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The Norwegian Value of Time Study
Part I

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Title: The Norwegian Value of Time Study
Part I and Part II

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Value of travel-time savings; Stated preference; Transfer price; Willingness to pay; Private travel purpose; Business travel purpose

Summary:
This documents reports on the Norwegian Value of Travel Time Study. The study covers long distance (inter-urban) and short distance (urban) private and business travel purposes. Long distance travel modes covered in this study are air, car, rail, bus and ferry. Short distance travel modes covered are car, rail, bus, tram, and subway. The study relies on stated preference technique as well as transfer price technique.
Part I is the main report (155 pages) and part II is the appendices.

Tittel: The Norwegian Value of Time Study
Part I and Part II

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Verdien av spart reisetid; Stated preference; Betalingsvillighet; Private reiseformål; Arbeidsreiser

Sammendrag:
Denne rapporten dokumenterer resultatene fra den norske tidsverdiundersøkelsen. Undersøkelsen dekker korte og lange arbeidsreiser og korte og lange private reiser. Transportmidlene for lange reiser i denne undersøkelsen er fly, bil, tog, buss, og ferge. På de korte reisene er transportmidlene bil, tog, buss, trikk og undergrunnsbane. Undersøkelsen er basert på Stated preference-teknikk og "transfer price technique".
Rapporten er delt i to. Part I er hovedrapporten (155 sider) og Part II er vedleggene.

Language of report: English

The report can be ordered from:
Institute of Transport Economics, The library
Gaustadalleen 21, NO 0349 Oslo, Norway
Telephone +47 22 57 38 00 - www.toi.no

Rapporten kan bestilles fra:
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Preface

This document reports on the Norwegian Value of Time Study. The main goal of the study is to provide for values of travel-time savings for social benefit-cost analysis. Another outcome of the study has been empirical evidence, for use in the evaluation of demand for travel. The Norwegian Value of Time Study is a comprehensive study, covering travel modes car, rail, bus, air and ferry for long distance (inter-urban) and car, rail, bus, tram and subway for short distance (urban) private and business travel.

The Ministry of Transport and Communications, the Public Roads Administration, the Norwegian Railways and the Civil Aviation Administration have financed the Norwegian Value of Time Study. The study was organised with a steering group comprising the sponsoring organisations and TØI and with a reference group comprising experts from Norway, Sweden and UK. We would like to acknowledge members of the reference group; Staffan Widlert (SIKA, Sweden), Staffan Algers (Transek, Sweden), John Bates (John Bates Services, UK), Arild Hervik (Møreforskning, Norway), Jan Owen Jansson (Linköping University, Sweden), Peter Jones (University of Westminster, UK) and Hugh Gunn (HCG, the Netherlands) for their valuable contributions.

The results from this study have been presented at different seminars; some of those organised by the Institute of Transport Economics. We acknowledge the Research Council of Norway for the support in organising one of these seminars in 1997.

Lars Rand, Inger-Anne F. Sætermo, Kjartan Sælensminde, Jan Erik Lindjord and Frode Hammer at the Institute of Transport Economics have worked with different parts of the Norwegian Value of Time Study. We acknowledge Peter Christensen for useful comments on the report. Laila Aastorp Andersen has provided secretarial support. Farideh Ramjerdi has been the project leader and is responsible for the report.

Oslo, December 1997
TRANSPORTØKONOMISK INSTITUTT

Knut Østmoe
Managing Director

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Summary:

The Norwegian Value of Time Study Part I

The value of travel time is probably the most important parameter in a social cost benefit analysis and marginal cost pricing in the transport sector. Most often the main part of the economic benefits of a transport project is the estimated values of time saving. Consequently, it is important that the values of travel-time savings be both theoretically and empirically correct.

The main purpose of the Norwegian Value of Time (*VoT*) Study is to provide for values of travel-time savings for social benefit-cost analysis. Another outcome of the study will be empirical evidence, for use in the evaluation of demand for travel.

The design of the *VoT* study should provide for identification of different factors that effect *VoT* and evaluations of these effects. The agenda of the Norwegian value of time study includes many of these important issues. We briefly point out some of these.

- Value of time in long distance travel (inter-urban < 50 km),vs. short distance travel (urban > 50 km)
- Travel purpose, including business
- Travel mode and associated values of time related to the components of time related to a mode
- Value of reliability of travel time
- Distribution of value of time
- Value of small time savings
- Symmetry in value of time savings and losses
- Role of income in value of time
- Changes in value of time over time

Scope of the study

The scope of the Norwegian *VoT* study is limited to passenger travel within Norway and with focus on:

- Private travel; commuting and other private travel purposes

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- Business travel

The *VoT* for freight transport will be addressed in a separate study (Minken, 1997). The approach adopted in the British *VoT* study (Bates et al., 1987), the Netherlands *VoT* study (HCG, 1990) and the Swedish *VoT* study (Algers, et al., 1995) has been used in this study.

Methodology

The theoretical underpinning of *VoT* is welfare economics (see Bruzelius, 1979). For private travel purposes two alternative approaches have been used for the measurement of *VoT*. For data from the stated preference (SP) technique, demand is formulated in terms of generalised cost of travel and the econometric model used for the estimation is a logit model. This formulation results in a fixed value of *VoT* that is equal to the ratio of the time and cost parameters. For data from the transfer price (TP) technique, regression models have been used to address the distribution of the *VoT*. For reviews of alternative econometric models used for the estimation of *VoT*, see Bruzelius (1979), Hensher (1987), and Daly (1996).

For business travel, we have deviated from the marginal productivity approach, i.e., that *VoT* should be equal to wage rate plus marginal wage increment. Instead we have used Hensher's approach, in which he recognises that both employee and employer can benefit from travel-time savings (Hensher, 1977). However, we have proposed some revisions in Hensher's formula. The main reason is the conviction that the original form results in double counting in the *VoT* for business travel. The revised formula is the following (compare with Equation 1 under section 3.1)

$$Vtts = (1-r-pq)*MP + r*vl + MPF$$

Where:

Vtts value of travel time savings

r proportion of travel time saved which is used for leisure

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

q relative productivity of work done while travelling compared with the equivalent work in the office

MP the marginal product of labour

vl the monetary value to the employee of leisure compared to travel time

MPF the value of extra output generated due to reduced fatigue.

In the Hensher's formula an additional term, i.e., *(1-r)*vw* appears on the right side, where "*vw*" is the monetary value to the employee of work time while in office compared to travel time. We propose that whether "*vw*" is connected with engagement in productive work or not, it should be captured by *MP*.

Study design

The starting point in the design of the Norwegian *VoT* study was the dimension of the study (see chapter 4). The Norwegian *VoT* study is based on SP technique as well as TP technique. In the Norwegian *VoT* study a choice based and stratified sampling approach was adopted. Effort was made to assure a national coverage.

The long distance (inter-urban) study was carried out in two waves. The first wave was conducted in March-April 1995 and the second wave in September-October 1995. In connection with the study three pilot studies were conducted. Two of these pilot studies were conducted in November-December 1994 and January -February 1995. The third pilot study was conducted before the second wave, in June 1995. The ages of the respondents were restricted to 18 years or older. The following table shows an overview of the design of the inter-urban study.

Table 1 Overview of the design of the long distance study

	No. of interviews	*Recruited at*	*Interviewed at*
Air, main lines	350	Airport/on board	Home
Air, STOL[1]	150	Airport/on board	Home
Rail, long distance	450	On board	On board
Rail, regional	450	On board	On board
Bus, long distance	250	On board	On board
Bus, regional	250	On board	On board
Ferry, over 25 minutes	500	On board	On board
Ferry, under 25 minutes	100	On board	Home
Car, 30-100 km	300	Phone	Home
Car, 101-300 km	300	Phone	Home
Car, 300+ km	900	Phone	Home
Total	3400		

1 Short Take Off and Landing

The decision to cover the *VoT* for short distance (urban) travel in the study was made after the study for long distance (inter-urban) had started. In the context of the valuation of public transport services in urban areas, considerable amount of research based on SP technique has been conducted since early 90's at the Institute of Transport Economics. Value of time was not the focus of these studies. However, these studies provide data for the estimation of *VoT* for the components of travel time with public transport in different urban areas in

Norway. These studies focused on the modes of transport used by the respondents. Hence these studies do not provide data for the estimation of VoT for alternative modes of transport. To minimise the cost of data collection it was suggested to benefit from the data collected in some of these studies. With this background, the *VoT* study focused mainly on car. However a minimum of data in connection with public transport had to be collected. This was necessary for addressing the *VoT* for alternative modes of transport.

The *VoT* study for short distance travel was conducted in September-October 1996. The recruitment in this study was by telephone that was followed by a home interview. The recruitment took place in Oslo, Bergen, Trondheim, Kristiansand and Tromsø. Since the sample did not cover rail passengers, additional recruitment in Akershus was conducted with focus on rail passengers. In connection with the study one pilot study was conducted in August-September 1996.

Among the different relevant studies, "Bus Passenger Preferences" (Kjørstad, 1995) "Assessing Environmental Benefits" (Sælensminde and Hammer, 1994) and "A new Initiative in Public Transport" (Kjørstad, Norheim and Renolen, 1994) were selected. There was more than one SP game in each of these studies. Only one game from each of these studies was used in the *VoT* study.

Table 2 Description of data used for the *VoT* study for short distance travel

Study	*No. of interview*	*Age of respondents*
Value of Time (1996)	1156	18+
Bus Passenger Preferences (1995)	1009	16+
Assessing Environmental Benefits (1994)	1691	18+
A new Initiative in Public Transport (1994)	403	16+

SP Game Design

Each respondent was given two SP games, one for the chosen mode and another for an alternative mode the respondent would choose for the same trip. This was to evaluate the mode specific differences of the *VoT*'s. The choice context used in the study was within-mode.

The SP games were presented as paired alternatives and a respondent was asked to state her preferred choice. Each respondent was presented nine paired choices. Fractional factorial design was used and the dominant alternatives were excluded from the choice set. The choices among dominant alternatives were later simulated and included in data to evaluate the effects on the estimates of the *VoT*. Only three attributes were used in all the games.

TP Design

The SP games were followed by TP questions. In this part the respondents were asked to state their willingness to pay (*WtP*) or accept, i.e., save, (*WtA*) for specific improvements (decrease in travel time, no transfer, reduction in headway) or increase in travel time. The TP questions were the following:

- *WtP* for a decrease in travel time by 25%
- *WtP* for a decrease in travel time by 10% (only in wave 2)
- *WtA* (save) for an increase in travel time by 25%
- *WtP* for not having any transfer (for those who had any)
- *WtP* for a 50% reduction in headway
- *WtP* for a package that includes all the improvements (decrease in travel time, no transfer and decrease in headway). The respondents are asked to indicate how much of this sum is related to the decrease in travel time.

Summary of findings

One main outcome of the study is that the values of travel-time savings are very different in the context of urban and inter-urban travel. It is very likely that the resource constraints, i.e., time and money, and activity utility are very different for inter-urban travel and urban travel. Furthermore the supplies of transport services in these two market segments vary significantly. In the following we summarise the main findings of the study.

Private travel

The following two tables show the *VoT* for private inter-urban and urban travel. The comparison of these two tables suggests that *VoT* for inter-urban travel is significantly higher than urban travel.

In-vehicle *VoT* in urban travel is respectively 35 percent of the average industrial wage rate (108 NOK/hr in 1995), 27 percent of wage rate and 45 percent of wage rate for car, public transport (bus, subway and tram) and rail.

In-vehicle *VoT* for inter-urban travel is 80 percent of the wage rate for car, 45 percent of wage rate for bus, 50 percent of wage rate with rail, 70 percent of wage rate for ferry and 150 percent of wage rate for travel with air.

The *VoT* for headway in the context of inter-urban travel are much lower than urban travel, except for ferry. Further evaluation shows that the *VoT* for headway intervals of over 30 minutes are significantly lower than headway *VoT* for headway intervals of less than 30 minutes. Furthermore, the relative headway *VoT* decreases with increase in headway interval. All inter-urban scheduled modes of travel, except for ferry, have longer headway intervals than 30 minutes.

A similar result emerges for urban travel, i.e., headway *VoT* for headway intervals of over 30 minutes are much lower than headway *VoT* for headway intervals of less than 30 minute. With the exclusion of headway interval longer than 30 minutes, the *VoT* for headway is 50 to 60 percent higher than in-vehicle time.

VoT for delay was not significant in the context of inter-urban travel. However, we believe this was due to the problems in the design of the SP study. We recommend the results from the Swedish *VoT* study (Algers, et al., 1995). The value for delay in this study is reported to be approximately 50% more than in-vehicle time.

Delay, in the context of urban travel, turned out to be quite significant. The *VoT* for delay is valued two to three times higher than in-vehicle time. Further analysis shows that the *VoT* for delay increases with increase in delay time.

Table 3 Value of time for private inter-urban travel, NOK/hr

Trips> 50	*Car*	*Ferry*	*Rail*	*Bus*	*Air*
In vehicle time	86 (±10)	75 (±13)	54 (±7)	48 (±8)	163 (±25)
Headway	-	32	7	3	18

Table 4 Value of time for private urban travel, NOK/hr

	Car	*Public Transport*	*Rail*
In Vehicle Time	39 (±4)	29 (±4)	48 (±14)
Walking Time	65	31	56
Delay	77	107	122
Headway		12	30

Transfer was not used as an attribute in the Norwegian *VoT*. In the context of long distance travel, there might not be very many trips that require more than one transfer. However, transfer time is quite important. We recommend the *VoT* for transfer from the Swedish *VoT* study (Algers, et al., 1995). The Swedish study reports the transfer *VoT* to be 40 percent to 140 percent higher than in-vehicle *VoT*. This study suggests that relative transfer *VoT* to in-vehicle *VoT* to be lowest for air and highest for rail and regional bus.

In the context of urban travel, walking time to relative to in-vehicle time is valued higher for car than for public transport. For car, walking time is valued more than 50 percent of in-vehicle time. For public transport, walking time is valued slightly higher than in-vehicle time.

The *VoT* increases with income both personal and household income. However, the increase in *VoT* with income in the context of urban travel is not as much as inter-urban travel. This comparison suggests a higher income elasticity of *VoT* for inter-urban than urban travel. It should be pointed out that similar pattern for income elasticity of travel demand has been reported (Ramjerdi and Rand 1992).

VoT for retired and unemployed is lower than other groups.

VoT varies over the geographical regions in Norway. This is partly explained by the variation of income over the regions in Norway.

VoT increases with travel distance and after a threshold it decreases with travel distance. There could be different explanations for this. One explanation could be that longer journeys allow for larger scope of activities that can be undertaken while travelling in both urban and inter-urban context. It could also be connected with the tighter time constraint for shorter inter-urban trips. Shorter inter-urban trip can allow for the scheduling of outbound and inbound trips on the same day or the scheduling of an activity on the same day as inbound or outbound trip. A further explanation is related to differences in transport services that depend on travel distance. As an example for inter-urban travel with car, the proportion of driving on higher quality roads increases with travel distance. The differences in transport services that depend on travel distance are present in other modes of travel, i.e., air, rail and bus.

It is not possible to detect any change in *VoT* with the size of the time saving. The design of the SP study has been such to avoid very small time savings or losses (less than 2 minutes for urban travel and less than 5 minutes for inter-urban travel).

VoT varies by travel purpose. It is highest for travel purpose work.

The evidence does not suggest that the *VoT* of car driver account for the *VoT* of car passenger.

The results from the TP study suggests that the willingness to pay (*WtP*) for travel-time saving is lower than willingness to accept a cost reduction (*WtA*) for an increase in travel time. However, the difference is only significant for inter-urban travel. Further evaluation of the differences between *WtP* and *WtA* suggests that the differences increase with income and travel distance.

The evaluation of the TP study suggests that a lognormal distribution best describes the distribution of *VoT*.

Business travel

In Hensher's approach and the revised approach we recommended, both employee and employer can benefit from travel-time savings. Even though this approach is theoretically appealing, there are several issues that make it difficult to apply.

The variables that enter the revised Hensher's formula seem to be clearly defined, yet none are simple to measure. Some of these problems are addressed under chapter 11. In this study we have used SP technique for the estimation of *"vl"*. We call *"vl"* the private *VoT* for business travellers. Variables *r*, *p* and *q* are calculated based on the information that the travellers provide and *MP* is calculated on the basis of the hourly wage of the travellers. We have assumed a value of zero for *MPF*.

The private *VoT* for business travellers are considerably higher than the *VoT* for private travel purposes. Note that for car and air, in the context of inter-urban travel, the private *VoT* of business travellers is much higher than the average industrial wage rate. The average wage of the inter-urban business travellers is, however, higher than the average industrial wage, especially for car and air. However, a *VoT* higher than wage rate can be considered theoretically “correct” (see chapter 11). The differences can be explained by the problems related to resource allocation in the labour market. Furthermore the correct values for economic analysis are the behavioural values (see Lisco, 1974). The following tables show a summary of the results for the private *VoT* of business travellers.

