The final publication is available at: Research in Transportation Economics

Volume 47, November 2014, Pages 50-60 10.1016/j.retrec.2014.09.018

Accounting for User Type and Mode Effects on the Value of Travel Time Savings in Project Appraisal: Opportunities and Challenges

Stefan Flügel[a,b]

sfl@toi.no, Tel.:004741520576

[a] *School of Economics and Business ,*
Norwegian University of Life Sciences (NMBU), P.O. Box 5003, NO-1432 Ås, Norway

[b] *Institute of Transport Economics (TØI), Gaustadalléen 21, NO-0349 Oslo, Norway*

Keywords: Value of Travel Time Savings, User Type Effect, Mode Effect, Project Appraisal, Distributional Weights

JEL classification: D61, D63, R40

Abstract

Differences in Value of Travel Time Savings (VTTS) between travel modes can play a decisive role in the ranking of projects that affect the travel time of different travel modes. Conceptually, between-mode differences in VTTS can be decomposed into the user type effect (UE) that accounts for differences in characteristics of user groups (e.g. income differences) and the mode effect (ME) that accounts for differences in travel modes (e.g. the comfort level). Several studies have disentangled and quantified these two effects. However, their potential use for project appraisal has not been thoroughly discussed in the literature.

Two opportunities of using information about ME and UE in appraisal are discussed: (i) Removing the UE from national mode-specific VTTS in order to obtain a set of VTTS that only differs by the comfort level of the modes (ii) Provide the VTTS in travel modes taking into account user type effects of travellers that switch modes after project implementation.
The former arguably improves on the equity approach in project appraisal under the normative argument of valuing individual's time saving equally. The latter can improve the overall precision of user benefit representation in project appraisal compared to the standard mode-specific approach, where mode switchers are assumed to have the same VTTS in the new mode independent of which original user group they belong to.

1. Introduction

Differences in Value of Travel Time Savings (VTTS) between travel modes can play a decisive role in the ranking of projects that effect the travel time of different travel modes. In a cost benefit analytical (CBA) framework, a social planner will, *ceteris paribus*, favour projects that reduce the in-vehicle travel time of travel modes with the highest VTTS, i.e. the travel mode for which its users have the highest willingness-to-pay (WTP) for travel time savings. As VTTS differences between modes may be substantial (e.g. in Norway the VTTS in air is 204 NOK/h while it is just 74 NOK/h in long-distance bus trips (Samstad *et al* 2010)), there is a possibility that certain projects are prioritised even though alternative projects safe more time in total and/or imply lower investment costs. As the general public and policy makers may regard such project ranking as opaque or unjust, it seems important to understand and possibly address the origin of between-mode differences in VTTS in order to define optimal standards for project appraisal.

Mode-specific VTTS differ not only because modes themselves differ (e.g. in the level of comfort), but also because the travel modes' user groups differ in characteristics (e.g. average income level). This difference in characteristics is due to self-selection of travellers to travel modes. Wealthy travellers are, for example, more likely to drive their own car (as they can afford to own one), while travellers with high preference for time savings (again, typically wealthy persons) are likely to choose air instead of slower modes like bus. Conceptually, between-mode differences in VTTS can be decomposed into mode and user type effects (Wardman 2004)[1]. User type effects (UE) are empirically obtained by the differences in VTTS of two user groups in a given travel mode, while mode effects (ME) are differences in VTTS in two modes for the same user group. Several studies have disentangled and quantified these two effects (e.g. Ramjerdi *et al* (1997), Fosgerau *et al* (2010), Ramjerdi *et al* (2010)), however, their potential use for project appraisal has not been thoroughly discussed in the literature.

Three CBA approaches regarding the degree of segmentation of VTTS by mode and user group can be distinguished.[2] This is not an exhaustive list, but rather an illustrative one, with two contrary approaches and one compromise approach.

1) The so-called *equity approach* that applies the same VTTS for all travel modes and user groups in a population. An equity VTTS is hard to justify through economic reasoning and is likely to yield to a misallocations of resources as it will seldom match the actual WTP of travellers affected by a specific project. However, the approach has its normative justification under the political paradigm of not taking into account individual differences in applied CBA. This approach is for example currently used in Denmark.

2) The *project-specific approach* that tries to account as precisely as possible for the WTP of the actual beneficiaries of the project. It is in clear contrast to the equity approach as it includes mode specific VTTS, geographical segmentation in VTTS[3] and opens up for specific valuation studies among the actual users of the infrastructure provided by the project. The Official Norwegian Report on cost benefit analysis has recently suggested that national values should only be used when the information about the VTTS of actual users is insufficient (NOU 2012, page 12). While this approach may appear theoretical appealing, there are practical limits to investigating project-specific VTTS.

3) The *(standard) mode specific approach* uses national VTTS values but it segments the market by travel modes. This approach might be seen as a practical compromise between the equity and the project specific approach, but arguably it lacks good conceptual reasoning. As it ignores direct user group

---

[1] Wardman actually called the ME "mode valued effect" which might be more precise. Other terms used to describe the same effect are "pleasantness-effect" (Mackie *et al* 2001) and "comfort effect" (Fosgerau *et al* 2010).

[2] This paper does not discuss other segmentation of VTTS, e.g. by trip purpose, trip length or travel time components. When not stated differently, the VTTS of a travel mode relates to the in-vehicle time.

[3] The VTTS in cities is often found higher than in rural areas (see Abrantes and Wardmann (2011), Börjesson and Eliasson (2012), and Østli *et al* (2012) for empirical evidence from the UK, Sweden and Norway).

segmentation (e.g. by geography) it might be defended under an equity argument. However, travel mode segmentation accounts indirectly for traveller's characteristics and preconditions because of the above mentioned self-selection. Note that this approach accounts for UE and ME by their sum but does take into account information about their relative sizes.

In this paper two opportunities for using information about ME and UE in order to define alternative VTTS approaches in project appraisal are discussed.
(i) *ME-dependent equity value,* that removes the UE from (standard) mode specific VTTS values, to obtain a set of VTTS values that only differs by the comfort level of the modes (i.e. differences due to the ME). This arguably improves on the equity approach while remaining consistent with the normative argument of valuing every individual's time saving (of same size) equally.
(ii) *VTTS of switching modes* provides VTTS values for situations where travellers switch travel modes. Knowledge about UE and ME enables a differentiation of VTTS by user groups defined by the (expected) choice of mode before and after project implementation. In principle this improves the overall precision of user benefit representation in project appraisal compared to the standard mode-specific approach, where mode switchers are assumed to have the same VTTS in the new mode independent of which original user group they belong to.
None of the two outlined implementations is without methodological and practical challenges, as will be discussed in the paper.

The paper provides definitions and theoretical background in Section 2. Section 3 describes ways to improve current VTTS approaches by incorporating knowledge about UE and ME in project appraisal. Section 4 gives an empirical example and illustrates the possible impact of different VTTS approaches on project ranking by means of a stylized case study. Section 5 concludes.

2. Definitions and Theory

2.1. Mode- and user type effects

2.1.1. Definitions

For a formal definition of the two effects, the differences in the representative VTTS[4] between mode k and l with associated current user groups g_k and g_l are as set out below:

(1) $\Delta VTTS_{k,l} \equiv VTTS_{k,g_k} - VTTS_{l,g_l} = VTTS_{k,g_k} - VTTS_{l,g_k} + VTTS_{l,g_k} - VTTS_{l,g_l}$

The mode effect (ME) is defined as the VTTS difference between two modes for a given user group:

(2) $$ME_{k,l,\,g_k} \equiv VTTS_{k,g_k} - VTTS_{l,g_k},$$

The user-type effect (UE) is defined as the VTTS differences of two user groups in a given travel mode:

(3) $$UE_{l,g_k,g_l} \equiv VTTS_{l,g_k} - VTTS_{l,g_l}$$

Then, one can write between-mode differences in VTTS as the sum of the two effects:

(4) $$\Delta VTTS_{k,l} = ME_{k,l,\,g_k} + UE_{l,g_k,g_l}.$$

Furthermore, assume that every individual q in the population can be associated with one user group g_q. Typically groups are identified by the current mode choice of q but other segmentation rules may be applied. We define the average mode effect over all groups g_q in a population as:

[4] The representative VTTS will in application typically be inferred as some mean value derived from a sample of travellers in the groups. In this section we are only making heterogeneity across groups explicit. Treating heterogeneity within groups is subject of discussion in later sections.

