Beyond traditional value-of-time: passenger behavior for multimodal door-to-door travels in the age of information technologies

Nathalie Lenoir, Isabelle Laplace

BEYOND TRADITIONAL VALUE-OF-TIME:

PASSENGER BEHAVIOUR FOR MULTIMODAL DOOR-TO-DOOR TRAVELS IN THE AGE OF INFORMATION TECHNOLOGIES

Nathalie Lenoir,
Isabelle Laplace
Ecole Nationale de l'Aviation Civile, Université de Toulouse, France

ABSTRACT :
Today, new services and products open a realm of possibilities to the imagination of individuals, leading to profound changes in the way we live and move. For practicality reasons, current transport models usually consider individual transport modes with the attributes of monetary costs and time costs, using the value of time savings of travellers. This leads to the supremacy of speed in models of passenger behaviour and in the evaluation of transport infrastructure project. However, today people seem to consider other attributes than just price and time of travel. Moreover they usually string together several transport modes from the origin to the destination, and take into account the whole package when deciding about their trip. In this paper we look at previous research on various transport modes (or combination of transport modes) in order to identify how people currently behave when they decide to travel and choose their transport modes. We highlight the need to review our concept of value of time savings with a highlight on the specific case of multimodal door-to-door travels.

1. INTRODUCTION

Today, new services and products open a realm of possibilities to the imagination of individuals, leading to profound changes in the way we live and move. While transport has traditionally been viewed as a constraint in daily life, mobility now becomes a part of it.

Beyond traditional transport modes organised by operators, additional services provide travellers with means to organise, control and optimise their own door-to-door mobility and to turn their travels into a useful or even enjoyable time.

For these reasons, the current way of analysing passenger travel choices does not seem to reflect anymore the way people behave when they decide to travel and choose their transport modes.

For practicality reasons, current transport models usually consider individual transport modes with the attributes of monetary costs and time costs, using the value of time savings of travellers. This leads to the supremacy of speed in models of passenger behaviour and in the evaluation of transport infrastructure project: it is assumed that people will always favour the fastest transport mode, unless it is more expensive than others. Speed becomes the very first attribute of the utility of travel, while the cost of travel enters the budget constraint of the individual.

However, today people seem to consider other attributes than just price and time of travel. Moreover they usually string together several transport modes from the origin to the destination, and take into account the whole "package" when deciding about their trip.

In this paper we look at previous research on various transport modes (or combination of transport modes) in order to identify how people currently behave when deciding to travel and choosing their transport modes. After presenting the origins of the concept of "value of time saving" in section 2 and explaining the concept in relation to transport in section 3, we focus on its limits in section 4. Then, we argue that we need to review the concept in section 5 by examining the role in the traveller's utility of information technologies, environmental factors and lifestyle preferences. The paper ends with the specific case of multimodal door-to-door travels and suggests that further research should strive to model the derived utility of the use of successive transport modes during a single journey.

2. THE ORIGINS OF THE CONCEPT

In basic microeconomic theory of consumer choice, individuals maximise the utility of consuming goods, subjects to a budget constraint. In standard analysis, the fact that it takes time to consume certain goods is not taken into account, which is a simplification that comes in handy in most cases.

In transport analysis, however, time is paramount: often, individuals would rather be somewhere else than in a bus, train or car, and enjoy more leisure time. There is a general time-allocation problem, considering that we all have a fixed amount of time per day.

Time has come into play in economic theory with the ambition of explaining the labour supply, and it is precisely how economists began analysing the use of time. A total amount of time is available (no more than 24 hours a day!) and individuals weigh the opportunity cost of various activities. There is a nearly infinite number of uses to which we can put our time: work, sleep, eat, play, drink with friends, raise children…

For simplicity's sake, economists first separated those uses in two categories: leisure and work. Leisure is a type of consumption that adds directly to the utility. Work, on the other hand, provides income that can be used to purchase goods that increase utility. The more people work, the greater their income, but the smaller the amount of leisure time. There is therefore a trade-off between labour time and leisure time. In general, the reassignment of time from one activity to another can have value for the individual.