Table 5 The private *VoT* for business inter-urban travel, NOK/hr

	Car	*Ferry*	*Rail*	*Bus*	*Air*
In-vehicle	185 (±41)	102 (±44)	118 (±28)	59 (±21)	313 (±67)
Headway	-	70	13	9	67

Table 6 The private *VoT* for business urban travel, NOK/hr

	Car	*Public transport*
In-vehicle	87 (±27)	80 (±48)
Headway	-	59
Delay	139	111

The private headway *VoT* for business travellers exhibits almost exactly the same pattern as the headway *VoT* for travellers for private purposes.

The private *VoT* for business inter-urban travellers increases with income, personal or household. However, the increase in *VoT* with income in the context of urban travel is not significant.

VoT increases with travel distance and after a threshold it decreases with travel distance.

It is not possible to detect any change in *VoT* with the size of time saving. As explained earlier the design of the SP study has been such to avoid very small time savings or losses (less than 2 minutes for urban travel and less than 5 minutes for inter-urban travel).

The following table shows the estimates of the different variables in the revised Hensher’s formula, i.e., *r, p, q* and *MP*. Note that the business inter-urban travellers would allocate a higher proportion of travel time saved to leisure than urban travellers do. They a have a higher estimate of their relative productivity of work done while travelling compared with equivalent work in the office. *MP*, calculated on the basis of hourly wage, is higher for inter-urban travellers than for urban travellers. However, it is only for inter-urban travel with air that *VoT*, i.e., *Vtts*, is higher than *MP*. The main reason for this is that the behavioural *VoT*, i.e., *vl*, the private *VoT* for business travellers are higher than *MP*. We suggested earlier that a higher *VoT* than *MP* should be considered theoretically correct and the appropriate value for use in economic analysis. However, in the context of inter-urban as well as urban travel, our recommendation is to use the lowest value among *MP* and business *VoT*. This is a conservative recommendation that seems appropriate until further research on *VoT* for business travel purposes.

Table 7 Business *VoT* according to the revised Hensher's formula

Mode	*r*	*p*	*q*	*MP* (*NOK/hr*)	*vl* (*NOK/hr*)	**Business *VoT* (*NOK/hr*)**
Inter-urban travel						
Car	.57	.03	.32	185	185	**181**
Air	.64	.07	.28	201	313	**267**
Rail	.72	.18	.39	153	118	**116**
Bus	.74	.06	.20	132	59	**75**
Ferry	.63	.03	.19	161	102	**130**
Urban travel						
Car	.39	.21	.02	170	87	**137**
Public transport	.43	.30	.07	131	80	**106**

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Oslo 1997, Part I: 155 sider
Part II: Vedlegg

Sammendrag:

Den norske tidsverdiundersøkelsen Del I

Problemstilling

Verdien av spart reisetid er en viktig parameter i samfunnsøkonomiske nyttekostnadsanalyser for transportsektoren som ofte utgjør størstedelen av nytten i et transportprosjekt. Det er derfor viktig at disse verdiene er basert på et best mulig grunnlag både teoretisk og empirisk.

Hovedformålet med den norske tidsverdistudien er å framskaffe verdier for spart reisetid til slike nyttekostnadsanalyser. Studien vil også gi empirisk belegg til bruk i evaluering av reiseetterspørsel.

Den norske tidsverdistudien er begrenset til innenlands persontransport og fokuserer på:

- Private reiser (til/fra arbeid og andre private formål)
- Tjenestereiser

Slik som studien er gjennomført har vi mulighet til å identifisere og evaluere ulike faktorer som har betydning for tidsverdiene. Vi ser bl.a. på:

- Tidsverdier for lange reiser (>50 km) og korte reiser (<50 km)
- Tidsverdier for reisetid (tid om bord) samt verdier for andre tidskomponenter som inngår i en reise (gangtid, ventetid mellom avganger, forsinkelser, osv)
- Pålitelighet av verdiene vi kommer fram til
- Symmetri i verdsetting av tidsgevinster og tidstap
- Inntektens betydning for verdsetting av reisetid

Metode

Private reiser

For private reiser har vi benyttet både Stated Preference (SP) og Transfer Price (TP)-teknikker. Framgangsmåten som er benyttet i vår studie er tidligere benyttet i tilsvarende studier i England (Bates et al., 1987), Nederland (HCG, 1990) og Sverige (Algers, et al., 1995).

Rapporten kan bestilles fra:
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I SP-undersøkelsen er etterspørselen formulert som en funksjon av generaliserte reisekostnader, og en logitmodell er benyttet for estimering. Fra logitmodellen har vi beregnet tidsverdien som forholdet mellom koeffisientene for tid og kostnad. For data fra TP-undersøkelsen har vi benyttet regresjonsmodeller for å finne fordelingen av tidsverdiene.

Tjenestereiser

For tjenestereiser har det vært vanlig å bruke marginal produktivitet som et anslag på verdien av spart reisetid. Vi har i stedet valgt å bruke Hensher's formel (Hensher, 1977). Denne formelen tar hensyn til at både arbeidsgiver og arbeidstaker kan ha nytte av en tidsbesparelse i tjenestereiser. Vi har imidlertid endret denne formelen noe, da vi mener den i sin orginale form gir rom for dobbelttelling av nytten ved spart reisetid. Den reviderte formelen er som følger:

$$Vtts = (1 - r - pq) * MP + r * vl + MPF$$

Der

Vtts	verdi av spart reisetid
r	andel spart reisetid som benyttes til fritid
p	andel spart reisetid som kunne vært benyttet til arbeid under reisen
q	relativ produktivitet av arbeid under reise sammenlignet med tilsvarende arbeid på kontoret
MP	marginal produktivitet
vl	arbeidstakers nytte av fritid sammenlignet med tid på reise
MPF	verdi av økt produktivitet grunnet redusert tretthet

Hensher's originale formel inneholdt et ekstra ledd: (1-r)*vw på høyre side hvor vw er arbeidsgivers verdsetting (i kroner) av arbeidstid på kontoret sammenlignet med reisetid. Vi har antatt at vw fanges opp av MP og har derfor utelatt dette leddet.

Design

Som nevnt er den norske tidsverdistudien basert på både SP og TP-teknikk. Respondentene ble rekruttert ut fra valg av transportmiddel på en bestemt reise. Videre ble utvalget stratifisert etter reisemiddelvalg. Vi har forsøkt å gjøre studien mest mulig landsdekkende.

Lange reiser

Datainnsamling til studien for lange reiser ble gjort i to omganger. Den første ble gjennomført i mars-april 1995 og den andre i september-oktober 1995.

I forbindelse med denne studien ble det også gjennomført tre pilot-studier. Én ble gjennomført i november-desember 1994, én i januar-februar 1995 og én i juni 1995. Utvalget var personer som var 18 år eller eldre. Tabellen under viser en oversikt over utvalget:

Tabell 1 Oversikt over utvalget

	Antall intervjuer	*Rekrutteringssted*	*Intervjusted*
Fly	350	Flyplassen/om bord	Hjemme
Fly, STOL*)	150	Flyplassen/om bord	Hjemme
Tog,	450	Om bord	Om bord
Tog, regional	450	Om bord	Om bord
Buss,	250	Om bord	Om bord
Buss, regional	250	Om bord	Om bord
Ferje, over 25 minutter	500	Om bord	Om bord
Ferje, under 25 minutter	100	Om bord	Hjemme
Bil 30-100 km	300	Telefon	Hjemme
Bil 101-300 km	300	Telefon	Hjemme
Bil 300+ km	900	Telefon	Hjemme
Totalt	3400		

*) Short Take-Off and Landing

Korte reiser

For å minimere kostnadene til datainnsamling benyttet vi i studien av tidsverdier for korte reiser hovedsakelig data som allerede forelå fra andre undersøkelser gjennomført ved TØI. I forbindelse med evaluering av kollektivtransportservice i byområder er det gjort flere studier basert på SP (stated preference)-teknikk. Estimering av tidsverdier har ikke vært formålet med disse undersøkelsene, likevel kan man bruke dataene til å estimere tidsverdier for de ulike komponentene av reisetid for kollektivtransport. Undersøkelsene fokuserte på reisemidlet respondenten faktisk hadde brukt og gir dermed ikke data for estimering av tidsverdier for alternative reisemidler. Vi valgte å bruke data fra følgende undersøkelser:

- *Kollektivtrafikantenes preferanser i Moss, Grenland, Kristiansand, Tromsø og Ålesund*, (Kjørstad, 1995)
- *Verdsetting av miljøgoder ved bruk av samvalganalyse: hovedundersøkelse*, (Sælensminde og Hammer, 1994), og
- *Ny giv for kollektivtrafikk i Drammensregionen: hovedresultater fra samvalganalyse*, (Norheim, Kjørstad og Renolen, 1994).

I hver av disse undersøkelsene var det flere SP spill, men vi valgte kun ett spill fra hver undersøkelse.

Det var nødvendig å samle inn ekstra data for reisende med bil. Et minimum av data i sammenheng med kollektivtransport måtte også samles inn for å gjøre det mulig å estimere tidsverdier for alternative transportmidler.

De ekstra dataene ble samlet inn i september-oktober 1996. Rekrutteringen ble gjort pr telefon i Oslo, Bergen, Trondheim, Kristiansand og Tromsø, og intervjuene ble gjennomført hjemme hos respondentene. (I forbindelse med denne studien ble det gjennomført en pilotstudie i august-september 1996.) I tillegg ble det rekruttert respondenter i Akershus med fokus på togpassasjerer.

Tabell 2 Beskrivelse av datagrunnlag for tidsverdistudien for korte reiser

Undersøkelse	*Antall intervjuer*	*Respondentenes alder*
Tidsverdistudien	1156	18 år og eldre
Kjørstad, 1995	1009	16 år og eldre
Sælensminde og Hammer, 1994	1691	18 år og eldre
Norheim, Kjørstad og Renolen, 1994	403	16 år og eldre

SP (stated preference) design (samvalganalyse)

Hver respondent gikk gjennom to spill, ett som gikk på reisemiddelet som faktisk var valgt på den aktuelle turen, og ett spill for et alternativt reisemiddel på samme tur. Dette ble gjort for å kunne evaluere de reisemiddelspesifikke forskjellene i tidsverdier.

Hvert SP-spill består av 9 sett med to alternativer i hvert. I hvert spill ble tre attributter benyttet. For hvert sett ble respondenten presentert de to alternativene og bedt om å angi hvilket av dem hun foretrakk. Faktorene verdsettes således indirekte gjennom de valg respondenten gjør. Fraksjonert faktoriell design ble benyttet. De dominante alternativene ble ekskludert, men ble senere simulert og inkludert i dataene for å evaluere effektene på de estimerte tidsverdiene.

TP (transfer price) design (likeverdprismetoden)

I undersøkelsen hadde vi også lagt inn noen TP spørsmål hvor vi ba respondenten angi hvor mye de er villig til å betale for gitte forbedringer (redusert reisetid, ingen transfer, oftere avganger, etc) evt. hvor mye avslag de vil ha for en reisetidsøkning.

Følgende endringer ble respondentene bedt om å verdsette:

- Betalingsvillighet for en reduksjon av reisetiden på 25%
- Betalingsvillighet for en reduksjon av reisetiden på 10%
- Hvor mye avslag de vil ha for å akseptere en økning i reisetiden på 25%
- Betalingsvillighet for å slippe reisemiddelbytte (for de som hadde det)
- Betalingsvillighet for en dobling av antall avganger
- Betalingsvillighet for en pakke som består av reduksjon av reisetid, ingen transfer og oftere avganger. (Respondentene ble bedt om å indikere hvor mye av dette som kan relateres til reduksjonen i reisetid)

Resultater

Et hovedfunn i undersøkelsen vår er at tidsbesparelser verdsettes ulikt for korte og lange reiser. I det følgende oppsummeres de viktigste funnene i studien:

Private reiser

Tidsverdiene for lange reiser (tid om bord) er høyere enn tidsverdiene for korte reiser.

For korte reiser er tidsverdien ca 35 % av gjennomsnittlig industriarbeiderlønn (108 NOK/t i 1995) for bil, 27 % for kollektivtransport (buss, t-bane og trikk) og 45 % for tog.

For lange reiser er tidsverdien ca 80 % av gjennomsnittlig industriarbeiderlønn for bil, 45 % for buss, 70 % for ferje og 150 % for flyreiser.

Tidsverdien for ventetid mellom avganger er lavere for lange reiser enn for korte reiser. Videre er tidsverdien når det er mindre enn 30 minutter mellom hver avgang høyere enn tidsverdien når det er mer enn 30 minutter mellom hver avgang.

Tidsverdier for forsinkelser var ikke signifikant for lange reiser. Dette tror vi skyldes designet av SP-spillet. Vi anbefaler derfor at verdier fra den svenske tidsverdistudien (Algers et al. 1995) brukes. Den fant at tidsverdien for forsinkelse er ca 50% høyere en tidsverdien for reisetiden.

Tidsverdien for forsinkelser på korte reiser var signifikant, og ble verdsatt 2-3 ganger høyere enn reisetiden. Tidsverdien for forsinkelser øker når forsinkelsen øker.

Tabell 3 Tidsverdier for private lange reiser. NOK/time

Reiser >50 km	*Bil*	*Ferje*	*Tog*	*Buss*	*Fly*
Reisetid	86 (±10)	75 (±13)	54 (±7)	48 (±8)	163 (±25)
Ventetid mellom avganger	-	32	7	3	18

Tabell 4 Tidsverdier for private korte reiser. NOK/time

Reiser<30 km	*Bil*	*Kollektivtransport*	*Tog*
Reisetid	39 (±4)	29 (±4)	48 (±14)
Gangtid	65	31	56
Forsinkelse	77	107	122
Ventetid mellom avganger		12	30

For lange reiser er det svært få reiser som krever mer enn ett bytte av reisemiddel. Tidskostnader forbundet med bytte av reisemiddel er viktig, men ble ikke undersøkt i vår studie. Vi anbefaler også her bruk av verdier fra de svenske studiene (Alger et al., 1995). Den fant at tid brukt på reisemiddelbytte verdsettes 40-140 % høyere enn reisetiden, og at den relative forskjellen mellom verdsettingen av byttetid og reisetid er lavest for fly og høyest for tog og buss.

For korte reiser har vi sett på verdsettingen av gåtid til reisemiddelet sammenlignet med verdsettingen av selve reisetiden. Gåtid verdsettes høyest for bil (50% mer enn reisetiden) og lavest for kollektivtrafikk (litt høyere enn reisetiden).

Tidsverdien for spart reisetid øker med både personlig og husholdningens inntekt. Den øker mer for lange reiser enn korte reiser, altså er inntektselastisiteten for tidsverdier høyere for lange reiser enn korte reiser. Tilsvarende mønster er tidligere funnet for etterspørsel etter reiser (Ramjerdi og Rand, 1992). Tidsverdien er lavere for pensjonister og arbeidsløse enn andre.

Tidsverdien varierer med geografiske regioner, noe som dels kan forklares med variasjon i inntekter mellom regionene.

Tidsverdien øker med reiselengde inntil en visse terskel, hvoretter den synker med reiselengde. En mulig forklaring på dette er at lengre turer gir større muligheter til aktivitet på reisen. Det kan også ha sammenheng med at strammere tidsrammer gjelder for korte reiser ettersom man ofte har planlagt returreise samme dag, eller man har planlagt andre aktiviteter samme dag som reisen gjøres. Sammenhengen mellom tidsverdi og reiselengde kan også ha noe med transporttilbudet å gjøre - tilbudet er ofte bedre på lange reiser enn korte reiser.

Det har ikke vært mulig å finne noen endring i tidsverdien etter størrelsen på tidsbesparelsen. SP-studien er designet slik at vi skal unngå svært små tidsbesparelser (under 2 min. for korte reiser og under 5 min. for lange reiser).

Tidsverdien varierer med reisens formål og er høyere for reiser til og fra arbeid enn for andre private formål.

Det ser ikke ut til at bilføreres verdsetting av reisetid tar hensyn til om det er passasjer i bilen eller ikke.

TP-studien indikerer at respondentene er villig til å betale mindre ekstra for en gitt reduksjon av reisetiden, enn avslaget de godtar for å kompensere en tilsvarende økning i reisetiden. Denne forskjellen er kun signifikant for lange reiser. Forskjellen ser ut til å øke med inntekt og reiselengde.

TP-studien indikerer videre at fordelingen av VoT best beskrives ved en lognormal fordeling.

Tjenestereiser

Ved å bruke Hensher's formel og vår reviderte utgave tar man hensyn til at både arbeidsgiver og arbeidstaker kan ha nytte av reisetidsbesparelser.

Variablene som inngår i Hensher's formel er klart definert, men ingen av dem er enkle å måle. Noen av problemene knyttet til dette tas opp i kap 11. I vår studie har vi brukt SP for å estimere "vl"; den private tidsverdien for tjenestereisende. Variablene r, p q er beregnet på bakgrunn av informasjon fra respondentene, og MP er beregnet på bakgrunn av respondentenes timelønn. MPF er antatt å ha verdi null.