(5) $$\overline{ME_{k,l}} \equiv \frac{1}{N}\sum_{g_q} N_{g_q} ME_{k,l,g_q},$$

with N_{g_q} being the amount of members in group g_q and N being the total amount of individuals in the population.

For later discussion we define an average VTTS in a transport mode, say *k*, as the weighted average of the representative VTTS in mode *k* over all groups in the population,

(6) $$\overline{VTTS_k} = \frac{1}{N}\sum_{g_q} N_{g_q} VTTS_{k,g_q}.$$

The VTTS in (6) can be seen as the representative VTTS for the whole population *in a given transport mode*. It is a modification of the "equity VTTS" ($\overline{VTTS}$) and is therefore referred to as the "ME-dependent equity value".

Note that the difference between the VTTS of two transport modes calculated by (6) will equal the average mode effect (in 5),

(7) $$\overline{VTTS_k} - \overline{VTTS_l} = \overline{ME_{k,l}}.$$

User groups may not only be defined by their current travel mode as in (1)-(4), but also by subgroups identified by their previous transport mode choice. We use the notation $g_{k/l}$ to identify an user group that consists of travellers having switched from mode *k* to mode *l*. Travellers that already previously have chosen *l* ("non-switchers") are labelled $g_{l/l}$.

We define the resulting VTTS in a transport mode *l* subject to mode switches of travellers (referred to as *VTTS of switching modes*, ${VTTS_l}^{S.M.}$) as the weighted average of different user groups now using *l*.

(8) $${VTTS_l}^{S.M.} = \frac{1}{N_l}(N_{g_{l/l}} VTTS_{l,g_{l/l}} + \sum_k N_{g_{k/l}} VTTS_{l,g_{k/l}})$$

with $N_l = N_{g_{l/l}} + \sum_k N_{g_{k\_l}}$, where $N_{g_{l/l}}$ is the number of non-switchers and $N_{g_{k/l}}$ is the number of travellers that are transferred from different travel mode *k*.

${VTTS_l}^{S.M.}$ will in general differ from $VTTS_{l,g_l}$, i.e. the representative VTTS for the generic users of transport mode *l*. Intuitively the difference is connected to user type effects.

Indeed, defining a weighted average of user type effects between different subgroups identified by their switching behavior ($g_{k/l}$) and a generic user group (g_l) as

(9) $$\overline{UE_l}^{S.M.} \equiv \frac{1}{N_l}(N_{g_{l/l}} UE_{l,g_{l/l},g_l} + \sum_k N_{g_{k/l}} UE_{l,g_{k/l},g_l}),$$

it can be shown that:

(10) $${VTTS_l}^{S.M.} - VTTS_{l,g_l} = \overline{UE_l}^{S.M.}.$$

2.1.2. Theoretical components and interpretation

The VTTS of individual *q* can be derived from time allocation models (Becker 1965, DeSerpa 1971, Jara-Diaz and Guevara 2003). From one of the early models (Oort 1969) the following decomposition of VTTS is obtainable.[5]

(11) $$VTTS_q = w_q + \frac{MU_q^W}{\lambda_q} - \frac{MU_q^T}{\lambda_q}.$$

[5] While VTTS equals just the wage rate in Becker's original model, most of the later proposed time allocation models, where the time spend in activities enter utility directly, obtain decompositions of VTT similar to the one by Oort (1969); see Jara-Diaz (2007, page 68,69) for an overview.

Hence, the VTTS is the sum of the nominal wage rate (w_q) and the marginal utility of work time (MU_q^W), minus the marginal utility of travel time (MU_q^T). The latter two terms are normalised by λ_q, the marginal utility of income, in order to transfer utility onto a monetary scale.

MU_q^T expresses the direct utility (disutility in most cases) from spending time in transport; it is likely to depend on the specific travel mode (in general $MU_q^{T_k} \neq MU_q^{T_l}$).

The expression ($w_q + \frac{MU_q^W}{\lambda_q}$) represents the total value of work and can be seen as the opportunity cost of travelling (OCT), i.e. the value which could have been obtained from activities other than travelling.[6] The OCT is independent of the travel mode ($OCT_q^k = OCT_q^l$) but differs across individuals and thereby also, on average, between user groups ($OCT_{g_k} \neq OCT_{g_l}$).

The VTTS in travel mode k of group g_k (current users of travel mode k), can be expressed as:

$$(12) \qquad VTTS_{k,g_k} = OCT_{g_k} - \frac{MU^{T_{k,g_k}}}{\lambda_{k,g_k}}.$$

where $OCT_{g_k}, MU^{T_k,\,g_k}, \lambda_{k,g_k}$ are representative values for the user group g_k.

Combining (12) and (2), the mode effect can be written as:

$$(13) \qquad ME_{k,l,\,g_k} = -\frac{1}{\lambda_{g_k}}\left(MU^{T_k,\,g_k} - MU^{T_l,\,g_k}\right).$$

The ME will therefore depend on the difference in direct disutility obtained from time spent in the two travel modes (scaled by the marginal utility of income of the given user group). The direction (sign) of the ME will indicate which travel mode offers a more useful/pleasant travel time and can be regarded as more "comfortable" in a wide sense. This might relate to the actual comfort of seats but also the possibilities to read, sleep, eat, work, use entertainment devices etc., as well as the perceived level of safety. λ_{g_k} will have an effect on the absolute size of ME but not on its sign. A user group with high average income (implying lower λ_{g_k}) will have higher ME even when the perceived "comfort difference" of modes is identical to the perception of user groups with lower income.

Combining (12) with (3) we obtain:

$$(14) \qquad UE_{l,g_k,g_l} = \left(OCT_{g_k} - OCT_{g_l}\right) - \left(\frac{MU^{T_l,g_k}}{\lambda_{g_k}} - \frac{MU^{T_l,g_l}}{\lambda_{g_l}}\right).$$

The UE will depend on the differences in representative opportunity costs in the two user groups and the (scaled) differences of the marginal utility of time spent in the given travel mode.

UE is due to self-selection as traveller characteristics will influence both the VTTS (by equation 11) and the choice of travel modes. Wealthy persons are more likely to self-select to expensive travel modes, while busy persons (high OCT) are likely to use fast travel modes. Self-selection also works through different perceptions of comfort level in the chosen mode compared to the discarded travel modes across user groups (e.g. train users might not drive as they have higher preferences for taking a nap than the average car user).

2.2. Project appraisal

2.2.1. Welfare effect of travel time savings

In general terms, projects should be compared (ranked) by their effect on social welfare, which is assumed to be expressible in terms of utility values of all individuals q.

$$(15) \qquad W_s = W_s\left(U_1, \dots, U_q, \dots, U_N\right)$$

[6] This would also include leisure time which equals the total value of work under the assumption that decision makers can freely assign time to activities that are remunerated.

Following Gálvez and Jara-Díaz (1998) in a compact and generally applicable specification, individual utility is a function of goods X_{iq} which again is a function of generalized income I_q and prices P.

Then, the welfare change due to time savings (or losses) is given by:

(16) $$dW_s = \sum_q \frac{\partial W_s}{\partial U_q}\frac{\partial U_q}{\partial I_q}\frac{\partial I_q}{\partial t_q} dt_q = \sum_q \Omega_q\, \lambda_q dB_q$$

where

- $\Omega_q = \frac{\partial W_s}{\partial U_g}$ is the (normative) social weight, expressing how much an utility unit of individual q contributes to social welfare
- $\lambda_q = \frac{\partial U_q}{\partial I_q}$ is the marginal utility of income of individual q
- $dB_q = \frac{\partial I_q}{\partial t_q} * dt_q$ is the user benefit from time savings, i.e. the monetary value of $q's$ consumer surplus variation (in a sense of Hicksian compensating variation, see e.g. Jara-Diaz 2007, page 99).

dB_q is approximately given as $VTTS_q\ \Delta t_q$, so that (16) can be written as (Gálvez and Jara-Díaz (1998), Mackie *et al* (2001)):

(17) $$\Delta W_s = \sum_q \Omega_q\, \lambda_q VTTS_q\ \Delta t_q.$$

Hence, the welfare change of an individual's travel time savings is due to the size of the time saving multiplied by the (subjective) VTTS, scaled by the marginal utility of income and multiplied by a normative weight set by the social planner.