Becker (Becker, 1965) started incorporating non-working time into utility models, where people consume goods and a time component is associated with the consumption of those goods. His model is based on the consumption of goods,

while time is devoted to the production of the final commodities. For Becker, consuming has a time cost: the cost of not earning money. For him, whatever the activity, the value of time is equal to the individual wage rate.

Johnson (Johnson, 1966) included work in the utility function, which led to a different value of leisure time, then Oort (Oort, 1969) included transport, which led to a specific value of travel time: there is a direct perception of travel time in the utility, which makes sense, since a reduction in travel time would increase time for leisure or work, but also directly impact utility, if travel is seen as an unenjoyable activity (has a negative impact on utility by itself).

De Serpa (DeSerpa, 1971) contributed to this research on the use of time by postulating that utility is dependent on goods and time periods (called activities). For him, the consumption of some goods include a minimum time. With no minimum time, indeed, individuals would adjust the time of all activities so that the value of time would be equal for all activities (leisure, work, transport). He defines leisure as those activities for which people would willingly attribute more time than the minimum required. Other activities, on the contrary, induce disutility and the value of time savings in these activities is positive (people would be willing to spend less time in those activities).

Evans (Evans, 1972) went even further by considering a utility function whose arguments are only the times spent in various activities. Individuals allocate their time between activities in a way that maximises their utility $U(T)$. However, activities require goods to be actually produced: market good become inputs for activities. The cost of activities can be either positive (the individual pays) or negative (he is paid). Activities will be interdependent through the budget constraint. Moreover, this model allows for a transformation function turning activities into goods and vice versa: $X = QT$, where X is the vector of goods necessary for each activity, and T the vector of activities. Q is a matrix containing the input of goods at a certain rate per unit time.

Although today the approach to consumer theory still rests on the consumption of goods, the role assigned to time by Evans through activities is worth discussing in the context of transport analysis, where the time dimension cannot be overlooked. Evans considers time devoted to activities as the basic source of utility. His model deals with the issue of the interrelation between all activities, through the total time constraint and the transformation function.

As Jara Diaz (Jara-Díaz, 2007) remarks, in a few years, time has become recognised as a fundamental component of utility: all activities are potential sources of satisfaction or dissatisfaction. Some activities would be assigned as little time as possible by the individual, while others are actually increasing utility (leisure). For the former activities, there is a value of time saving.

As transport is traditionally seen as a source of disutility (people would rather be doing something else than travelling), this value of time saving has been

paramount in transport studies, and transport investment evaluation, as can be seen in the next part.

3. THE VALUE OF TIME SAVINGS IN TRANSPORT

The value of time saving, sometimes shortened as “value of time”, has been widely used in transport investment evaluation and transport policy.

As we showed in the preceding section, each activity has its own value for each individual. However, difficulties arise when we try to model the individual’s behaviour, or to compute those values in order to perform evaluations.

Studies can be based on values obtained through surveys (method of declared preferences) or on values obtained from individual behaviour, estimated empirically through econometric models (method of revealed preferences). But both methods have biases, and values obtained differ from study to study. Waters (Waters, 1992) studies values of travel time savings used in various countries, in particular for road transport projects evaluation. He finds that studies have produced a very wide range of estimates: for non-work travel time, he finds estimates that tend to converge to a value of 30 to 60 percent of the wage rate.

In order for studies inside a country to be comparable and orient efficiently public choice and public policy, normalised values have often been chosen, as close as possible to a real average of values revealed by individual behaviour. In France, the “Commissariat général du plan” (France Commissariat général du Plan, 2001) has suggested values to be employed in transport studies. In the UK, the department for transport recommends normalised values which are periodically updated[1].

Those values have been widely used in cost benefit analysis, as they are necessary to compute the generalised cost of a transport mode, comprising the monetary cost and the cost of time spent in transport.

Other types of models which are very popular in transport studies are discrete choice models. They use mode specific utility levels. Individuals choose the transport mode that brings them the higher utility. Utility is usually represented by a linear function that combines costs and characteristics of each mode, including time and socio-economic variables for each individual or group of individuals.

