments are not widely used in practice, concluding that the main impediments were lack of user-friendliness and institutalization, as well as organisation barriers.

Duranton and Guerra (2016) argue for the centrality of accessibility in thinking about urban development since it links land use, housing and transportation. Accessibility emerges as the outcome of choices made by firms and residents. However, a theory of urban locations where both residents and firms would choose their locations remains elusive. While the simplest stylized models yield transparent results, changes to assumptions to reflect realism increase both complexity and the sensitivity of outcomes to place-dependent factors such as urban amenity or the cost of travel.

While improved access is the main user benefit resulting from transport investment, quantification and monetisation within a coherent theoretical framework has proved difficult, with little application in practice. Yet the expected diminishing returns from access are consistent with evidence for travel demand saturation.

Travel demand saturation

Demand saturation is a general phenomenon, reflecting a sufficiency of supply of a product or service in relation to the needs of a consumer. Thus ownership of many kinds of appliances may exceed 90 per cent of households. There is evidence that good levels of choice of many kinds of services are available to those with use of a car or good public transport. For example, it has been estimated that 80 per cent of the urban population of Britain has access to three or more large supermarkets, and 60 per cent to four or more, within a 15-min drive. (Metz 2010, 2013). With such choice available, it is to be expected that there would be less need to travel further for yet more choice. Choice of food shops has increased in recent decades, the result of growth of investments by households in cars, by governments in road capacity, and by the supermarket businesses in more stores, growth that is now past its peak.

Saturation of travel demand is consistent with very simple model of travel behaviour in which the marginal utility of a service declines with increasing choice, while access and choice increase with the square of the speed of travel, since what may be accessed in a given travel time is related to the area of a circle whose radius is proportional to speed.

Valuing transport investments

The conventional approach to valuing transport investments, in which the main benefit is supposed to be travel time savings, has been well developed and is in wide use, based on the outputs of conventional transport models in which changes in land use are generally disregarded. The main shortcoming of this approach is that in reality the benefits to users of such investment are experienced largely as greater choices arising from improved access - choices of employment, homes, services and social interactions, choices that are subject to diminishing returns. Moreover, access is inherently spatial, unlike time savings, and the spatial distribution of benefits is important for decision makers (Metz, 2017).

The question is whether a better means of valuing transport investment could be devised. As discussed above, although in principle access would be a better measure of impact, it has proved difficult to attach economic value to the concept and to employ it in practice.

Another possibility would be to focus on changes in land use, whether new developments or more intensive use of existing properties, that arise from the improved access as the result of transport investment. There are a number of studies where the value of such changes has been estimated ex post. Mohammad et al (2013) carried out a meta-analysis of the impact of 23 rail projects on land and property values, finding a wide range of outcomes, dependent on contextual and methodological factors. Grimes and Liang (2010) used changes in land values to estimate the benefit-cost ratio of an extension to a motorway in Auckland, New Zealand. Lee, Lim and Leong (2018) have shown that the benefits of a new rail line in Singapore, as estimated from property value uplift and intensification, were greater than convention time savings and other user benefits. Sharma and Newman (2018) found substantial increases in property values in Bangalore associated with the construction of an urban rail route. Song et al (2019) estimated house price increases associated with extension of a light rail route in London.

There appears to be only a limited number of published cases that attempt to justify investment by ex ante forecasts of increase in real estate values. A study of the impact of proposed new river crossings in east London identified all major development sites within the relevant area and assessed the scope for development as this would be affected by the increased access to labour, customers and suppliers (TfL, 2014). Outputs were stated as numbers of residential units and area of floor space for non-residential property. Although no attempt was made to ascribe monetary values to these developments, that would be a natural next step to facilitate an economic appraisal of the proposed river crossings based on changes in land use and real estate values. This example illustrates how the outcome of decisions to make transport investments depends on decisions by planners and developers. The conventional approach to transport economic appraisal that disregards changes in land use simplifies the modelling and analysis, at the cost of misleading decision makers about the nature of the ultimate benefits.

