THE VALUE OF COMFORT IN TRAIN APPRAISAL

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ABSTRACT

Evidence has shown that both, personal and business travellers use the travel time spent on public transport as an opportunity to work, conduct business or to enjoy the trip. Public transport and, when autonomous vehicles hit the road, also cars promise a tremendous potential of social benefits. However, this direct utility of travel time is not covered as well as it should be in policy and project assessments, skewing planning and investment decisions. In this paper we present a new and practical application to appraise a rise or fall in the level of comfort offered to train travellers. Moreover, we describe how the benefits of an improved level of service can be included in a cost-benefit analysis (CBA). This new application measures the value of comfort indirectly through changes in the value of travel time savings (VTTS) that appear due to a difference in the level of comfort. It takes into account all the societal benefits that can be derived from increased productivity during the trip or from the personal satisfaction of the traveller, or from a mixture of both. In the paper, the method is applied to rail. However, the methodology is general applicable for all passenger transport modes.

1. INTRODUCTION

Good morning. It is 6:30 AM and time to get ready for work. Between you and your office are several train kilometres. So you roll out of the house and into your crowded train, hoping to arrive at the office by 9:00 AM. Now, imagine an alternative. When you enter the train, it is easy to find a comfortable seat. Moreover, you can choose to enjoy the ride or to open your laptop, connect to the Wi-Fi and start your work day. And train stations also offer comfortable places to meet and work. Knowing as you do that the trip can be spent usefully as work time means that you will need less time at the office.

Evidence has shown that both personal and business travellers use the travel time spent on public transport as an opportunity to work, conduct business or enjoy the trip (Fickling et al., 2009; OECD/ ITF, 2014; Kroes and Koopmans, 2014). Moreover, this possibility may also become fully available for car drivers soon. Due to continued and accelerating technological development, partially and fully autonomous vehicles may hit the road in the near future. These self-driving cars could return hundreds of productive hours annually to drivers who now waste significant portions of their day in traffic. Public transport and, soon, also cars, promise a tremendous potential of social benefits. However, generally, this direct utility of travel time is not covered as well as it should be in policy and project assessments, which, consequently, skews planning and investment decisions. In this paper we present a new and practical application of Fickling et al. (2009) to appraise the varying levels of comfort and convenience offered to train travellers. This method can also be applied to other modes of passenger transport.

We follow Kroes and Koopmans (2014) and use the broad definition of comfort. In that definition, comfort covers all aspects of the total train trip relating to how pleasant a trip is and the possibilities for spending the travel time usefully. Examples include: punctuality of the train, frequencies, walking conditions at the station, feeling safe and secure, and the walking distance to the bus station or bike parking stalls. A narrower definition focuses on comfort aspects in the train, such as: clean and comfortable vehicles, the possibility of having a seat and the ability to work on a laptop. All these aspects are also included in the broad definition.

In Chapter 2 of this paper we discuss the potential societal benefits of increased comfort. Chapter 3 describes the traditional way, and a new and practical application of Fickling et al. (2009) to appraise the various levels of service offered to train travellers. Chapter 4 provides a concrete example of this new application. Insights into the productive use of rail travel time are based on available data from value of time and value of reliability studies conducted in The Netherlands (Significance et al., 2013), available data from Netherlands Railways (NS) pertaining to activities performed during train trips, and the UK study about the productive use of travel time and working time savings for rail business travellers (Fickling et al., 2009). We describe how the benefits of an improved level of service can be included in a cost-benefit analysis (CBA). In Chapter 5 we discuss the policy impacts of better capturing the comfort aspects of a project. Finally, Chapter 6 provides conclusions and discussion (see also Wardman and Lyons, 2016).

2. THE POTENTIAL BENEFITS OF COMFORT

2.1 About time and disutility

People spend their time on various activities throughout the day. Most of this time is spent at home, but many activities, such as work, social relationships or recreation, require us to undertake trips. In cost-benefit analysis, everything must be translated into economics, and hence also the utility of travel time. The activity that we engage in at another location is the primary activity, while the trip to and from that location is a secondary activity. Economists regard the time needed for undertaking trips as disutility, because the travel time comes at the expense of the time otherwise spent engaging in the main activity (or spent at home). When spending time, therefore, the relative value of time matters. Welfare economics theory postulates that an individual experiences maximum utility when spending a certain amount of time. He or she is only prepared to deviate from that optimal pattern if a guaranteed financial remuneration exists for doing so. Conversely, one may assume that he or she endeavours to optimise the time spent. In standard applications of welfare theory, a crucial point in the value of time calculation is the assumption that the marginal utility of travel time is routinely negative: extra travel time means the individual has less time left over for things that he or she prefers to do (such as, for the morning commute, sleeping longer or having breakfast and leaving later). The more utility people can ascribe to time for these extra objectives, the more they are prepared to pay for travel time gains. This sounds logical and familiar, but in practice it is not the whole story.