2.2.2. Cost Benefit Analysis (CBA)

The standard approach in CBA is the "willingness-to-pay (WTP) calculus" (Sugden 1999), where the benefits of travel time saving projects (here without cost and taxes) are represented by the sum of individual WTP:

(18) $$\Delta W_s^{CBA} = \sum_q dB_q = \sum_q VTTS_q\ \Delta t_q$$

This equation can be rewritten as:

(19) $$\Delta W_s^{CBA} = \sum_{g_q} \sum_{q \in g_q} \frac{VTTS_q}{\overline{VTTS_{g_q}}} \overline{VTTS_{g_q}}\, \Delta t_q,$$

where $\overline{VTTS_{g_q}}$ is the average VTTS of the group g individual q belongs to. In applied CBA the factor $\frac{VTTS_q}{\overline{VTTS_{g_q}}}$ is omitted (i.e. the heterogeneity in VTTS within groups is not regarded):

(20) $$\Delta W_s^{appl.CBA} = \sum_{g_q} \sum_{q \in g_q} \overline{VTTS_{g_q}}\, \Delta t_q = \sum_{g_q} \overline{VTTS_{g_q}}\, \Delta t_g$$

with $\Delta t_g = \sum_{q \in g_q} \Delta t_q$ being the aggregated (net) time savings of group g.

When talking about *distributional* weights in CBA one is usually referring to a factor α_q or α_{g_q} put as a weighting factor on individual or group specific user benefits;

(21) $$\Delta W_s^{w.CBA} = \sum_q \alpha_q VTTS_q\ \Delta t_q\ ,$$

or in applied studies

(22) $$\Delta W_s^{w.appl.CBA} = \sum_{g_q} \alpha_{g_q} \overline{VTTS_{g_q}}\, \Delta t_g.$$

Comparing (21) with (17) we see that α_q corresponds to $\Omega_q \lambda_q$ and is therefore a combination of a (normative) social weight and the marginal utility of income.

As pointed, out by Gálvez and Jara-Díaz (1998), CBA standards that set $\alpha_q = 1$ correspond to a situation where Ω_q are set to $1/\lambda_q$, i.e. where social weights are inversely proportional to the marginal utility of income. As the marginal utility itself is decreasing with income, CBA standards imply higher weights for wealthy persons when transferring utility to wealth. Or, framing it differently, un-weighted CBA ignores differences in the marginal utility of income among individuals when transferring WTP to wealth.

With a positive economic perspective (implying Ω_q=1), the classical argument is that the un-weighted sum of actual WTP should be used in project appraisal and that redistribution of welfare should be done by means of a (second-best) income tax (given that lump sum transfer from "winners" to "losers" are not feasible). It is argued that distributional weights in CBA will lead to efficiency losses compared to a redistribution of wealth via the income taxes (Harberger 1978). Johansson-Stenman (2005) questions this proposition and shows cases (i.e. model assumptions) for which factors α_q (being equivalent to λ_q given Ω_q=1) are called for to account for the fact that poor persons profit more from marginal decreases in income tax. Considering that the appropriateness of model assumptions, the means of redistributing wealth and the sources of funding[7] differ from project to project it seems difficult to conclude generally about the efficiency of weights in CBA.

Comparing (22) with (19), it is evident that taking averages of groups (the VTTS segmentation in user groups) has a likely distributional element. The most extreme case, i.e. the equity approach of VTTS that takes a grand average of VTTS over all persons,

$$(23) \qquad \Delta W_s^{appl.CBA,equity} = \overline{VTTS} \sum_{q \in N} \Delta t_q,$$

implies in standard CBA (α_{g_q}=1) that $\Omega_q = \frac{VTTS_q}{\lambda_q \overline{VTTS}}$. This expression resembles a strong normative weight and is likely to yield to a misallocation of resources in an economic sense. For instance, user benefits from travel time savings of a transport project that accrue mainly to travellers with above-average VTTS ($\frac{VTTS_q}{\overline{VTTS}_{g_q}} > 1$) will be underestimated with the equity approach.

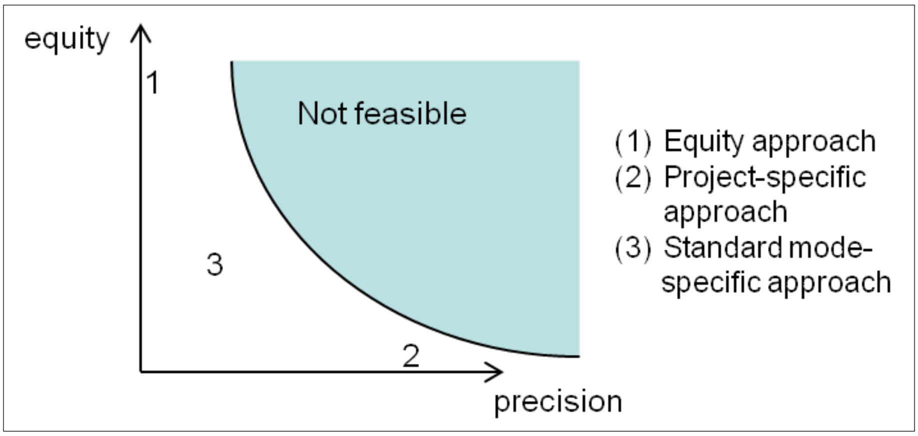
3. Concepts of accounting for ME and CE in project appraisal

3.1. Directions of improving VTTS-approaches in project appraisal

Before outlining ways to account for UE and ME in project appraisal, this section is intended as a general discussion on directions to improve current VTTS-standards in project appraisal.

The three current VTTS-approaches introduced in section 1, i.e. (1) equity approach, (2) project-specific approach and the (3) standard mode specific approach can be compared by the two dimensions precision and equity. A schematic illustration is given in Figure 1.

Figure 1: Illustration of VTTS-approaches on the equity and precision dimension



[7] See Börjesson and Eliasson (2012) for a discussion on the importance of funding source for transport project appraisal.

Precision is referred to as the degree to which a VTTS-approach is able to account for the actual VTTS of travellers. A VTTS-approach that multiplies individual time savings with the actual VTTS for every traveller (without taking any averages) would "score" highest. A VTTS-approach would score lower when it takes averages over heterogeneous travellers. Precision would also be lower when factors influencing VTTS are ignored in the derivation of VTTS (e.g. if the approach would ignore the mode effect or the user type effect). From the three bespoken VTTS-approaches, the project specific approach has in general the highest precision as it does not apply national averages of VTTS but strives to account for the VTTS of the particular users of a transport project. The standard mode specific approach is more precise than the equity approach as it accounts for the mode- and the user type effect (while the equity approach ignores both effects).

Equity is referred to the degree to which VTTS-approaches imply equal VTTS for travellers in the population. The equity VTTS approach scores highest here as it applies the same VTTS for all possible travellers. The standard mode specific approach scores lower on equity because different travellers will be assigned different VTTS according to their transport mode choice which in many cases will be due to self-selection (such that rich travellers get assigned a higher VTTS on average). The project specific approach is the least equitable of the three as it applies different VTTS values for different locations/projects in the nation.

Obviously a VTTS-approach cannot be very precise and equitable at the same time. However, it might be possible to find improvements on either of the two dimensions. For instance, an equity approach that calculates a faulty average over the population can be improved on the precision dimension by replacing it by the more precise one. In that case the level of equity is fully retained while precision is improved. Improving equity while retaining the existing level of precision seems hard to achieve, but it might be possible to improve a lot of the equity dimension, without losing much precision (see discussion later).

Which VTTS-approach is most appropriate/preferable for project appraisal does obviously depend on how the social welfare function is specified. For instance, assuming a welfare function in line with normative weights of $\Omega_{\mathrm{q}} = \frac{VTTS_q}{\lambda_g \overline{VTTS}}$ (compare above), the equity approach is preferable. In this regards, it has to be underlined that equity and precision in Figure 1 refer to VTTS (and user benefits given an objective measure of Δt_q) and not to welfare units. One should always be interested in a most precise representation of the specified welfare function for project appraisal.