Respondentenes egen verdsetting av reisetid for tjenestereiser er betraktelig høyere enn tilsvarende verdsetting av reisetid for private reiser. For lange tjenestereiser med bil og fly er reisetiden verdsatt høyere enn gjennomsnittlig industriarbeiderlønn. (De som reiser med bil og fly har imidlertid i snitt høyere lønn enn en industriarbeider.)

Tidsverdier høyere enn lønnsnivå kan være teoretisk "korrekt" (se kap. 11). Forskjellen kan forklares ved problemer knyttet til ressursallokering i arbeidsmarkedet. Tabellen under oppsummerer resultatene for respondentens verdsetting av tidsverdier for tjenestereisende:

Tabell 5 Verdsetting av tidsverdier for lange tjenestereiser. NOK/time

	Bil	*Ferje*	*Tog*	*Buss*	*Fly*
Reisetid	185 (±41)	102 (±44)	118 (±28)	59 (±21)	313 (±67)
Ventetid mellom avganger	-	70	13	9	67

Tabell 6 Verdsetting av tidsverdier for korte tjenestereiser. NOK/time

	Bil	*Kollektivtransport*
Reisetid	87 (±27)	80 (±48)
Ventetid mellom avganger	-	59
Forsinkelse	139	111

Verdsettingen av reisetiden for lange tjenestereiser øker med både personlig og husholdningens inntekt. (For korte reiser er ikke denne økningen signifikant.) Videre øker tidsverdien med reisens lengde inntil en viss terskel hvoretter den synker med reisens lengde.

Det er ikke mulig å finne noen endring i tidsverdien avhengig av størrelsen på tidsbesparelsen. Som nevnt tidligere er SP-studien designet slik at vi unngår svært små reisetidsbesparelser.

Tabell 7 Tidsverdi for tjenestereiser beregnet vha en revidert versjon av Hensher's formel

Transportmiddel	*R*	*p*	*q*	*MP(nok/t)*	*vl(nok/t)*	*Vtts(nok/t)*
Lange reiser						
Bil	0,57	0,03	0,32	185	185	181
Fly	0,64	0,07	0,28	201	313	267
Tog	0,72	0,18	0,39	153	118	116
Buss	0,74	0,06	0,20	132	59	75
Ferje	0,63	0,03	0,19	161	102	130
Korte reiser						
Bil	0,39	0,21	0,02	170	87	137
Kollektivtransport	0,43	0,30	0,07	131	80	106

Tabell 7 viser estimatene for de ulike variablene i den reviderte versjonen av Hensher's formel, dvs r, p, q og MP. Legg merke til at de som har lange tjenestereiser vil allokere en større del av spart reisetid til fritid enn de med korte tjenestereiser. De med lange reiser har også et høyere anslag på produktivitet under reisen. MP beregnet på bakgrunn av timelønn er høyere for lange reiser enn korte reiser. Det er kun for lange reiser med fly at tidsverdien er høyere enn MP. Hovedårsaken til dette er at for tjenestereiser med fly vurderer den reisende verdien av spart reisetid til å være høyere enn MP. Vi anbefaler å bruke den laveste verdien av MP og Vtts. Dette er en konservativ anbefaling som synes passende inntil videre.

1 Introduction

The value of travel time is probably the most important parameter in both social benefit-cost analysis as well as evaluation of the external costs of transport. Most often the main part of the economic benefits of a transport project is the estimated value of travel-time savings. Consequently, it is important that the values of travel-time savings are both theoretically and empirically correct. The importance of "correct" value of time saving in the evaluation of a specific policy, e.g., investment or pricing, is twofold. Firstly, it can be used in the evaluation of demand, in terms of trips and traffic for alternative modes of transport, and for different market segment. Secondly, these values are central in the evaluation of the transport policy.

Norway has a long tradition in using value of travel-time savings as a part of the evaluation of transport projects. The official Norwegian recommendation on the values of travel-time savings is confined to road transport and is published in the "Consequence Analysis" (Konsekvensanalyser). This publication provides the official guidelines for evaluation of road investment projects. The values of time (VoT) are set in relation to the average wage of industrial workers, based on international evidences on VoT.

There are not too many Norwegian studies with focus on the value of travel-time savings. However, more recently, based on Norwegian data, a number of travel demand models have been estimated from which estimates of travel-time savings follow. These studies are either on mode choice or route choice. Logit models with linear generalised cost functions have been used in all of these studies. Most of them are based on different travel studies, national or local. Comparison of the reported results is difficult because of the use of different types of data. Different studies have relied on alternative approaches to calculate time and cost variables. Ramjerdi (1993) gives a summary of these studies. In the context of the valuation of public transport services in urban areas, considerable amount of research based on SP technique has been conducted since early 90's. Value of time had not been the focus of these studies. However, these studies have provided estimates of VoT for components of travel time with public transport in different urban areas in Norway. Norheim, et al., (1996) provide an overview of these studies.

The need for a comprehensive VoT study for Norway evolved from a Nordic seminar on the VoT held in Finland in December 1991. A comprehensive value of time study had been proposed for Sweden. The plan for a less ambitious study was underway for Finland. There was a consensus that there would be significant gains by the co-ordination of the Nordic studies especially Norwegian value of time study with the Swedish one. An outcome of the seminar on "Value of Time in Transport" organised by TØI in Oslo in May 1992 was the recognition of the importance of a comprehensive value of travel time study in Norway. Special emphasis and effort was made to co-ordinate the Norwegian Value of Time Study with the Swedish Study.

Originally the scope of the study was to be limited to long distance travel (inter-urban) passenger travel for private and business travel purposes. The scope was later extended to cover the shorter daily (urban) travel for private and business as well. The study was spread over four years (1994-97). The VoT study with focus on inter-urban travel was conducted first. Some results from the long distance travel study were presented at a seminar on VoT in Oslo, at the end of the February 1996. The VoT study with focus on urban travel was conducted in 1996 and some results from this study were presented at an international seminar on VoT in Oslo in May 1997.

The Ministry of Transport and Communications, Public Roads Administration, the Norwegian Railways and the Civil Aviation Administration have financed the Norwegian VoT Study. The study was organised with a steering group from the sponsoring organisations and TØI with a reference group that also included experts from Sweden and UK. However, through the periodic seminars and less formal contacts related to this subject the study has gained from the experts from the Netherlands and Sweden in particular.

The principles used in the design of the Norwegian VoT study was based on the general consensus that emerged from the 1991 Seminar. This also formed the basis for design of the Swedish VoT study that started earlier than the Norwegian study and was conducted in a relatively short time compared with the Norwegian study. The timing of these studies were such that the Norwegian VoT study has gained from the experiences of the Swedish VoT Study. The study relies mainly on the Stated Preference (SP) technique. Transfer Price (TP) technique has also been explored in this study, mainly for the evaluation of the technique.

In the following sections we describe the aims of the study, the underpinning theories and methodologies used in the study. Then a summary of the findings of the study will be presented. We will then make some suggestions for further research.

2 Objectives of the study

The main purpose of the Norwegian *VoT* Study is to provide for values of travel-time savings for social benefit-cost analysis. Another outcome of the study will be empirical evidences, for use in the evaluation of demand for travel.

The design of the *VoT* study should provide for identification of different factors that effect *VoT* and evaluations of these effects. The agenda of the Norwegian value of time study includes many of these important issues. We briefly point out to some of these.

- value of time in long distance travel (interurban),vs. short distance travel (urban)
- travel purpose, including business
- travel mode and associated values of time related to the components of time related to a mode
- value of reliability of travel time
- distribution of value of time
- value of small time savings
- symmetry in value of time savings and losses
- role of income in value of time
- changes in value of time over time

Evidently the conclusions on the appropriate theoretical framework will be the starting point of the empirical study.

The scope of this study was limited to passenger travel, i.e., private travel and business travel. Freight and commercial traffic is not addressed in this study. In another study issues related to the valuation of travel time for freight transport are addressed (Minken, 1997).

3 The theoretical framework

Conventionally, value of travel-time savings for trips made during the working hours, i.e., business trips, has been based on the marginal productivity approach. On this basis the value of travel time savings for business trips can be approximated by the cost of labour for the employers, i.e., wage rate plus marginal wage increment. Hensher (1977) provides an alternative approach for the valuation of business travel-time savings. This approach assumes that both employer and employee can benefit from travel-time savings. The marginal productivity approach forms the basis for the valuation of travel-time savings for the employer. However the estimation of *VoT* for the employees is based on the same principles as *VoT* during leisure time.

The basis for the valuation of travel-time savings during leisure time, i.e., for private travel purposes, such as for trips to work, has been microeconomic theory. With some exception, travel is considered as an intermediate good. Hence it is the travel-time savings that should constitute value. Since there is no observable price for travel time, welfare economics provides tools in the form of theory and formal derivation of econometric models, for the measurement of value of travel time.

3.1 Travel time savings, business travel

The valuation of business travel time savings was initially based on the neo-classical economic theory that at the margin, wage rate is a measure of production lost or gained by changes in the work force (e.g. quicker business travel), if the resulting change in wage is small. However, as Hensher (1977) suggests market distortions make the value of an employee's time different from the marginal wage rate.

Based on the marginal productivity theory, then as long as travel-time savings during working hour affects neither the quality nor the duration of working time, this saving could be valued at wage rate plus marginal wage increment or overhead. This, in principle is the value of travel-time savings to the employer. In the case of business travel, the traveller and the employer (to whom the opportunity cost of travel is incurred) are not often the same. Consequently, one has to account for this fact for the estimation of value of travel time.

Hensher (1977) suggests an alternative approach for deriving a value of time saving for business travel. In this formulation he recognises that both the employee and the employer can benefit from travel-time savings as follow:

$$Vtts = (1-r-pq)*MP + (1-r)*vw + r*vl + MPF \qquad (1)$$

Where:

Vtts	value of travel time savings
r	proportion of travel time saved which is used for leisure
p	proportion of travel time saved at the expense of work done while travelling
q	relative productivity of work done while travelling compared with the equivalent work in the office
MP	the marginal product of labour
vl	the monetary value to the employee of leisure compared to travel time
vw	the monetary value to the employee of work time while in office compared to travel time
MPF	the value of extra output generated due to reduced fatigue.

The valuation of business travel-time savings can be based on revealed preference data. As Gunn (1991) points out, under the assumption that "the traveller is behaving voluntarily or otherwise in the informed best interest of the employer", the resulting value of travel-time savings is that of the employer's. However, the value of travel time from revealed preference data should reflect joint valuation of *VoT* for employee and employer, and it is not possible to differentiate between the benefit to the employee and to the employer two with this method.

An alternative approach is the application of the SP technique. On the basis of the design of the study, one can evaluate the employee's valuation of *VoT* (for alternative use, i.e., pleasure or work). The employer's valuation can also be estimated directly through interviews with travellers to determine variables in Relation 1. For further discussions on Hensher’s formula and proposed revision of the formula see Chapter 11.

3.2 Travel-time savings, private travel

In welfare economics it is assumed that the consumer has preferences that can be presented by a utility function (of certain mathematical properties). Furthermore it is assumed that the consumer chooses according to her preferences, i.e., she maximise utility subject to her income and time constraints. Under these assumptions demand functions can be derived. By collecting information about these functions the preference of the consumer may be revealed.

In this way the value of time can be derived for the choice of discrete alternatives. Under some restrictive assumptions, two parameters define the value of time that is often referred to as the subjective value of time (*SVT*). These are the marginal utility of time and the marginal utility of cost. These parameters are the time and cost parameters in the discrete choice model for the choice of alternatives. The above form underpinning theory for the valuation of *VoT* for private trips in the Norwegian *VoT* study.

Different choice context could be observed for the estimation of the value of time, e.g., route choice, mode choice, etc. The Norwegian *VoT* study is based on “within-mode” choice context. Within-mode choice, also referred to as “abstract” choice involves choices between identical alternatives, except for the differences in travel attributes.

Different type of data can be collected for the estimation of the parameters of the value of time. Revealed preference (RP) stated preference (SP) and transfer preference (TP) approaches have been the most common in the context of *VoT* studies. In RP approach data is collected when a traveller’s choice among alternatives is actual. In SP approach data is collected when a traveller chooses among alternatives in a hypothetical situation. In TP approach data is collected on the choice in a hypothetical situation. Furthermore, data on exact amount that a traveller is willing to pay for choosing a superior alternative, or willing to accept as a reduction in price for choosing an inferior alternative is collected.

For the estimation of *VoT* during leisure two alternative approaches have been used, namely Stated Preference (SP) and Transfer Price (TP). For data from the SP approach, demand is formulated in terms of generalised cost of travel and the econometric model used for the estimation is a logit model. This formulation results in a fixed value of *VoT* that is equal to the ratio of the time and cost parameters. For data from the TP technique, regression models have been used for the estimation *VoT* as well as addressing the distribution of the *VoT*. For reviews of alternative econometric models used for the estimation of *VoT*, see Hensher (1987) and Bruzelius (1979). An excellent recent review is by Daly (1996).

3.3 Economic theory

Mishan (1975) states that "time is not only inseparable from all production and consumption activities, it is complementary to such activities. Time is in fact the unit in which such activities can be measured. When a person is prepared to pay for a good, the consumption or provision of the good in question clearly used up time- a fact that is known to the person who agrees to consuming or to providing the good. Thus is not the good per se for which the person pays, or requires to be paid, but for the specific activity per unit of time, whether the activity involves producing, consuming, creating idling, or any combination thereof. If a person engages in any less of such activities, his welfare can increase or decrease; the activity in question, that is, generates a utility through time."

It should be rather clear that it is not the element of time that has value. Rather it is the intensity of utility or disutility of an activity during a time period that generates value. It is in this context that time is treated as an economic resource. All individuals have the same fixed quantity of time that unlike some other economic resources cannot be stored. The different allocation of time among activities as production, consumption and leisure produces different values, that effects individual's utility level and budget. It is assumed that the allocation of time to different activities will be such that the utility is maximised subject to money and time constraints. Consequently it is possible to examine the value that the individual sets for transferring time from one activity to another at the margin, e.g., from travel to some other activity. Examples of the earliest economic approach to time allocation are works by Mincer (1962) and Becker (1965).

There is an extensive literature in which constrained optimisation models are used to analyse individual or household production choices. Based on the model formulation, it is possible to produce different classifications for activities. For each constraint the Lagrangean multiplier provide an economic interpretation that is equal to the shadow price or opportunity cost of that constraint. The marginal utility of time divided by marginal utility of income (money) produces the marginal value of time. The various formulations of theory of allocation of time have different empirical implications for the marginal value of time. See Gonzalez (1997) for a good review of literature on this subject. The underpinning theories for the derivation *VoT* in the mode choice models are the time allocation models such as that by De Serpa (1971).

De Serpa (1971) originally introduced a time allocation model in which the utility function is defined for time variable t_i, which means that time per se may yield utility or disutility to the consumer. This reflects the assumption that the time may have different "activity contents" or that the use of the time is experienced differently depending on the activity for which it is used.

De Serpa defines an individual preference function, twice-differentiable real valued, $U(X)$, where

$$X = (X_1,....,X_n,T_1,...T_n) \qquad (2)$$

X_i is the quantity of the *ith* consumption good and T_i is time allocated to the *ith* good. Then the formulation of the model of consumer behaviour is

$$\text{Maximise:} \quad U((X_1,....,X_n,T_1,...T_n) \qquad (3)$$

$$\text{Subject to:} \quad Y = \Sigma P_i X_i$$

$$T^0 = \Sigma T_i$$

$$\text{and} \quad T_i > a_i X_i \quad i = 1,....,n$$

Y is the money income, T^0 is the time constraint and a_i is a technologically or institutionally determined minimum amount of time required to consume one unit of X_i .

Then the allocation of time and money resources can be expressed as the Lagrangean function,

$$L = U((X_1,...,X_n,T_1,...T_n)+\lambda (Y - \Sigma P_i X_i)+ \mu (T^0 - \Sigma T_i)+\Sigma K_i (T_i - a_i X_i) \quad (4)$$

where $K_i > 0, i=1,...,n$ and μ and $\lambda >o$

Lagrangean multipliers μ and λ are marginal utility of money and time and the ratio μ/λ can be interpreted as the value of time. K_i can be interpreted as the marginal utility of saving time (of a change in a_i) and K_i/λ the value of time saving. Hence it is possible to differentiate between time as a resource and time as a commodity. The relation is given by

$$K_i/\lambda = \mu/\lambda - \delta U/\delta T_i/\lambda \quad (5)$$

This formulation of the consumer behaviour leads De Serpa to define activities. He uses Tipping's (1968) original definition of pure leisure activity and intermediate activities. An intermediate activity is when time constraint is binding. A pure leisure activity is when time constraint is not binding. With this definition travelling will be an intermediate activity except for travelling for pleasure.