2.2 Budgets and value

The investments that people must make in order to engage in a primary activity are not only comprised of time and money, but also the effort they must expend. Effort can be physical, when one opts to walk or cycle, or mental, such as determining one's route, planning and, while travelling, checking to ensure the correct route is being followed, especially if this is first time a certain trip is made. Moreover, travellers in principle choose the path of least resistance; that is, they want to travel as quickly, inexpensively and effortlessly as possible (Van Wee & Dijst, 2002; Peek & Van Hagen, 2004). Owing to rising prosperity, the time budget is increasingly important, and time plays an increasingly larger role in making (trip)choices (Pine & Gilmore, 1999). The invested budget has an expected value. Moreover, it follows that the money, time and effort people invest in travelling to activities they want to pursue must be less or at least equal to the (expected) value of those activities (Van Hagen en De Bruyn, 2012). Thus, the expected value of an activity is greater than or equal to the expected costs invested for engaging in an activity, including the trip (see Figure 2.1). This also means that an activity can be cancelled because it costs too much time, money and/or effort to engage in, as it is nonsensical to invest more than one receives in return.

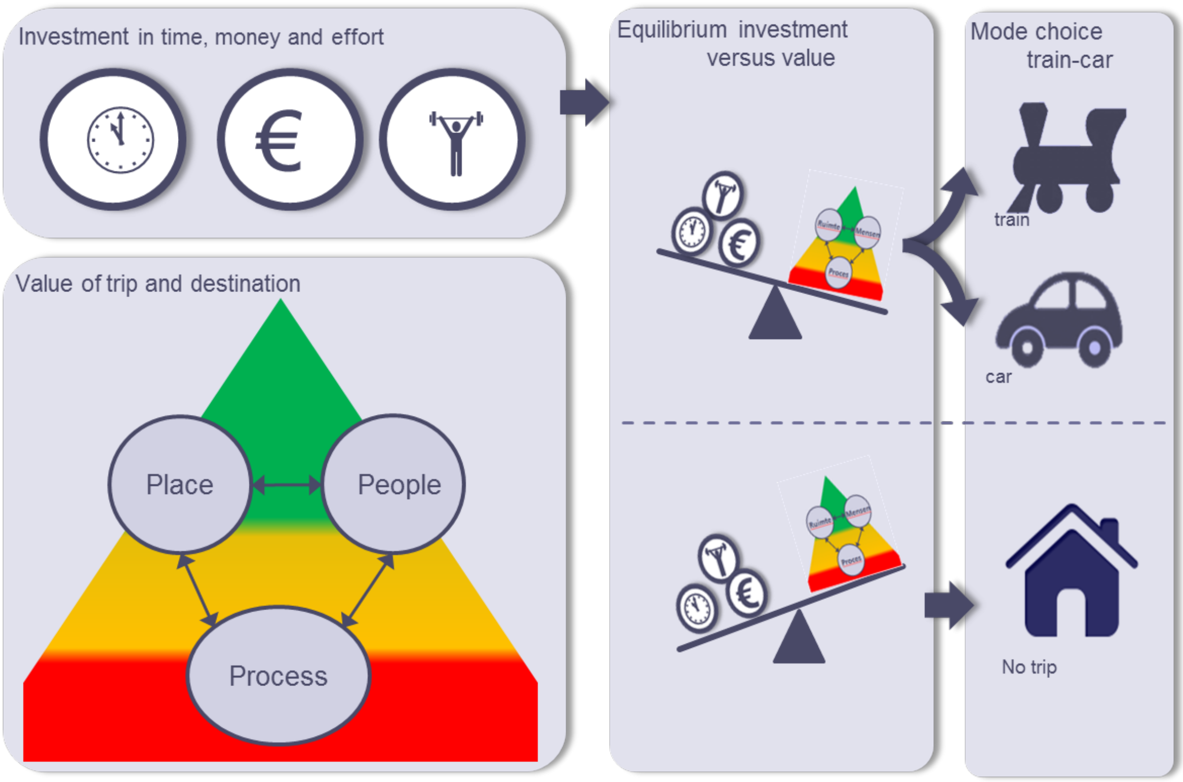

Figure 2.1:Budget function as interconnected vessels and must be equal or lower than the value

Relevant in this context is the fact that the time spent travelling to a destination can also be useful and even enjoyable (which of course also produces utility). People can experience a pleasant journey when travelling through a beautiful landscape, for example, or when they can play games along the way or when travelling with pleasant companions. In fact, the trip can even have more value than the activity one is travelling to; this for example is the case when travelling by Orient Express or aboard a cruise ship, whereby the functional trip is subordinate to the pleasure offered by the trip itself. A useful trip is a trip in which the traveller can engage in other activities while travelling, such as reading, working, telephoning or emailing; activities that one must otherwise do at home or at the destination. If people must engage in these activities at their destination, this, like the travel time, comes at the expense of the time they could otherwise spend on engaging in the activity at their destination. By being able to engage in such activities while travelling, time is saved during the trip, as it were.

