International Transport Forum

What is the Value of Saving Travel Time?

Summary and Conclusions

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Roundtable

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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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What we did

This report examines the effects of technology on travel behaviour and the implications for transport appraisal practice. It focuses on the rationale and methods for segmenting the value of reductions in travel time so as to take into account how travellers spend their travel time. With increasing availability of connected technologies, the conventional way of treating travel time as entirely wasted time is no longer valid because technologies make it possible to carry out a wide range of activities while travelling. But exactly how do travellers use their time and just how much should the value of reductions in travel time used in transport appraisal be modified?

The report summarises the findings of an ITF Roundtable meeting held in Paris in September 2018 that brought together 30 experts from 14 countries. It is complemented by six discussion papers on specific aspects: The fundamental principles of valuing reductions in travel time (Fosgerau, 2019), how such valuations might change with mobility patterns (Meunier, 2019) and in the light of behavioural choices (Goodwin, 2019) as well as on the methodologies available for evaluating time use while travelling (de Jong and Kouwenhoven, 2019; Batley, Dekker and Stead, 2019 and Molin, 2018). Discussions also covered evidence of time use in South Korea, the United Kingdom and the Netherlands.

What we found

People obtain positive utility from a wide range of activities undertaken during travel time, including work activities, leisure activities and even sleep. These offset some of the loss of utility resulting from time spent travelling and lower the marginal value of travel time changes.

Estimates of the value of reductions in business travel time based on willingness-to-pay are consistently lower than those derived via the formerly widely used cost saving analysis (CSA) approach. This might be interpreted as providing an indication of the size of these positive utility values. Improved information and telecommunication technology (ICT) has expanded the range of business and leisure activities that can be undertaken while travelling and studies reporting that values of reductions in travel time have not increased in line with GDP – i.e. income elasticities of the value of reductions in travel time that are significantly lower than unity – can also be interpreted as demonstrating increases in the actual utility of travel time over recent decades.

At the same time, data suggests that only a minority of travel time is spent working, even for business travellers, and the proportion of travel time spent working does not seem to have increased with this potential for productivity gains. This may be because some of the utility of travel time, when travel conditions permit, derives from leisure activity, relaxation and "time spent doing nothing".

The quality of travel conditions affects willingness-to-pay to reduce travel time, as travel undertaken in crowded and uncomfortable conditions creates greater disutility. Less crowded, more comfortable conditions also facilitate using travel time for other activities. Transport investments that improve passenger comfort during journeys can significantly reduce the disutility of travel, even though travel time is not reduced. This implies transport planners must take a broad view of potential projects, which explicitly includes potential trade-offs between qualitative and quantitative improvements.

The analytical approach increasingly applied to incorporate improvements in comfort or convenience into cost-benefit analysis when appraising transport projects and policies is to apply different weights to different travel time. Appraisal in Denmark and Sweden, for example, weights walking time the same as in-vehicle-time, but weights waiting time and transfer-time at twice the value of in-vehicle-time. A similar approach might be used to account for the increased utility of travel time that results from improvements in the services offered, such as the provision of wi-fi.

The value of reductions in travel time after considering the potential worthwhile use of time during travel can sometimes be 20-25% lower than conventional values. This probably represents an upper bound to the reduction, as the proportion of trips where time can be spent productively in practice is limited by a range of factors including duration of travel and crowding.

Project appraisal guidelines on benefit parameter values benefit from periodical updating to account of changes in user preferences, market conditions and the state of technology. The longer the interval between successive updates, the more changes need to be reflected in the update. For example, when the United Kingdom updated the value of reductions in travel time in 2015 from the 1994 values, the values for non-work travel time had increased by around 50% for commuting, but had been reduced by around 25% for other non-work trips. The overall valuation of reductions in travel time was around 10% lower on average, reflecting the possibilities for using travel time productively and shifts in user preference over time.

The emergence of autonomous vehicles can potentially enable their users to use time spent travelling productively. This may reduce the value of reductions in travel time. Whilst a lower value might make longer commutes more acceptable, the unreliability of travel time in congested cities makes locations close to work attractive. Therefore, automation may make little difference to single occupant commuting patterns. Shared automated cars might generate urban sprawl if take-up is sufficient to liberate road space for more commuters.

What we recommend

Update the value of reductions in travel time periodically to reflect changes in preferences and travel patterns

Travel preferences and patterns are affected by lifestyle choices, culture, social norms and demographics. These factors and their impacts vary over time. Thus, willingness-to-pay studies should be conducted at regular intervals to understand what changes have occurred in the way travellers value the quantity and quality of travel time. A survey every five to ten years will ensure the values continue to reflect current preferences.

Account for the quality of travel conditions

The quality component of travel time needs to be incorporated in assessment of the benefits of quicker journey times. The factors that affect the quality of the travel experience include comfort, convenience, frequency, reliability and the possibilities for utilisation of time spent travelling on other activities. In practical terms this means assessing the willingness-to-pay for reduced travel time versus the willingness-to-pay for improvements in travel conditions, and integrating these two assessments in project choice functions.

Employ stated preference surveys supported by other evidence for determining the value of reductions in travel time

The stated preference approach continues to be an important means of deriving the values of reductions in travel time, despite its limitations. Well-designed surveys avoid bias and allow segmentation of the value of reductions in travel time into meaningful components, while avoiding double-counting the impacts. Stated preferences surveys can sometimes be supplemented with revealed preference studies. Qualitative surveys are also useful for obtaining a broader picture of how, and under what conditions, people make certain choices, as well as better understanding what factors travellers consider. Such qualitative surveys can also help to improve the stated preference survey by assisting the interpretation of the overall survey results.

Investigate how the use of Big Data can improve understanding of travel behaviour

A large amount of real-time data can be extracted from ICT systems. Big Data is already being used by cities for managing travel demand in real-time. It is worth investigating how such data can be utilised for a better understanding of travel behaviour and travel patterns in the context of valuing reductions in travel time.

Continue to use cost-benefit analysis in transport decision making

Cost-benefit analysis should continue to play a central role in transport decision making. CBA has strong theoretical foundations and can marshal important evidence. Adopting different values of reductions in travel time for different modes (e.g. high-speed rail versus metro) or journey characteristics (e.g. long versus short distances) adds to the sophistication and utility of the CBA.

Strengthen the link between modelling, appraisal, monitoring and evaluation

Close links between modelling practice, appraisal, monitoring and evaluation help to validate and improve the assessment of value of reductions in travel time and should be strengthened. Better understanding the valuation of the quantitative and qualitative components of the value of reductions in travel time should also help to advance the development of models. Well-conducted ex-post evaluations can help to provide evidence of how travellers respond to the reductions in travel time and improvements in journey quality. They can hence validate the results of the surveys on which value of reductions in travel time used in transport modelling and appraisal are based.

The role of value of travel time in transport appraisal

Measuring the reduction in travel time has long been a fundamental element of the economic case for transport infrastructure investment. Reducing the amount of time spent on travel enables transport users to spend the time they have saved more productively or more enjoyably. For over fifty years, techniques have been developed and refined to put a monetary value on reduction in travel time made available by investment in transport. This value that can be measured has made it possible for policy makers to be well informed about the benefits of the project and allows them to compare the value of reductions in travel time with the costs of the project (including financial, social and environmental costs). Further, the costs and the benefits can be weighted, facilitating an evidence-based decision about the merits of the project.