Estimating those models yields values of time which can be mode and group specific. It is to be stressed, however, that this so-called utility function is in fact a conditional indirect utility function that considers all things outside of the transport choice to be independent of this choice. This is a severe limitation since it does not allow for reallocation of time gained (or lost) by choosing the fastest (slower)

[1] https://www.gov.uk/government/publications/values-of-travel-time-savings-and-reliability-final-reports

mode. Those models are also usually linearly specified for simplicity reason and require very detailed data to be estimated.

4. THE LIMITS OF THE CONCEPT

The use of average values of travel time savings in transport studies and cost benefit analysis places a lot of emphasis on time, and occults the many dimensions of transport and the many dimensions of our perception of time. It has led to transport policies focused on travel time reduction of individual modes, while other dimensions could be equally important, like quality of transport, usage of travel time, safety, security, reliability, ease of use…

Metz (Metz, 2008), contends that travel time saving is a myth, not supported by evidence, by looking at the national travel survey data in the UK. It looks like people actually use time gained through better infrastructure to travel further, because average travel time in conserved in the long run. He calls this "additional access": individuals use the new infrastructure to access places that were formerly too remote. It looks like decreasing transport time on a given route opens up new possibilities to travel further or elsewhere. This does not really undermine the concept of travel time savings, but rather highlights the fact that reducing travel time induces all kinds of restructuring into people's activities, generating new activities, including travels.

In addition, Mokhtarian and Salomon (Mokhtarian and Salomon, 2001) dispute the theory according to which travel involves disutility to be endured. They argue that people can have an intrinsic desire to travel and that the destination may play a more ancillary role than the trip itself. They define as the "undirected travel" the movement through space for which the destination rather than the trip is ancillary and the "utilitarian travel" the movement for which the destination is completely primary while the trip is ancillary. The proportion of both types of travel can vary according to the persons and the situations. For instance, when commuting, a passenger can enjoy the full trip or a part of it because he can have time for reading, listening to music or just taking a break between his occupation place and his home. In other words, Mokhtarian and Salomon (Mokhtarian and Salomon, 2001) argue that a positive utility for travel exists and can be derived from a composite of three different activities:

- The activities conducted at the destination;
- The activities of travelling themselves;
- The activities conducted when travelling.

The first category of activities is in line with the conventional wisdom in transport modelling, which considers that the only objective of a trip is to reach the destination in order to perform activities. The second category deviates from it. It relates to the intrinsic aspect of travelling itself. For instance, people can choose to make a cruise on a liner mainly to enjoy the sensation of sailing and then

derive a positive utility from the trip itself. Authors point out, however, that such activities correspond to a small proportion of the overall travel.

The third category seems more significant. It refers to activities than can be performed while travelling. They warrant greater consideration in terms of positive utility (Lyons, 2003). Examples of these activities are (Lyons and Urry, 2005):

- Sleeping / snoozing;
- Reading for leisure;
- Working (reading / writing / typing / thinking);
- Talking to other passengers;
- Window gazing / people watching;
- Playing games;
- Listening to radio / music;
- Phone calls / text messages (work or personal);
- Eating / drinking;
- Entertaining children.

They group activities such as reading, listening to music, watching TV or video, etc. as well as the ability to use the time for relaxing or thinking, what Mokhtarian and Salomon (Mokhtarian and Salomon, 2001) define as "Anti-activities". The associated positive utility is then linked to the "productive travel time use" (Lyons, 2003). Lyons et al. (Lyons et al., 2007) confirm the existence of productive travel time use by using a survey carried out among 26,221 rail passengers in Great Britain in 2004. Between 50% and 57% of the passengers interviewed considered the rail travel time as being of some use, while 17% to 30% of them regarded it as being very worthwhile. For Jain and Lyons (Jain and Lyons, 2008) travel time can sometimes be perceived by the individuals as a gift rather than a burden. They argue that *"the individual traveller gains something from the experience of travelling and from being in a mobile space away from other fixed location activities (or people) – something that would not otherwise have occurred*". They consider two categories of travel time in which the traveller gains some positive benefits from the journey:

- The transition time which refers to the temporal opportunity to translate, adjust or prepare oneself for activities at destination;
- The timeout which refers to the opportunity to have productive travel time uses.