2.3 The context determines the value of time

In assessents of the Value of Time, we find that the notion that travel time can also have value is missing. In their article, titled 'The gift of time', Jain & Lyons (2008) address this subject, stating that travel time need not be a loss of time; rather, travel time can also be spent usefully and pleasurably, because people can interact with others, engage in various activities or simply rest. Some travellers consciously opt for longer or slower trips, in order that they may spend more time listenening to music, doing extra work or to simply arrive feeling more rested (Bull, 2000; Salomon

& Mokhtarian, 1997; Redmond & Mokhtarian, 2001). Jain & Lyons (2008) conclude that not only does the utility or pleasure itself inform the value of travel time (equipped time), but that travel time also has value as buffer time (transition time) between two activities, such as between home and work, or even in offering one the opportunity to evade other obligations and hence, when travelling, to ultimately decide for oneself what one wants to do (time out). If we consider the value or utility of a trip in this way, we can thus state that a trip, in and of itself, can also have utilily, depending on the context. The concept of utility and value of time may well be enriched by making a distinction between the accessibilty, in which travel time is seen as trip time (hours and minutes), and the value of this time as experienced by the traveller (see Anex). The figure below illustrates this distinction. The time spent on the trip is shown on the x-axis, and the experienced value on the y-axis. The time spent indicates how much (travel) time the travellers must invest in order to engage in an activity elsewhere, and by this we therefore mean the accessibilty. The y-axis indicates whether the utility was experienced during the trip, which can be a trip involving practical utility, during which work is done for example, as well as a pleasant trip, in which enjoyment is derived from the trip itself. We observe that the origin and destination locations have the highest value (lowest cost), as these are the activities that we structure our lives around. This approach directly adheres to the notion that travelling is a secondary activity, and that generally travelling is less valuable than engaging in a main activity. We also see that during the trip itself, the in-train time has the highest value, followed by the access and egress time. The waiting/interchange time is ultimately deemed the least valuable experience. We know from research (Van Hagen, 2011) that waiting time is subjective, experienced as two to three times longer than the objective clock-time. This corresponds with the assessment that waiting time has the lowest utility, some two to three times lower than the in-train time (Wardman et al, 2004). The accessibilty on the x-axis can be increased by travel time gains, which can occur for example by <u>accelerating</u> the trip, such as by driving faster, higher frequencies and more direct connections, as well as by designing transport hubs in a manner that minimises time loss, owing to the introduction of escalators and shorter walking distances, for example. No clock-time is gained on the y-axis, but the value of the time spent is increased through the creation of a <u>pleasant</u> accomodation area, in the train and at the station, whereby time seemingly passes more quickly (Van Hagen, 2011). Services can also be offered that allow the trip and waiting times to be spent usefully or pleasurably; examples include shops, food and drink concessions, or live piano music performances in the station. In the train, provisions such as comfortable seats, electric outlets, good lighting and connectivity (free Wi-Fi, for example) help allow for an optimal use of time.

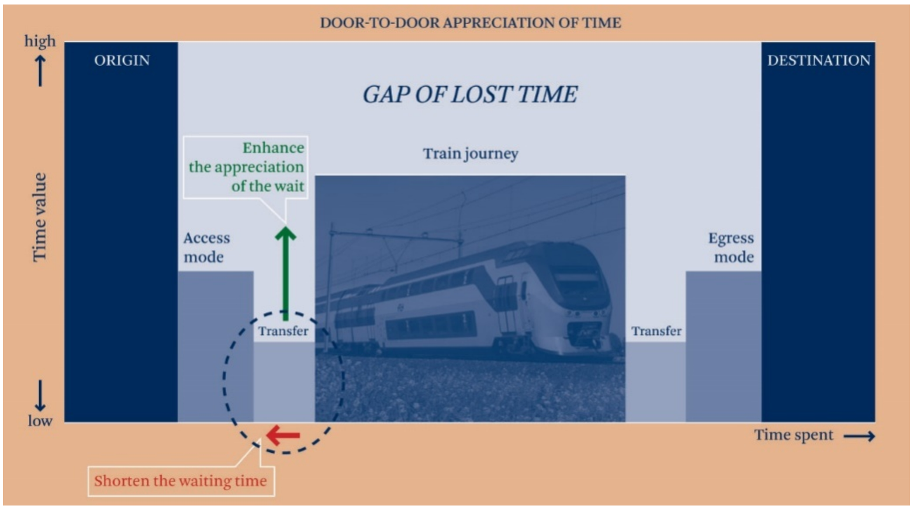

Figure 2.2:Travel times can be shortened and the value of travel time can be increased
Source: Van Hagen, 2011

2.4 We certainly do not want to become emotional?

The emotional expericence determines how people experience time (Van Hagen, 2011). If people experience a time interval positively, then time seemingly passes more quickly. If they have a negative experience, time seemingly passes more slowly. Reversal theory (Apter, 2007) and time psychology (Zakay, 1989) reveal that people experience positive emotions when finding themselves in a comfort zone; they are thus able to relax or feel happy, and in both cases time seemingly passes more quickly (Van Hagen, 2011). This is illustrated in Figure 2.3. When people are stressed or bored, time seemingly passes more slowly. If passengers in a train can sit, they are thus able to relax or do something enjoyable, and time passes more quickly; however, if they must wait on a train station platform (bored) or rush to change trains (stressed), they experience negative emotions and time seemingly crawls (Figure 2.3). The qualification utility or disutilty is seemingly largely dependent on how travellers experience time - positively or negatively.