The terms *value of time* (VOT), *value of travel time* (VTT) and *value of travel time savings* (VTTS) are often used interchangeably by transport professionals. These mainly refer to the value of reductions in travel time (hereinafter also referred as value of travel time or VTT). VTT in this context should not be taken to refer to the value being put on time in a general sense but to the value of changes in time spent in travelling relative to an alternative use of that time.

Reductions in travel time have a further role to play; they provide decision-makers with information about the merits of a transport project. The value transport users put on those reductions influences their response to a change in the transport network. The response, for example, in terms of the increase in demand or modal shift, to a project which reduces travel time will be greater if the value of reductions in travel time is high. The benefits related to this generated traffic and, in the case of public transport schemes or tolled highways, the additional revenues from this traffic can help to strengthen the case for the scheme. More broadly, the estimated value of reductions in travel time is a proxy for the ultimate economic benefit of investment in a transport project, derived from reduced transport costs to industry, improved access to jobs, enhanced competition, development of property served by the transport project and so on (SACTRA, 1999; Mackie et al., 2003; Wallis, 2009; Austroads, 2011).

The practice of putting an economic value on travel time can be traced back to as early as the 1940s (West, 1946 cited in Moses et al., 1963). Historically, travel time reduction was typically valued based on average earnings and tended to overstate the travel time benefits and overshadow other benefits (Becker, 1965; Johnson, 1966). In his seminal article titled "A Theory of the Allocation of Time", Becker (1965) uniquely merges goods consumption with time use when defining the preference measurements (i.e. the utility function) over a set of goods and services of household. He proposed differentiating the value of reductions in travel time by activity (e.g. standard work, overtime hours and leisure). This approach makes it possible to model trade-offs between spending time on work and non-work activities explicitly, which has been fundamental for developing theories beyond the simple view of valuing time based on average earnings. Using this approach, Johnson (1966) demonstrated that the value of time spent on leisure activity should be lower than the wage rate. He also highlighted the importance of other aspects of the "quality" of the trip and people's willingness-to-pay for higher quality travel (e.g. on freeways vs. busy urban roads).

The first international Roundtable meeting was conducted by the predecessor of the ITF, the European Conference of Ministers of Transport (ECMT) Roundtable Number 6 on the theoretical and practical aspects of valuing travel time was held in 1969. One of the reports prepared for that Roundtable

(Harrison and Quarmby, 1969) discusses the need to analyse how travellers make choices considering a range of factors, as reductions in travel time are a composite entity that depends on different attributes and situations. It identifies the need to sufficiently differentiate between social groups, particularly in their attitudes to the disutility of travel, in attributing a money value to those reductions. This was written before stated preference (SP) or choice experiment techniques became commonly used in valuing travel time (Goodwin, 2019). For this reason, Goodwin argues that Harrison and Quarmby (1969) is the most influential publication of all time in shaping subsequent development of methods for estimating value of time in the United Kingdom and many other countries. Two subsequent Roundtables reviewed the value of travel time (ECMT Roundtable number 30 in 1976 and number 127 in 2003). Amongst other things, both the 1976 and 2003 roundtable reports highlighted the importance of taking into account the differences in individual socio-economic factors, including the utilities of money and time between different individual groups (Goodwin, 2019).

Today there is evidence that makes it possible to deconstruct travel time and its value into various components such as in-vehicle, waiting, walking, congested and uncongested time, and by distance travelled (Abrantes and Wardman, 2011; Small, 2012; DfT, 2015a; Daly, Sanko and Wardman, 2017). The idea to consider the use of time in valuing travel time is not new. Hensher (1977) developed a formula to recognise the effect of time use while travelling, differentiating between time spent on work and leisure activities, and the relative productivity of work undertaken whilst travelling and at the normal work place. Lyons and Urry (2005) argued that the utilities derived from travelling do not merely arise from the use of that time for work purposes, but can also include values from time spent alone (e.g. transition between home and work) or being able to substitute location-based activities (e.g. watching television shows, eating or reading for leisure). The scope and type of activities that can be conducted while travelling are further increased with digital technologies (Lyons and Urry, 2005) and, potentially, with the use of autonomous vehicles in the future.

As the world becomes more advanced technologically, the value of travel time may be changing structurally. Gary Becker explained the relationship between time and rising incomes in his speech at the Nobel Prize award ceremony in 1992 –

> *"The most fundamental constraint is limited time. Economic and medical progress have greatly increased length of life, but not the physical flow of time itself, which always restricts everyone to twenty-four hours per day. So while goods and services have expanded enormously in rich countries, the total time available to consume has not" (Becker, 1992).*

As the time available is fixed while income increases, the average amount of time available per unit of income is decreasing, or equivalently, the average amount of money available per unit of time is increasing. Linder (1970), also explained that time has become the rarest resource and that individuals are ready to pay more and more to save time, especially for certain types of travel. At the same time, technological advances are increasing the options for using travel time productively to some extent. This implies a reduction in the utility cost of travelling, thus suggesting lower valuations of time spent travelling than would otherwise be calculated, even in a context in which the value of time in a general sense is increasing. The task of this Roundtable was to shed light on the nature and extent of this downward pressure on the value of reduction in travel time.

The objectives of the Roundtable were to:

- consider the evidence of changes in travel time use over time and the likely impacts on the values of travel time and the implications for modelling and appraisal

- better understand the relationships between valuation of travel time, reliability, comfort, distance and trip purposes
- explore the best way to improve measurement and assessment of utility derived from time spent travelling in the appraisal of infrastructure investment decisions.

Work commissioned for the Roundtable included a discussion paper that sets out the basic principles and rationale for valuing reductions in travel time and discusses whether the fundamental principles continue to hold with automation and increased opportunities for carrying out in-vehicle activities (Fosgerau, 2019). It also included two discussion papers that look at the likely impacts on VTT of changes in mobility patterns (Meunier, 2019) and behavioural choices (Goodwin, 2019). Several presentations discussed evidence regarding time use while travelling, including in South Korea, the Netherlands and the United Kingdom. Methodologies to estimate VTT considering use for business time while travelling were also explored using the *Hensher approach* (de Jong and Kouwenhoven, 2019); the *willingness-to-pay approach* (Batley, Dekker and Stead, 2019); and a *value of activities* concept (Molin, 2018, based on Adjenughwure, 2017).

Discussions at the Roundtable sought to address a number of challenges identified in the discussion papers and to review recent evidence about the extent to which the VTT time might be changing and the causes of such changes.

This report first describes the challenges to the conventional approach to valuing reductions in travel time and the theoretical foundations of time use and valuation of the use of time. It then examines the empirical evidence of time use from current and recent studies. Followed by a discussion on the appropriateness and feasibility of segmenting VTT. The report closes with a discussion of appraisal, modelling and policy implications and makes some recommendations.

What are the challenges to valuing reductions in travel time?

In traditional transport appraisal practice, travel time is assumed to be completely unproductive and it is assumed that time not spent travelling is used productively (Fosgerau, 2019). Therefore, the value businesses place on a reduction in travel time is reflected in the wage rate paid (Wardman and Lyons, 2016). A number of challenges have emerged in recent years to this conventional way of thinking about reductions in travel time, particularly regarding the way time is used while travelling.