The objective to score high on the precision dimension is straightforwardly motivated in standard CBA ($\alpha_q = 1$) and from a positive economic perspective (Ω_q=1). Each imprecision in the user benefit representation can bias the project ranking and can lead to a misallocation of resources in an economic sense.

The objective to score high on the equity dimension can be motivated by the general notion of fairness.[8] Indeed, the underlying motive for the VTTS equity approach seems to be the alleged tendency of travel modes with high estimated VTTS (usually car and air) to be more frequently used by wealthier persons. In this sense the equity approach is a radical way to eliminate any between mode differences in VTTS due to traveller's characteristics and preconditions. In the Danish Value of Time Study the following explanation for the choice of the equity approach is found: "*In line with the discussion concerning income differences, the steering group for the project has expressed the view that the cost-benefit analysis will be considered most relevant by policy makers if the analysis treats everybody equally. It has therefore been decided to use the grand average of 67 DKK per hour as the central value to be applied to all transport modes" (Fosgerau et al 2007, page 19/20).* Hence, besides the general fairness arguments (e.g. that wealthier people should not get assigned higher VTTS just because they are wealthier), also a presumed gain in political acceptance of CBA seems to motivate this approach. For instance a distinct geographical segmentation of VTTS is likely to be difficult to implement and maintain politically in case of resistance by stakeholders from disadvantaged regions. Even ethnical reasons might

[8] There exists a rich literature of the concept of fairness (or justice) in political philosophy. The equity approach seems well compatible with the "difference principle" (Rawls 1971, 2001) arguing that economic inequality should be arranged such that it profits the least-advantaged members of society.

be put forward to motivate the equity approach, for instance by referring to the value of statistical life (VSL) in CBA-calculus for which it is endorsed to use a common value for all travellers (as if not CBA-calculus might imply the saving a life of an affluent persons is worth more for society than saving a life from a poor person). For VTTS the ethical argument seems less convincing but the principle that every individual unit of time saving should be worth the same for society (independent of the characteristics and preconditions of the persons by whom the time savings are experienced) is hard to discard on the basis of lacking valid normative reasoning.

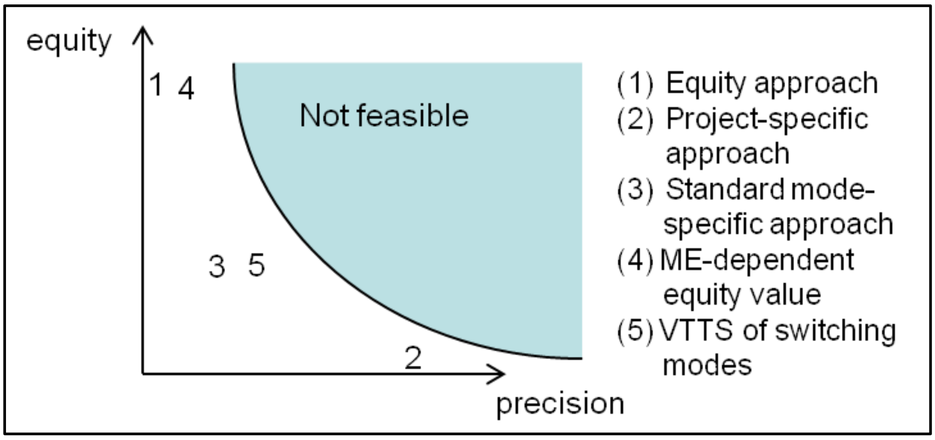
3.2. ME-dependent equity values

Assume that a social planner's normative credo is that every individual unit of time saving should contribute equally to the total benefit of transport projects, but that he is critical of a single equity VTTS because he acknowledges that utility of spending time in travel modes will differ by the travel modes' comfort level. In this case, empirical information about UE and ME will enable him to correct for the user type effect and to obtain a set of VTTS that varies between modes only on account of the mode effect (i.e. the travel mode's comfort level in a wide sense).

A direct way to achieve this is to calculate the "ME-dependent equity value" defined in (6) as the weighted average of the VTTS in a given transport mode over all user groups in the population. It can be seen as an improvement of the equity approach on the precision dimension as it includes information about the mode effect (going from 1 to point around 4 in Figure 2 below). From another perspective, it can also be seen as an improvement over the standard mode specific approach on the equity dimension as this VTTS can be thought of as being controlled for self-selection (going from 3 to 4 in Figure 2 below).This is because all possible travellers are included in the calculation independent of their mode choice. The ME-dependent equity value has a lower precision compared to the standard mode specific approach (as the UE is obviously important for a precise VTTS representation), but the ME-dependent equity value retains the normative credo of "value every individual unit of time saving equally". It comes in the modified version of: “value every individual unit of time saving *in a given transport mode* equally".

In practical applications one will often lack information about a travel mode's VTTS for at least some user groups. In the Norwegian Value of Time Study the design of the stated preference (SP) study includes only choice experiments for which the VTTS in car is possible to estimate for current car user and for every respondent that has car as his (first-choice) alternative mode (i.e. a subsample of all user groups). Hence, some self-selection is likely to remain. While this is an empirical problem which can be overcome by stated preference (SP) studies with a sufficient number of observations in each user group, there is also a conceptual point of discussion, namely if all citizens or just the potential users should be included in the calculation. This can be seen as a normative question, which may be illustrated by the example of certain affluent persons never taking the bus (they would rather take a cab). If this group of affluent persons would be left out of equation (6), one would underestimate $\overline{VTTS}_{bus}$ and one would not have gotten entirely rid of the self-selection problem. Therefore, departing from the normative credo of the equity approach, it is recommended to try to include as many user groups as possible, so as to establish VTTS values that only differ by the mode effect. Then also λ_q, impacting the absolute size of ME as shown in equation (13), can be thought of being representative for all citizens.

Figure 2: Illustration of VTTS-approaches (including the two proposed approaches) on the equity and precision dimension



3.3. VTTS of switching modes

Some travel time saving projects will have a notable effect on traveller's mode choice. In usual CBA practice, travellers that shift from mode *k* to *l* are assumed to shift VTTS from $VTTS_{k,g_k}$ to $VTTS_{l,g_l}$. As this change in VTTS is due to the sum of ME and UE, individuals shift not only travel mode but are also treated as they shift their characteristics influencing UE, e.g. the income level. Obviously, this assignment is restrictive and Mackie *et al* (2001) claims even that "[u]ntil the income effect [UE] can be properly disentangled from the 'pleasantness' effect [ME], there is more to be lost than gained from subdividing in-vehicle time savings by modes" (page 102).

Given knowledge about the ME of user group g_k one can express the change in VTTS after mode shift as going from $VTTS_{k,g_k}$ to $VTTS_{l,g_k}$. If all travellers of a mode *k* were forced to switch mode to *l*, $VTTS_{l,g_k}$ would indeed be the value to consider. However, mode choice is usually voluntary so that there is a self-selection between travellers that switch modes and those who choose not to. The correct VTTS to use is therefore $VTTS_{l,g_{k/l}}$, where subscript *k/l* indicates the user group defined by the former mode *k* and the new mode *l*. The change in VTTS is due to user type effects within current users ($VTTS_{k,g_k}$ to $VTTS_{k,g_{k/l}}$) and the mode effect of user group $g_{k/l}$ ($VTTS_{k,g_{k/l}}$ to $VTTS_{l,g_{k/l}}$).

Given information about the different $VTTS_{l,g_{k/l}}$ and the expected number of mode shifts after project implementation it is then possible to calculate a (project specific) VTTS in mode *l* as the weighted average of VTTS over all user groups now using *l*; see (8) in section 2.1.1. for the mathematical expression.