For pure leisure activity, the associated Lagrangean multiplier has zero value and hence marginal value of time equals to μ/λ. This value is referred to as the "resource value of time". Thus all leisure activities, the marginal valuation of time is equal to the resource value of time at the optimum. However because of the physical constraints (in time and space) or indivisibility the full value of leisure time cannot be realised (MVA, et al., 1987). As will be discussed, the constrained transferability of time is difficult to incorporate formally in the model. Even though pure leisure time has a value, there is no value at the margin to a saving of leisure time or value of saving of leisure time is zero. For an intermediate activity, K_i/λ represents the value of saving time for that activity.

Alternative formulations of the model introduced by De Serpa have been offered (Bruzelius, 1978). Bruzelius differentiates between time spent for leisure, work, and other activities, at the same time he introduces an additional time allocation constraint. His first time allocation constraint is the same as De Serpa's, i.e., a minimum amount of time must be spent at an activity. His second time allocation constraint is binding at all times. His formulation produces similar conclusion as De Serpa's.

A necessary condition for time saving or losses to constitute an economic problem is that time allocation constraint must be binding, and that the Lagrangean multiplier associated with that constraint must be nonzero.

In general, in the models of De Serpa's type the consumer maximises her utility function, again of certain mathematical properties, subject to a budget constraint, a time budget constraint and different types of time allocation constraints. The formulation results in demand functions where time requirements are recognised explicitly (MVA, et al., 1987, HCG 1990). In the formulation given by MVA, et al. (1987) T_w, time spent at work is recognised explicitly. Earned income is then wT_w, where w is the hourly wage rate and unearned income is A. MVA impose a minimum, T'_w, on work time and T'_i on time spent in activity i. Then the Lagrangean function is given by:

$$L = U((X_1,...,X_n,,T_w,T_1,...T_n) + \lambda (A + wT_w - \Sigma P_i X_i) + \mu (T^0 - T_w - \Sigma T_i) + \phi(T_w - T'_w) + \Sigma K_i (T_i - T'_i) \quad (6)$$

Where, $K_i >=0, i=1,...,n, \phi >=0$ and μ and $\lambda >o$

Lagrangean multipliers μ and λ, ϕ, and K_i can be interpreted in the De Serpa's formulation. From the first-order condition with respect to T_i follows:

$$K_i/\lambda = \mu/\lambda - \delta U/\delta T_i/\lambda \quad (7)$$

The first-order condition with respect to T_w is

$$\delta U/\delta T_w + \lambda w + \lambda T_w \delta w/\delta T_w - \mu + \phi=0 \quad (8)$$

or

$$K_i/\lambda = w+ (1/\lambda)* \delta U/\delta T_w - (1/\lambda)* \delta U/\delta T_i + T_w \delta w/\delta T_w + \phi/\lambda \quad (9)$$

This equation decomposes the value of travel-time savings into five components. The first two along with the forth gives the opportunity cost of travel assuming it could be spent at work instead. The third term gives the direct utility loss from spending time in travel. The fifth term gives the effect of the binding work-hours constraint.

Implicit in these theoretical frameworks is that a consumer can treat time as any other commodity. However, time cannot be saved in the same manner as other resources. Economic activities are constrained in space and time. Constraints in time can be socially related (e.g. working hours of offices, shops and services) or physically related (nights and day, seasons, etc., and human consumption needs). This is what MVA et al. refers to as "constrained transferability of time"

Winston (1982) develops this theoretical framework further by addressing activity timing. The theoretical models described so far do not provide insight to activity timing. He develops a time-of day dependent utility for an activity. The utility of activity *i* at time *t* is a function of the satisfaction from the activity itself and the intensity with which it is performed. Both the satisfaction and the intensity can be dependent on the time *t*, which results in a time-of day dependent utility for an activity.

Winston assumes that the utility derived from an activity has two components; the satisfaction from doing something and the satisfaction of achieving something; i.e. process and goal achievement utility. Alternative assumptions about the distribution of the process and goal achievement utility than those made by Winston have been presented (Root, McNally and Recker 1986)

The theoretical framework presented so far is static. It assumes that the decision-maker generates his alternatives for a pre-determined time-horizon (e.g., day, week, year, and lifetime) and is then able to execute the chosen course. Root and Recker (1983) give a more realistic account for a dynamic framework.

One purpose of this review is to point out that modelling a comprehensive model of time allocation and time scheduling is extremely complex. In addition the complexity of a realistic utility maximisation based approach is likely to be beyond analytical treatment.

3.4 Consumer surplus

Even though consumer’s surplus is a quite controversial concept, it is widely used and there is substantial agreement on the correct quantities to be measured. That is the amount the consumer would pay or need to be paid to be just as well off after the price change as he was before the price change, or the Hicksian compensation variation measure. An alternative measure that takes ex post price change utility as the base of compensation is the Hicksian equivalent variation measure (Hausman, 1981). The primary condition for the Marshallian measure of consumer surplus to correspond to the Hicksian compensation variation is to have constant marginal utility of income.

Jara-Diaz and Farah (1988) provide a review of the relation between utility, demand and the various measures of consumer surplus. A summary of this review will be presented here, since it will introduce some of the concepts used in this work.

They start with a model of consumer behaviour where an individual maximises her utility and its solution is as follows

Maximise:	$U(X)$	Solution: $X = X^{*}(P, I)$ demand functions	(10)
Subject to:	$PX^{T} \leq I$	Optimum: $U[X^{*}(P, I)] = V(P, I)$ indirect utility function	
	$X \geq 0$		

where X is the vector of goods and services consumed during a period, $U(X)$ is the utility function, P is the vector of prices for goods and services and I is income. The dual of the maximisation problem above and its solution is as follows

Minimise:	PX^{T}	Solution: $X = X^{C}(P, U')$ compensated demand	(11)
Subject to:	$U(X) \geq U'$	Optimum: $P[X^{C}(P,U')]^{T} = e(P, U')$ expenditure function	
	$X \geq 0$		

If the set of prices changes from P^{0} to P^{1}, the bundle of goods consumed will change from X^{0} to X^{1} and the level of utility from U_{0} to U_{1} .

The definition of the compensation variation, *CV*, results in the following

$$U_{0} = V(P^{0}, I) = V(P^{1}, I - CV) \quad (12)$$

Taking the inverse in (12) and using expenditure functions we obtain

$$CV = e(P^{0}, U_{0}) - e(P^{1}, U_{0}) \quad \text{or} \quad CV = -\int_{p^{0}}^{p^{1}} \sum_{i} X_{i}^{c}(P, U_{0}) dP_{i} \quad (13)$$

The definition of the equivalent variation, *EV*, leads to

$$U_{1} = V(P^{1}, I) = V(P^{0}, I + EV) \quad (14)$$

Taking the inverse in (14) and using expenditure functions we get

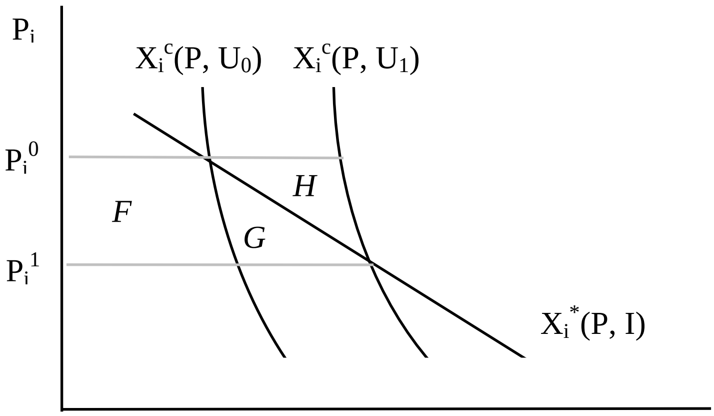
$$EV = e(P^0, U_1) - e(P^1, U_1) \quad or \quad EV = -\int_{P^0}^{P^1} \sum_i X_i^c(P, U_1)dP_i \tag{15}$$

The definition of the Marshallian measure of consumer surplus leads to

$$\Delta MCS = -\int_{P^0}^{P^1} \sum_i X_i^*(P, I)dP_i \tag{16}$$

Figure 3.1 illustrates different measures of the consumer surplus.

Figure 3.1 Different measures of consumer surplus (Adapted from Jara-Diaz and Farah, 1988)



EV = F + G + H: CV = F: Δ MCS = F + G

Value of time saving should be defined in terms of compensation variation (*CV*) or equivalent variation (*EV*). It is not always necessary to know the indirect utility function *V*. It would be sufficient to get information on how much an individual is willing to pay for an improvement or avoid a deterioration (*WtP*). Conversely how much an individual is willing to accept for a deterioration or for the absence of an improvement (*WtA*).

Where the change from one situation to another implies improvement *WtP* equals *CV*. Where the change from one situation to another implies deterioration *WtA* equals *EV*. Under these condition *WtA* should be larger than *WtP* (see Figure 3.1).

The differences between elicited *WtP* and *WtA* measures of welfare changes have been the subject of many recent studies (see for example Adamowicz, et al., 1993). Hanemann (1991) suggests that the differences depend on income effect as well as substitution effect. Kahneman and Tversky (1979) reject the conventional economic theory and an alternative behavioural approach for the explanation of the differences.

3.5 Econometric models

Most empirical work on determining the value of travel time is based on formulation of demand in terms of generalised cost. Bruzelius (1979) examines the traditional method for measuring the value of time saving and concludes that this measure is theoretically correct if (in addition to the requirement on demand function) the marginal value of time (saving) is constant and not a function of the prices, time requirement and income. As Bruzelius points out these are strong assumptions about consumer behaviour.

In that case the demand function can be formulated in terms of the generalised cost of a journey, which is the sum of the price of a journey plus the time requirement multiplied by the constant marginal value of time (saving).

The theoretical framework of allocation of time puts requirements on the formulation of econometric models that can be used to measure the value of travel-time savings. Most empirical work on determining values of travel time savings are based on the assumption that demand can be expressed in terms of one parameter only, the generalised cost of the journey. These models have produced good statistical properties. Demand functions in terms of generalised costs, appear to be the only successful travel demand model today.

Hensher (1987) and Bruzelius (1979) give thorough reviews of alternative econometric demand models used for the estimation of value of travel time. Bruzelius summarises his review by stating that “most of these models are based on similar stochastic specifications, i.e., that the values of travel time are fixed, while the fixed cost vary in general, according to the normal or an extreme value distribution”. The assumption that the values of time are fixed in the population is restrictive.

Based on stochastic specifications mainly logit or probit models are used for the estimation of value of time. Popularity of these models can be explained by more efficient use of survey data and the fact that they are directly based on a micro economic theory of demand.

See Daly (1996) for an excellent review of the subject as well as recent advances beyond that covered by Ben-Akiva and Lerman (1985).

More recently there has been a revival of interest in estimating a distribution of value of time (in the population) rather than constant value of time (see Ben-Akiva, Bolduc and Bradley, 1993, and Gopinah and Ben-Akiva, 1993).

3.6 Role of income

Train and McFadden (1978) provided a rigorous theoretical treatment of how income and price should enter the specification of the utility functions for a discrete choice model. The inclusion of a variable that represents modal cost (price) divided by individual wage rate in the specification of utility in disaggregate demand modelling, comes from their analysis.

Jara-Diaz and Farah (1987), re-examine the Train and McFadden approach and suggest an expenditure rate, i.e., individual's earnings per unit of available time, to replace wage rate. Furthermore, they suggest that the usual linear specification of representative utility that results from the Train and McFadden approach to be inadequate.

Small (1992) points out that "these specifications can guide the empirical researchers in specifying how the value of time might vary with socio-economic variables."

3.7 Data

As stated earlier different types of data can be collected for the estimation of the parameters of the value of time. It was also stated that revealed preference (RP) stated preference (SP) and transfer preference (TP) approaches have been the most common in the context of *VoT* studies. When choice is observed in an actual situation, then the choice variable measures revealed preference (RP). Statement of choice, in a hypothetical situation, measures stated preference (SP). In TP approach data on the exact amount that a traveller demands as compensation for choosing an inferior alternative, or is willing to pay for a superior alternative, is also collected.

Stated preference studies are less expensive than RP and allow control over variation of independent variables and the correlation between them, especially between time and cost. The correlation between time and costs in RP data makes the estimates of *VoT* to have large errors and often requires SP data for good accuracy. MVA, et al., (1987) gives an overview of advantages and disadvantages of SP and RP approaches in the context of value of travel time study. The properties of revealed preference data and stated preference data are summarised by Bradley and Kreos (1990).

Since the estimation of *VoT* requires the estimates of the marginal utility of time and cost, i.e., the coefficients of the indirect utility function, binary choices simplifies both data collection and the modelling context (see Daly, 1996).

Research by Morikawa (1989) provides basis for combining data from different sources such as data from RP and SP techniques (Ben-Akiva and Morikawa, 1990, and Bradley and Daly, 1991).

3.8 Empirical evidences on value of time and current practices

There is a great amount of literature on empirical studies of value of time. Bruzelius (1979) and Hensher (1987) provide a thorough review of most of these studies. MVA, et al., (1987) provide a review of some studies along with results from the British value of time study. HCG (1990) describes findings from the Netherlands value of time study. Small (1992) and Waters (1992) provide some additional empirical results, mainly on the value of travel time for journeys to work in an urban context. Wardman (1997) provides a review of evidence on the value of time in the UK. There has been some new national studies such as the 1994 UK *VoT* study (see Gunn, Bradley and Rohr, 1996), the Swedish *VoT* study (see Algers, Lindqvist Dillén and Widlert, 1995) and the Finish *VoT* study (see Pursula and Kurri, 1996).

The empirical evidences from these studies are not quite comparable. However they provide a useful summary of the range of the value of travel-time savings. It needs to be emphasised that most empirical evidence on *VoT* has been in the context of urban travel (short distance). There have been some recent studies with focus on inter-urban travel (long-distance) such as the Swedish and the Norwegian *VoT* studies. These studies suggest considerably higher *VoT* for inter-urban than urban travel.

There are numerous explanations for at least parts of the variations among empirical evidences on values of travel time. Following is a summary of some of these.

- trip purpose
- type of data (e.g., SP versus RP techniques)
- direction, i.e., time loss versus time gain (*WtA* versus *WtP*)
- trip length
- size of time saving
- additional attributes of the choice, i.e., those that determines comfort, e.g., congestion and search time for parking place for travel by car and walking, waiting, transfer and in-vehicle time by public transport
- personal and household characteristics of the travellers
- cultural and locational differences
- choice context (e.g., route choice, speed choice, mode choice, within-mode choice)

Travel purpose and value of time

Conventionally, time for business travel used to be valued at wage rate plus overhead. As mentioned earlier, Hensher (1977) proposes an alternative approach for the calculation of *VoT* for business travel. For non-business (private) travel purposes, *VoT* is conventionally valued at a percentage of wage rates, usually 30-

50 percent. It should be emphasised that this convention has developed mainly based on empirical evidence on *VoT* in the context of urban travel.

Time for commuting to and from work used to be valued higher than other non-work travel purposes. Recent evidences suggest that all non-work travel purposes and commuting to and from work should be valued the same.

Income and value of time

Most studies support that there is an influence of incomes on values of travel time. However, as a matter of public policy most governments specify that a constant value of travel-time savings be used for project evaluation. The main argument for this is the question of principle (question of efficiency versus equity).

Although most officials recommend a constant *VoT*, value of time is usually adjusted for future economic growth.

Size of the time savings

Are small amounts of travel-time savings less valuable than large amount? Welch and Williams (1997) provide an overview of the controversy and debate on the subject that dates back to late 60's. They also point out that "the variation (of *VoT*) with respect to the duration of time saved have received relatively little empirical attention over the past period. This is of some interest and concern because the detailed assumptions underpinning the economic evaluation of *small* time savings have long been the subject of substantial critical comment and vigorous counter-argument between those who advocate a constant unit value (CUV) for time savings, and those who promote a discounted unit value (DUV) approach, in which the benefit of each unit of time saved is reduced (possibly to zero) below one or more critical thresholds."

They also point out that "Central to the controversy are fundamental disagreements about the specification and estimation of micro-relations pertaining to behaviour of firms, households, and individuals, and the implications of associated "willingness to pay" measures for the evaluation of transport system changes. The most contentious aspect concern the extent and speed with which perceived or non-perceived travel-time savings, absorbed into time budget, are converted into productive work or more satisfying activities, in the light of logistical/scheduling indivisibilities and organisational inertia."

Welch and Williams (1997) recognise that the "small time savings" issue remains important and unresolved. However they point out that small time savings often account for a large proportion of the benefits of a project and with DUV a project's benefits related to time savings will be reduced substantially.

There is some empirical evidence that suggest small amounts of travel-time savings are less valuable than large amounts (see for example Gunn, Bradley and Rohr, 1996).

Stated Preference versus Revealed Preference technique

Carson, et al., (1996) point out that the comparison of contingent valuation (CV) estimates for government-provided quasi-public goods with estimates obtained from revealed preference (RP) techniques has played a key role in assessing the validity and reliability of contingent valuation method. Furthermore they point out that such comparisons are generally assumed to represent convergent validity rather than criterion validity, since it is not possible to assert the "true" value with either of the methods. Carson, et al., (1996) examine 83 studies containing 616 CV/RP comparisons for quasi-public goods. They conclude that, "CV estimates are smaller, but not grossly smaller, than their RP counterparts." They find the sample mean CV/RP ratio for the complete data set is 0.89 with a 95 percent confidence interval (0.81-0.96).

