TOPIC 18
ENVIRONMENT AND
SUSTAINABLE MOBILITY

VALUES OF TRAVEL TIME SAVINGS IN ROAD TRANSPORT PROJECT EVALUATION

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Abstract

Empirical results of many studies of the value of travel time savings (VTTS) are summarized. There is a substantial range in the estimated VTTS. The values of VTTS used for transport project appraisal by different agencies and countries also differ substantially. Important research directions are identified.

INTRODUCTION

The value of travel time savings (VTTS) is a major component of almost all economic evaluations of transport infrastructure investments. Its importance for transport project evaluation has been recognized explicitly at least since 1950 and numerous empirical studies have been conducted since the early 1960s, ie since the first application of social cost benefit analysis (SCBA) to evaluating public investments in transport infrastructure (Coburn et al. 1960; Foster and Beesley 1963). Typically, the value of time savings constitutes the majority of economic benefits from transport projects.

Despite long interest in the subject and numerous empirical investigations, the appropriate values for VTTS in project appraisal remain unsettled. In the last few years, major new empirical investigations have been commissioned along with extensive literature reviews (Bates and Glaister 1990; TTI 1990; Lawson 1989; Miller 1989; and MVA Consultancy et al. 1987). Unfortunately, precise measures of the VTTS remain elusive. This is inevitable. As we know both from theoretical analysis and empirical study, the VTTS is not some universal constant; rather it is a value which can and will vary from place to place, under different circumstances and travel situations. Nonetheless, government agencies need to adopt some figures in order to carry out consistent economic evaluations of transport projects.

Following brief comments on the evolution of the theory of valuing travel time savings, the first part of this paper reports on a survey of empirical studies of VTTS, including findings by other reviews of this literature. Over 35 empirical studies were reviewed in this author's research project (Waters 1992), and these were supplemented from reviews by other authors (Bruzilius 1979; Cherlow 1981; Hensher 1976 and 1989). This paper concentrates on the estimated values for non-work travel time, primarily the value for commuting time. The range of empirical estimates is substantial.

The second part of the paper reviews the VTTS recommended by various government or quasi-government agencies for road project evaluation purposes. These too show a remarkable variation across countries and/or government jurisdictions.

DOES TIME HAVE A VALUE?

Except to theoretical physicists, time is fixed. There are only 24 hours per day in which to live, work and play. Strictly speaking, it is not possible to save time literally, but time can be reallocated. Reducing time spent in one activity enables that time to be put to other uses.

There are theoretical links between wage rates and the value of time, although this relationship has become less clear as our models of consumer behaviour and time allocation have become more sophisticated. A simple neoclassical model portrays the household's income-leisure tradeoff: leisure time must be sacrificed in order to work to generate income. The wages received are compensation for the loss of time. In a simple model where people are free to choose the number of hours worked, and ignoring any disutility of work, the wage rate would be a measure of the marginal value of time, whether spent working to increase income or retained as leisure.

But the world is not so simple. People do not necessarily control their hours of work, in which case the value of time savings could be above or below the wage (Moses and Williamson 1963). There is disutility associated with (at least) the last increments of hours worked, therefore the wage is not just compensation for time sacrificed (eg Johnson 1966; Oort 1969). More general formulations of the value of time savings recognise that time is an intimate part of consumption activity, along with money budget constraints, (Becker 1956; Evans 1972). And there can be constraints on the amounts of time required for various activities and on the ability to substitute time from one activity to another; these affect the marginal value of time saved (eg de Serpa 1971 1973; De Donnea 1971, 1972, 1973; Train and McFadden 1978; Bruzelius 1979). (The most

comprehensive discussion of the value of travel time is Bruzelius 1979. A concise but lucid review of the theory is in MVA Consultancy et al. 1987; Small 1992: 37ff provides an even more concise review of the theory as well as some empirical studies.)

The net result is that theory provides us with warnings that postulated simple relationships between wage rates and values of time are incomplete, and guidance for the type of constraints or relationships to look for in setting up empirical investigations of VTTS. But ultimately, determining a representative VTTS is a matter of empirical study rather than by derivation from theoretical principles.