The UK National Infrastructure Commission recently commissioned a study of how land values respond to changes in land use and infrastructure improvements, as a basis for informing future investment decisions. Comprehensive property databases were drawn upon to model how prices depend on property characteristics and location. This enabled creation of a web-based ‘property value uplift’ tool that can be used to calculate how values and rents of existing properties would respond to small scale investments in roads or public transport, and also values for prospective new settlements (Halket et al, 2019). A similar study has quantified the relationship between transport and property values in the North of England with a view to inclusion in the case for new investment (Nellthorp et al 2019).

A policy objective that has emerged recently in Britain is the desirability of making transport investments that would make land accessible for new housing, to help accommodate a growing population (DCLG, 2017). This has prompted consideration of methodology to capture the housing benefits of transport investment (DfT, 2019). The conventional approach to transport appraisal does not include the uplift in real estate values in calculating the benefit-cost ratio on the grounds that this would double count economic benefits already included in time savings. However, such uplift may be taken into account by decision makers in judging the value for money of the investment (DfT, 2018). This approach is problematic, as an example may illustrate. Consider a proposal to construct a bypass around a town experiencing traffic congestion. The conventional economic case would be based mainly on travel time savings plus accident savings and reduced vehicle operating costs. However, the new road may make agricultural land available for development, in which case developers may seek planning consent to build new houses. If consent were granted by the planners, the economic case for the road would be very different from what it would be without consent, as regards both traffic flows and nature and scale of the economic benefits. It would be difficult to argue that the additional economic value of the new houses would be captured in the time savings of the scheme without the housing.

The implication of travel time invariance is that transport investments would generally result in changes in land use. Decisions on such investments should therefore not be taken in isolation but in a tripartite collaboration involving planners, developers and transport authorities, where related development could be taken into account.

Addressing how changes in land use and values are affected by transport investment is relevant to the possibility of capturing some of the uplift in value that could be used to help fund the investment, a topic of increasing interest (Medda, 2012; TfL, 2017). For example, the extension of London’s Northern Line tube to a large brownfield site at Battersea is costing £1 billion, to which the developers have contributed a quarter as cash and additional taxes paid by businesses locating in the area will contribute the remainder (Porter, 2014). This followed an earlier appraisal of a range of alternative property and transport investments, which identified extension of the tube as the preferred option (TfL, 2009).

Conclusions

The observed invariance of average travel time is arguably the most ubiquitous and secure characteristic of travel behaviour at population level. There is reason to suppose that the hour a day average travel time dates back to the first settled agricultural communities (Marchetti, 1994). For the future, it would be appropriate for unchanging average travel time to be a feature of central case projections, recognising that there would be variant cases to reflect, for instance, the possibility that autonomous vehicles would permit more time being spent travelling.

The observed invariant average travel time implies that the availability of time acts as a constraint on travel behaviour, suggesting both upper and lower bounds. A succession of innovative technologies, starting with the railway in the nineteenth century, permitted faster travel and hence greater distances traversed within the time constraint, to gain more access to desired destinations and choice of opportunities. However, there is now little scope for yet faster travel in the developed economies, with new technologies such as electric or autonomous vehicles unlikely to make much impact on speed. The time constraint therefore will limit any increase in average distance travelled.

The travel time constraint is also a key explanatory factor in relation to the phenomenon of road traffic congestion. As congestion increases, so do delays, the prospect of which deter some road users who make alternative choices. Congestion is therefore largely self-regulating, but for the same reason difficult to mitigate, in that interventions designed to reduce car use by some groups in effect create road space for others previously deterred, as does building additional carriageway. However, the impact of congestion on road users can be mitigated by digital navigation technologies that take account of traffic conditions to provide optimal routing and estimated journey times, thus reducing journey time uncertainty, an important detriment arising from congestion.