In the context of *VoT*, Wardman (1997) compares the estimates of *VoT* from RP and SP techniques. This comparison is based on studies conducted in UK. He looks at 444 *VoT* estimates, out of which 6% were obtained by RP technique. He develops a regression model to explain variation in *VoT* across studies as a function of relevant variables, including the type of data by collection techniques, i.e., RP and SP. He concludes that, "the values (from SP approach) are sufficiently close to what would be obtained by an RP approach. This is encouraging with regard to the validity of using SP methods for valuation purposes." He also states that "A further encouraging feature of the results is that this reasonable degree of correspondence between RP and SP values of time is apparent across studies which have largely been conducted independently."

Wardman (1997) takes five studies where both disaggregate behavioural RP and SP models have been developed. The RP values average 6.34 with a 95% confidence interval of (4.8-7.88). The SP values average 5.27 with a 95% confidence interval of (4.25-6.29). Note that the sample mean of SP/RP ratio for the data set is 0.83, quite similar to that reported by Carson, et al., (1996). However, Wardman points out that even though the RP values are on average 20% higher than the SP values, the difference in the mean is not significant.

Direction, i.e., time loss versus time gain (*WtA* versus *WtP*)

We pointed out earlier economic theory suggests that *WtA* to be larger than *WtP*. Different empirical evidence confirms that time losses are valued higher than time gains (MVA, et al., 1987, Gunn, Bradley and Rohr, 1996, and Algers, Lindqvist Dillén and Widlert, 1995).

Travel time for components of a trip

Ample evidences, mainly in the context of urban travel, point to a higher value for other components of a travel time compared with in-vehicle time, such as search time for parking place, walking, waiting and transfer time by scheduled modes.

Most official guides recommend to value waiting and search time as well as access and egress time 2-3 times relative to in-vehicle.

EVA Manual (1991) assigns a value for disposition time as one of the components of a trip. Disposition time is defined as "the time spent with planning a trip, adjustment to the time scheduling of the transport services (before leaving origin) and, waiting at destination (due to 'slack'-time allowed for uncertainty in travel-time or due to the frequency of service)."

Congestion and delay (variability of travel time)

There is a more recognition for a higher *VoT* for travel by car under congestion compared with free flow traffic (see for example Gunn et al., 1996, and Wardman et al., 1996). This is due to differences in comfort factors connected with driving during congestion and free flow time.

It is, however, important to point out that by delay we mean the variability of travel time. Different factors might cause delay, i.e., variability of travel time. The probability of delay increases as the volume gets close to capacity. Delay is usually defined in terms of the probability of the occurrence of delay and the duration of delay. This approach results in the estimation of the *VoT* for expected delay. An alternative approach is the valuation of expected deviations of arrival time (early or late) from the preferred arrival time. In this approach, early/late arrival is usually defined by the probability and the length of deviation of arrival time from the planned arrival time. It is important to point out that a wide definition of delay have been used in different studies and it is necessary to allow for this fact for the comparison of the *VoT* for delay.

There is similar recognition for delay by car or by scheduled modes (see for example MVA et al., 1987, Gunn et al., 1996, Algers, Lindqvist Dillén and Widlert, 1995), i.e., *VoT* for delay is higher than in-vehicle *VoT*.

Car passenger and car driver

There is some recognition that the value time for car passenger is lower than car driver (MVA, et al., 1987, and Waters, 1992). However, most official guides do not acknowledge for a differentiation between the value of time for car passenger and car driver.

There are not too many studies that address the *VoT* for car passenger explicitly. The Swedish study (Algers, et al., 1995) reports similar *VoT*'s for car driver and car passenger.

Value of time and age

It is a common practice to reduce the value of travel-time savings for youth, students as well as for elderly and retired people. The argument for this is based on the lower opportunity cost of time for these groups than other adult people. Some official guides, e.g., AASHTO, do not call for a separate value of time by age group.

Trip length

More recent empirical evidences support that *VoT* increase with trip length (see for example Wardman, 1997, Gunn, et al., 1996). The Swedish Value of Time study, with focus on inter-urban travel shows that the *VoT*'s are considerable higher for longer trips (Algers, Hugosson, and Lindqvist Dillén, 1995).

4 Dimension of the study

The scope of the Norwegian *VoT* study was limited to passenger travel within Norway and with focus on:

- private travel; commuting to work and other private travel purposes
- business travel

The approach in the British (Bates et al., 1987), the Netherlands (HCG, 1990) and the Swedish (Algers, Lindqvist Dillén, and Widlert, 1995) *VoT* studies for the valuation of private value of travel-time savings has been used in this study. The following dimensions were adopted for this study:

Trip length: Urban travel (shorter travel length), Inter-urban travel (long travel length).

Theories of allocation of time suggest that the valuation of time depends on the resource values of time and money budget and the activity utility. It is very likely that resource values and activity utility are very different for inter-urban travel and urban travel (Ramjerdi, 1993). Furthermore the supplies of transport services in these two market segments vary significantly. The differences in the two market segments require different designs of the SP study.

On the basis of the above discussions, it was decided that two separate studies should be conducted for these market segments. In the context of Norway, trips over 30 kilometres were defined to be inter-urban travel and shorter than 30 kilometres were defined to be urban travel. The main reason for choosing 30 kilometres was to have a good coverage over trip length. Another reason for choosing 30 kilometres was compliance with the Swedish *VoT* Study The data from these two studies is merged later for further evaluation of this segmentation.

Travel purpose: Private travel purposes include commuting to work, and other non-work trips such as education, shopping, personal business, recreation, social visit, escorting others, etc. Business travel purposes include travels for meetings, conference, seminar, course, exhibition, study tour, etc.

Short distance (Urban) mode of travel: Car and public transport (bus, tram and rail), as well as the different time components of travel with these modes and delay.

Long distance (Inter-urban) mode of travel: Car, ferry, rail, air, and bus (coach) as well as the different components of these modes.

Within these dimensions the effects of the following sources of variation are evaluated.

Persons: Age, sex, employment status, education, household status such as number of wage earners or children of different age categories in the household, income groups. Additionally, working hours' arrangement such as fixed working hours, flexible hours, etc., that has a bearing on time restrictions.

Conditions: Time of day, week, weather condition, congestion, speed, etc.

Time of year is a significance factor for Norway especially for mode car with respect to darkness and road surface condition. It was decided that the inter-urban study should be conducted in two waves to address this issue.

Car occupancy and travelling party size: For the evaluation of the true costs and possible contributions to the conditions of travelling.

Taxation or subsidies: For the evaluation of the true costs to individuals.

5 Study design

The starting point for the design of the Norwegian *VoT* study was the dimension of the study mentioned in the previous chapter. The Norwegian *VoT* study is based on SP technique as well as TP technique. In the Norwegian *VoT* study a choice based and stratified sampling approach was adopted. Effort was made to assure a national coverage.

5.1 Long distance travel

The study was carried out in two waves. The first wave was conducted in March-April 1995 and the second wave in September-October 1995.

In connection to the study three pilot studies were conducted. Two of these pilot studies were conducted in November-December 1994 and January-February 1995. The third pilot study was conducted before the second wave, in June 1995. There was also a pilot study, with focus on business travel that was conducted in June 1995. The respondents in this study were recruited among employees at the Institute of Transport Economics.

Table 5.1 shows an overview of the design of the study while Figure 5.1 shows the comparison of the targets and actual number of interviews by mode.

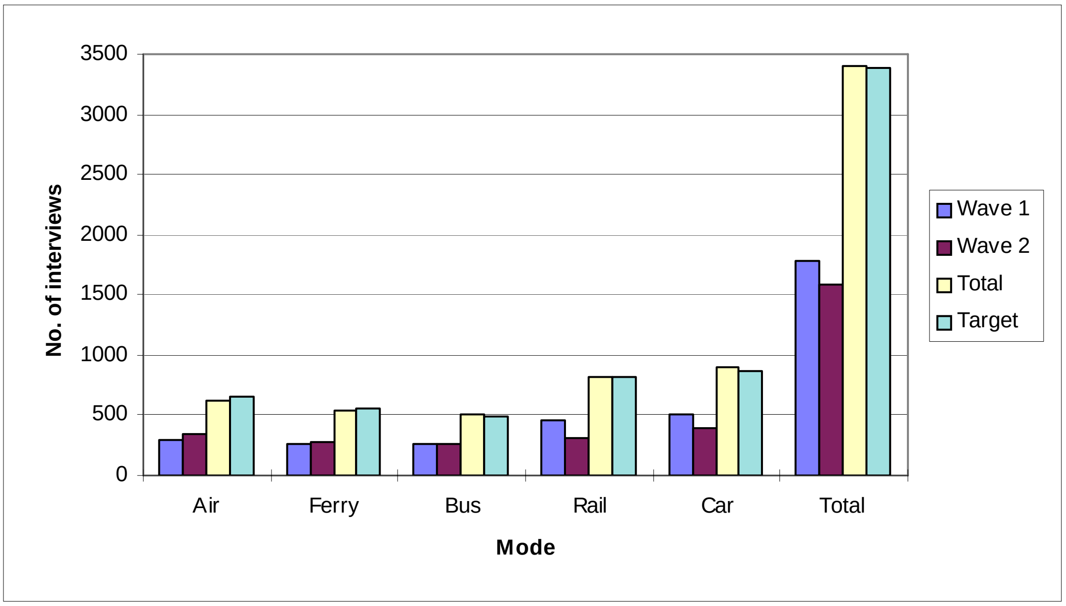
The ages of the respondents were restricted to 18 years or older.

Table 5.1 Overview of the design of the study

	No. of interviews (target)	*Recruited at*	*Interviewed at*
Air, main lines	350	Airport/on board	Home
Air, STOL[1]	150	Airport/on board	Home
Rail, long distance	450	On board	On board
Rail, regional	450	On board	On board
Bus, long distance	250	On board	On board
Bus, regional	250	On board	On board
Ferry, over 25 minutes	500	On board	On board
Ferry, under 25 minutes	100	On board	Home
Car, 30-100 km	300	Phone	Home
Car, 101-300 km	300	Phone	Home
Car, 300+ km	300	Phone	Home
Total	3400		

1 Short Take off and Landing

Figure 5.1 A comparison of target and the actual number of interviews by mode



5.1.1 Car

In the Swedish *VoT* study, the recruitment for mode car is by the registration of licence plates of cars that drive on specified routes. The choices for recruitment in the Norwegian study were to either adopt the Swedish approach or use telephone. Based on different considerations the decision was to use telephone. The target group was among those who had made a long distance trip in the previous two weeks. Figure 5.2 shows the locations of the cities where recruitment with telephone were made. These cities are

- Oslo
- Bergen
- Kristiansand
- Stavanger
- Florø
- Trondheim
- Mo i Rana
- Tromsø

The recruitment was such that certain criteria connected to travel purpose and trip distance were met. The main focus for travel purpose was business trips. The criteria for recruitment was to get about equal number of respondents who have made an actual long distance travel of 30-100 km, 101-300 km and over 300 km. Half of the respondents were asked to relate to their outbound trips, while the other half were asked to relate to their inbound trips.

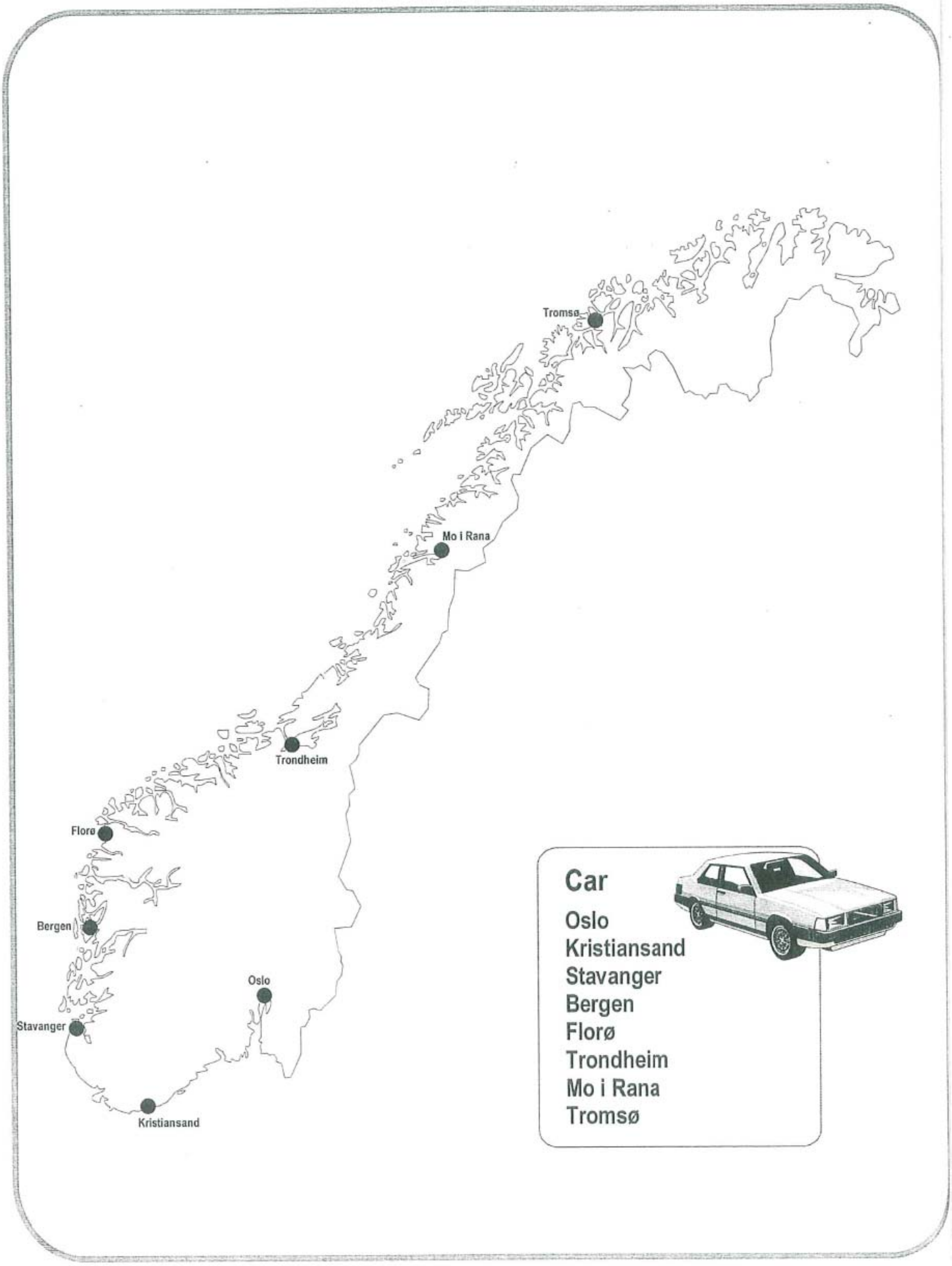


Figure 5.2 Locations of the cities where recruitment were made for long-distance travel with car

5.1.2 Ferry

Table 5.2 shows the description of the six ferry routes that were selected for the purpose of this study. Figure 5.3 shows the locations of these ferry routes. Recruitment was carried out on quay and onboard. For ferry routes longer than 25 minutes the interview was carried out onboard. For ferry routes shorter than 25 minutes the interview was carried out at home. The number of respondents that were recruited on each route was almost the same. Ten percent of the respondents that were interviewed on board in the first wave were car passengers (about 25 respondents). This was with the aim of the evaluation of the *VoT* for car passengers.

Table 5.2 Description of the ferry routes

County	*Route*	*Travel time*	*No. of tours per day*
Vestfold/Østfold	Moss-Horten	35 min	8-38
Rogaland	Mortavika-Arsvågen	25 min	30-60
Hordaland	Brimnes-Bruravik*	10 min	52-58
Sogn og F.	Dragsvik-Vangsnes	25 min	41-49
Møre og R.	Molde-Vestnes	35 min	18-46
Finnmark	Kåfjord-Honningsvåg	40 min	18

* Home interview in Oslo or Bergen

5.1.3 Bus

Bus passengers were recruited and interviews on board on selected bus routes. Table 5.3 shows an overview of the bus routes that were chosen for this study. The only route on which bus and rail operate in parallel is Oslo-Minnesund-Gjøvik. On many routes there are extra departures in the weekends, in addition to the minimum number of departures per day. Figure 5.4 shows where the bus routes are located.