In principle, the VTTS of switching modes ($VTTS_l^{S.M.}$) improves over the (standard) mode specific VTTS ($VTTS_{l,g_l}$) on the precision dimension (moving from 3 to point around 5 in Figure 2 above) as it takes into account the new composition of travellers with their characteristics underlying the user type effect However this implies that one is able to get precise estimates of the values of $VTTS_{l,g_{k/l}}$. For this, current users of all transport mode *k* that will switch to transport mode *l* must be identified and their VTTS in the new transport mode *l* must be estimated. In principle, SP techniques would be susceptible to provide such information on a project-to-project basis, given that respondents are truthfully telling and revealing both their (intended) switching behaviour as a result of a concrete project and their VTTS in the new travel mode. However there is a potential danger of strategic behaviour on the part of respondents directly affected by the project. Thus such estimates might lack validity.[9] Another issue is that SP-studies are costly and many project-specific SP-studies will have a small sample if they are

[9] For the national VTTS studies in Denmark and Norway, where choice experiments are framed independent of specific project, no empirical evidences for strategic behaviour could be found (Fosgerau *et al* 2010, Flügel *et al* 2011).

warranted at all. This can easily lead to inconsistencies between SP-studies conducted for different projects.

In absence of project specific VTTS estimates, one faces a conceptual challenge in how to obtain good proxies of the different user groups based on national studies. Using data from the Norwegian Value of Time study, one assumes that travellers switching from *k* to *l* coincide with respondents having *l* as a (first choice) alternative mode to *k*. This may or not may be a good approximation (obviously depending on the specific project).

Note also that when national values (usually obtained not more than every 5-10 years) are used as an approximation, then one should idealistically define user groups by their sequence of mode shifts over consecutive projects. However it seems difficult (practically impossible) to keep track of the composition of different user groups. The VTTS of switching modes is therefore rather a short term concept of the evaluation of user benefits.

Some transport model systems are capable of predicting mode choice behavior and user benefits (by log-sums) simultaneously. Here the VTTS relevant for project appraisal (or parameters underlying VTTS) are included as explanatory variables in the mode choice model (i.e. they are known before mode choice is predicted). This is however not possible for the concept of *VTTS of switching modes* as its value depends on the predicted mode choice (weighted averages over user groups defined by their switching behavior are used in equation (8)). This methodological problem seems hard to resolve. However, common practice in many countries (also in Norway) is to calculate user benefits in CBA sequentially after the mode choice is predicted. In this case, *VTTS of switching modes* can be calculated given reliable information about the number of switchers from different travel modes and their values of travel time savings.

4. Application

4.1. Estimation

Although it is possible to estimate the VTTS from time allocation models (Jara-Díaz *et al* 2008), the clear majority of studies that estimate VTTS is based on discrete choice data, either of the revealed preference (RP) or stated preference (SP) type. [10] To disentangle ME and UE one needs the VTTS for one user group in different travel modes and the VTTS in one travel mode for different user groups (compare definitions (2) and (3)). Cross-sectional data with just one choice observation per decision maker will in general not provide this information. An experimental design used in recent SP-studies that disentangle ME and UE, is to let respondents go through two sequences of route choice tasks; one in their current mode and one in their (first-choice) alternative mode (Fosgerau *et al* 2007, Ramjerdi *et al* 2010)[11]. In those studies, route alternatives were characterized just by two attributes, travel time and travel cost, facilitating the "integrated approach" to VTTS estimation (Fosgerau *et al* 2006) in which VTTS can directly be parameterized with covariates. Fosgerau *et al* (2010) specified the logarithm of VTTS of respondent *n* in choice task *t* as:

(23) $$\log VTTS_{nt} = \beta' \boldsymbol{X}_{nt} + \delta' \boldsymbol{D}_{nt} + u_n$$

where u_n is the normally distributed, person specific random term, X_{nt} are socio-economic or design variables for respondent *n* in choice task *t*, and $\boldsymbol{D}_{nt}$ are dummy variables representing respondent *n*'s current and alternative mode choice and whether or not *t* refers to a choice task in *n*'s current or alternative mode. The estimated relative sizes of elements in δ' give information about user type and mode effects (see details in Fosgerau *et al* (2010)). When using socio-economic variables in X_{nt} it is important to realize that ME and UE are statistically controlled for the effects of these variables, so that

[10] SP studies are often used for the specific purpose of VTTS estimation. Among VTTS-SP-studies, route choice experiments are in general preferred over mode choice experiments as the alternative specific constants in mode choice models are likely to capture some of the "comfort effect", which should conceptually be associated with the disutility of travel time.

[11] This approach was earlier used in studies described in Algers *et al* (1996) and Ramjerdi *et al* (1997).

the full size of the ME and UE will not be obtained (Flügel *et al* 2011). For instance, Fosgerau *et al* (2010) controlled for income and several background variables. In this case it is likely that the size of the UE is reduced.[12] A great advantage of the integrated approach is that one can control for design variables (SP artefacts) such as the absolute size of the travel time saving (Δt), which often has a direct effect on empirical VTTS estimates.[13] This makes the estimation of UE and ME more consistent and valid.

4.2. Empirical example

This section discusses some empirical evidence based on data from the Norwegian Value of Time study (Ramjerdi *et al* 2010). The subsample of private long distance trips (>100km) within Norway with travel modes car, bus (coach), rail and air is considered. For interpretation of the mode effect, two elements are important: (1) only car drivers (not passengers) are included (drivers are likely to perceive relatively more discomfort due to lack of sleeping and reading possibilities) and (2) only in-vehicle time is considered, although for the air mode, the time spent at the airports is included.

The model specification does not control for socio-economic variables, so that the full size ME and UE are obtained. Table 1 gives relative values as estimated from the integrated estimation model described above. Groups g_{car}, g_{bus} g_{rail} and g_{air} consist of respondents that that were not routed into the alternative mode choice experience. As the routing was random, these groups are regarded as the representative user group of the corresponding user modes. For the other groups, the first travel mode in the subscript indicates the current mode and the second transport mode the alternative mode.

Table 1: Relative Value of Travel Time Saving (VTTS) with 95% confidence intervals based on Flügel et al (2011, page 16[14])

User Group	Relative VTTS in ...			
	Car	**Bus**	**Rail**	**Air**
g_{car}	1.00 (normalized)			
$g_{car/bus}$	1.050 (0.890-1.239)	0.905 (0.767-1.067)		
$g_{car/rail}$	1.168 (0.998-1.366)		1.004 (0.859-1.174)	
$g_{car/air}$	1.105 (0.757-1.613)			1.927 (1.318-2.819)
g_{bus}		0.627 (0.548 -0.717)		
$g_{bus/car}$	0.821 (0.660-1.022)	0.682 (0.511-0.843)		
$g_{bus/rail}$		0.607 (0.471-0.782)	0.601 (0.462-0.782)	
$g_{bus/air}$		0.530 (0.376-0.748)		0.934 (0.653-1.337)
g_{rail}			0.763 (0.668-0.873)	
$g_{rail/car}$	1.061 (0.879-1.280)		0.944 (0.784-1.137)	
$g_{rail/bus}$		0.724 (0.590-0.888)	0.712 (0.586-0.887)	
$g_{rail/air}$			0.830 (0.678-1.017)	1.183 (0.962-1.455)
g_{air}				1.384 (1.231-1.556)
$g_{air/car}$	1.016 (0.836-1.235)			1.412 (1.169-1.706)
$g_{air/bus}$		0.597 (0.432-0.843)		1.145 (0.810-1.616)
$g_{air/rail}$			0.647 (0.544-0.769)	1.048 (0.885-1.242)

[12] See Flügel *et al* (2011) for some empirical tests regarding the influence of controll variables on the estimation of UE and ME.
[13] In Flügel *et al* (2011), the elasticity of Δt on VTTS was estimated at around +20%. Given that this is a real phenomenon and not just an SP specific finding, it would also have an effect on the appraisal of projects that provide different absolute sizes of travel time savings. However, this issue is not further discussed in this paper.
[14] Additional user groups that rejected the offered alternative mode are not displayed here.

Comparing line by line one obtains the ME; comparing column by column one obtains the UE. One can distinguish between user type effects across and within current users (UEa and UEw). Comparing e.g. $VTTS_{car,g_{car/bus}}$ with $VTTS_{car,g_{bus/car}}$ gives the UEa (current car versus current bus users), while comparing e.g. $VTTS_{car,g_{car/bus}}$ with $VTTS_{car,g_{car/rail}}$ gives UEw (alternative mode bus versus alternative mode rail). UEa is due to self-selection to current modes, while the UEw effect is due to self-selection to alternative modes (Flügel *et al* 2011).