Challenges to the conventional approach of valuing travel time

The first challenge comes from the observation that information and communication technology (ICT) has revolutionised the way in which people spend time (Mokhtarian and Salomon, 2001; Ory and Mokhtarian, 2005; Lyons and Urry, 2005). This applies to the way in which people work, the place where they work, their leisure time and what they do while travelling, in particular when travelling by public transport. The ability to undertake some work and leisure activities while travelling implies that some utility is generated, thereby reducing the value of travel time. The ability to account for the utilisation of time spent travelling can influence choices as to the type of transport projects in which to invest (Wang and Hensher, 2015).Moreover, the prospect of autonomous vehicles (AVs), the users of which would be freed from the task of controlling the vehicle, might suggest opportunities for using time more productively or more enjoyably during travel on the highway network (Pudane, et al. 2018; Meunier, 2019).

The policy context for transport investment is also changing in many countries. Faster journeys are no longer seen by the public as the only improvements they want from the transport system. Improved comfort, safety and reliability, liveable cities, good information about the trip to be made and the overall quality of the journey all rank high in travellers' preferences. Investment to encourage active travel is another priority that can both make short trips better for the individual and reduce spending on treating ill-health. A better understanding of how people value changes in the quality of a journey and the relationship between these quality attributes and the value of reductions in travel time (unadjusted for the quality of a journey) can help to ensure that appraisal methods remain relevant and continue to address policy priorities.

Goodwin (2019) outlines how social and demographic trends are also likely to have an impact on social expectations and, hence, on the type of project that best meets the needs of a future generation of travellers. Data for England and Wales show young people, in particular young males, travelling significantly less by car and slightly more by public transport than the previous generation. Goodwin also observed a reduction in driving licence holdings amongst 21-29 year olds from 75% in 1992 to 63% in 2014. There are many possible causes behind this change which may vary with the stage of life for each individual. Young people are now more likely to live in cities, to get married later and to have lower disposable incomes than the previous generation, while the costs of car use, in particular the costs of insurance, have risen. Preferences and lifestyles, choices often influenced by ICT, might also have contributed to the change (Chatterjee et al., 2018). If the reasons underlying the demand for travel change with the stages of life, the value travellers place on reductions in travel time may also change over time. It is necessary to monitor the key indicators to understand how changes might evolve over time.

Theoretical foundations of time use and valuing the use of time

Taking changes in travel time into consideration when undertaking a transport cost-benefit analysis and forecasting changes in travel patterns is based on firm theoretical foundations. The value of reductions in travel time is based on standard microeconomic utility maximisation theory (e.g. Becker, 1965; Johnson, 1966 Harrison and Quarmby, 1969). This asserts that consumers care about their consumption level, the proportion of time they spend at work, on leisure and on travel and that they select the combination of these factors that maximise their utilities. Value of reductions in travel time is defined as the willingness-to-pay to reduce travel time and is derived by understanding the trade-off between time and money.

The utility of money is sensitive to the amount of money people have, and the utility of time is sensitive to the amount of time that people have (Goodwin, 2019). Individuals make trade-offs between money and time as they approach the limits of their monetary budget constraint or the time budget constraint and the value of the more constrained commodity (money versus time) will increase. Goodwin highlighted the implications of the phenomenon in Table 1, which shows the effects of the interaction between the marginal utility of time and money.

Table 1. Hypothesis for the effects of time and money on value of time

	Time Poor	Time Rich
Money Poor	A low-income employed single parent with little time or money. High utility of reductions in travel time, high utility of money savings. **True value of time indeterminate, but would be credited with low value of time in usual method.**	A retired pensioner on a state pension, plenty of time but little money. Low utility of reductions in travel time, high utility of money savings. **Revealed value of time low.**
Money Rich	A high income entrepreneur working all the hours of the week and receiving a very large income. High utility of reductions in travel time, low utility of money savings. **Revealed value of time high.**	A retired person with a very high personal pension and much leisure. Low utility of reductions in travel time, low utility of money savings. **True value of time indeterminate, but would be credited with high value of time in normal method.**

Source: Goodwin (2019).

In choice modelling, estimates of the willingness-to-pay for reductions in travel time are typically obtained by the ratio of marginal utilities of time and money (i.e. the marginal rate of substitution between time and money). It is therefore important to incorporate differences in the utility of money (due to income) and the utility of time (due to life style) when assessing the VTT as it is possible to misclassify the true VTT for the two extreme cases ("time poor money poor" and "time rich money rich"). In addition, Börjesson and Eliasson (2018) argue that

> *"The VTT should always account for variation stemming from differences in the marginal utility of time, for example due to different travel time component, modes and trip purposes."*

Income can affect time use and hence the VTT. High earners tend to have better access to technologies and hence are more able to use time in ways that yield positive utility, but they also have higher VTT due to the income effect (Molin, 2018; Adjgenuwhure 2017). Their greater connectivity affects time use, mode choice and decisions on trip distance or duration. However, despite the important role of income in valuing reductions in travel time, the common practice of indexing VTT to growth in income is an inaccurate approach to updating VTT because the marginal utilities of time and of money may follow different paths over time. It is also important that estimates of the value of reductions in travel time are differentiated by different travel time components and consider time-related quality factors (Börjesson and Eliasson, 2018; Goodwin, 2019).

Fosgerau (2019) argues that the economic attractiveness of different locations is strongly influenced by the time and cost of access to them through the transport system and the monetary cost and the time spent in travel are the main elements of the disutility of travel. Reducing either or both increases the welfare of travellers, by giving them more time to spend either earning income at work or enjoying their leisure. Fosgerau demonstrates that the theory on which transport analysis relies remains valid under conditions in which the trade-off between the time spent in travel and the time spent in other activities changes to allow for time spent in travel becoming more productive or more enjoyable.

For private travel, and without considering time use while travelling, he proposes that the VTT is equal to the after tax wage rate plus the difference between the marginal willingness-to-pay to increase work time and the marginal willingness-to-pay to reduce travel time (first row of Table 2). If working is preferable to travelling, then the WTP is higher and vice versa. Fosgerau proposes introducing an additional term to the theoretical model to account for the productivity of time spent when travelling relative to time spent at work or at leisure. For time spent working while travelling, the wage rate component of the VTT is scaled down by the difference in productivity between working while travelling and at work ($1-\alpha_W$) (second row of Table 2). For leisure activities during travel time, Fosgerau scales down both the wage rate and the WTP in the equation by the difference in productivity of leisure during travelling and leisure time ($1-\alpha_L$) (third row of Table 2).

Table 2. Time use and value of reductions in travel time for private travel – the modified theoretical model

	Utility function and its determinants	VTT for private travel
VTT without considering time use while travelling	$U(C,t_L,t_W,t_D)$ • Consumption C • Leisure time t_L • Work time t_W • Travel time t_D	$w+\frac{U_{t_W}}{U_C}-\frac{U_{t_D}}{U_C}$ • Net wage rate w • WTP to increase work time $\frac{U_{t_W}}{U_C}$ • WTP to decrease travel time $\frac{U_{t_D}}{U_C}$
VTT with in-vehicle work activities	$U(C,t_L,t_W,t_D+t_{DW})$ • Consumption C • Leisure time t_L • Work time t_W • Travel time t_D • Work while travel t_{DW}	$(1-\alpha_W)*w+\frac{U_{t_W}}{U_C}-\frac{U_{t_D}}{U_C}$ • Work productivity while travelling α_W • Net wage rate w • WTP to increase work time $\frac{U_{t_W}}{U_C}$ • WTP to decrease travel time $\frac{U_{t_D}}{U_C}$
VTT with in-vehicle leisure activities	$U(C,t_L,t_W,t_D+t_{DW}+t_{DL})$ • Consumption C • Leisure time t_L • Work time t_W • Travel time t_D • Work while travel t_{DW} • Leisure while travel t_{DL}	$(1-\alpha_L)*w+(1-\alpha_L)*\frac{U_{t_W}}{U_C}-\frac{U_{t_D}}{U_C}$ • Leisure productivity while travelling α_L • Net wage rate w • WTP to increase work time $\frac{U_{t_W}}{U_C}$ • WTP to decrease travel time $\frac{U_{t_D}}{U_C}$

Note: WTP = willingness-to-pay
Source: Based on Fosgerau (2019).