EVIDENCE ON THE VALUE OF TRAVEL TIME SAVINGS

This section summarises estimates of VTTS from various empirical studies. This summary review cannot do justice to the work and richness of empirical results of some of the studies. The present paper is confined to the broadest overview of the values of VTTS which emerge from a large number of studies. Where studies report various estimates of VTTS depending on travel conditions, income, etc., we use their "base values" for in-vehicle travel time. For convenience, we compare the studies in terms of VTTS expressed as a percent of the wage. For non-work time, it is the net or after-tax wage which would be relevant for studying consumer behaviour, although the convention has been to use the gross or before-tax wage because this is more readily available from standard statistical sources. We reemphasize that there is no theoretical reason why we should obtain identical estimates of VTTS as a percentage of the wage from one study or one country to another. Nonetheless, it is interesting to examine the range of results reported.

Empirical approaches

Empirical studies consist largely of two approaches: (1) direct interview or questionnaire methods ("stated preference" or SP studies); and (2) "revealed preference" (RP) studies which infer implied values of time from situations where people make economic choices involving travel time and other decisions.

RP studies were the more traditional empirical approach to VTTS. These identify situations where people are thought to be making choices which involve time tradeoffs, eg, people's willingness to pay for time-saving devices. Typical examples include: route-choice decisions (people choose different routes, such as toll roads, which save time but are more costly); mode choice (faster travel costs more but saves time); location choice (urban land values reflect, in part, a premium for reduced commuting time); and speed-choice (driving faster saves time but increases operating costs). Statistical estimation can infer implied values to the time savings of travellers in these situations.

Until relatively recently, questionnaire methods were not popular among economists studying VTTS (or many other consumer issues) because of the danger of biased responses by those interviewed. However, questionnaire design and administration have become more sophisticated and reliable. SP studies emphasize developing questions and hypothetical time tradeoffs which can be readily understood by interviewees, and build in cross-checks or feedbacks to check the reliability of the stated preferences (Bates et al. 1988). Questionnaire methods have the advantage of directly posing questions of interest to researchers, and for being able to isolate the importance of different influences on a decision. In contrast, multicollinearity among influencing variables is a persistent problem encountered by empirical RP studies. Many of the more recent empirical studies of VTTS use the SP approach.

The empirical studies cited below include both types of empirical approaches.

Measures of the Value of Travel Time Savings

Table 1 presents the estimates of VTTS from a number of studies, listed in chronological order. The VTTS is expressed as a percent of the average wage (see Waters 1992 for further discussion). The entries in Table 1 are from Waters (1992) supplemented by studies cited in Bruzelius (1979), Cherlow (1981), Miller (1989) and TTI (1990).

The figures in Table 1 are from a number of countries, modes and travel circumstances. One must be cautious in making comparisons across diverse studies. It is well known that the VTTS can vary substantially even within a single data set (eg Lee and Dalvi 1969, 1971). Nonetheless, Table 1 illustrates the variation in VTTS across empirical studies. The VTTS ranges from 2.7 percent to 254 percent of the wage in different studies, almost a 100-fold variation. Deleting the lowest and highest estimate gives a range from 12 percent to 170 percent, still over a ten-fold variation. While part of the variation among VTTS will be random, many of the differences might be explained by specific characteristics which underlie the particular VTTS study, such as traveller and/or trip characteristics, eg work time versus non-work time, commuting versus leisure travel, congested versus uncongested conditions, etc.

Explaining variations in VTTS?

The reasons for different values of time savings are many. They arise from inevitable statistical or sampling errors, but more fundamentally from differences in uncontrolled variables which influence VTTS.

Compiling characteristics of numerous studies may make it possible to identify some systematic influences on the values for VTTS which arise in the various studies. A so-called "meta-analysis" can be conducted. Ideally, the various studies should be reviewed in detail to identify factors which need to be considered and/or data or calculations modified to make the data bases and interpretation of results more consistent. For the present, only a preliminary analysis has been performed.