The 95 % confidence intervals in Table 1 are rather broad and overlapping in most cases. However, there is a clear pattern of relative VTTS across user groups and across modes, which is easier to spot when scaling and rearranging VTTS in "pairs of user groups" (Table 2).

Table 2: Value of Travel Time Savings, mode effects and user type effects, Comparison of "pair of user groups"

in € per hour*	VTTS in Car	VTTS in Bus	ME		VTTS in Car	VTTS in Rail	ME		VTTS in Car	VTTS in Air	ME
$g_{car/bus}$	19.7	17.0	-2.7	$g_{car/rail}$	21.9	18.8	-3.1	$g_{car/air}$	20.7	36.1	15.4
$g_{bus/car}$	15.4	12.8	-2.6	$g_{rail/car}$	19.9	17.7	-2.2	$g_{air/car}$	19.1	26.5	7.4
UEa	-4.3	-4.2		UEa	-2.0	-1.1		UEa	-1.7	-9.7	
	VTTS in Rail	VTTS in Air	ME		VTTS in Bus	VTTS in Air	ME		VTTS in Bus	VTTS in Rail	ME
$g_{rail/air}$	15.6	22.2	6.6	$g_{bus/air}$	9.9	17.5	7.6	$g_{bus/rail}$	11.4	11.3	-0.1
$g_{air/rail}$	12.1	19.7	7.5	$g_{air/bus}$	11.2	21.5	10.3	$g_{rail/bus}$	13.6	13.4	-0.2
UEa	-3.4	-2.5		UEa	1.3	4.0		UEa	2.2	2.1	

*using 18.75 €/h for the normalized groups which roughly corresponds the 150 NOK/h, the recommended unit value for private long distance car-trips in Norway (Ramjerdi et al. 2010)

As a reading example: For the $g_{car/bus}$ - $g_{bus/car}$ pair we see that current car users (with alternative mode bus) have a VTTS in car of 19.7 €/h, while current bus users (with alternative mode car) have a VTTS in bus of 12.8 €/h. Hence $\Delta VTTS_{car,bus}$ is 6.9 €/h. As shown in equation (4) this change can be associated with UE (here UEa) and ME. The UEa is -4.3 and indicates that current car users have higher opportunity cost than bus users (income differences and self-selection); the ME of -2.6 tells us that sitting in bus is more comfortable (in a wide sense) than driving a car.[15]

Studying the direction of the ME, the following consistency over all user groups is observed: Time in mode air (including waiting times at airports) is perceived least "comfortable" and car (as a driver) is less comfortable than bus and rail (the differences between rail and bus being quite small). Studying the direction of the UEa it is evident that car drivers (bus passengers) have higher (lower) VTTS than other current users in any given travel mode.

Another way of looking at the estimation results from Table 1 is to regard the VTTS of the alternative mode as the value which would be most applicable for user group after switching travel modes. Table 3 gives the values which may be established under this assumption.[16]

[15] The direction of the mode effect between bus and car might be a particularity of long distance travel. Fosgerau *et al* (2010) finds evidence that the reversed direction of ME between car and bus. The Danish study does not segment in long and short distance and presumably most bus trip are short-distance, where busses are often crowded.

[16] Similar tables were previously reported in the Norwegian Value of Time Study (Samstad *et al* 2010, Ramjerdi *et al* (2010), Flügel and Minken (2011)). There the 'official' VTTS for each travel mode was used to calculate the VTTS for switching modes. The results in this table are based on results in Table 1 scaled the 'official' VTTS of

Table 3: Value of Travel Time Savings after switching travel modes

in € per hour Current mode	VTTS after switching mode to …				Change in VTTS compared to representative user group (UEw+ME)			
	car	bus	rail	air	car	bus	rail	air
car	*18.8**	17.0	18.8	36.1		-1.8 (0.9-2.7)	0.1 (3.2-3.1)	17.4 (2.0-15.4)
bus	15.4	*11.8**	11.3	17.5	3.6 (1.0+2.6)		-0.5 (-0.4-0.1)	5.8 (-1.8+7.6)
rail	19.9	13.6	*14.3**	22.2	5.6 (3.4+2.2)	-0.7 (-1+0.2)		7.9 (1.3+6.6)
air	19.1	11.2	12.1	*26.0**	-6.9 (4.3-7.4)	-14.8 (-4.5-10.3)	-13.8 (-6.3-7.5)	

*Estimated Value of the representative user groups.

As a reading example: Current rail users - that have a representative VTTS of 14.3 €/h[17] - have a VTTS of 22.2 €/h in their alternative mode air. The difference of 7.9 €/h can then be thought of being the best estimate (with the data available) for the change in VTTS after a mode switch from rail to air. The differences is decomposable into a UEw of 1.3 € (current rail users that (can afford to) switch to air are likely to be wealthier than the average current rail user), and a ME of 6.6 €/h (rail more "comfortable" than air[18]). As discussed earlier the UEw of 1.3 € should be included in the VTTS-change after mode shift whenever it is reasonable that mode choice is voluntary (in most cases presumably).

The ME for air is particularly high and explains most of the VTTS differences to the other modes. A rather low overall impact of the UE might be explained by the relatively low income disparity in Norway.

4.3. Stylized case study

For an illustration of the concepts described, imagine the following hypothetical scenario.

- A road section has recently been upgraded from 2 to 3 lanes and the extra lane will soon open
- The road administration (thereafter: social planner) wonders if they should dedicate the extra lane (or part of it) to bus services only.
- Denote by $0 \leq \pi \leq 1$ the share of length of the extra lane dedicated to bus services. For $\pi = 1$ the whole lane is dedicated for bus services and no private car is allowed to drive there. $\pi = 0$ means free use of the extra lane, which will mostly benefit car drivers.
- The resulting time savings (in hours) are assumed to be $\Delta T_{bus} = \pi$ and $\Delta T_{car} = 1 - \pi$.
- Before opening the extra lane, there are 10,000 daily users of the road with market shares $P^0(car)$ = 0.5 and $P^0(bus)$ = 0.5.

car. The average values for other mode than car do not equal the official values in Norway. However, the ordinal ranks of VTTS are the same ($VTTS_{air} > VTTS_{car} > VTTS_{rail} > VTTS_{bus}$).

[17] This is the VTTS in rail for group g_{rail} in Table1 multiplied by 18.75 to convert it into absolute numbers.

[18] Many elements of "comfort" seem to favour train over air, e.g. more sitting space, the possibility to walk around, no annoying security checks, better (perceived) safety, possibility to talk on the mobile phone etc.

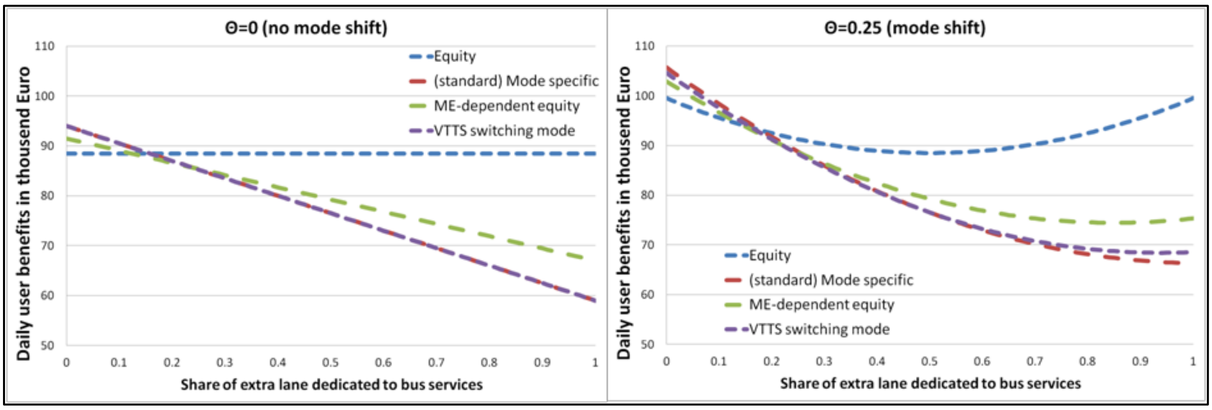
- After opening the extra lane, market shares will be $P^1(car)=\frac{1}{1+e^{\theta(2\pi-1)}}$ and $P^1(bus)=\frac{1}{1+e^{\theta(1-2\pi)}}$ with $\theta \geq 0$ being a sensitivity parameter for the effect of time saving on demand (for θ = 0 there will be no transferred demand between car and bus despite changes in the relative travel times).[19]
- No induced demand and no transferred demand from other travel modes.
- Travel time savings are the only user benefits and no third-party benefits and cost exist.
- The social planner wants to maximize the total benefits of the extra lane by finding the optimal project specification as given by the value of π.