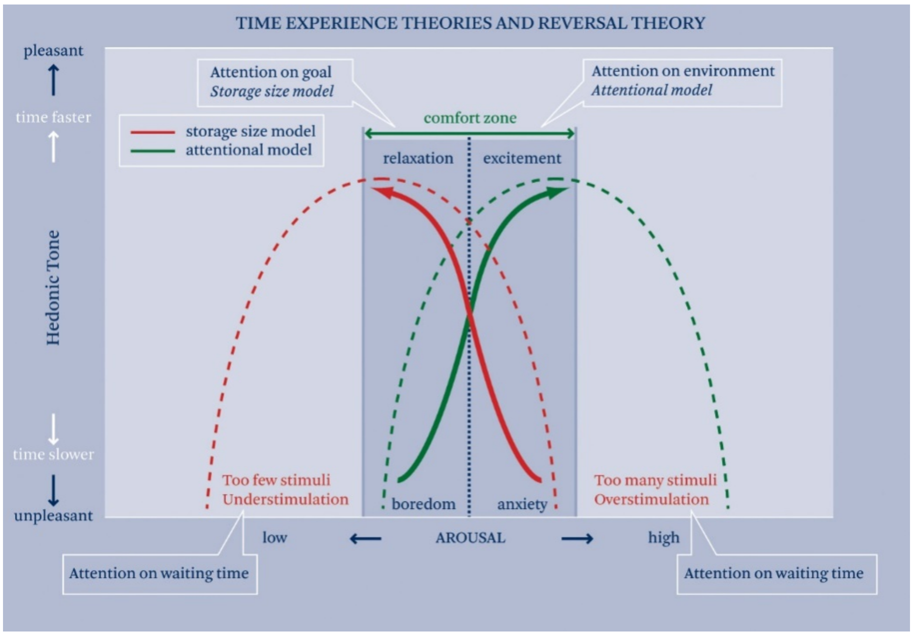

Figure 2.3:Time seemingly passes more quickly for happy and relaxed passengers than it does for bored and stressed passengers
Source: Van Hagen, 2011

3. MEASURING AND VALUING COMFORT

3.1 THE TRADITIONAL WAY TO VALUE COMFORT

Including the societal benefits from increased levels of comfort during travels in CBA is important, since otherwise the benefits from transport investments may be underestimated. A large body of valuation studies are available pertaining to convenience and comfort factors (CPB/ KiM, 2009; Wardman, 2013; Kroes and Koopmans, 2014; OECD/ ITF, 2014). These studies examine the travellers' willingness to pay for comfort. Valuations are typically expressed in equivalent units of in-vehicle time and can be included in a CBA through the valuation of travel time savings (VTTS). The following summary of the importance of convenience multipliers was derived from a recent review of key international studies on convenience and comfort factors in public transport (OECD/ ITF, 2014) .

Table 3.1: Summary of importance of comfort multipliers

Convenience term	**Multiplier**
Late time	3.0- 5.0
Walking with more than normal effort	4.0
Walking in crowded conditions	2.5- 4.0
Walking and waiting in normal conditions	1.75- 2.0
Standing in the vehicle / crowding	1.50- 2.0
Headway	0.5- 0.8
Displacement time	0.4- 0.6
Interchange penalties	5- 15 min travel time
On-vehicle information	<< 1 min travel time
Off-vehicle information	<< 1 min travel time

Source: OECD/ ITF, 2014

Remark: Multipliers relate to in-vehicle-time; the last three convenience terms (interchange and, on and off vehicle information) are not multipliers but penalties and relate to travel time.

Table 3.1 shows that arriving a minute later than promised in the timetable is regarded as up to five times as important as a minute of saved travel time. In many situations, an increase in public transport service quality reduces the generalised journey costs and may provide benefits to travellers that are comparable to speed improvements.

Working with time multipliers is attractive because they are potentially much more transferable across different contexts and cultures than monetary values, which suffer from the vagaries of currency markets, and the varying income levels and income standards across countries and among the travelling public (OECD/ ITF, 2014). Monetary values of VTTS exist in different countries; consequently, by applying the multipliers to the values of VTTS, obtaining the monetary valuations of the values of comfort that a CBA needs is a straightforward matter.

A disadvantage of working with time multipliers is the so-called packaging problem. Jones (1997), and Bates and Jones (1998), describe how this problem arises when trying to value (many) different individual comfort attributes of a journey that collectively contribute to the travellers' willingness to pay for comfort. Jones notes that in these cases it commonly happens that the value derived from a stated preference experiment in improving the level of each individual comfort attribute amounts to a figure that is considerably different from the value that the respondents ascribe to the package of improvements as a whole. Usually, the sum of the values of the individual attribute improvements are of a much higher amount than the directly derived package value. A solution to this problem can be scaling down the values as derived directly from the SP analysis. Jones (1997) reports that in some studies scaling down factors as low as one-third had to be applied, which in turn can have a major impact on the viability of investment programs.