The observed travel time invariance implies that there are reasons why the population as a whole does not take opportunities to reduce the amount of time spent travelling when offered that possibility by investments that permit faster travel. This implication has not been recognised in conventional transport economic analysis, where it is assumed that travel time savings are the main user benefit of such investment (or, at least, an acceptable proxy for the user benefit). This approach derives from a simplifying assumption made at the outset of the disciple, that origins and destinations of trips could be taken as unchanged. It was subsequently recognised that travel demand would change as a result of reduction of the cost of travel (of which time costs are the main element), which prompted the development of variable demand transport models. Nevertheless, the output of such models takes the form of traffic volumes and speeds, permitting comparison of the ‘do something’ investment case with the ‘do minimum’ case, the resulting time savings being the main input to the cost-benefit calculation. Arguably, a better simplifying assumption would have been to suppose that average travel time is invariant, so that the consequences of investment would be user benefits in the form of enhanced access, which impacts on land use and shifts economic benefit to real estate owners, as well as giving rise to additional traffic – induced traffic.

The assumption of travel time saving as the main benefit from road investment leads to underestimation of induced traffic. Such additional traffic increases both vehicle operating costs and traffic-related externalities such as congestion, noxious emissions, carbon emissions, noise and collisions. Decision makers are generally led to believe that road investments will reduce congestion and improve connectivity, which is not consistent with the experience that it is not in practice possible build our way out of congestion. What additional road capacity can achieve is to increase the number and length of trips made, which has economic benefit for those making them, yet the additional volume of traffic has offsetting externality disbenefits. The conventional approach to the economic appraisal of investments based on time savings thus tends to lead to excessive investment in additional road capacity through underestimation of induced traffic.

In contrast, the conventional approach to economic appraisal tends to result in too little investment in urban rail, for which the scope for real estate development is insufficiently recognised. What is needed for all transport investment is an approach based on valuing actual outcomes, of both benefit and disbenefits, rather than theoretical time savings. Time savings should be taken into account when observed, as should changes in real estate values and externalities. Double counting of benefits is avoided in an evidence-based approach since users take benefits either as access or as time savings, but not both simultaneously.

Existing approaches to transport modelling are problematic. Conventional four-stage models disregard changes in land use. Both fixed trip and variable demand versions do not recognise travel time invariance. Models constrained to hold average travel time constant in the long run would necessarily need to project changes in land use, yet land-use/transport models have not entered into general use.

One possible way forward would be to aim to model land-use/transport interactions in a site-specific, bottom-up way, rather than through a general top-down approach. The example of the River Thames Crossing cited above illustrates the possibility of such location-specific analysis. This is necessarily the approach of developers when offered the opportunity to contribute to the cost of transport infrastructure that would enhance the value of their land, as for example the extension to London’s Northern Line tube to Battersea, discussed above. The ‘property value uplift’ tool, commissioned by the National Infrastructure Commission, could form the basis of a general approach to incorporating the benefits of enhanced real estate values into economic appraisal of transport investments in a spatially specific manner.

The function of the transport system is to move people through space. Investment results in more such movement, whether to achieve higher speeds so that people travel further in the time available, or in more capacity at unchanged speed so that more people are able to travel. In either case, land use is likely to change, with corresponding changes in real estate values, depending on decisions of planners and developers. Conventional economic appraisal neglects the spatial distribution of benefits through its focus on notional time savings. Recognising the invariance of average travel time would enhance the relevance of appraisal to decision makers.

References

Ahmed, A., and P. Stopher. 2014. “Seventy Minutes Plus or Minus 10-a Review of Travel Time Budget Studies.” Transport Reviews 34 (5): 607–625.

Beck, M., Hess, S., Cabral, M. and Dubernet, I. (2017). Valuing travel time savings: A case of short-term or long-term choices? *Transportation Research Part E*, 100, 133-143.

Daly, A., Tsang, F. and Rohr, C. (2014). The Value of Small Time Savings for Non-business Travel. *Journal of Transport Economics and Policy*, 48(2), 205–218.

DCLG (2017). *Housing Infrastructure Fund: Supporting Document for Forward Funding*. London: Department of Communities and Local Government.

DfT (2018). *Capturing housing impacts in transport appraisal; case studies*. London: Department for Transport.