Table 5.3 Description of the bus routes

Route no.	*Route*	*Travel time, hours*	*Min. no. of departures per day in one direction*
22-147	Oslo-Minnesund-Gjøvik	2.5	2
22-130	Oslo-Trysil	3.5	1
22-144	Lillehammer-Bergen	10.5	1
22-221 (180E)	Kristiansand-Voss	10.0	1
22-611	Trondheim-Røros	3.0	3
22-670	Trondheim-Namsos	3.5	1
22-720	Narvik-Bodø	6.5	2
22-800	Narvik-Tromsø	4.5	2

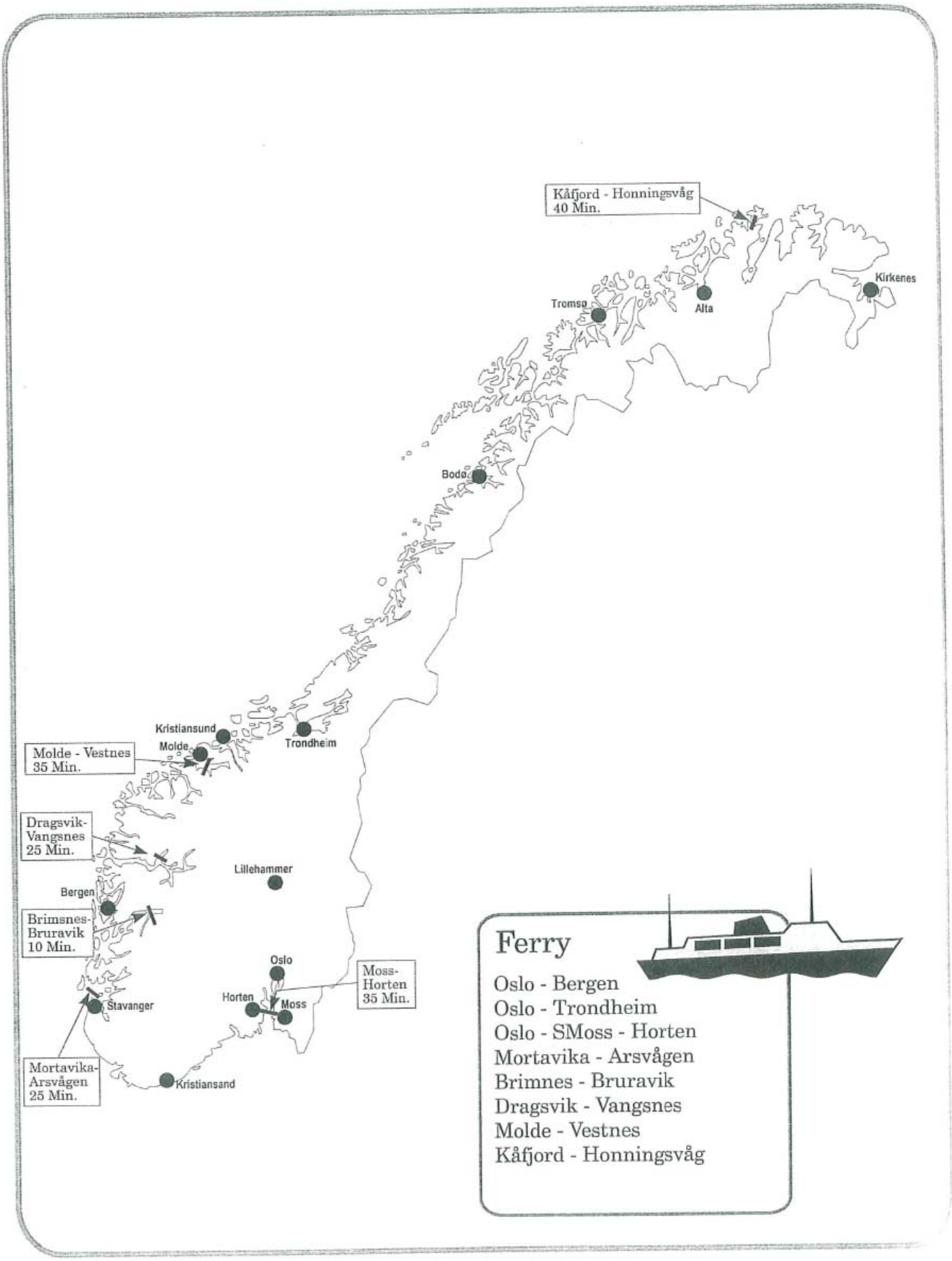


Figure 5.3 Location of ferry routes selected in the study

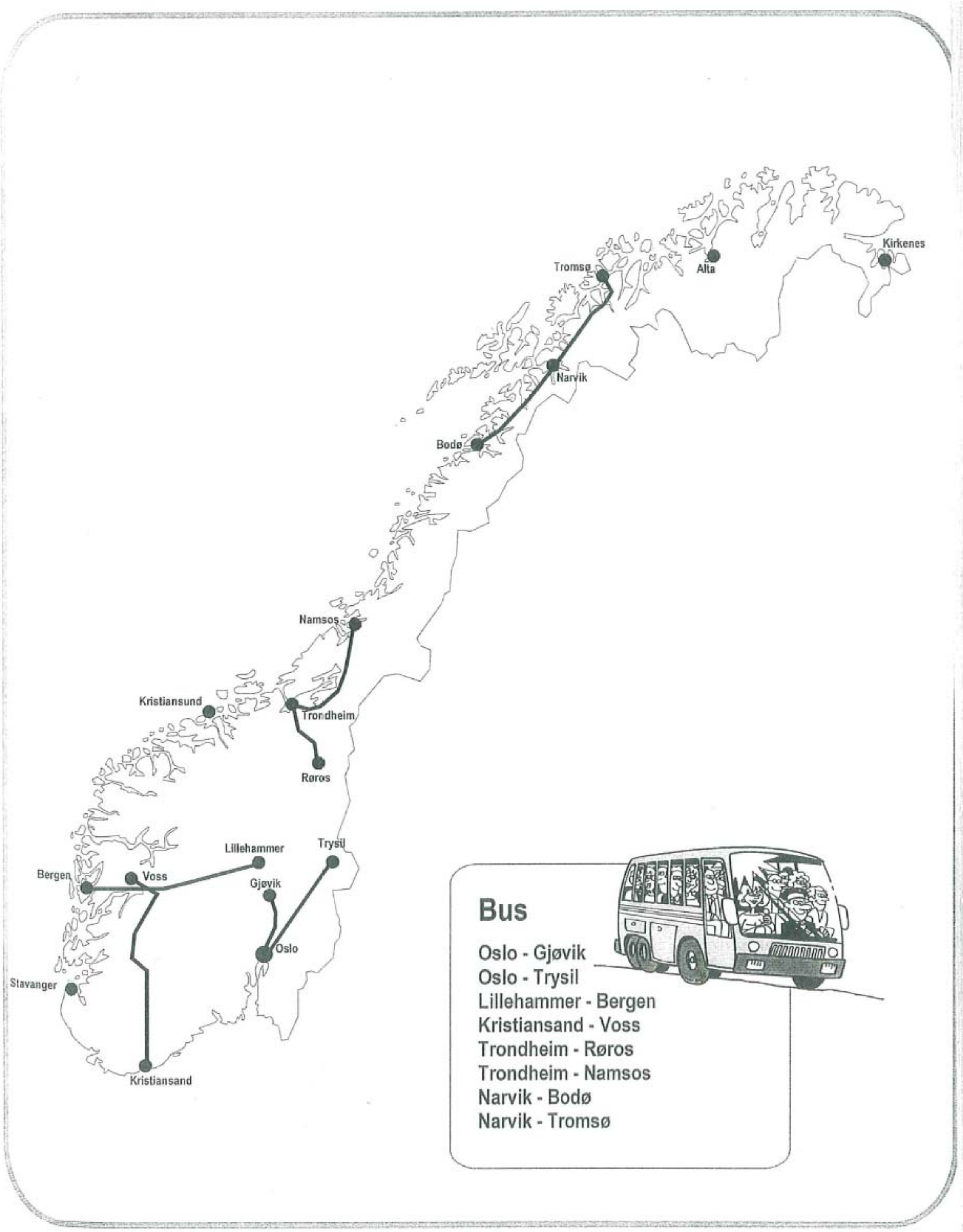


Figure 5.4 Location of bus routes selected for long distance study

5.1.4 Rail

Tables 5.4 and 5.5 show the overview of the rail routes selected for the study. Figure 5.5 shows the location of these routes. Trips on night trains were excluded. On some of the long distance routes the number of departures per day is one to two.

Table 5.4 Description of the long distance rail route

Route no.	*Route*	*Travel time, hours*	*No. of departures per day in one direction*
21-041	Oslo-Bergen	7.00	3
21-021	Oslo-Trondheim o/Dovre	7.25	3
21-051	Oslo-Stavanger	7.00	3
21-071	Trondheim-Bodø	9 .00	1

Table 5.5 Description of the regional rail route (over 30 km)

Route no.	*Route*	*Travel time, hours*	*No. of departures per day in one direction*
21-031	Oslo-Gjøvik	2.00	8
21-460	Oslo-Kongsvinger	1.50	12
21-001	Oslo-Halden	1.75	13
21-020	Skien-Lillehammer	5.50	8
21-450	Eidsvoll-Kongsberg	2.50	10

5.1.5 Air

It would have been best to recruit air passengers on board rather than at the airport. Recruitment at airport could result in missing passengers with tight schedules. These passengers can have different *VoT* than others who come to the airport with enough time ahead of departure time. SAS and Braathen did not give permission to recruit passengers on board. Consequently the air passengers with these carriers were recruited at the airport and interviewed at home. However, Widerøe granted permission to recruit passenger on board. For flights that were not fully booked, a ticket had to be purchased for the interviewer. Otherwise, the interview person was permitted to get aboard without payment for a ticket. Recruitment on board was more efficient and less costly than recruitment at the airport.

Recruitment on flights with more than 10 minutes delay was avoided. The home interviews were made in Oslo, Bergen, Kristiansand, Stavanger, Trondheim and Tromsø. At the time of interview at home, half of the respondents were asked to relate to their outbound trip, the other half were asked to relate to their inbound trip.

Table 5.6 shows an overview of the long distance air routes selected for the study.

Table 5.6 Description of the long distance air route (over 30 km)

Route no.	*Route*	*Travel time, min*	*Carrier*
25-125	Oslo-Bergen	50	Braathen/SAS
25-302/25-303	Bergen- Stavanger	40	SAS/Widerøe
25-161	Oslo-Trondheim	55	Braathen/SAS
25-181	Trondheim-Tromsø	120	SAS

For passengers with STOL the following routes in the Vestlandet, Trøndelag and the North of Norway with carrier Widerøe were selected:

- Route 25-301 Oslo/Bergen - Sogn og Fjordane - Møre
- Route 25-401 Oslo/Trondheim - Helgeland - Bodø
- Route 25-301 Oslo/Bergen - Sogndal - Førde - Sandane - Ørsta - Florø
- Route 25-401 Oslo/Trondheim - Namsos - Rørvik - Brønnøysund - Mosjøen - Sandnessjøen - Mo i Rana - Bodø

The home interviews were made in Oslo, Bergen, Kristiansand, Stavanger, Trondheim and Tromsø as well and Mo i Rana and Florø.

Figure 5.6 shows the location of long distance and STOL routes.

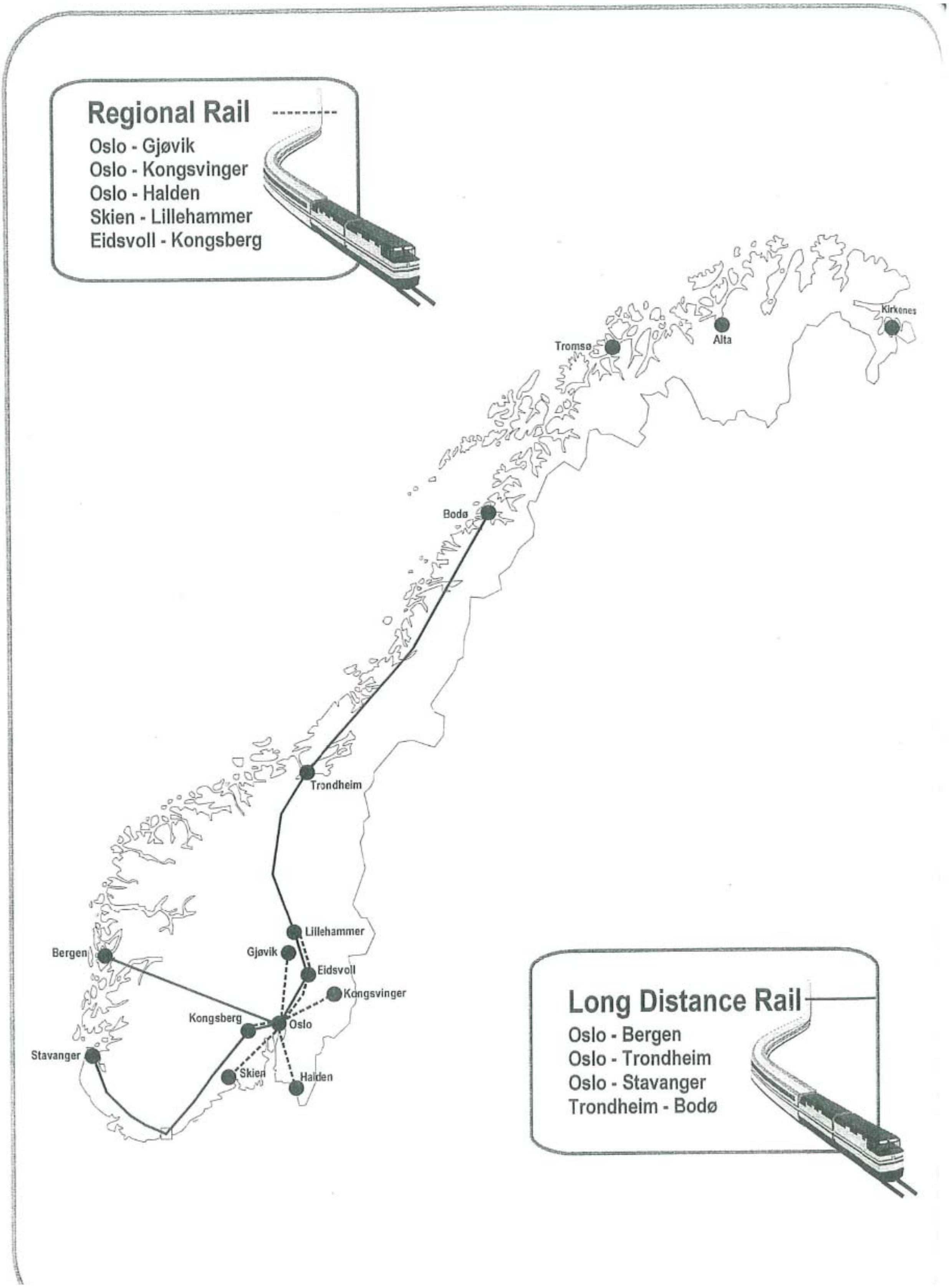


Figure 5.5 Location of rail routes for long distance travel

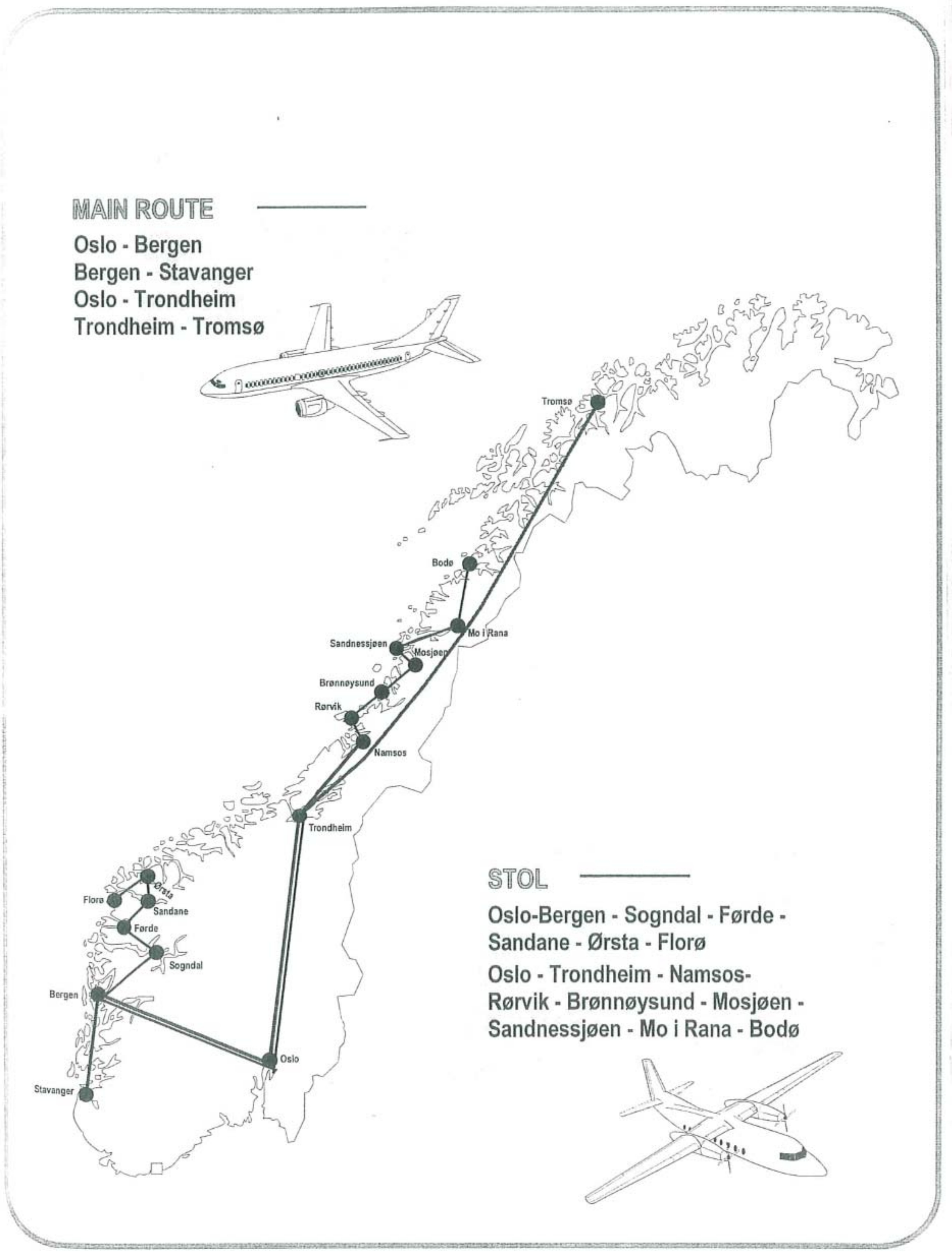


Figure 5.6 Location of main and STOL routes for long distance travel with air

5.2 Short distance travel

The decision to cover the *VoT* for short distance (urban) travel in the study was made after the study for long distance (inter-urban) had started. As it was pointed out earlier, in the context of the valuation of public transport services in urban areas, considerable amount of research based on SP technique was conducted since early 90's at the Institute of Transport Economics. Value of time had not been the focus of these studies. However, these studies have provided estimates of *VoT* for components of travel time with public transport in different urban areas in Norway. These studies focused on the chosen mode of transport rather than the alternative modes of transport available to the respondents. To minimise the cost of data collection it was suggested to benefit from the data from some of these studies. With this background, the *VoT* study focused mainly on car. However a minimum data in connection with public transport had to be collected. This was necessary for addressing the *VoT* for alternative modes of transport.