3.2 UNRAVELING THE VALUE OF TRAVEL TIME SAVINGS

In this paper we describe a new and practical CBA application of Fickling et al. (2009) to appraise a rise or fall in the level of comfort offered to travellers.

The monetary valuation of a travel time saving consists of three components: the resource utility of time (the utility that could be attained if the travel time was used for some other activity), the direct utility of travel time (compared to some reference activity, such as work or leisure, for example), and (to translate minutes into money) the marginal utility of money (Börjesson and Eliasson, 2012). Thus:

Value of travel time saving = (resource utility of time – direct utility of travel time) / marginal utility of money[1]

Whereby:
Resource utility of time/ marginal utility of money= opportunity cost of travel time

Direct utility of travel time/ marginal utility of money= Direct value of travel time

The resource utility of time is the utility attained when being at the origin or destination of the trip. In other words, it is the disutility of travelling due to not being able to spent that time at the origin or destination. And hence, the VTTS will be higher on the way to an important meeting or for parents on the way to pick up their small children from school. The marginal utility of money can be expected to be related to the income of the traveller. A higher income will lower the marginal utility of money and result in a higher VTTS.

The direct utility of travel time is affected by factors such as comfort of the mode, how enjoyable the trip is, and the ability to use the travel time in a productive way, due to for instance improved IT support on trains, as well as the ability to save time during the day by opting to have breakfast in the train or at the station instead of at home. If, *ceteris paribus*, the direct utility of travel time increases, the VTTS should decrease.

By analysing the 1988 and 1997 VTTS car and public transport data collected in The Netherlands, Gunn (2001) had already observed this phenomenon: during this period, real income substantially increased (wages rose more than prices). While income effects are the largest known systematic driving force in increasing VTTS, the Dutch VTTS's for commuting and other purposes did not significantly change in real terms during the years 1988 - 1997. In other words, Gunn's study revealed effects that were as important as income growth in altering the VTTS. Gunn hypothesized that the reasons were due to net systematic increases in the direct utility of travel time.

To investigate this further, Significance (2013) made a comparison between the Dutch VTTS data collected in 1997 and 2010. Over that period, real income has increased by about 30%. For motorists (commuting and business trips) the VTTS has decreased in real terms between 1997 and 2010. This development has not occurred for train passengers, however. The increasing use of mobile telephones during journeys could be one plausible explanation for car travel's lower valuation. For trains we notice an increase in the VTTS. Here the increase in the direct utility of travel time plays a smaller role than with cars. This is perhaps owing to the fact that is has always been possible to read work reports in the train, for example.

Hence, when, *ceteris paribus,* the direct value of travel time increases, the *difference* in the direct value of travel time is reflected in the difference of the VTTS. This *difference* is the so-called value of comfort (VoC). Given this, the VoC can be written as (Van Ginkel, 2014):

Value of Comfort = VTTS under the original level of comfort – VTTS under the new level of comfort

or in short: VoC = VTTS_OLC – VTTS_NLC

Whereby:
The new level of comfort is higher than the original level of comfort
The unit value of the VoC is Euro per hour. The number of hours to which the VoC figure should be applied is those of the travel time *with* the new level of comfort.

[1] For the underlying micro economic modeling, see appendix 1.

4. NS NETHERLANDS RAILWAY STUDY ABOUT THE VALUE OF COMFORT

While traveling by train, there is a clear value in higher levels of comfort: being seated comfortably, and being able to spend the travel time in a useful or pleasant way gives higher value to the trip than an uncomfortable journey. Using a rather straightforward calculation method and some assumptions based on best available information, we tried to apply the above-stated theories to travel by train. This method is still being developed, and we invite readers to suggest improvements. Yet it has already provided some interesting preliminary results.

The method combines data from several sources:

- NS/CQM (2015): OD matrix for year 2014: number of trips per OD (Origin-Destination)
- NS (2013) Timetable 2014: travel times per station pair
- NS (2015) Klimaat survey: trip purposes
- NS (2015) *Vervoercapaciteit naar Tevredenheid* (Seating Capacity Research): the way time was spent during the train trip
- KiM (2013) Value of Time study: value of time for train trips per trip purpose
- Mott McDonald (2009) and Fickling, Gunn, Kirby, Bradley, Heywood (2009): reduction of travel time savings due to time spent in a useful way

The estimation consists of several steps, which are elaborated below.

Step 1: Determine the total number of trips

In total over 370 million trips were made with NS in 2014. The Klimaat survey was used to divide these trips by trip purpose (see figure 4.1). Trip purposes Commuter, Education and Leisure each account for roughly one-third of the total number of trips, while Business only accounts for a small percentage of the number of trips (about 5%).