An elementary analysis is to regress the VTTS on variables to see if they can explain part of the variation across the studies. Button (1994) explored a previous version of this data set. Using dummy variables, he investigated the influence of country (UK as the base), mode (auto as the base) and trip purpose (leisure or interurban relative to commuting). However, none of the variables were statistically significant. For this study, the variations in VTTS were related to time (has the estimated VTTS been changing over time?), country of study and trip purpose (interurban and commuting relative to leisure or unclassified studies). Where studies reported a range of values for VTTS, a simple average was taken to be used in the regression. A regression can be sensitive to outliers. A couple studies with extreme values for VTTS were eliminated before the regression. A scatter plot of the data with respect to time (Figure 1) shows wide variation hence a low fit; the relationship with other variables is also poor. The regression results are:

Variable	*Coef*	*t-ratio*	*prob*
Constant	0.4469	3.99	0.000
Year	0.007896	1.68	0.099
USA	-0.0525	-0.51	0.615
UK	-0.0819	-0.71	0.480
AUS	-0.2022	-1.80	0.079
Comm	-0.0289	-0.26	0.799
Int	-0.2032	1.45	0.152

R-sq = 19.9%
R-sq(adj) = 10.0%

Table 1 Empirical estimates of the Value of Travel Time Savings (VTTS)

Author	Country	VTTS as a % of Wage Rate	Trip Purpose	Mode
Dawson & Smith (1959)	UK	86%	Interurban	Auto
Mohring (1960)	USA	22-43%	Commuting	Auto, Transit
Claesson (1961)	Sweden	64%	--- [g]	--- [g]
Claffey et al. (1961)	USA	65%	Interurban	Auto
Becker (1965)	USA	42%	Commuting	Auto, Transit
Beesley (1965)	UK	33-50% [b]	Commuting	Auto
Lisco (1967)	USA	40-50%	Commuting	Auto, Transit
Thomas (1967)	USA	72%	Commuting	Auto
Quarmby (1967)	UK	20-25%	Commuting	Auto, Transit
Lave (1968)	USA	42%	Commuting	Bus, Auto
Stopher (1968)	UK	21-32% [b]	Commuting	Auto, Transit
Oort (1969)	USA	33%	Commuting	Auto
Lee & Dalvi (1969)	UK	30%	Commuting	Bus
Hansen (1970)	Norway	36%	Commuting	Auto, Transit
Thomas & Thompson (1970)	USA	40-85%	Interurban	Auto
Howe (1971)	Kenya	102%	--- [g]	--- [g]
Lee & Dalvi (1971)	UK	40%	Commuting	Auto
Wabe, J. (1971)	UK	43%	Commuting	Subway, Rail
Charles River Associates (1972)	USA	32%	Commuting	--- [g]
Dawson & Everall (1972)	Italy	60-89%	Interurban	--- [g]
Talvittie (1972)	USA	12-14%	Commuting	Auto, Transit
Kentner (1973)	Germany	91%	--- [g]	--- [g]
Kenter (1973)	Germany	40%	--- [g]	--- [g]
Algers et al. (1974)	Sweden	21%	Commuting	Auto, Transit
Hensher & Hotchkiss (1974)	Australia	2.7%	Commuting	Hydrofoil, Ferry
Hensher & Delofski (1974)	Australia	39%	Interurban	--- [g]
Kraft & Kraft (1974)	USA	38%	Interurban	Bus
O'Farrell & Markham (1975)	Ireland	86%	--- [g]	Auto, Rail
McFadden (1975)	USA	28%	Commuting	Auto, Transit
Ghosh, Lees & Seal (1975)	UK	73-89%	Interurban	Auto
McDonald (1975)	USA	45-78% [b]	Commuting	Auto, Transit
Ghosh et al. (1975)	UK	73%	Interurban	Auto
Guttman (1975)	USA	63%	Leisure	Auto
Hensher (1977)	Australia	145%	Commuting	Auto
		39%	Commuting	Auto
Hensher & McLeod (1977)	Australia	35%	Leisure	Auto
Nelson (1977)	USA	20%	Commuting	Auto, Rail
Hensher (1982, cited in 1989)	Australia	23-45%	Commuting	Auto
Hauer & Greenough (1982)	Canada	46%	Commuting	Auto
Edmonds (1983)	Japan	67-101% [f]	Commuting	Subway
Thomas (1983)	Malaysia	42-49% [c]	Commuting	Auto, Bus, Rail
Algers & Wildert (1985)	Sweden	52.5%	Commuting	Taxi, Bus
Chui & McFarland (1985)	USA	20-30%	--- [g]	All modes
Deacon & Sonstelie (1985)	USA	82%	Interurban	Auto
Hensher & Truong (1985)	Australia	52-254% [b]	Leisure	Auto
Guttman & Memashe (1986)	Israel	105%	Commuting	Auto, Transit
Fowkes (1986)	UK	59%	Commuting	Auto, Bus
Hau (1986)	USA	27-59% [d]	Commuting	Rail, Coach
Winston & Associates (1987)	USA	46% [e]	Commuting	Auto, Bus
Horowitz (1987)	Australia	75%	Interurban	Mul. modes
Bates et al. (1987) (Route choice)	UK	68%	Interurban	Auto
		43%	Commuting	Auto, Transit
Bates et al. (1987) (Survey)	UK	62%	Commuting	Auto, Transit
Chui & McFarland (1987)	USA	82%	Interurban	Auto
Mohring et al. (1987)	Singapore	60-120% [b]	Commuting	Bus
Hensher (1989)	Australia	36%	Commuting	Auto
Hensher (1990)	Australia	34%	Commuting	Auto
Cole Sherman (1990)	Canada			
Comparison Model		93%	Commuting	Auto
		116%	Leisure	Auto
Logit Model		170%	Commuting	Auto
		165%	Leisure	Auto