The Hensher equation (see Box 1) provides a theoretical approach to derive the value of business travel time (VBTT), one which is seldom used in practice due to a lack of robust estimates of the components within the equation. However, if the trade-off is between whether to convert business time not spent travelling on work or on leisure, Fosgerau (2019) demonstrates that the Hensher equation can also be reduced to $(1-\alpha)*W$, where W is the gross wage rate. The gross wage rate is the total cost to business and the relative productivity of time spent working, α, offsets to a degree the total time out of the office. In-vehicle productivity is likely to be higher for longer trips since longer trips allow discrete activities more time to be carried out.

Box 1. The Hensher equation

The *conventional representation* of the Hensher equation:

$$VBTT = (1\text{-}r\text{-}pq)MPL + MPF + (1\text{-}r)VW + rVL$$

where:

r is the proportion of travel time saved that is used for leisure

p is the proportion of travel time saved that is at the expense of work done while travelling

q is the relative productivity of work done while travelling relative to at the workplace

MPL is the value of the marginal product of labour

MPF is the value of extra output due to reduced (travel) fatigue

VW is the difference between the employee's valuations of ‘contracted’ work time and travel time

VL is the difference between the employee's valuations of leisure time and travel time.

Source: Wardman et al. (2015).

These relationships between the relative productivity of activities conducted while travelling and time spent on other activities make it relatively straightforward to adjust values of reductions in travel time to reflect the way travellers actually use travel time. However, they appear to have little relevance to demand management interventions designed to improve travel time reliability. Fosgerau (2019) finds a reduction in the VTT likely to have little direct effect on the value travellers place on improvements to reliability because it has little effect on the costs and inconvenience experienced by the traveller of failing to arrive at the scheduled time.

The modified theoretical model is useful for exploring the likely impact of ICT and lower VTT on urban form, which might be expected to result in people opting for longer-commuting trips, thus resulting in decentralisation and urban sprawl. Reduced transport costs might also result in a shift in employment and population from smaller to larger cities because the larger cities provide for greater agglomeration benefits and so higher incomes for their residents.

Can the value of reductions in travel time be zero?

A VTT equal to zero would imply that travellers would be willing to travel for long, even infinite periods of time because their ability to use the time productively or enjoyably would be as great as when not travelling. This will not happen because of competitive uses for time for different purposes at different locations. There is a temporal budget constraint that prohibits VTT approaching zero. Baumol (1973) argued:

> *“if our individual had additional time, he could make more money, but that is prevented by the twenty-for-hour limit to his day…money income is really congealed time and not vice versa. Additional time will purchase more income, but additional income does not purchase more time. The wage increase does ease the budget constraint, but does not loosen the constraint that really binds.”*

There are two situations in which a lower value of reduction in travel time should be applied in appraisal despite an increasing value being put on time in a general sense:

- when the mode of transport and its supporting environment enable a range of activities (work or leisure) to be carried out while travelling
- when it is possible to separately identify the value of reduction in travel time and the value of activity.

The next two sections will discuss these situations in more detail.

Evidence of time use and its value

Three Roundtable presentations and the accompanying discussion papers described findings from recent research. Both the UK's Department for Transport (Batley, Dekker and Stead, 2019) and the Dutch Government (de Jong and Kouwenhoven, 2019) recently commissioned studies to review and update the values of reductions in travel time used in transport appraisal. In addition, an assessment of the values used in France and the evolution of these values over a period of 50 years provided a long term view of historic trends and some of the possible causes of the changes in the value of reductions in travel time over time (Meunier, 2019).

Time use while travelling

Both the UK and Dutch studies showed that people only spend a limited amount of time on work-based tasks when travelling on their employer's business. Results of the three Dutch studies conducted over the last 30 years summarised in de Jong and Kouwenhoven (2019) show only a small increase in the proportion of time spent working from around 3% in 1988 to around 6% in 1997 and 2011. There are practical limits on the proportion of travel time that can be spent productively: car drivers have little opportunity to engage in work while travelling (although this might change with the introduction of AVs) and rail users need to spend time in waiting, walking and finding a seat. However, neither study showed rail users spending as much as half of their travel time working, and most of the surveys showed significantly less, even though the work done was almost as productive (around 90%) as at the normal place of work (de Jong and Kouwenhoven, 2019). Many travellers would take any reductions in travel time as additional leisure time rather than devoting them to work (Pawlak, Polak and Sivakumar, 2017). A better understanding of the work/life balance, especially in the context of knowledge-based employees, might help to provide background and context to these findings on the value of reductions in business travel time.

Both studies collected data on how people spend their time when travelling and the survey showed that rail and public transport passengers spend their time in a range of activities. The Dutch study found that the ability to use travel time productively or enjoyably across all journey purposes, including business travel, reduced the value people put on reductions in travel time by 20% when compared with a trip on which such activities were not possible.

Table 3. International surveys on passenger transport travel time use

Study	Country / City, mode	Sample size (persons)	Percentage of passengers undertaking activities (%)						
			Reading for leisure	Sleeping or resting	Listening to music	Talking on Phone	Text messaging	Talking to other passengers	No activity (window gazing)
Ohmori and Harata (2008) *	Japan – Tokyo, rail	84	61.9	66.7	8.4	-	13.1	-	-
Timmermans and van der Waerden (2008) *	United States – San Francisco, PT modes	161	4.8	6.1	1.6	3.2	2.8	13.8	-
Lyons et al. (2012) *	United Kingdom, rail					Use of phone: Personal	Use of phone: work		
	2004	22 866							
	Out		53	13	9	17	8	16	56
	Return		57	19	9	22	8	4	58
	2010	19 715							
	Out		54	13	20	29	15	14	53
	Return		56	16	21	32	15	13	54
Gripsrud and Hjorthol (2009)	Norway – Oslo and Trondheim, rail (June-August 2008)	1 196				Use of phone: Personal	Use of phone: Work		
		Commuter	35	36	26	45	24	19	50
		Business	27	31	7	35	32	35	60
Thomas (2009) *	NZ – Wellington, PT modes	1 703	12.7	0.7	8.9	-	2.4	23.9	-
Russell (2012) *	NZ – Wellington. Rail and bus (Nov/Dec 2008)	812	21.7	8.9	19.2	1.5	9.2	15.4	65.3
Adjenughwure (2017)	The Netherlands, Rail	1 558				Work or study			
		Commute	34		7	16			
		Leisure	46		7	3			
NZ HTS (2018) **	NZ –national, PT modes (June 2018)	363 At least a quarter of the time	10.7	3.0	17.1	Personal 3.9 Work 4.7		4.1	54.0
		Some of the time	14.3	1.9	7.2	Personal 30.9 Work 11.6		49.9	62.8
Varghese and Jana (2018)	India -Mumbai, all modes	Number of trips = 4 452	general 8.6 ICT 8.9	7.9	Music and games 10.4	Personal 4.6 Work 1.3		17.3	40.5
Bounie et al. (2018)	Paris region, PT modes (2015)	501 commuters	90	-	73	89	96	-	-
Wang and Loo (2018)	China – Shanghai, Nanjing, high speed rail (Feb – May 2016)	885				ICT use: **Personal**	ICT use: **Work**		
		Work trips	24.7	26.3	23.1	**23.6**	**56.0**	7.4	Combined with sleeping/resting
		Non-work trips	28.1	34.3	35.2	**44.9**	**12.6**	8.9	

Note: * denotes studies results sourced from Russell (2012)

** denotes information obtained from a private communication with the New Zealand Ministry of Transport.

Time use while travelling can vary with culture and travel distance. However, most evidence on time use while travelling for other countries suggests that less than 20% of passengers conduct work related tasks

(Table 3). Since it is infeasible for the passengers to spend the entire travel time conducting work activities and only a portion of trips are suitable for conducting in-vehicle work tasks, the overall proportion of time spent working must be even smaller.