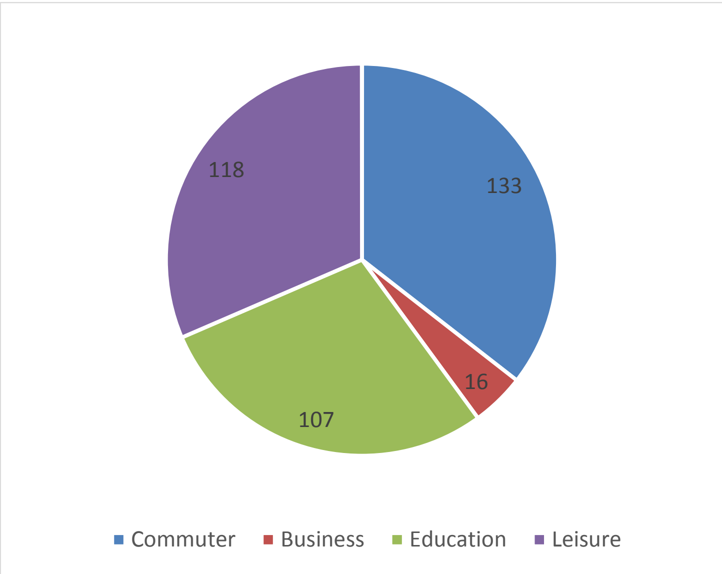

Figure 4.1: Number of train trips by purpose (in millions)
Source: NS, 2015, Klimaat survey

Step 2: Determine the total travel time

The average trip duration is 36 minutes (time spent on the train plus interchange time), with a difference in trip duration per trip purpose: longer travel times for Business and Leisure, and shorter travel times for Commuter and Education. The trip duration is relatively short when compared to international figures, because the Netherlands is a small and densely populated country. With 370 million trips, and an average duration of 36 minutes per trip, the total trip time amounts to 220 million hours per year.

Step 3: Determine the total value of time for all trips: VTTS_NLC

From KiM (2013) we derive the following values of travel time savings for the train by trip purpose.

Table 4.1: Value of travel time savings for train travels (in Euro's of 2010)

TRIP PURPOSE	VTTS PER PERSON (€/HR)
COMMUTER	11.50
BUSINESS	19.75
EDUCATION	7.00
LEISURE	7.00
AVERAGE	9.25

Source: KiM, 2013

For our calculation we need the value of total travel time, which unfortunately is not available. Though the VTTS is meant for travel time *savings*, let us suppose we can use it for a broader perspective: to determine the *total* value of travel time, by just multiplying trip duration with VTTS. The total value of the 220 million hours trip time is slightly more than €2 billion (220 million * €9.25). This figure corresponds with the VTTS under the new level of comfort (VTTS_NLC) from the previous chapter.

Step 4: Determine the positive and negative components of travel time: VTTS_OLC and VoC

This monetary value of €2 billion consists of a positive and a negative component, as the VoC formula from the previous chapter can be rewritten into:

VTTS_NLC = VTTS_OLC – VoC

To calculate VTTS_OLC we used the result of Mott McDonald (2009) for Business passengers: there is a 50% reduction of travel time savings for business passengers, because they can spend the travel time in a useful way[2]. Mott McDonald (2009) only derived this result for Business passengers, but in our calculation we also need this for other trip purposes. Here we use seating capacity research conducted by NS (2015). In this research respondents with different trip types were asked if they had spent their time in a useful way, and also in the way they wanted to spend their time. By applying these proportions to the result of Mott McDonald for Business passengers, we find relative comfort values ranging from 29% for Leisure passengers to 50% for Business passengers (as in Mott McDonald), and 35% on average. This means VTTS_OLC is €9.25 / (1-35%) = €14.25, and VoC equals €5.00 per hour. The total VTTS_OLC for all trips now becomes €3.1

[2] The result from Mott McDonald is derived from a UK study. Though UK transport characteristics (like fares and travel times) differ from those in the Netherlands, we use this as a first estimate for the Dutch situation.

billion per year (220 million hours * €14.25). Applying the 35% reduction again amounts to the €2 billion per year for VTTS_NLC, with direct comfort benefits of €1.1 billion per year.

Step 5: Distinguish the maximum potential of direct travel time benefits and the value currently reached

Not all of the travel time can be spent in a useful way: we assumed[3] that at the beginning of each trip passengers need 2 minutes to 'install' themselves in their seats (finding a seat, taking off their coat, getting things to do from their bag, etc.), and 2 minutes at the end to pack up their belongings. This is in line with results from Fickling et al. (2009) stating a relationship between the part of the trip (in percentiles) and the possibility to use time productively. For a trip with an interchange the 2 minute 'penalties' are counted twice: once for each trip leg. The figure below shows this in an example: for a total trip duration of 50 minutes, at most 37 minutes can be spent usefully (=74% in this example). If the same trip would not have an interchange the total travel time would be 45 minutes plus for instance 2 minutes stopping time at station C = 47 minutes, with 43 minutes time to be spent usefully (=91%). For the average of all trips (including those with an interchange), 29 out of the average 36 minutes can be spent usefully (=80%). With 370 million trips, this amounts to a total of 180 million hours spent usefully.