DfT (2019). *Appraisal and Modelling Strategy: Informing Future Investment Decisions.* Paras 6.7 et seq. London: Department for Transport.

DNTS (2016). *Danish National Travel Survey* [https://www.cta.man.dtu.dk/english/tvu ]

Downs, A. (1962). The Law of Peak-Hour Expressway Congestion. *Traffic Quarterly*, July, 393-409.

Duranton, G. and Guerra, E (2016). *Developing a Common Narrative on Urban Accessibility: An Urban Planning Perspective*. Washington DC: The Brookings Institution.

Duranton, G. and Turner, M. (2011). The Fundamental Law of Road Congestion: Evidence from US Cities. *American Economic Review*, 101, 2616-2652.

Geurs, K. and van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, 12(2), 127-140.

Geurs, K., Zondag, B., de Jong, G. and de Bok, M. (2010). Accessibility appraisal of land-use/transport policy strategies: more than just adding up travel-time savings. *Transportation Research Part* *D*, 15(7), 382-393.

Goodwin, P. (1996). Empirical evidence on induced traffic. *Transportation*, 23(1), 35-54.

Grimes, A. and Liang, Y. (2010). Bridge to Somewhere: Valuing Auckland’s Northern Motorway Extensions*. Journal of Transport Economics and Policy*, 44(3), 287-315.

Halket, J., Mysliwski, M., Nesheim, L. and Simpson, P. (2019). *Property Value Uplift Tool: Final Report*. London: Institute for Fiscal Studies.

Handy, S. and Borneat, M. (2014). *Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions*. California Air Resources Board.

Hickman, R. and Dean, M. (2018) Incomplete cost – incomplete benefit analysis in transport appraisal, *Transport Reviews*, 38(6), 689-709.

ITF (2017). *Linking People and Places: New ways of understanding spatial access in cities*. Paris: International Transport Forum.

Ladd, B. (2012) “You can't build your way out of congestion.” – Or can you? *disP - The Planning Review*, 48(3), 16-23.

Lee, H., Lim, W. and Leong, W. (2018). Land enhancement and intensification benefits of investing in an urban rail network. *Research in Transportation Economics*, 69, 512-522.

Litman, T. (2019). *Generated Traffic and Induced Traffic: Implications for Transport Planning*. Victoria BC: Victoria Transport Policy Institute.

Mackie, P., Batley, R. and Worsley, T. (2018). Valuing transport investments based on travel time saving – a response to David Metz. *Case Studies on Transport Polic*y, 6(4), 638-641.

Marchetti, C. (1994). Anthropological invariants in travel behaviour. *Technological Forecasting and Social Change*, 47(1), 75-88.

Medda, F. (2012). Land value capture finance for transport accessibility: a review. *Journal of Transport Geography*, 25, 154-161.

Metz, D. (2005) Journey quality as the focus of future transport policy. *Transport Policy*, 12(4), 353-359.

Metz, D. (2008). The myth of travel time saving. *Transport Reviews*, *28*, 321–336.

Metz, D. (2010). Saturation of demand for daily travel. *Transport Reviews*, 30(5), 659-674.

Metz, D. (2013). Mobility, Access and Choice: A New Source of Evidence. *Journal of Transport and Land Use*, 6(2), 1-4.

Metz, D. (2017). Valuing transport investments based on travel time savings: Inconsistency with United Kingdom policy objectives. *Case Studies on Transport Policy*, 5, 716-721.

Metz, D. (2018). Tackling Urban Traffic Congestion: The experience of London, Stockholm and Singapore. *Case Studies on Transport Policy,* 6, 494-498.

Metz, D. (2019). *Driving Change: Travel in the Twenty-First Century*. Newcastle upon Tyne: Agenda Publishing.

Mitchell, K. (2018). *An analysis of long-term trends in travel patterns*, in *Analyses from the National Travel Survey*. London: Department for Transport. 2018.

Mohammad, S., Graham, D., Melo, P. and Anderson, R. (2013). A meta-analysis of the impact of rail projects on land and property values. *Transportation Research Part A*, 50, 158-170.