Looking to the future, the EU-funded MoTiV study has the objective of providing detailed information on how people use their time when travelling and their perceptions of the travel experience, based on a sample of 5 000 transport users in ten member states over a period of fifteen days (Lugano, Cornet and Karadimce, 2018). The project is funded under the EU Horizon 2020 programme and will provide an open access data set for researchers. By providing a better understanding of the factors that determine the experience of the journey, a more complete picture of the choices made by the traveller should emerge.

The effect of time use on how people travel

The findings of a recent Korean study (Lee et al., 2018) demonstrated the potential for ICT to influence mode choice in Seoul. A discrete mode choice model was estimated, using SP-based evidence about the preferences of users between car, bus and rail when trading travel time and travel costs and options for ICT connectivity on the public transport modes only. The results showed that, when faced with such choices, transport users' choice of mode is influenced by the existence and quality of ICT connectivity for both bus and rail modes. Thus investment in ICT could be an effective alternative to reducing journey times as a means of encouraging modal shift, by enabling better utilisation of travel time while travelling and thus providing public transport users with a better quality of journey. Provision of free wi-fi connection services on intercity trains was also found to increase ridership in other countries, particularly by attracting new riders (e.g. Dong et al., 2015). Another preliminary analysis using conservative benefit assumptions of the deployment of 4G technology over Paris' regional public transport network (RATP) concluded that such an intervention can deliver a large net societal benefit, with a six-year payback period (Bounie et al., 2018).

Looking into possible future use of AVs, Nielsen and Haustein (2018) conducted an online survey of expectations regarding self-driving cars in Denmark. Their study found three broad groups of participants, based on their attitudes towards autonomous vehicles, comprised of around one-third each of sceptics, the indifferent and enthusiasts. Sceptics generally do not believe the time use, time-saving, safety and environmental benefits will be significant. Enthusiasts are located in urban areas and do not drive as much as the sceptics. Results show nearly half of the respondents believe the level of travel would remain unchanged after the adoption of AVs, but 19% of respondents believe it would increase while only 6.5% believe it would decrease (the remainder 24% answered 'don't know'). Around 20% also thought they would use the AV for longer distances.

The ability of drivers to use in-vehicle time more productively or enjoyably may change their trade-off between preferred arrival time and the amount of time they were willing to spend driving in congested traffic. Van de Berg and Verhoef (2016) undertook an extensive analysis of the impact of AVs on congestion in a bottleneck setting. Their work supported the view that the in-vehicle productivity offered by AVs affects only the VTT and not the utility related to arrival time. They see AVs are more likely to occupy the middle of the demand peak where journey times are longest, with manually driven cars occupying the shoulders of the peak (Van de Berg and Verhoef, 2016; Fosgerau, 2019).

Fosgerau (2019) made a speculative assessment using the theoretical model discussed earlier of the potential penetration of AVs. This was based on the data depicting how rail travellers use their time and of the likely costs of purchasing an AV. The assessment took account of the amount of time car owners spend each year in driving, the amount of productive work they might achieve in an AV and the limited evidence on car drivers' willingness-to-pay to avoid the task of driving, based in part on surveys of car passengers. This suggested that car drivers placed a significantly lower value on the benefits of owning an AV than current estimates of the premium that manufacturers would charge for such vehicles. Thus, he argues that the take up of AVs by individuals is likely to be limited unless the price of AVs falls. In addition, if AV trips are most likely to take place during peak hours, travel time reliability will continue to be an important rationale for households to locate in, rather than away from, city centres. Thus, the risk that the use of AV will exacerbate urban sprawl as high earners take advantage of such technology to move further away from city centres is likely to be small, at least in the short to medium term.

However, a shared mobility model of AVs, in which they were more the equivalent of a shared taxi than a replacement for the privately owned car, may suggest different conclusions. Modelling work by Van de Berg and Verhoef (2016) found that if AVs have a higher occupancy rate and remove traffic from the roads the resulting reduction in congestion would have implications for urban form, decentralisation and city size, making outer parts of the city more attractive for household location.

Reliability and the quality of travel time

As noted in Harrison and Quarmby (1969), reductions in travel time have long been used as a composite entity that inherently captured comfort, crowding, unexpected delays and other factors that affect the overall quality of the time spent travelling (Goodwin, 2019). Consequently, factors that affect values of time include: personal and household characteristics, time periods, journey purposes, income, mode and trip duration, distance and use of travel time (Wardman, 1997; Gunn, 2001; Small, 2012; DfT, 2014).

Batley et al. (2019) report on a number of multipliers that have been used in scheme appraisal in the United Kingdom to modify the standard values. Many of the multipliers served to increase the value of reductions in travel time to represent travel under especially onerous conditions, such as travel on an overcrowded train, with a value of up to double the value used for uncrowded conditions. It is standard practice in the United Kingdom to adopt higher values for crowding on rail schemes, including those that provide more capacity to relieve overcrowding without reducing journey times.

Batley et al. (2019) and de Jong and Kouwenhoven (2019) investigated British and Dutch travellers' willingness-to-pay for improvements in reliability. The reliability ratio, usually measured through the standard deviation of the achieved journey time when compared with the average or the expected journey time, relates travellers' willingness-to-pay to reduce the variability of travel time to the standard VTT and is used in the United Kingdom, the Netherlands and in France (Meunier. 2019).

The UK study found a reduction in the reliability ratio (from 0.8 to 0.4) from the previous study, indicating a reduced willingness-to-pay, perhaps because the development of ICT systems now gives transport users information about delays in real time and enables them to inform others of their expected arrival time. The Dutch and the French studies showed broadly comparable values (0.8 to 1.1) for the reliability ratio, with the business value generally slightly higher than the values for other purposes. Derivation of separate values for reductions in travel time and journey time reliability in a stated preference survey remains a challenge. The Roundtable was given examples of the questions asked by the Dutch study to help respondents understand the objective of the survey. In the past, research studies tended to focus on reductions in travel time alone. It is uncertain whether the relationship between value of reliability (VoR) and VTT continues to hold when the quantity and quality aspects of VTT are separated. If the relationship has changed, it may be necessary to revisit how best to establish VoR separately (Meunier, 2019).

Changes in value of reduction in travel time, over time

France has used a value of reduction in travel time in transport investment appraisal and modelling for more than 50 years (Meunier, 2019). At first, a single value was used and only in the case of road schemes, although account was taken of the increased comfort provided by motorways. Greater differentiation was introduced In the 1990s, with a higher value of reduction in travel time for public transport, followed by other differentiation factors including mode, journey purpose, distance and reliability, with a separate value for trips in the Paris region. Segmentation of the VTT between road and rail was to enable assessment of high-speed rail investment projects at that time.