5. EVOLUTION OF THE CONCEPT

The existence of positive utility derived from travel highlights the need to review our concept of value of time savings. Ettema and Verschuren (Ettema and Verschuren, 2008) contend that the opportunity of multitasking while travelling (i.e. the possibility to simultaneously engage in multiple activities during the travel time) may have an impact on the traveller's value of time. They stress that if multitasking while travelling has been possible for a long time, the development of ICT (Information and Communication Technology) tools allow for a wider range of multitasking options. The use of ICT tools may therefore influence passengers' travel utility and consequently their value of time saving. But the information age is not the only factor to take into consideration. Lifestyle preferences as well as environmental factors may also influence passenger's behaviour and experience of travel.

5.1. Role of Information Technologies

Lyons and Urry (Lyons and Urry, 2005) explore how the information age affects travel and specifically travel time use. As mobile communications enable people to move, access information and communicate simultaneously, they argue that even tiny slivers of time can be made productive. According to Weight (Weight, 2008) this is due to the fact that mobile phones can "*convert formerly 'downtime' space like trains into places where specific and personal activities can comfortably occur*". Jain and Lyons (Jain and Lyons, 2008) stress that the way people spend their travel time is evolving with ICT development as well as with transport infrastructure. More precisely, Lyons and Urry (Lyons and Urry, 2005) explain that it is not the ICTs themselves that change the use of travel time but rather the modifications these new technologies brings to the types of activities that can be undertaken on the move and their attributes. They stress the need for empirical evidence to study and estimate to what extent ICT use on the move will influence the pool of social practices. Aguilera et al. (Aguiléra et al., 2012) confirm that research is needed to "*understand how the availability of mobile technologies is reshaping the role and appreciation of the travel experience in our daily lives*".

5.2. Role of Environmental Factors

Generally, utility expressions in transportation studies include the generalised cost of getting between two points as well as some characteristics of the travellers. However these expressions rarely include the influence of the origin and the destination points. Cervero (Cervero, 2002) stresses the importance of also adding three core dimensions of built-up environments: density, diversity and design. The author defines these three factors as follows:

- *"Density reflects how intensively land is used for housing, employment and other purposes";*
- *"Diversity reflects the land-use diversity of trip origins and destinations";*

- *"Design reflects the quality of walking environment and the physical configuration of street networks."*

Cervero (Cervero, 2002) explains that omitting these factors in the utility expression could lead to biased estimations since estimates could overstate the influence of included variables.

Lyons and Urry (Lyons and Urry, 2005) consider that vehicles and travel places can also be seen as points of meetings, as for instance airports that propose meeting rooms and as a result become destinations in their own right.

5.3. Role of perceptions and transport attributes

Cervero (Cervero, 2002) suggests that in addition to considering factors such as travel time, cost, and socio-economic characteristics, travel demand modellers should also integrate the influence of built-up environment (see section 5.2) as well as lifestyle preferences. Sarkar and Mallikarjuna (Sarkar and Mallikarjuna, 2017) confirms this by stressing that besides quantifiable variables, latent variables representing individual preferences exist. Sarkar and Mallikarjuna (Sarkar and Mallikarjuna, 2017) have shown that flexibility and comfort are important determinants of travel behaviour. Vredin Johansson et al. (Vredin Johansson et al., 2006) also show the importance of adding flexibility and comfort variables together with modal time and cost variables in travel demand modelling. They also demonstrate the need to integrate indicators of environmental preferences in the utility formula. If the safety variable was insignificant in the model estimated, the authors stress that this does not necessarily mean that safety considerations are not relevant. They argue that design of the safety variable should be improved for a better reliability.

Anable and Gatersleben (Anable and Gatersleben, 2005) classify the practical aspects of travelling as *instrumental factors*. They distinguish short-term individual instrumental factors such as convenience, comfort, predictability, flexibility or monetary costs from long-term collective instrumental factors such as those related to health, fitness or environment. They also define a second category related to *affective factors* i.e. factors which refer to the feeling evoked by travelling (stress, excitement, pleasure, control, etc.). Their results show that for work journeys, travellers attach more importance to the former, and especially to convenience, than to affective factors. For leisure journeys, however, travellers place the same importance on instrumental and affective factors. They consider relaxation, freedom and an absence of stress to be as important as flexibility and convenience.