Mokhtarian, P. and Chen, C. (2004). TTB or not TTB, that is the question: a review of the empirical literature on travel time (and money) budgets. *Transportation Research Part A,* 38(9-10), 643-675.

Mokhtarian, P., Salomon, I. and Singer, M. (2015) What Moves Us? An Interdisciplinary Exploration of Reasons for Traveling, *Transport Reviews*, 35(3), 250-274.

Nellthorp, J., Ojeda Cabral, M., Johnson, D., Leahy, C. and Jiang, L. (2019). Land Value and Transport (Phase 2): Modelling and Appraisal. Final Report to TfN, WYCA and EPSRC. Leeds: Institute for Transport Studies, University of Leeds.

Noland, R. and Lem, L. (2002). A review of the evidence for induced travel and changes in transportation and environmental policy in the US and the UK. *Transportation Research Part D*, 7 (1), 1-26.

NHTS (2018). *Summary of Travel Trends: 2017 National Household Travel Survey*. Washington DC: Federal Highway Administration.

NTS (2018). *National Travel Survey: 2017 report*. London: Department for Transport.

NZHTS (2018). https://www.transport.govt.nz/mot-resources/household-travel-survey/new-results/overview/

Olde Kalter, M, Hoogendoorn-Lanser, S. and Geurs, K. (2014) *Towards a Better Understanding of Dynamics in Travel Behaviour*. European Transport Conference. Frankfurt.

Porter, C. (2014). *Northern Line Extension to Battersea: Infrastructure Investment to Enable Development and Land Use Change*. European Transport Conference. Frankfurt.

SACTRA (1994). *Trunk Roads and the Generation of Traffic*. Standing Advisory Committee on Trunk Road Assessment. London: Department of Transport.

Schafer, A. and Victor, D. (2000). The future mobility of the world population. *Transportation Research Part A*, 34(3), 171-205.

Silva, C., Bertolini, L., te Brömmelstroet, M., Milakis, D., and. Papa, E. (2017). Accessibility instruments in planning practice: Bridging the implementation gap. *Transport Policy*, 53, 135-145.

Small, K. (2012). Valuation of travel time. *Economics of Transportation*, 1 (1-2), 2-14.

SNTS (2017). *Swedish National Travel Survey 2015-2016*. Stockholm: Traficanalysis.

Song, C. and Wei, C. (2018). Travel time use over five decades. *Transportation Research Part A*, 116, 73-96.

Song, Z., Cao, M., Han, T. and Hickman, R. (2019). Public transport accessibility and housing value uplift: Evidence from the Docklands light railway in London. *Case Studies on Transport Policy,* 7(3), 607-616.

Stopher, P., Ahmed, A. and Liu, W. (2017). Travel time budgets: new evidence from multi-year, multi-day data. [*Transportation*](https://link-springer-com.libproxy.ucl.ac.uk/journal/11116), 44 (5), 1069–1082.

TfL (2009). *Vauxhall Nine Elms Battersea: Transport Study Report*. Transport for London.

TfL (2014). *River Crossings Development Study, Task 126 Final Report*. London: Transport for London.

TfL, 2017. *Land Value Capture: Final Report*, Annex 7 Literature Review. London: Transport for London.

Venter, C. (2016). *Developing a Common Narrative on Urban Accessibility: A Transportation Perspective*. Washington DC: The Brookings Institution.

van Wee, B., Rietveld, P. and Meurs, H. (2006). Is average daily travel time expenditure constant? In search of explanations for an increase in average time. *Journal of Transport Geography*, 14(2), 109-122.

Vickerman, R. (2017). Beyond cost-benefit analysis: the search for a comprehensive evaluation of transport investment. [*Research in Transportation Economics*](https://www-sciencedirect-com.libproxy.ucl.ac.uk/science/journal/07398859), 63, 5-12.

WSP (2018). *Latest Evidence on Induced Travel Demand: An Evidence Review* [for the Department for Transport]. Manchester: WSP and RAND Europe.