The growth in the value of reduction in travel time used in appraisals over the past 50 years in France suggests a time series income elasticity well below unity. Similar trends have been noted in the values used in other countries (e.g. Gunn, 2001; Börjesson, Fosgerau and Algers, 2012; Significance, VU University Amsterdam and John Bates Services, 2013; Wardman and Lyons, 2016). While there is no clear evidence to explain why people's willingness-to-pay to save travel time was not increasing as fast as GDP per capita, ICT is likely to be a part of any explanation for the downward trend in the VTT relative to income (Meunier, 2019; Goodwin, 2019). Another reason could be related to an increase in the number of explanatory variables included in the analysis of the trade-off between time and money, making it possible to separate the time effect from other effects (Meunier, 2019). Further research on how VTT has evolved over time across different countries could help to improve understanding of why VTT has grown at a slower rate than income and inform whether and how the relationship might change over time.

Information and telecommunication technology (ICT) is likely to have had impacts on transport that go well beyond modifying trends in the value of reductions in travel time. ICT has an effect on the number and type of trips people make and on the places to which they travel. It facilitates the chaining of trips, for example by providing the opportunity to pick up shopping at the railway station, so combining the home commute with a shopping trip. Activity-based models may provide a better understanding than the conventional transport model of the choices people make and the role of travel in those choices.

Valuing the quantity and quality of time spent travelling

Valuing reductions in travel time

Stated preference surveys have become the principal approach to valuing reductions in travel time because of the detail on travel behaviour that they can reveal and their potential to investigate the counterfactual. They are particularly useful for understanding the preferences of users given their socio-demographic characteristics and related budgetary, time and other constraints. Views are, however, divided on the robustness of the results obtained because estimates can be affected by the framing of the questions posed. At the same time, recent developments in discrete choice modelling have helped improve the robustness of SP estimates by including the social influence variables in the utility function in order to account for heterogeneity across individuals (e.g. Hensher, Rose and Greene, 2015). Validating SP estimates using the results of revealed preference studies would add credibility to the SP study results. For example, by comparing the passengers taking expensive high speed rail journeys to those taking lower cost conventional rail trips could reveal any differences in the VTT for these users based on actual uses. However, care is needed when selecting the right case studies to derive VTT. The cases examined have to have enough in common with the project being assessed to provide pertinent values. Other qualitative questions, as part of the SP survey, can also be useful for understanding and controlling for any confounding factors.

The British (Batley, Dekker and Stead, 2019) and Dutch (de Jong and Kouwenhoven, 2019) studies discussed at the Roundtable meeting assess the value of reductions in business travel time using SP surveys. The category of travel described as 'employer's business' covers employees travelling in the course of their working day to meetings and other engagements: it excludes the category of professional drivers who are paid to drive. Business time has conventionally been valued at double or more the value applied to commuting and to leisure values and makes up a major part of the benefits of a typical scheme. Past practice has been to adopt the 'cost savings approach' (CSA) to all business travel time. Using an estimate of the wage rate plus other employment related costs as the value assuming that the employee is unproductive on the journey, travels exclusively in paid working time and is indifferent to being at work and travelling during work hours.

The increase in use of ICT, the greater flexibility of the working day and the blurring of the distinction between work and leisure has cast doubt on the continued appropriateness of the CSA as a means of valuing business travel time. One of the objectives of the stated preference studies was to investigate potentially more realistic valuation methods and determine evidence-based values that reflect current working practices. The Dutch study used a reduced form of the Hensher equation (Box 2), which breaks down the components of time use during a journey to establish the values that both the employee and the employer put on saving business travel time. These include terms to represent factors such as the amount of time spent in productive work while on the trip, the productivity of that work and the extent to which work trips are made in unpaid leisure time. The surveys carried out for the Dutch study derived values for each of these constituents of a typical business journey. The results continue to show reductions in business travel time being valued at a significantly higher level than the commuting or leisure values.

Box 2. The reduced Hensher equation

The reduced form of the Hensher equation:

$$VBTT_R = (1-r-pq)PV_{WT} + L$$

where:

r is the proportion of travel time saved that is used for leisure

p is the proportion of travel time saved that is at the expense of work done while travelling

q is the relative productivity of work done while travelling relative to at the workplace

PVWT = productive value of a unit of work time to the employer (similar to MPL in the Hensher equation)

L = the value of reductions in business travel time to the employee (simplified last two terms of the Hensher equation)

Source: Based on de Jong and Kouwenhoven (2019).

Although one part of the UK study was also aimed at deriving values of the constituents of the Hensher approach through SP surveys, the main focus was on willingness-to-pay (WTP) surveys of business travellers to establish directly their decision when faced with a trade-off between travel time and money (Batley et al., 2019). While surveys of employers might at first sight be expected to give reliable values, it was rarely possible, especially in the case of larger firms, to identify a manager in the firm responsible for implementing such decisions. Most firms had a policy governing employee travel but such policies did not extend to the detail of the trade-offs needed to inform the research study. The information provided by the small number of firms that gave relevant responses tended to corroborate the much more extensive results of the survey of employees, on which the new values are based.

In order to ensure that the employer's interests were represented in any response, employees were asked to take into account their employer's policy on company travel. Information was also collected on how travel time was spent, whether on work activities or not, how productive this was and whether the travel time was taken from work or from leisure. The UK study showed clear differences between rail and road values, but values for both modes that increased with journey time and distance. Whether a traveller worked on the reference trip made no difference to the value they placed on reductions in travel time. One explanation for this apparently inconsistent finding would be that these individuals place a high value on the activity they undertake at either end of the journey, whether having more time in a meeting or reaching their home earlier at the end of the day.

Differences in VTT by modes are also thought to be driven by self-selection, with those travelling for longer and/or with higher incomes (and therefore higher WTP) opting to travel by rail. The United Kingdom segments the values of reductions in travel time for business travellers by distance band and by mode. The higher values for the longer distance trips largely reflect the higher incomes of longer-distance travellers and the constraints on other activities when much of the day is spent in travelling. Batley, Dekker and Stead (2019) found that 'pure' distance has little effect as changes in the VTT are dominated by *reference time and cost* in the SP exercise; and *income effects*. This finding also applies to the French study, despite the possibility of greater time use opportunities for longer trips.

A common conclusion of Batley, Dekker and Stead (2019) and de Jong and Kouwenhoven (2019) is that the value of business travel time remains a significant part of transport scheme benefits despite ICT and other improvements to the quality of a journey. Both studies followed the convention of segmenting travellers who were not on a business trip into commuters travelling to and from work and those travelling for leisure or other journey purposes. Commuters are found to be willing to pay around 20%-50% more than leisure travellers to reduce travel time on their journey.

Traditionally, the collective value of reduction in travel time (not distinguished by any factor or group of individuals) used in CBA assessment guides was often equated to the individual value; distinguished by specific factor or group of individuals (Meunier, 2019). However, studies have found collective and individual willingness-to-pay can be different (Mouter and Chorus, 2016; Meunier, 2019). This is because individual or consumer values are restricted by budget constraints and are influenced by an individual's own choices, whereas collective or citizen values are observed from their behaviour in public social life (e.g. in elections) (Mouter and Chorus, 2016). Further research to understand whether and how these perspectives might affect segmentation of the quantity and quality aspects of VTT is warranted.