Kenyon and Lyons (Kenyon and Lyons, 2003) also highlight the role of habits in demand for travel especially with regard to the transport mode choice. They argue that modal choice is "*an automatic and, to an extent, a mindless decision, regardless of the journey characteristics*". Their results suggest that even when a traveller undertakes a new journey, he/she rarely considers alternative modes to his/her usual primary transport mode. As an illustration of this, Şimşekoğlu et al. (Şimşekoğlu et al., 2015) show that "*the strength of car use habit is a negative*

significant predictor of both intentions to use public transport and actual public transport use". More generally, Lanzini and Khan (Lanzini and Khan, 2017) show that habits and past use are the main predictors of the traveller's behaviour.

6. NEEDS OF CONCEPT EVOLUTION FOR MULTIMODAL DOOR-TO-DOOR TRAVELS

As far as we know, few authors have worked on the specific case of multimodal door-to-door travel demand. Nevertheless, multimodal door-to-door trips are very common, not only in the case of commuting but also for long-distance trips. Schakenbos et al. (Schakenbos et al., 2016) study the valuation of a transfer in a multimodal public transport trip and show that the disutility during an interchange depends on:

- the total door-to-door travel time,
- the distribution of the time spent between the access, the egress, the waiting time and the primary transport time
- the headway (i.e. the waiting time between two vehicles of a same transport mode, e.g. two trains, two metro, etc.).

Clauss and Döppe (Clauss and Döppe, 2016) explain that because of logistical complexity as well as potential problems during the transfer between two different modes, multimodal travels are generally considered as having a limited customer acceptance. However, their results tend to show that by combining travel modes offering different advantages and disadvantages, multimodal travels are perceived as providing a "*high situational and personal adaptability for urban travellers*" and are therefore fully in line with the growing request for "individualised travels". Clauss and Döppe (Clauss and Döppe, 2016) argue that when combining provision of service and high degree of innovativeness (e.g. dedicated smartphone applications or the development of new transport modes such as car sharing, city bikes, etc.), providers of multimodal travel options differentiate new travel modes and could fulfil heterogeneous demand.

There is therefore a strong need for research going beyond the traditional concept of value of time saving and modelling the multimodal traveller's utility. This need is particularly strong for long-distance door-to-door multimodal travels that are rarely considered in the literature. Those long-distance door-to-door travels are generally multimodal travels (except those made by own-private cars), since they often involve other transport modes than the primary mode. For instance, travelling by air requires using other transport modes than air transport to access and leave the airport. From the passenger's perspective, the door-to-door air travel is therefore a multimodal travel.

7. CONCLUSION

Although the traditional approach to consumer theory still rests on the consumption of goods, time has become identified as a fundamental component of utility. In transport analysis, travel time is usually seen as a disutility, leading to the concept of “travel time savings”, widely used in transport investment evaluation and transport policy. This has led to policies of reduction of travel time for individual transport modes.

Nowadays, this paradigm is questioned as information technologies evolve and change the way we travel, by enabling us to use travel time in different ways and to string several transport modes in a single trip more easily than ever before. Researchers also stress that people take into consideration their own perceptions of other dimensions of travel such as convenience, comfort, predictability, flexibility, feelings evoked, etc. The role of habit is also important and should be investigated.

In order to reflect actual passenger’s behaviour, travel analysis has thus to become multimodal and much less focused on travel time per se. In addition to traditional travel time, cost and traveller’s socio-economic characteristics, further research on the modelling of multimodal door-to-door travel utility should therefore explore the role of information technologies, other transport attributes, environmental factors and traveller’s perceptions. For instance, how much does the existence of ICT but also the continuity of service and reliability between successive transport modes impact the travel experience and passenger’s derived utility of travel? What role does habit play for the choice of primary, access and egress transport modes? What role does perception of travel (stress, enjoyment, pleasure, boredom…) plays into travel choice?