Notes:

b Varies with income of the traveller.
c Estimates are sensitive to data selected.
d Varies with income of the traveller and the model used.
e Paper used 5.71% of daily income in its model (an 8 hour day is assumed).
f Inferred values (study actually valued waiting time).
g Dash --- indicates trip purpose or mode not known.

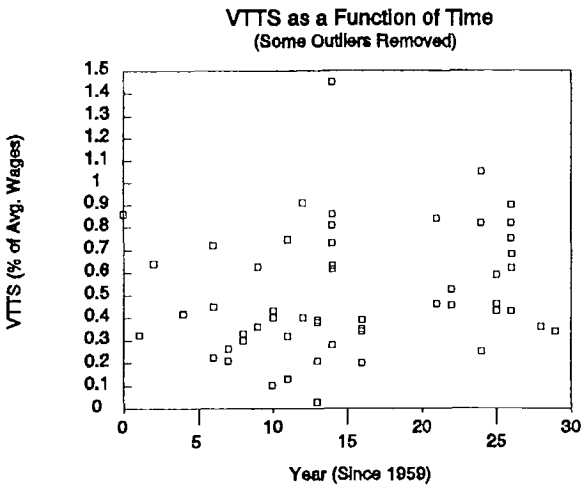

Figure 1 Scatter plot: VTTS as a function of time

The regression intercept the predicted VTTS is 44.7 percent of the wage, drifting upward at less than one percentage point per year (but significant only at the 90 percent confidence limit). Most other variables are insignificant except for interurban travel, which tends to have slightly higher values of time than commuting or "other." Because the "other" includes studies which were unclear on the trip purpose (hence will include some of the trip purposes being investigated), the coefficient probably is a slight underestimate. The only country to appear possibly significant is Australia which is noticeable less than other countries; however, this result may be sensitive to one study with a particularly low VTTS (ferry commuting).

Another attribute to investigate would be how the study was conducted: using revealed preference (RP) data or stated preference (SP) methods. We were unable to categorize a sufficient number of studies to investigate this. Miller (1989) compared values of VTTS from several studies of the VTTS; he found substantial variation in the estimated VTTS from both RP and SP studies. He also compared different approaches to estimating VTTS, viz., speed choice are route choice models (implied values of time from motorists' choice of speed or route) tended to produce higher estimates of VTTS than transit-car mode choice studies (Miller 1989).