Values of reductions in travel time with and without an activity

One of the challenges faced by researchers investigating people's willingness-to-pay for improvements in journey quality or for reductions in travel time is that of self-selection. People who choose a specific mode or set of quality attributes do so because these attributes reflect their own preferences rather than the preferences of the typical traveller. So a comparison between the users of different modes or qualities of trip finds it difficult to disentangle the characteristics of the travellers from the attributes of the trip. The extent of self-selection is demonstrated in several studies by the finding that people who make use of ICT when travelling put a higher value on saving time on the journey than those who make no use of such technologies. Those who value reduction in travel time come highly equipped to make good use of their travel time.

A recent Dutch study aimed at overcoming this potential source of bias was presented to the Roundtable (Molin, 2018, based on Adjenughwure, 2017). Travellers who habitually used a laptop, smart phone or other electronic device or read a book were asked to imagine that they had left their device at home. The aim of the study was to derive a value for each of the key types of activity (such as reading, working and listening to music) undertaken on the train which could be separated from the value of reductions in travel time by comparing the values of reductions in travel time with and without an activity. The method adopted (Box 3) is consistent with the theoretical model discussed earlier (Fosgerau, 2019).

Box 3. Value of activity while travelling methodology

The methodology for establishing the value of activity is summarised below:

$$VOA = VOT_{NAC} - VOT_{AC}$$

$$U_i = \beta_C C_i + \beta_C * VOT_{AC} * T_i + \beta_C * VOA * T_i * NAC$$

where VOA = value of activity

VOT_{NAC} = value of time without activity

VOT_{AC} = value of time with activity

U = utility function

C = travel cost

T = travel time

NAC = dummy for non-activity condition (1 = non-activity condition; 0 = activity condition)

β_C = coefficient estimate for the travel cost variable

i = individual i

Source: Adjenughwure (2017); Molin (2018).

The study showed that an individual who uses a device while travelling attaches a value to the ability to spend travel time usefully but that this value is not big enough to eliminate any benefit from reducing the travel time on that same journey. The ability to derive value from engaging in an activity while travelling provides analysts with the opportunity to inform policy makers about the benefits of measures to allow travellers to make better use of travel time, such as quiet carriages or improved internet connectivity. That is, travellers value better utilisation of space and improved conditions of urban travel, in addition to speed (Crozet and Mercier, 2018). In project appraisal, the benefits of improving the quality of travel time can be estimated by multiplying the value of activities by the change in the time of use. Information on changes in time use is difficult to model but may be possible through the use of stated preference surveys to gauge how time use may change in response to changes in comfort level. The findings are also relevant to any assessment of the implications of AVs for transport investment.

Appraisal, modelling and policy implications

Fosgerau (2019) concludes that conventional cost-benefit framework used in the appraisal of transport projects is able to accommodate the changes in the way people use travel time. The extent to which the use of ICT might reduce the conventional value put on reductions in travel time cannot be established from the theory alone. Evidence from surveys and analysis of travellers' behaviour are needed to determine how values might have changed over time and between modes and how ICT might have influenced those changes. Goodwin (2019) noted that the 6th ECMT Roundtable held in 1969 recognised the composite nature of the value of reductions in travel time and that Harrison and Quarmby (1969), discussed in the ECMT Roundtable report other variables that are important to the traveller, including overcrowding and irritation at delays, that can influence the value travellers put on reductions in travel time.

The cost benefit framework itself and its use in transport appraisal has its critics. The values incorporated in the method are based on the users' willingness-to-pay for the transport network, with a greater weight being put on the values stated by those who use the network most, in order to make the values representative of the use of the network. Critics of the existing approach have suggested that ability to pay should not be a factor in determining the values used to assess the benefits of a publicly-funded project and that each individual's value should carry an equal weight. The Roundtable considered this critique and concluded that adjusting appraisal values was unlikely to be effective in addressing inequality between individuals when compared with policies that are directly aimed at this objective. Moreover many countries use a national average value of reduction in travel time, which has the effect of distributing more of the transport budget to improve journey time or reliability towards lower income regions than would be the case when using values fully differentiated by user. This may or may not be consistent with the needs of the lower income regions.

There is a trade-off between the degree of segmentation and the level of perceived precision of the VTT estimates. The purpose of transport appraisal is not to establish precise estimates but to establish credible ranges of estimates that allow flexible assessment of the costs and benefits for a broad range of users and behavioural responses. Ideally, behavioural VTT (that reflects the underlying travel behaviour of the respondents) should be used for both modelling and appraisal purposes to ensure policy decisions do not lead to misallocation of resources across the transport sector. While the discussion in the literature has focused on income effects on VTT, the ability to consider quality of travel time components is arguably more important (Börjesson and Eliasson, 2018). In modelling, evidence on behavioural responses to changes in the quantity and quality of travel time should be used to improve the assessment of transport demand and modal shift effects, to capture the effects of ICT and time use on travel. These could be substantial (Meunier, 2019).

In current practice, multipliers are typically used to increase VTT to consider the effects of crowding, comfort and reliability. When such estimates are considered in conjunction with the value of activity, care should be taken to avoid understating (due to omission) or overstating (due to double counting) the overall impacts (Adjenughwure, 2017; Meunier, 2019). Segmentation of VTT between quantity (pure travel time) and quality (comfort, reliability and time use, etc.) components is useful to inform appraisal and policy decisions. It is also important to know what components make up the overall reductions in travel time incorporated in the appraisal.

Despite self-reporting errors and other limitations, the lack of better alternatives means that stated preference survey methods continue to be a useful and valid approach to estimating VTT. Techniques are increasingly available to overcome some of the potential biases of this method and to help users of such surveys understand the effects of latent/intangible attributes such as travel time use opportunities. Stated preference surveys are enhanced when supplemented by qualitative surveys to get a better picture of how people interpret the questions and to better understand what factors they considered in choosing how to travel, apart from those included in the survey. The relation between VTT and the values put on reliability, comfort and time use will affect survey design and the practical application of the estimates produced. One important issue to be addressed in survey design is the level of segmentation required to account for the trade-off between money and time amongst different users. In addition, close attention should be paid to the effects of income on the marginal utility of money (Goodwin, 2019) and to ensuring VTT is based on actual behavioural responses, to enable selection of more efficient transport projects (Börjesson and Eliasson, 2018).

Changes in the value of reductions in travel time, and in other benefit parameter values can, when applied in appraisal, result in changes in the relative merits of the options presented to decision-makers. For example, changes in values of reductions in travel time and value of reliability adopted in the United Kingdom have changed the benefit-cost ratios for a sample of schemes (Batley, Dekker and Stead, 2019). New parameters reduced the VTT for leisure and all but the longest business rail trips and at the same time increased commuter values. The reductions in VTT for business and leisure travellers more than offset the increase in commuter values for all but the few long distance rail projects considered and some of the schemes with a high percentage of commuter trips. The average reduction in scheme benefits was around 10%, but there was substantial variation between schemes (due to differences in the mix of traffic and users), with some experiencing a reduction of 40%. It is essential to ensure that proposed changes to parameter values are consistent with the broader evidence on the preferences of the users before they are adopted.