Table 5.7 shows an overview of the data collected under the *VoT* study for short distance travel in September-October 1996. The recruitment in this study was by telephone that followed by a home interview. The recruitment took place in Oslo, Bergen, Trondheim, Kristiansand and Tromsø. Since the sample did not cover rail passengers, additional recruitment in Akershus was made with focus on rail passengers. In connection with the study one pilot studies was conducted in August-September 1996.

Table 5.7 Overview of recruitment locations in the *VoT* study for short distance travel

	Car	*Public Transport*[1]	*Total*
Oslo	305	84	389
Bergen	128	109	237
Trondheim	107	6	113
Kristiansand	132	1	133
Tromsø	121	109	230
Akershus		54	54
Total	793	363	1156

1 Includes bus, tram, underground and rail

Table 5.8 shows a brief description of data in the *VoT* study for short distance travel and other studies. Among the different relevant studies, "Bus Passenger Preferences" (Kjørstad, 1995) "Assessing Environmental Benefits" (Sælensminde and Hammer, 1994) and "A new Initiative in Public Transport" (Kjørstad, Norheim and Renolen, 1994) were selected. Figure 5.7 shows the coverage of different studies for urban *VoT*.

There were more than one SP games in each of these studies. Only one game from each of these studies was used in the *VoT* study. Figure 5.7 shows the coverage of the different studies.

Table 5.8 Description of data used for the VoT study for short distance travel

Study	*No. of interview*	*No. Of choices*	*Age of respondents*
Value of Time (1996)	1156	9	18+
Bus Passenger Preferences (1995)	1009	9	16+
Assessing Environmental Benefits (1994)	1691	4	18+
A new Initiative in Public Transport (1994)	403	7	16+

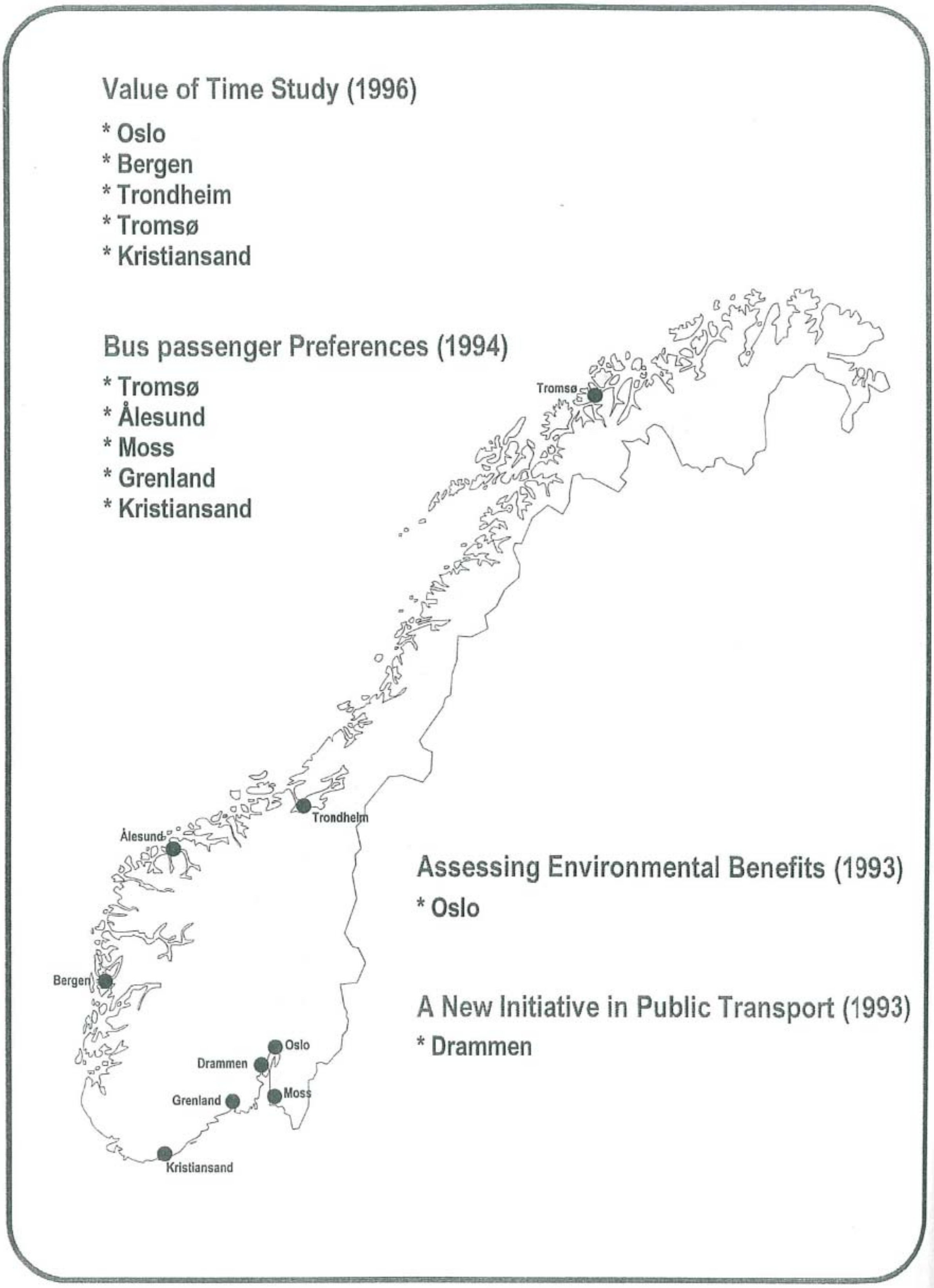


Figure 5.7 Coverage of the different studies for urban *VoT*.

6 SP Game Design

Each respondent was given two SP games, one for the chosen mode and another for an alternative mode the respondent would choose for the same trip. This was to evaluate the mode specific differences of the *VoT*'s. The choice context used in the study was within-mode.

Appendix I shows the questionnaires used in the *VoT* study.

The SP games were presented as paired alternatives and a respondent was asked to state her preferred choice. Each respondent was presented nine paired choices. Fractional factorial design was used and the dominant alternatives were excluded from the choice set. The choices among dominant alternatives were later simulated and included in the data to evaluate the effects on the estimates of the *VoT* (see section 6.8). Only three attributes were used in all the games.

6.1 Long distance travel

One of the issues connected with the design of the study was to find an attribute in addition to cost and time for travel mode car. In the first pilot study that was conducted in November-December 1994, distance between rest areas was chosen as the third attribute. The evaluation of the first pilot study suggested this attribute was not important for car. In the second pilot study that was conducted in January-February 1995, two other attributes were tested. These were automatic traffic control and road maintenance. The evaluation of the second pilot study showed that automatic traffic control (photo box) works quite satisfactorily as a third attribute for mode car. Table 6.1 shows the attributes that were included in the games. Tables 6.2 and 6.3 show the level of attributes for car and scheduled modes.

Table 6.1 Description of attributes included in the games

Attributes	*Included in*			
	Chosen Mode		*Alternative Mode*	
	Car	Scheduled Modes	Car	Scheduled Modes
Cost	X	X	X	X
Photo box	X		X	
In-vehicle time	X	X	X	X
Frequency		X		X
Delay		X (rail only)		

Table 6.2 Level of attributes in SP games for car, long distance travel

Attribute	*Level 1*	*Level 2*	*Level 3*	*Level 4*
Price	-X%	Base	+(X*2/5)%	+X%
In vehicle time	-25%	-10%	Base	+25%
Photo box (PhB)	The present no. of PhB	More PhB in 50 and 60 km/hr zones	More PhB in all zones	

X is calculated on the basis of the assumed range of *VoT*

Table 6.3 Level of attributes in SP games for scheduled modes. Long distance travel

Attributes	*Level 1*	*Level 2*	*Level 3*	*Level 4*
Price	-X%	Base	+(X*2/5)%	+X%
In vehicle time	-25%	-10%	Base	+25%
Frequency	-50%	Base	+50%	

X is calculated on the basis of the assumed range of *VoT*

The preliminary evaluation of data from the first wave created concern about some features of the design of the SP games for travellers by modes air and air as well as for business travellers.

A pilot study was conducted among the employers at the Institute of Transport Economics, at a rather small cost. This pilot study proved very useful. This was mainly due to the accessibility of the respondents for collecting further information about their response as well as the design of the questionnaire. The focus of this study was on the private *VoT* for business travel. Two outcomes of this study are worthwhile mentioning. One is related to the manner in which the monetary cost of a trip is presented to the respondents. For private travel purposes, the respondents felt that they need to know the total cost of trip rather than the difference in cost of an alternative and the base cost. For business travel purposes, the respondents felt the difference in the cost of an alternative and the base cost was more relevant. This is exactly the cost that occurs to business travellers. Another interesting outcome of this study was that out of about 20 respondents, only one had correct information on regulations for compensation outside working hours while travelling.

Another pilot study was conducted in June 1995 with focus on air and rail passengers. These two pilot studies resulted in some changes in the design of the SP games in the second wave. Table 6.4 shows the differences between the design of the SP games in the two waves of the study.

Table 6.4 Features of the SP design in the first and second wave, long distance travel

	Design feature	*First Wave*	*Second Wave*
Private travel	VoT Range, NOK/hr	50-300	50-300
	Presentation of costs	Total cost	Total cost
Business travel	VoT Range, NOK/hr	50-300	50-600
	Presentation of costs	Total cost	Difference in cost of an alternative and the base cost
Travel mode, air	VoT Range, NOK/hr	50-300	50-600
	In vehicle time	On board time	Airport-airport time

6.2 Short distance travel

Table 6.5 shows the attributes that were used in SP games in different studies. All the studies were based on within-mode choice context.

Table 6.5 Description of attributes used in different studies

Study	*Price*	*In Vehicle Time*	*Walk time*	*Headway*	*Delay*
Value of Time (1996)					
Main Mode	X	X		X	X
Alternative Mode	X	X		X	X
Bus Passenger Preferences (1994)	X		X	X	
Assessing environmental Benefits (1993)	X	X	X		
A New Initiative in Public Transport (1993)	X	X	X		

Table 6.6 shows the level of attributes used in the SP games for car in the Value of Time Study. Tables 6.7 shows the level of attribute used in the SP games for 50% of the respondents while table 6.8 shows these attributes for the other 50%.

Table 6.6 Level of attributes in SP games for car

Attributes	*Level 1*	*Level 2*	*Level 3*	*Level 4*
Price	-X%	Base	+(X*2/5)%	+X%
Travel time	-25%	-10%	Base	+25%
Delay	1 of 10 a delay of X minutes	2 of 10 a delay of X minutes	2 of 10 a delay of 2X minutes	

For delay *X* = Travel time*0.5 if travel time is 15 minutes or less and *X* = Travel time*0.25 if travel time is over 15 minutes

Table 6.7 Level of attributes in 50% of SP games for public transport, urban travel

Attributes	*Level 1*	*Level 2*	*Level 3*	*Level 4*
Price	-X%	Base	+(X*2/5)%	+X%
Travel time	-25%	-10%	Base	+25%
Frequency	-50%	Base	+50%	

Table 6.8 Level of attributes in the rest of SP games for public transport, urban travel

Attributes	*Level 1*	*Level 2*	*Level 3*	*Level 4*
Price	-X%	Base	+(X*2/5)%	+X%
Travel time	-25%	-10%	Base	+25%
Delay	1 of 10 a delay of X minutes	2 of 10 a delay of X minutes	2 of 10 a delay of 2X minutes	

Only the data from the first SP game in "Bus Passenger Preferences" (Kjørstad, 1995) was used. This study covers Moss, Grenland, Kristiansand, Tromsø and Ålesund and was conducted in 1994. Table 6.9 shows the level of attributes used in the SP game in this study.

Table 6.9 Level of attributes in the SP game for bus (Kjørstad, 1995), urban travel

Attributes	*Level 1*	*Level 2*	*Level 3*
Price	-25%	Base	+25%
Walk time	2 minutes	5 minutes	10 minutes
Frequency	-50%	Base	+5 min
Shelter	Yes	No	

The data from the first SP game in "Assessing Environmental Benefits" (Sælensminde and Hammer, 1994) was used. This study was conducted in the Oslo area in 1993. Table 6.10 and 6.11 show the level of attributes in the first game for car and public transport respectively.

Table 6.10 Level of attributes in SP games for car (Sælensminde and Hammer, 1994), urban travel

Attributes	*Level 1*	*Level 2*	*Level 3*
Price	Base	+50%	+100%
Travel time	-25%	Base	+25%
Walk time	Base	+50%	

Table 6.11 Level of attributes in SP games for public transport (Sælensminde and Hammer, 1994), urban travel

Attributes	*Level 1*	*Level 2*	*Level 3*
Price	-25%	Base	25%
Travel time	-25%	Base	+25%
Seat availability	Seat available	Seat not available.	

Table 6.12 shows the level of attributes used in the first SP game in "Initiative in Public Transport" (Kjørstad, Norheim and Renolen, 1994). This study was conducted in Drammen in 1993. The first SP game was selected for the *VoT* study.

Table 6.12 Level of attributes in SP games for public transport (Kjørstad, Norheim and Renolen, 1994), urban travel

Attribute	*Level 1*	*Level 2*	*Level 3*
Price	-25%	Base	+25%
Walk time	-50%	Base	+50%
Frequency	-50%	Base	+5 min
Shelter, PT	Yes	No	

6.3 Evaluation of the SP design

The SP designs were evaluated by use of different criteria. In a later paper by Sælensminde some of these evaluations will be reported fully. Here we briefly report some of the findings.

Lexicographic choices

Lexicographic choices are caused either by the respondent's use, intentional or unintentional, of a simplifying decision rule or by the fact that one or more factors dominate the preferences of the respondent.

In the test for lexicographical choices, we only have studied if a respondent has chosen the best alternative for one of the factors in all his choices. If the respondent has chosen the alternative with the lowest price in all his choices, we define that he has answered lexicographic with respect to price. We did not examine how the respondent chooses when the level of the factor he sorts after (or is dominant in his preference) is the same in a choice situation.

Between 22 and 44 per cent (depending on travel mode) of the participants in the Norwegian *VoT* study answered lexicographic. The factors the respondents have sorted after vary considerably between modes.

When using the respondents' valuations from the TP technique, it is concluded that the lexicographic answers in a stated preference study are mainly caused by the actual preferences of the respondents.

Consistency in choice

In order to test for the respondent's consistency in choice, one has to assume that the respondents have a given preference structure and that the choice is based on rational decisions as defined within consumer theory.

In total for the whole material (when respondents with lexicographic answers are removed from the sample) between 20 and 39 per cent of the respondents have answered in a way that makes all the choices mutually consistent.