Clearly there is much room for improvement in comparing and investigating explanations of differences among VTTS studies. This is an intriguing line of research. As is evident, there is wide variation to be explained, and initial exploratory regressions, such as the above, are not very enlightening.

What is a representative value of VTTS?

The foregoing analysis was not helpful in explaining variations in VTTS among studies. More detailed data and analysis is necessary to provide more accurate estimates for specific circumstances. In the meantime, countries and road authorities must adopt figures from the information available.

Focussing only on automobile commuting studies, Table 1 contains 32 studies based on commuting trips which include automobiles. Figure 2 plots VTTS as a percent of the wage for the auto-transit commuting studies. We used a middle value for those studies reporting a range for the VTTS. The range is from 12-14 percent to 170 percent of the wage. Next, we arbitrarily eliminate the highest and lowest VTTS estimate (170 percent and 12-14 percent, respectively), and calculate the mean, which is 48.0 percent. However, the mean has an upward bias in this type of calculation, the median is a more appropriate indicator of central tendency. The median value is about 40 percent of the wage.

Limiting the analysis to automobile commuting studies in North America, Table 1 contains 15 studies. The VTTS as a percent of the average wage varies from 12-14 to 170 percent; the mean is 59.1 percent with a median value of 42 percent. The mean is 54.2 percent if the highest and lowest figures are omitted. The non North American studies involving auto commuters (17 of them) have a narrower range and mean of 38.2 percent. It appears that a representative VTTS for auto commuting would be in the 35 to 50 percent range, probably at the upper end of this range for North America. For interurban/rural travel in North America, slightly higher values may be appropriate (eg see discussions in TTI 1990).

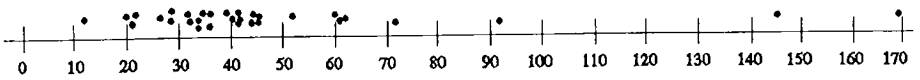

Figure 2 Scatter plot of Values of Commuter Time Savings involving auto travel (from Table 1)

VTTS IN PRACTICE: COMPARISONS ACROSS COUNTRIES AND AGENCIES

Different countries and decision-making agencies have adopted different values for VTTS in project evaluation. An Appendix available from the author summarizes the VTTS adopted by various agencies in several countries. Table 2 summarizes the VTTS for work and non-work time in the various jurisdictions, expressed in 1992$US. There are substantial differences in the values adopted. It may not be surprising that the VTTS would differ among countries, because of cultural and income differences. On the other hand, these figures are all from relatively wealthy countries where car travel is a common characteristic of life. More striking, there is comparable variation in the VTTS employed *within* countries as compared *across* countries. The variability is even higher than indicated by these base value comparisons; many countries or jurisdictions add various adjustments to the base VTTS depending on trip and traveller characteristics. A few agencies do not distinguish between work and non-work time (notably AASHTO 1977 including its update), but most agencies use different values for work and non-work time. However, the values adopted differ considerably. In Table 2, the ratio of VTTS for work and non-work time ranges from 1:1 to over 5:1 across the jurisdictions.

Several countries or road authorities have undertaken major reviews of VTTS in recent years. The U.K. sponsored extensive studies of VTTS (MVA Consultancy et al. 1987) and ultimately raised their base VTTS from 25 percent to 40 percent of the wage (Sharp 1988). New Zealand reviewed the evidence on VTTS (Miller 1989 and Bone 1991). A value of 60 percent of the wage was suggested by Miller while Bone recommended 40 percent; ultimately 40 percent was the figure

chosen. The U.S. Federal Highway Administration is using 60 percent as a VTTS for highway evaluation. The 1977 AASHTO "Red Book" (AASHTO 1977), the principle guide for road and transit investments in the U.S., used a VTTS of $3.90 (1975$US); this was 52 percent of the average family or household hourly earnings. TTI (1990) reviewed the VTTS to be used in the update of the AASHTO manual. TTI recommend a VTTS per person hour of $9.32 (1989$), about $10.54 in 1992$. Alternatively, they suggest using 70 to 80 percent of the wage for VTTS (TTI 1990, p.92).