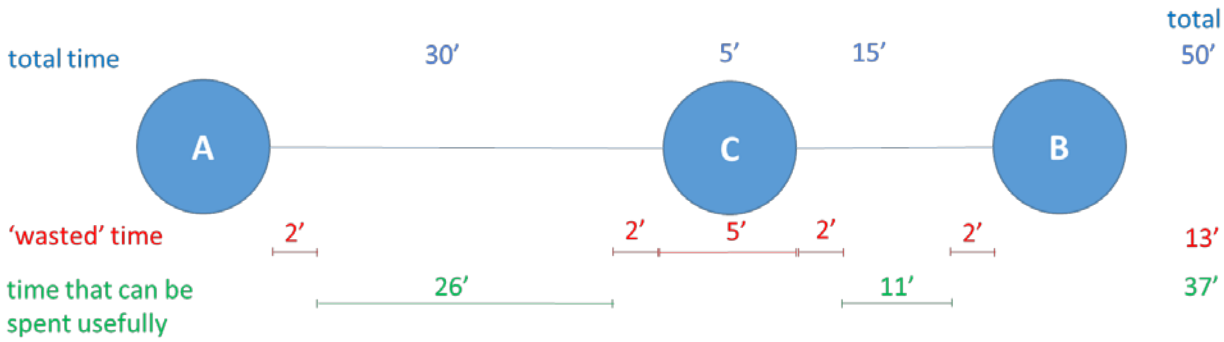

Figure 4.2: Time that can be spent usefully on a trip from origin A, via interchange C, to destination B

However, not all passengers reach this maximum. In order for the passenger to derive value from his trip, we assume that he must spend the travel time usefully, and in the way he wants to. From research on seating capacity (NS, 2015), we found that this applies to around 40% of all passengers. This means that out of the 180 million hours that can be spent usefully, 70 million hours are in fact spent usefully. Multiplying this with the VoC of €5.00 amounts to €350 million of the value currently reached by passengers. As the potential is €1.1 billion, this means a potential of €750 million is still to be reached.

Step 6: Cashing the potential value

Part of this potential can be fulfilled by several measures. If for instance passengers can find a seat more easily because they are informed in advance about available seats per carriage while waiting for the train, then the installation time can be reduced. Following the same logic packing time may be reduced due to for instance better information provision about arrival and interchange times. If

[3] These assumptions still need to be validated.

these measures would reduce installation time and packing time to 1 minute each, by following our calculation method, the potential value of this would be €35 million.

If for instance by differentiating rolling stock and providing sufficient seating capacity all passengers spend their time as planned, the total value is €140 million, or nearly 20% of the potential value.

The larger share of the potential value is hard to fulfil: only about half of the passengers regard their travel time as useful, even when they have spent their travel time in the way they planned. Consequently, nearly €400 million of the potential value remains out of reach.

5. POLICY IMPACTS

The substantial benefits now provided by rail as a potential working environment or enjoyable ride are evident. Not only public transport but also the development of the self-driving car promises tremendous societal benefits. Gunn (2001) indicates that comfort effects are as important as income growth in terms of altering the VTTS. From chapter 4 we can see that the VoC for train travels may be around half of the current VTTS. Moreover, we expect that the influence of comfort on the VTTS of train passengers and motorists will increase in the near future, owing to ongoing developments of technological innovations affecting the use of travel time and to the development of new transport policies and private investments in comfort. The development of ICT technology, comfortable trains, train stations, and autonomous-driving technology encompasses investments from industries, research organisations and governments.

However, generally, improvements in the direct utility of travel time are not covered as well as it should be in policy and project assessments. This skews planning and investment decisions (OECD/ITF, 2014; Kroes and Koopmans, 2014). In order to include the social benefits of improvements in the level of travel comfort in the CBA, three items are required:

- to predict how much a project will improve comfort levels in the eyes of the traveller,
- monetary values to convert a difference in comfort level into money units,
- a model to predict whether travellers will change their route choice, mode choice or departure time due to changes in comfort.

The monetary value of changes in comfort may be included in the CBA, by means of making use of comfort multipliers and applying them to the values of VTTS. However, this is not standard practice. Moreover, when trying to value (many) different individual comfort attributes of a journey that collectively contribute to the travellers' willingness to pay for comfort the so-called packaging problem may arise, leading to over- or underestimations of benefits.

The new CBA application based on fickling et al. (2009) as described in this paper covers the first and second items and eliminates the packaging problem. This new application measures the VoC indirectly through changes in the VTTS that appear due to a difference in the level of comfort. It takes into account all the benefits that can be derived from increased productivity during the trip or from the personal satisfaction of the traveller, or from a mixture of both. The VoC should be applied to the number of hours of the travel time with a new level of comfort, whereas the VTTS should be applied to the hours of travel time saved. In the CBA, the comfort benefits should be added to the benefits of travel time savings and travel time reliability improvements without double counting.

The NS Netherlands railways study as described in chapter 4 is cross-sectional, based on current travel patterns. Behavioural studies should be undertaken to assess the extent to which travel demand for rail is influenced by the ease or difficulty of being able to work productively or relax satisfactorily during rail travel. This will establish whether changes must be made in modelling practice, in order to allow the aspect of comfort to be included in transport demand forecasting models. Better capturing the effects of transport policies or investments that affect the level of comfort in train travels (or other transport modes) in the CBA will encourage proper considerations of options. Project appraisal will then not only offer incentives for policies that reduce average travel time, but also for policies that improve productivity or satisfaction during traveling.