With the empirical information of Table 3, the social planner considers four sets of VTTS estimates:
(i) *Equity VTTS*. $\overline{VTTS}$ is calculated as the average of the VTTS of the representative current users in all four modes: $VTTS_{car,g_{car}} = 18.8€/h$, $VTTS_{bus,g_{bus}} = 11.8€/h$, $VTTS_{train,g_{train}} = 14.3€/h$ and $VTTS_{air,g_{air}} = 26.0€/h$. As this is a hypothetical setting, it is conveniently assumed that all modes have the same market shares nationwide; hence an (un-weighted) averages of $\overline{VTTS} = 17.7€/h$ is applied.
(ii) *Standard mode specific VTTS.* This approach uses the VTTS values given in (i) separately.
(iii) *ME-dependent equity values*. $\overline{VTTS}_{car}$ is here calculated as the un-weighted average of $VTTS_{car,g_{bus/car}} = 15.4€/h$, $VTTS_{car,g_{rail/car}} = 19.9€/h$, $VTTS_{car,g_{air/car}} = 19.1€/h$ and $VTTS_{car,g_{car}} = 18.8€/h$. Note that this calculation does not include all user groups in the population and idealistically one would also like to include the VTTS in car for user groups that do not use car as their current or first-best alternative mode. But, for instance $VTTS_{car,g_{rail/bus}}$ is not available in the Norwegian Value of Time study. Hence, $\overline{VTTS}_{car}$, calculated at $18.3€/h$, will still contain some self-selection. The same applies for $\overline{VTTS}_{bus}$ which is calculated at $13.4\ €/h$. Note that $\overline{VTTS}_{bus}$ is greater than $VTTS_{bus,g_{bus}}$ because the former is (at least partly) corrected for the user type effect.
(iv) *VTTS of switching modes*. It is given as the set of values: $VTTS_{car,g_{car\_car}} = 18.8€/h$, $VTTS_{bus,g_{car\_bus}} = 17.0€/h$, $VTTS_{car,g_{bus\_car}} = 15.4€/h$ and $VTTS_{bus,g_{bus\_bus}} = 11.8€/h$. As information about $VTTS_{car,g_{car\_car}}$ (i.e. the VTTS in car for users that use car before and after project implementation) is not available, $VTTS_{car,g_{car}}$ (i.e. the VTTS in car for the representative user of car) is used as an approximation. The same is applied for bus.

Figure 3 below depicts the total user benefits of time savings (in 1000€/day) obtained by equation (18), i.e. calculated as the sum of WTP for individual time savings (depending on π) using each of the four sets of VTTS. The left graph refers to the situation without mode shift ($\theta = 0$), while the right graph represents a situation where there is some mode shift (the arbitrary choice of $\theta = 0.25$ implies that for $\pi = 1$ ($\pi = 0$) the market share of bus (car) increases from 50% to 56.2%).

[19] The formula for the market shares after opening the lane can be derived from an incremental logit model with generic time coefficient. This is a simplification ignoring the fact that time coefficients are likely to differ between travel modes (and user groups). Note that there is an inconsistency present when mode specific VTTS are used in project appraisal.

Figure 3: Total user benefits of travel time savings for different values of π



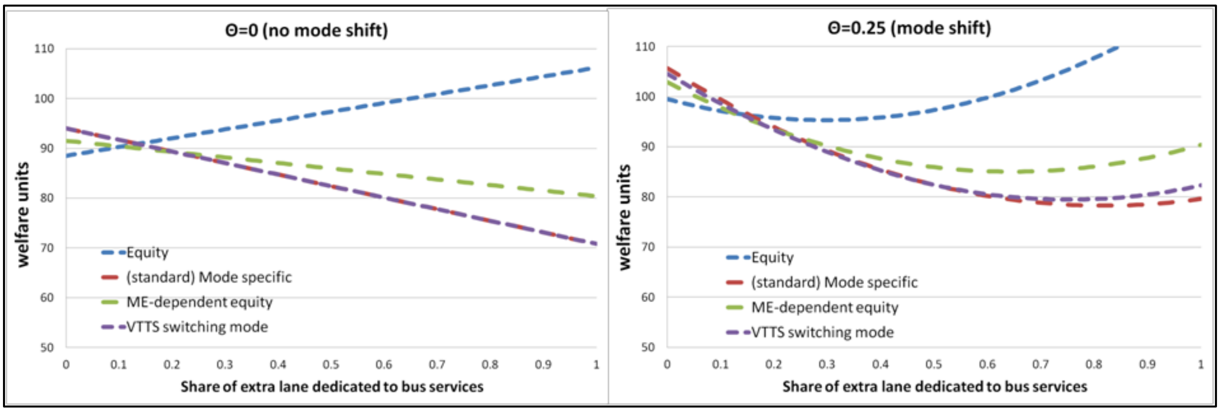
Considering the left graph ($\theta = 0$), the equity approach has the same user benefits independently of the chosen π. This underlines the potentially strong redistribution effect of the equity approach, as other arguments for bus (e.g. a slightly more favourable environmental impact compared to car) might tilt the decision in favour for bus users. Using mode specific values, the social planner should set $\pi = 0$, which maximizes time savings for car drivers. This is a simple consequence of the higher VTTS in car in the Norwegian data. Also under the ME-dependent equity values, it is indicated that the social planner should make the lane free for use. Here, the $\pi = 1$ project specification comes out relatively better compared to the (standard) mode specific VTTS, as UE has been removed from VTTS, increasing $VTTS_{bus}$ somewhat (from 11.8 €/h to 13.4 €/h). That the $\pi = 0$ project specification is still favourable (even after excluding UE) is due to the mode effect between car and bus which for the Norwegian data was found positive (implying that time in bus is more useful (comfortable) than time spend driving the car). The VTTS of switching modes corresponds to the mode specific set of values, under the assumption in this example that car (bus) users that do not switch have the same VTTS as representative car (bus) users.[20]

Considering the right graph in Figure 3, representing a situation with mode shift (for all values of π but 0.5), the equity approach implies that π should be set either to zero or to one (these are equally good project specification assuming the same VTTS in bus and car). For the other three sets of VTTS, it is again shown that $\pi = 0$ gives the highest total benefits. Now there is a difference between the (standard) mode specific and the VTTS of switching modes, as "switchers" have been assigned a different VTTS value. With the chosen θ value, the difference is rather small. The gap between the two approaches increases when applying a higher value of θ (i.e. when assuming a higher number of "switchers" compared to "non-switchers").

Suppose now that the social planner wants to account for the fact that bus users have (on average) higher marginal utility of income. Assume that discrete choice models indicate that the marginal utility of the average bus user is 20% higher than for average car users. After some discussion a distributional weight of 1.2 for bus users is therefore agreed upon. Figure 4 depicts the resulting effects on welfare (which no longer can be expressed on a monetary scale).

[20] As mentioned above, this assumption was made because there were no specific VTTS estimates available for non-switchers. If they would be available and if the value would differ compared to the VTTS of the representative car drivers this two approaches might very well imply different user benefits.

Figure 4: Welfare of travel time savings for different values of π using distributional weight for bus users of 1.2



Now $\pi = 1$ is proposed as the best project specification using the equity VTTS. Bus users are prioritized twice here, (i) because they are assigned the same VTTS as in car even though actual WTP (indicated by the Norwegian Data) is lower and (ii) because of the distributional weights chosen in this example. The former is defendable under the normative argument and the latter might be defended under an economic perspective (given that the marginal utility of income (and welfare function) is represented well with the weights). However, combining the two arguably lacks normative as well as economic reasoning. The other sets of VTTS come to the same project ranking as without distributional weights. This is because the ratio of VTTS is higher than 1.2. However, the gap in relative difference between project specification $\pi = 0$ and $\pi = 1$ is smaller given the choice of distributional weights.