Conclusions

Everyone faces a constrained time budget, of 24 hours a day. This time budget is generally allocated into two broad categories – location specific activities (home-based, work-based, other non-home based) and mobility related activities (transit, waiting, in-vehicle etc.). The 24-hour limit on the total time able to be spent on these categories means that the value of reductions in travel time will remain a key factor in valuing both the benefits of transport investment (Baumol, 1973; Becker, 1992; Crozet, 2010) and the benefits of transport policies such as congestion pricing. The value of reductions in travel time is a complex concept, as it depends both on factors related to the quality of the journey and to the characteristics of the traveller, in particular the traveller's ability to pay. Studies for updating the values of reductions in travel time in appraisal methods need to account for changes in these factors so as to ensure that policy makers find the results plausible. Such changes are equally important to informing predictions of changes in behaviour and forecasts of benefits over the life of an investment scheme.

Evidence on *how* the value of reduction in travel time might be adjusted to reflect *differences in the quality* of a journey is important. Improving the quality of a journey might be as beneficial as investment to reduce journey times – i.e. the quantity of time spent on the journey. Examples of such options include investing in longer commuter trains to reduce overcrowding or providing public transport users with free Wi-Fi. Some countries make use of multipliers that increase the value of reduction in travel time where journeys are undertaken on crowded trains. This can provide a justification for investing in more capacity and reducing the value of time spent on the rail journey from the crowded value to its unmodified or reference value.

Assumptions about how the value of reduction in travel time changes over time can have an important influence on the transport appraisal process, determining the overall size of scheme benefits. While some countries assume the value increases at the same rate as GDP per capita, others assume a lower rate of growth. The three recent studies presented suggested that the value of reductions in travel time is growing at a lower rate than income, perhaps because ICT and other changes have made travel less onerous when compared with other ways of spending time. This means assuming VTT increases with income over time is unlikely to be accurate. Further analysis of this evidence in the context of the factors that have influenced historic values might help to give analysts and policy makers more confidence in the forecast values of reductions in travel time. Updating values and carrying out new surveys, for example once every five to ten years, will ensure that the values remain relevant to the current generation of transport users.

Interpretation of the evidence on how business travellers and their employers value travel time remains a challenge. Business travellers spend only part of their journey engaged in work-related activities despite the journey being undertaken during working hours. Conversely, some continue to work and generate value for their employer when travelling outside their normal working hours. A greater understanding of work practices, in particular in the knowledge-based sectors, might help to corroborate the evidence reviewed at the Roundtable.

Research aimed at deriving time values for different qualities of travel need to start from a clearly-defined reference value. For example, if a factor to adjust the value of travel time downwards to a lower value in order to take account of investment in ICT connectivity is required, the researcher needs to have a good understanding of the conditions prevailing when the survey was carried out to establish the reference value.

Most of the evidence for the values presented to the Roundtable was derived from stated preference surveys. While the practice of stated preference has been improved since the method was first introduced, concerns remain about the quality of evidence based on what people say about how they will behave. However, stated preference remains the only feasible means of deriving values for some options, such as the use of AVs, which can be described as a possible scenario but are currently unavailable. More generally, the alternative of using observations of actual behaviour (i.e. revealed preference) has two drawbacks. First, there are very few examples of people trading off only between money and reductions in travel time: most choices involve a large number of other considerations concerning the quality of the trip and the characteristics of the traveller which cannot easily be disentangled from the time/money trade-off. Second, such studies require a large amount of expensive data collection. That said, opportunities to use revealed preference based studies to inform, or validate, stated preference based conclusions should be sought out.

'Big Data', defined as the collection and analysis of large amounts of data on the trips people make and the choices they face through using ICT, provides a potential source information that might eventually supplement or replace existing methods of deriving values of reductions in travel time. Mobile phones, roadside cameras and other sources of data open up the possibility of analysing schemes that improve the quality of a journey or reduce travel times. This would give access to an alternative source of information on how people respond to these improvements. The Roundtable suggested a scoping study to investigate the feasibility and limitations of this approach to valuing reductions in travel time and journey quality should be undertaken.

None of the studies reviewed suggested that the value of reduction in travel time was likely to become close to zero. However, better valuation methods that can account for both positive utilities derived during travel and different levels of disutility given by differences in the quality of the travel experience should be pursued in order to inform better project choices.

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Annex: List of participants

WORSLEY Tom (Chair)	Professor, Institute for Transport studies, University of Leeds, UK
BATLEY Richard	Director, Institute for Transport Studies, University of Leeds, UK
BAUERNFEIND Maximilian	Federal Ministry for Transport, Innovation and Technology, Austria
BÖRJESSON Maria	Professor, VTI Swedish National Road and Transport Research Institute
BRUNS Frank	Partner and Head of Transportation Economics and Financing, EBP, Switzerland
CROZET Yves	Professor, University of Lyon, France
DE JONG Gerard	Director, Significance, The Netherlands
DEIGHTON-SMITH Rex	Project manager, International Transport Forum (ITF)
DEKKER Thijs	Institute for Transport Studies, University of Leeds, UK
FOSGERAU Mogens	Professor, University of Copenhagen, Denmark
GALETOVIC Alexander	Professor, Faculty of Economics and Business, University of Andes, Chile
GOODWIN Phil	Emeritus Professor, University College London, UK
HOPKINS Debbie	Transport Studies Unit, University of Oxford, UK
HULLEBERG Nina	Research Mathematician, Institute of Transport Economics (TOI), Norway
JULIEN Arantxa	Research project manager, French Ministry for an Ecological and Solidary Transition, France
KATO Hironori	Professor, The University of Tokyo, Japan
KIM Young Tae	Secretary General, International Transport Forum (ITF)
KONING Martin	Researcher in Economics, IFSTTAR-SPLOTT, France
KOUWENHOVEN Marco	Research Leader, Significance, The Netherlands
LEE Sungwon	Chief Research Director, The Korea Transport Institute, Korea
LEUNG Joanne	Policy Analyst, International Transport Forum (ITF)
LUGANO Giuseppe	MoTiV Project manager, University of Žilina, Slovakia
LYONS Glenn	Professor, University of West of England, UK
MASCLE-ALLEMAND Anne-Laure	Independent Consultant, France
MEUNIER David	Associate Researcher, Laboratoire Ville Mobilité Transport, France
MOLIN Eric	Associate professor, Delft University of Technology, The Netherlands
PAN Haixao	Professor, Department of Urban Planning, Tongji University, China
PERKINS Stephen	Head of research and policy analysis, International Transport Forum (ITF)
RAVEAU Sebastian	Associate Professor, Pontifical Catholic University of Chile, Chile
STEAD Iven	Transport Appraisal and Strategic Modelling, Department for Transport, UK
VASSALLO Jose Manuel	Professor, Polytechnic University of Madrid, Spain
WORTELBOER-VAN DONSELAAR Pauline	Programme manager, Netherlands Institute for Transport Policy Analysis (KIM), The Netherlands
WU Ping	Associate Research Fellow, China Academy of Transportation Sciences, China
YANG Dong	Senior Engineer, China Academy of Transportation Sciences, China

International Transport Forum

What is the Value of Saving Travel Time?

This report revisits the rationale and methods for estimating the value of reductions in travel time. In doing so, it considers changes in the way people use time and specifically explores whether the value of time will fall towards zero as connected technologies allow a wide range of activities while travelling. The report also reviews evidence and methodologies to account for the utility derived from such activities, as well as implications for modelling, appraisal and policy planning. It summarises the findings of an ITF Roundtable held with 30 experts from 14 countries in September 2018 in Paris.

All resources from the Roundtable on Regulating App-Based Mobility Services are available at:
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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

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