Moreover, it makes no difference to the Dutch government if investments are made in rail infrastructure in order to speed up travel times or make travel times more reliable or to invest in the comfort of trains or train stations, provided that the same societal benefits can be reached by enhancing the quality of time spent in the train or in the station when travelling. If benefits due to comfort improvements are better reflected in appraisal, trade-offs between investments in infrastructure and the quality experienced during train trips or at stations can become clear.

6. CONCLUSION AND DISCUSSION

There are many possible ways to improve public transport comfort quality, including reduced crowding, increase the possibility to work on a lap top, increased service frequencies, nicer waiting areas, and better traveler information. The significant societal benefits by rail as a potential working environment or enjoyable ride are evident. Not only public transport, but also the development of the self-driving car promises tremendous societal benefits. However, these benefits are not covered as well as they should be in project assessments.

Traditional transport evaluation methods tend to focus on societal benefits due to speed. Saved travel time is valued by the Value of Travel Time Savings (VTTS) and included in cost-benefit analysis (CBA). The VTTS is one of the key components of user benefits in current economic appraisal of transport projects. However, if travel comfort increases, and as a consequence travel time can be spent in a productive and joyful way, then VTTS decreases. This development of decreasing VTTS already occurs in The Netherlands. Especially for motorists (commuting and business). VTTS will be zero in the hypothetical situation where travel time can be spend as productive or joyful as time spent at home or at the destination.

Currently, benefits due to changes in comfort may be taken on board of the CBA by means of comfort multipliers and applying them to the VTTS. However, this treatment to capture comfort benefits is not standard practice to evaluate policies with a focus on improvements in transport comfort quality. Focusing only on the well established benefits could bias future investment decisions, overlook and disadvantage service quality improvements that provide benefits comparable to speed improvements.

It is obvious that the ongoing development of ICT technology and autonomous-driving technology offers a huge potential to use travel time to work, conduct business, contact friends, listen to music or watch a movie. With better evaluation techniques, policies and programs can be identified that more effectively respond to these societal needs.

In this paper we described a new and practical application of fickling et al. (2009) to predict how much a project will improve the level of comfort in the eyes of the traveler and to convert this improvement into a monetary value that can be used in CBA. Therefore, we have endeavored to enrich the VTTS calculation method by distinguishing between time as accessibility and thereby disutility, and time as it can be spent valuably (the difference between “time well saved” and “time well spent”). In the paper, the method is applied to rail. However, the methodology is general applicable for all passenger transport modes.

We invite our fellow professionals to consider this approach, and in doing so we hope a more comprehensive understanding of VTTS can be developed, one that is more aligned with the actual experience of the traveller. We believe it is crucial that such a discussion occurs, given the major role that VTTS plays in infrastructure investment decisions, according to current practice. New insights will allow for more comprehensive considerations of investments in the railway sector, public transport in general and road transport.

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APPENDIX 1: MICRO ECONOMIC MODEL

By Gerard de Jong (Significance and ITS Leeds)

Based on:

- DeSerpa, A. (1971) A theory of the economics of time. **The Economic Journal** 81, 828-846.
- Jara-Diaz, S.R. (2008) Allocation and valuation of travel time savings. In: **Handbook of Transport Modeling**. D.A. Hensher and K.J. Button, eds. Elsevier, Oxford.
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Notation used:

Travel modes j (j=1, ..., M) with travel time t_j and travel costs c_j

Consumer goods = X_i (i=1, ..., n)

Time used for activities related to the consumption of the associated goods= T_i

Travel time= T_{travel}

Prices of goods= P_i

Income= Y

Total of available time= τ

Then the maximum utility (U), conditional on the use of mode j (as is usually modelled in discrete choice models), is:

$\text{Max}_j \ \text{Max}_{X,T}\ U (X_1, ..., X_n, T_1, ... T_n \mid j)$

Subject to the following constraints:

$\Sigma_i P_i X_i + c_j = Y$ with Lagrangian multiplier λ

$\Sigma_i T_i = \tau$ with Lagrangian multiplier μ

$T_i \geq a_i X_i$ with Lagrangian multipliers K_i for all i except i=travel

$T_{travel} \geq t_j$ with Lagrangian multiplier K_{travel}

$X_i \geq 0$

$T_i \geq 0$.

Solving this system gives the following function for the value of travel time savings (VTTS) that can be used in cost-benefit analysis:

$VTTS = K_{travel}/\lambda = \mu/\lambda - (\partial U/\partial T_{travel})/\lambda$

Whereby:

μ/λ= opportunity cost of travel time. It is the disutility of travelling that is due to not being able to spent that time at the origin or destination of the trip (value of time as a resource).

$(\partial U/\partial T_{travel})/\lambda$= direct value of travel time: the money value of the direct utility that is derived from spending the travel time. This is affected by factors such as the comfort of the mode, how enjoyable the trip is and the ability to use the travel time in a productive way. It is monetised by λ, the marginal utility of income.