Transport Canada reviewed the VTTS to be used for transport project appraisal. Drawing on the review by Lawson (1989), Transport Canada's (1990) draft report recommends 50 percent of the average wage as the VTTS for non-work time savings. The same VTTS for non-work time would be used for all modes.

A review for the Government of British Columbia has also recommended 50 percent of the wage as a base VTTS for the evaluation of highway projects, but with an upward adjustment for the VTTS during congested conditions (Waters 1992a). (A base value of 40 percent of the wage, plus adjustments, was adopted).

Looking across these recent reviews, there are still substantial differences in the VTTS recommended for project evaluation, not to mention considerable differences in the adjustments to base values, eg: trip purpose (work, commute, shopping, to school, leisure), income, age, travel conditions (congestion), size of time savings, etc.

Table 2 Summary comparison of Values of Travel Time used for road project evaluation in various countries and government agencies (rural area figures where distinguished; in approx. $US1992)

Country/jurisdiction	$/vehicle hr. (non-work time)	$/person hr. (non-work time)	$/person hr. (work time)
North America			
United States			
AASHTO (used by several states)		10.17	10.17
Recommended new AASHTO		10.54	10.54
California	7.42	--	--
Florida	13.72	10.56	--
New York		5.38	--
Canada			
Transport Canada		5.62	18.79
Ontario		2.02	7.58
Quebec		1.91	9.11
Alberta		5.52	11.97
British Columbia		5.70	15.63
Europe			
United Kingdom		3.05	--
Germany		0.94	5.62
Finland		4.07	8.22
Holland (base figure)		3.34	4.35
(avg. adjusted)		6.07	9.45
Sweden (rural)		3.79	20.46
Australia			
New South Wales (rural)		5.71	21.57
South Australia (rural)		5.65	21.37
Queensland (private car)		6.08	23.51
New Zealand		3.63	11.32

Note:

- These figures should be regarded as approximate. It is necessary to convert currencies and index them up for inflation. Different figures result depending on the indexing procedures.

CONCLUSIONS AND DIRECTIONS FOR RESEARCH

It comes as no surprise, but the initial purpose of this paper was to draw attention to the diverse estimates of value of travel time savings (VTTS) in the empirical literature as well as the variations in the VTTS used in transport project evaluation, especially for roads. There are substantial differences in the VTTS adopted by different countries and agencies in the world. The actual range is even higher than what is shown here, because many jurisdictions do not explicitly value time savings in connection with road projects. There are implicit weights which result from their decisions. We do not know what these implied values might be but it is likely they imply an even wider range of values for travel time savings.

Given the importance of VTTS in road (and other transport) project evaluation, it is surprising there has not been more communication across decision-making agencies to exchange information, views, and converge on more consistent practices. Such cooperation is common in technical matters of road building and maintenance. Under the present evaluation frameworks in different regions and departments, an identical project could be rated very differently because of differences in the assumed VTTS.

Unfortunately, the empirical evidence does not offer a clear guide to the appropriate value for VTTS. Different studies, using different methodologies at different places and time, for different travel conditions, have produced a wide range of VTTS estimates. These diverse estimates converge to between 30 to 60 percent of the wage rate as the average VTTS for non-work travel time. This is still a variation of 100 percent in the most important benefit category in nearly all transport projects. Of course, some types of service-sensitive markets could reveal VTTS higher or lower than the average. There are a sufficient number of studies in existence that there is promise in trying to identify characteristics of the sample and/or methods employed which might help explain the variation in VTTS estimates in existing studies. The present wide variation of VTTS in project evaluation frameworks implies considerable inconsistency in the application of economic evaluation frameworks in different jurisdictions. This is an awkward situation for economists and policy analysts who advocate greater reliance on economic evaluation methods for government expenditure decisions. There is a need for research not only on measuring the VTTS but also on what specific figures are being used in project evaluation frameworks in various agencies and jurisdictions.

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