Note that the (standard) mode specific set of VTTS is close to the ME-dependent equity VTTS without distributional weights (Figure 3). And obviously they would coincide when weights where chosen $\alpha_{car} = \frac{\overline{VTTS}_{car}}{VTTS_{car,g_{car}}} = 0.973$ and $\alpha_{bus} = \frac{\overline{VTTS}_{bus}}{VTTS_{bus,g_{bus}}} = 1.136$. This shows that information on ME-dependent equity VTTS can also be used to set distributional weights that account for differences in user groups. This might be interesting from a normative perspective but also with an economic rational given that differences in the marginal utility of income (which were shown to be important elements of social welfare) are represented well by such distributional weights.

5. Conclusion

This paper discussed two conceptually appealing strategies to account for the mode and user type effects in assessing the value of travel time savings in project appraisal.

The *ME-dependent equity VTTS* was argued to be preferable over a single equity value, as it accounts for the mode effect, which was shown to be an important element of between-mode differences in VTTS. It does correct for the user type effect (self-selection) and is therefore consistent with the normative principles of the equity approach. With this set of VTTS, a unit of travel time saving *in a given travel mode* is valued equally for all types of persons. In a framework where one uses (standard) mode specific VTTS and wants to correct for the marginal utility of income, it was shown that the information about *ME-dependent equity VTTS* can also be used to calculate distributional weights. From this perspective, it implicitly (but only approximately) takes account of the marginal utility of income, and might therefore better fit the purpose of project appraisal, where changes in welfare matter (rather than the single monetary value of aggregated willingness-to-pay). To rigorously establish *ME-dependent equity VTTS,* one needs *VTTS* of a representative sample of the population for all travel modes. To avoid long and complicated SP questionnaires, an idea would be to take random subsamples, e.g. every respondent goes through a sequence of route choice tasks in two (random) travel modes.[21] In the Norwegian Value of Time Study the modes considered for route choice experiments depend on the current and (first-best) alternative travel mode. When calculating *ME-dependent equity VTTS* based on this value, only part of the self-selection is controlled for.

The *VTTS for switching modes* is in principle preferable to (standard) mode specific VTTS in situations where projects lead to changes in mode choice. This is because it takes into account the fact that there are user type effects between "switchers" and "non-switchers". In principle, it therefore provides a more detailed representation of actual WTP. However, when project specific valuation studies are not feasible, one has to rely on proxies for the actual (project specific) group of switchers. As this may involve a notable inaccuracy, it is not certain that one would actual gain precision in every project appraisal. Besides, for most projects, having a minor impact on mode choice, it does not seem worthwhile to account for it (especially in countries with rather low user type effects as in Norway). However, for big projects own valuation studies might be called for in order to assess the resulting VTTS for the (predicted) post-project market.

A hypothetical case study was used to illustrate that the chosen VTTS approach might have a strong impact on decision making. In this stylized example, the establishment and inclusion of different VTTS sets were rather straightforward. The applicability in more realistic and complicated settings is left for further research.

Acknowledgments

I want to thank Farideh Ramjerdi for introducing me to the topic and her contribution to the Norwegian Value of Time Study (without this project, this paper would not have been written). I also thank Harald Minken for his contribution to an unpublished working document on the VTTS of switching modes, Lasse Fridstrøm for proof-reading and Ståle Navrud for providing some useful comments. I am also grateful for comments and suggestions from Jonas Eliasson and two anonymous reviewers. All remaining errors, omissions and misconceptions are of course my own responsibility.

References

Abrantes, P. A. L. & M. R. Wardman (2011) Meta-analysis of UK values of travel time: An update. *Transportation Research Part A: Policy and Practice*, 45**,** 1-17.

Algers, S., J. L. Dillen & S. Widlert. (1996) The National Swedish Value of Time Study. Paper presented at *PTRC International Conference in Value of Time*.

Becker, G. (1965) A Theory of the Allocation of Time. *The Economic Journal*, 75**,** 493-517.

Börjesson, M. & J. Eliasson. (2012) Experiences from the Swedish Value of Time study. Working papers in Transport Economics from CTS - Centre for Transport Studies Stockholm (KTH and VTI)

DeSerpa, A. (1971) A Theory of the Economics of Time. *The Economic Journal*, 81**,** 828-846.

Flügel, S., K. Hjorth & F. Ramjerdi. (2011) Between-mode differences in value of travel time estimates: Evidence from Norway. Paper presented at *Kuhmo Nectar Conference*. Stockholm, Sweden. http://indico.conferences.dtu.dk/getFile.py/access?contribId=130&sessionId=84&resId=0&materialId=paper&confId=75

[21] However, even in this case it might be that relatively many respondents drop out of the questionnaire when the travel mode is not relevant for them. Hence some self-selection is likely to remain.

Flügel, S. & H. Minken. (2011) Praktisk bruk av tidsverdier for overført persontrafikk i nytteberegning. Oslo: Institute of Transport Economics (available on demand)

Fosgerau, M., K. Hjorth & S. V. Lyk-Jensen. (2006) An integrated approach to the estimation of the value of travel time. In *Association for European Transport and Contributors*.

--- (2007) The Danish Value of Time Study. Copenhagen: Danish Transport Research Institute.

--- (2010) Between-mode-differences in the value of travel time: Self-selection or strategic behaviour? *Transportation Research Part D: Transport and Environment,* 15**,** 370-381.

Gálvez, T. & S. Jara-Díaz (1998) On the social valuation of travel time savings. *International Journal of Transport Economics,* 25 205-219.

Harberger, A. C. (1978) On the Use of Distributional Weights in Social Cost-Benefit Analysis. *Journal of Political Economy,* 86**,** S87-S120.

Jara-Díaz, S. R. (2007) *Transport Economic Theory*. Emerald Group Publishing Limited.

Jara-Díaz, S. R. & C. A. Guevara (2003) Behind the subjective value of travel time - The perception of work, leisure, and travel from a joint mode choice activity model. *Journal of Transport Economics and Policy,* 37, part 1**,** 29-46.

Jara-Díaz, S. R., M. A. Munizaga, P. Greeven, R. Guerra & K. Axhausen (2008) Estimating the value of leisure from a time allocation model. *Transportation Research Part B: Methodological,* 42**,** 946-957.

Johansson-Stenman, O. (2005) Distributional Weights in Cost-Benefit Analysis—Should We Forget about Them? *Land Economics,* 81**,** 337-352.

Mackie, P. J., S. Jara-Díaz & A. S. Fowkes (2001) The value of travel time savings in evaluation. *Transportation Research Part E: Logistics and Transportation Review,* 37**,** 91-106.

NOU. (2012) Samfunnsøkonomiske analyser. Norges offentlige utredninger 2012: 16 http://www.regjeringen.no/pages/38064911/PDFS/NOU201220120016000DDDPDFS.pdf

Oort, C. (1969) The evaluation of travelling time. *Journal of Economics and Policy,* 3**,** 279-286.

Rawls (1971) *A Theory of Justice*. Cambridge, Massachusetts: Belknap Press

Rawls (2001) *Justice as Fairness: A Restatement*. Cambridge, Massachusetts: Belknap Press

Ramjerdi, F., K. Sælensminde, L. Rand & I. F. Sætermo. (1997) Summary: the Norwegian Value of Time Study, Part 1. Oslo: Institute of Transport Economics.

Ramjerdi, F., S. Flügel, H. Samstad & M. Killi. (2010) The Norwegian Value of Time Study. Oslo: Institute of Transport Economics.

Samstad, H., F. Ramjerdi, K. Veisten, S. Navrud, K. Magnussen, S. Flügel, M. Killi, A. H. Halse, R. Elvik & O. San Martin. (2010) Den norske verdsettingsstudien - Sammendragsrapport. Oslo: Institute of Transport Economics.

Sugden, R. (1999) Developing a consistent cost-benefit framework for multi-modal transport appraisal University of East Anglia.

Wardman, M. (2004) Public transport values of time. *Transport Policy,* 11**,** 363-377.

Østli, V., A. H. Halse & F. Ramjerdi. (2012) Regional variasjon i verdien av reisetid. Oslo: Institute of Transport Economics.