Hence, one main issue in the utility modelling of multimodal door-to-door travels is obviously not to consider each transport mode separately with associated key determinants but to think the multimodal travel as a combination of elements with potential complex relationships and influences.

REFERENCES

Anable, J., and Gatersleben, B. (2005). All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes. Transp. Res. Part Policy Pract. *39*, 163–181.

Becker, G.S. (1965). A Theory of the Allocation of Time. Econ. J. *75*, 493.

Cervero, R. (2002). Built environments and mode choice: toward a normative framework. Transp. Res. Part Transp. Environ. *7*, 265–284.

Clauss, T., and Döppe, S. (2016). Why do urban travelers select multimodal travel options: A repertory grid analysis. Transp. Res. Part Policy Pract. *93*, 93–116.

DeSerpa, A.C. (1971). A Theory of the Economics of Time. Econ. J. *81*, 828–846.

Ettema, D., and Verschuren, laura (2008). Multitasking and Value of Travel Time Savings. Transp. Res. Rec. 19–25.

Evans, A.W. (1972). ON THE THEORY OF THE VALUATION AND ALLOCATION OF TIME*. Scott. J. Polit. Econ. *19*, 1–17.

France Commissariat général du Plan (2001). Transports: choix des investissements et coût des nuisances (La documentation française).

Jain, J., and Lyons, G. (2008). The gift of travel time. J. Transp. Geogr. *16*, 81–89.

Jara-Díaz, S.R. (2007). Allocation and Valuation of Travel-Time Savings. In Handbook of Transport Modelling, (Emerald Group Publishing Limited), pp. 363–379.

Johnson, M.B. (1966). TRAVEL TIME AND THE PRICE OF LEISURE. Econ. Inq. *4*, 135–145.

Kenyon, S., and Lyons, G. (2003). The value of integrated multimodal traveller information and its potential contribution to modal change. Transp. Res. Part F Traffic Psychol. Behav. *6*, 1–21.

Lanzini, P., and Khan, S.A. (2017). Shedding light on the psychological and behavioral determinants of travel mode choice: A meta-analysis. Transp. Res. Part F Traffic Psychol. Behav. *48*, 13–27.

Lyons, G. (2003). Future mobility: It's about time.

Lyons, G., and Urry, J. (2005). Travel time use in the information age. Transp. Res. Part Policy Pract. *39*, 257–276.

Lyons, G., Jain, J., and Holley, D. (2007). The use of travel time by rail passengers in Great Britain. Transp. Res. Part Policy Pract. *41*, 107–120.

Metz, D. (2008). The Myth of Travel Time Saving. Transp. Rev. *28*, 321–336.

Mokhtarian, P.L., and Salomon, I. (2001). How derived is the demand for travel? Some conceptual and measurement considerations. Transp. Res. Part Policy Pract. *35*, 695–719.

Oort, C.J. (1969). The Evaluation of Travelling Time. J. Transp. Econ. Policy *3*, 279–286.

Sarkar, P.P., and Mallikarjuna, C. (2017). Effect of perception and attitudinal variables on mode choice behavior: A case study of Indian city, Agartala. Travel Behav. Soc.

Schakenbos, R., Paix, L.L., Nijenstein, S., and Geurs, K.T. (2016). Valuation of a transfer in a multimodal public transport trip. Transp. Policy *46*, 72–81.

Şimşekoğlu, Ö., Nordfjærn, T., and Rundmo, T. (2015). The role of attitudes, transport priorities, and car use habit for travel mode use and intentions to use public transportation in an urban Norwegian public. Transp. Policy *42*, 113–120.

Vredin Johansson, M., Heldt, T., and Johansson, P. (2006). The effects of attitudes and personality traits on mode choice. Transp. Res. Part Policy Pract. *40*, 507–525.

Waters, W.G. (1992). Values of Travel Time Savings Used in Road Project Evaluation: A CrossCountry/Jurisdiction Comparison. p.

Weight, J. (2008). Phones and trains: How to subvert industrial time. In ANZCA Conference, Wellington, July, p.