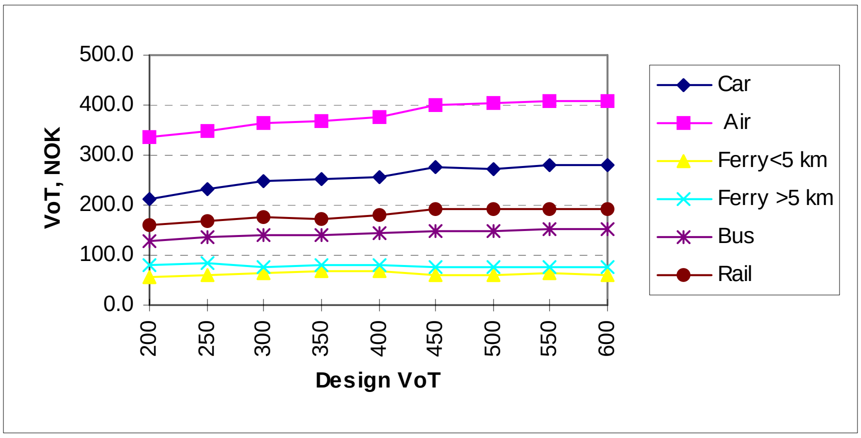
Inconsistent choices (could) result in higher *VoT* in a SP analysis. The analysis of data from TP technique shows that this cannot be explained by the differences in the preferences of the respondents. Consequently this must be the result of a complex choice situation that has created problems for the respondents.

The results show that for both games in the value of time study, the existence of inconsistent choices is largest in the beginning of the choice sequence and decreasing after that. This implies that the respondents may need some training to make these kind of conjoint decisions, but that they did not get tired due to all the choices they were faced with in this study.

Design *VoT*

The designs of SP games are based on a pre-assumed range of *VoT*. Figure 6.1 shows the results from a sensitivity analysis to evaluate how the design *VoT* effects the estimated *VoT*. The result presented in this figure is based on SP data collected for travel purpose business in the second wave as an example.

Figure 6.1 Relationship between the design *VoT* and the estimated *VoT*, long distance business travel



See models:2gb200, 2gb250, 2gb250, 2gb350, 2gb400, 2gb450, 2gb500, 2gb550, 2gb600

The evaluation of Figure 6.1 shows that the design *VoT* has been appropriate, and with a design *VoT* of greater than 450 NOK/hour, the estimated *VoT*'s will not change.

Dominant alternative

We explained earlier that a fractional factorial design was used in the design of the SP games. Furthermore the dominant alternatives were excluded from the choice set. The choices among dominant alternatives were later simulated and included in the data.

Figures 6.2, 6.3, and 6.4 show how the estimated *VoT* and the t-values for time and cost coefficients change with the change of the share of simulated data (on the choice among dominant alternatives) for travel modes car, air and rail for inter-urban travel and private travel purposes.

The evaluation of these figures suggests that estimated *VoT* does not change much with an increase in the share of simulated data. One exception is car for which the *VoT* decreases from about 84 NOK/hours with no simulated data to 76 NOK/hours with 22.2% simulated data. However, as these figures show the t-values increase with the increase in the share of simulated data. In fact the increase is most significant for car. What we have not presented in these figures is the correlation between time and cost coefficients that decreases with increase in the share of simulated data. All the changes in t-values and the correlation coefficients produce the highest t-values for *VoT* with 15-19% of the simulated data depending on the travel mode. Bradley (1990) reports similar finding on the effect of inclusion of data on choice among dominant alternative.

Figure 6.2 Evaluation of dominant choices, mode car, long distance private travel

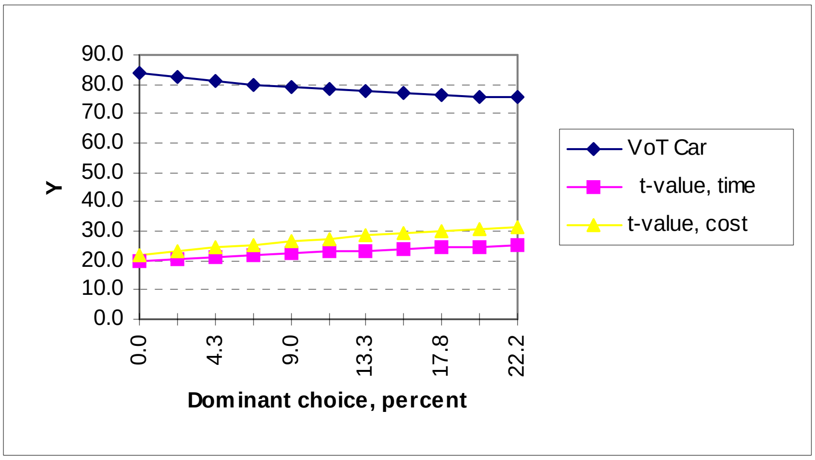


Figure 6.3 Evaluation of dominant choices, air, long distance private travel

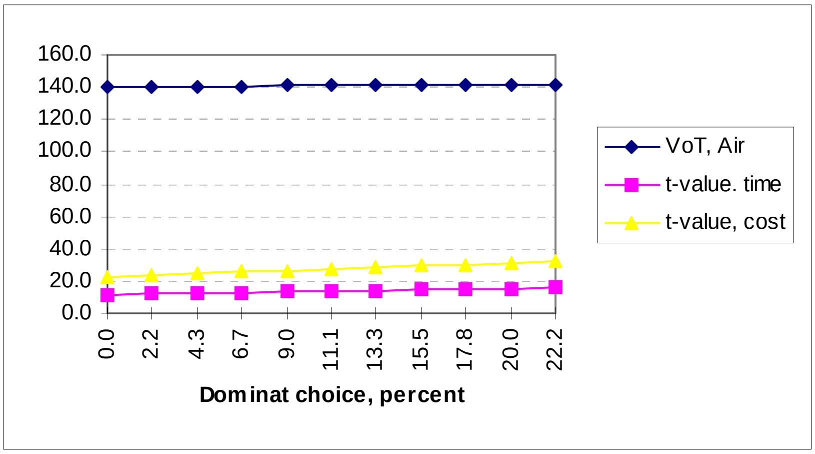
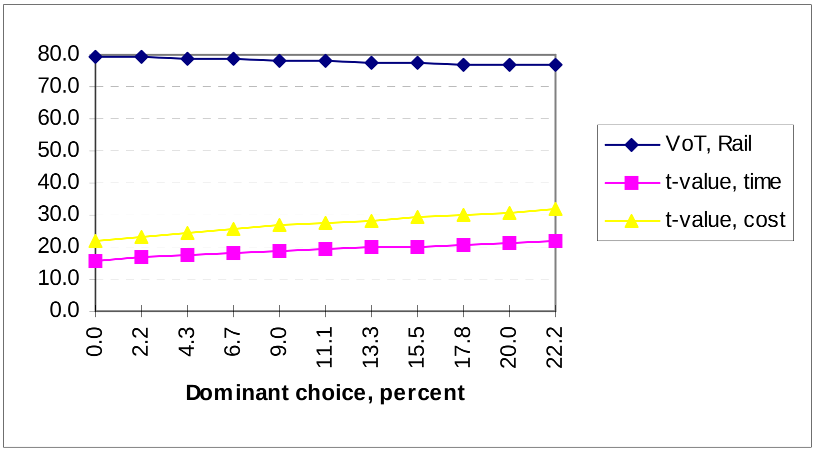


Figure 6.4 Evaluation of dominant choices, Rail, long distance private travel



See models: 2GP, D01, D10, DFLD

7 TP Design

The SP games were followed by Transfer Price (TP) questions. In this part the respondents were asked to state their willingness to pay (*WtP*) for specific improvements (decrease in travel time, no transfer, reduction in headway) or willingness accept (*WtA*) (a decrease in travel cost) for an increase in travel time. The TP questions were the following:

- *WtP* for a decrease in travel time by 25%
- *WtP* for a decrease in travel time by 10% (only in wave 2)
- *WtA* for an increase in travel time by 25%
- *WtP* for not having any transfer (for those who had any)
- *WtP* for a 50% reduction in headway
- Willingness to pay for a package that includes all the improvements (decrease in travel time, no transfer and decrease in headway). The respondents are asked to indicate how much of this sum is related to the decrease in travel time.

Before the TP questions some of the respondents were reminded of their budget constraint. The budget constraint was presented as follows:

- One fourth of the respondents was given a reminder that they should consider all other possible transport improvements when they state their willingness to pay.
- One fourth of the respondents was given a reminder that they should think of all other possible transport improvements and services and goods other than transport when they state their willingness to pay.

For short distance travel, the TP questions were exactly the same as for inter-city travel. However, after these questions, the respondents were asked to state their *WtP* for environmental improvements (decrease in air pollution) and reducing risk of accident on road as well as a package of measures comprising time reduction, environmental improvements and reduced risk of accident. The additional data related to *WtP* for environmental improvements, and reduced accident rates will be evaluated as a part of another research project.

8 Field Work

8.1 Long distance travel

To capture the effects of the time of the year with respect to road surface condition, wave one was conducted in March-April 1995 and Wave 2 in carried out in September 1995. The geographical coverage of the study for different travel modes is presented in Figures 5.2 to 5.6.

Home survey and on-board survey were used in this study. Socio-economic data of the respondents and their households and specific data connected with business travel were collected in the survey. Computer was used for conducting the surveys. Surveys for travel modes car and air were conducted at home while surveys for modes rail and bus were conducted on board. For mode ferry both on board and home surveys were used. Table 8.1 shows an overview of the recruitment and survey methods.

Table 8.1 Overview of the method of recruitment and survey method

	No. of interview				
	1 wave	*2 wave*	*Total*	*Recruited*	*Interviewed*
Air	295	334	629	At airport/board	Home
Rail	463	363	826	On board	On board
Bus	264	251	515	On board	On board
Ferry	261	228	489	On board	On board/Home
Car	510	435	946	Phone	Home
Total	1793	1611	3404		

Table 8.2 shows an overview of the response rates. The response rate for travel mode air was lower than for car. The main reason for this was that those who were recruited for interview were not at home at the scheduled time or they had called to cancel the interview. This was in general a main reason for non-response in interviews at home. It should, however, be pointed out that GALLUP had not kept a record of contacts made for recruitment for travel modes air, car and ferry to be interviewed at home.

Table 8.2 Overview of the response rate

	Response rate, percent	
	1 wave	*2 wave*
Air	73.2	71.5
Rail	81.8	75.2
Bus	80.4	77.4
Ferry	88.6	74.8
Car	79.6	78.5

8.2 Short distance travel

Table 8.3 shows an overview of the different studies that were used for urban *VoT*'s. In previous chapters these studies are described. The dates in this table refer to the year data was collected.

Table 8.3 Overview of studies used for urban *VoT*

Study	*No. of interview*	*No. of choices*	*No. of games*	*Age of respondents*
Value of Time (1996)	1156	9	2	18+
Bus Passenger Preferences (1994)	1009	9	1	16+
Assessing Environmental Benefits (1993)	1691	4	1	18+
A new Initiative in Public Transport (1993)	403	7	1	16+

Table 8.4 shows the response rate in the *VoT* study for urban travel that was conducted in 1996. Tables 8.5, 8.6 and 8.7 show the response rate in Bus Passenger Preferences (Kjørstad, 1995), A new Initiative in Public Transport (Kjørstad, Norheim and Renolen, 1994) and Assessing Environmental Benefits (Sælensminde and Hammer, 1994).

Table 8.4 Response rate, *VoT* study (1996)

	No.	*%*
Total no of calls	16539	100
Refused to answer	1949	12
Not in the target group	9182	56
Tel. no. Not in use	1185	7
Interviewed by phone	3962	24
Selected for interview	1326	100
Refused home interview	28	2
Were not available	112	8
Other reasons	30	3
Interviewed	1156	87

Table 8.5 Response rate, Bus Passenger Preferences (Kjørstad, 1995)

	No.	*%*
Total no of calls	10992	100
Refused to answer	666	6
Interviewed by phone	2793	25
Not in the target group	7533	69
In the target group		
Made at least 1 trip per month	2610	100
Refused home interview	1364	52
Were not available	237	9
Interviewed	1009	39

Table 8.6 Response rate, A new Initiative in Public Transport (Kjørstad, et al., 1994)

	No.	*%*
Total no of calls	4483	100
Refused to answer	180	4
Interviewed by phone	1288	29
Not in the target group	2846	63
In the target group		
Made at least 1 trip per month	1120	100
Refused home interview	584	52
Were not available	133	12
Interviewed	403	36

Table 8.7 Response rate, Assessing Environmental Benefits (Sælensminde and Hammer, 1994)

	No.	*%*
Total no of calls	5150	100
Refused to answer	1390	27
Refused home interview	1595	31
Were not available	565	11
Interviewed	1600	31

9 Descriptive analysis of data

Appendix II shows the description of data used in the *VoT* study for inter-urban and urban travel. Here we present the description of these data according to travel purpose, travel distance and income.

9.1 Long distance travel

Table 9.1 shows the distribution of travel distance by different inter-urban travel modes. For travel with car the travel distance is not representative. This is because the recruitment was done so that it ensured enough respondents with different travel distances in the sample. The travel distance for ferry refers to the total travel distance from origin to destination, rather than travel distance on ferry. The average travel distance by this mode is shorter than other modes. This table shows an average travel distance by air that is by far longer than other scheduled travel modes.

Table 9.1 Distribution of respondents by travel distance and inter-urban travel modes

Mode	*Car*		*Air*		*Ferry*		*Bus*		*Rail*	
Distance, km	Count	%	Count	%	Count	%	Count	%	Count	%
Under 20		0.0		0.0	15	3.1		0.0		0.0
21-40	68	7.3		0.0	30	6.1	9	1.8	25	3.0
41-60	70	7.5	3	0.5	35	7.2	21	4.1	65	7.9
61-100	150	16.0	4	0.6	108	22.1	51	9.9	121	14.7
101-150	163	17.4	16	2.6	71	14.5	138	26.8	160	19.4
151-300	244	26.1	101	16.3	128	26.2	206	40.1	118	14.3
301-500	161	17.2	154	24.9	66	13.5	76	14.8	154	18.7
501-700	65	6.9	221	35.8	18	3.7	8	1.6	132	16.0
over 700	15	1.6	119	19.3	17	3.5	5	1.0	48	5.8
Total	936	100.0	618	100.0	488	100.0	514	100.0	823	100.0

Table 9.2 shows the distribution of respondents by travel purpose and inter-urban travel modes. As expected it was much simpler to recruit business travellers by air than by other travel modes. It was rather difficult to recruit business travellers by bus.

Table 9.3 shows the distribution of respondents by private travel purposes and inter-urban travel modes. This table shows that recreation and private visit are the dominant private travel purposes. Commuting, unlike urban travel, is not a main travel purpose in inter-urban travel; however, it is quite significant by rail.

Table 9.4 shows the distribution of respondents by business travel purposes and inter-urban travel modes. This table suggests that the main business travel purposes are customer visits, meetings and conferences for all travel modes except for rail. For rail the main business travel purposes are exhibitions and work in local offices, however, customer visit and meetings are also important.

Table 9.2 Distribution of respondents by travel purpose and inter-urban travel modes

Mode	*Car*		*Air*		*Ferry*		*Bus*		*Rail*	
Purpose	Count	%	Count	%	Count	%	Count	%	Count	%
Private	733	78.3	257	41.2	286	58.5	442	85.8	678	82.1
Business	203	21.7	367	58.8	203	41.5	73	14.2	148	17.9
Total	936	100.0	624	100.0	489	100.0	515	100.0	826	100.0

Table 9.3 Distribution of respondents by private travel purposes and inter-urban travel modes

Mode	*Car*		*Air*		*Ferry*		*Bus*		*Rail*	
Purpose	Count	%	Count	%	Count	%	Count	%	Count	%
Commuting	18	2.5	15	5.8	26	9.1	51	11.5	124	18.3
School	11	1.5	8	3.1	16	5.6	56	12.7	48	7.1
Daily shopping		0.0		0.0		0.0	1	0.2	3	0.4
Other shopping	21	2.9		0.0	9	3.1	1	0.2	17	2.5
Private business	54	7.4	10	3.9	40	14.0	17	3.8	30	4.4
Recreation	264	36.0	39	15.2	65	22.7	65	14.7	74	10.9
Private visit	283	38.6	148	57.6	107	37.4	219	49.5	282	41.6
Accompanying	16	2.2	6	2.3	9	3.1	3	0.7	17	2.5
Other purposes	66	9.0	31	12.1	14	4.9	29	6.6	83	12.2
Total	733	100.0	257	100.0	286	100.0	442	100.0	678	100.0

Table 9.4 Distribution of respondents by business travel purposes and inter-urban travel modes

Mode	*Car*		*Air*		*Ferry*		*Bus*		*Rail*	
Purpose	Count	%	Count	%	Count	%	Count	%	Count	%
Conference, etc.	37	18.2	94	25.6	24	11.8	32	43.8	1	1.0
Exhibition, etc.	1	0.5	7	1.9		0.0		0.0	52	44.1
Study tour	2	1.0	8	2.2	3	1.5	2	2.7	5	4.2
Customer visit	55	27.1	45	12.3	83	40.9	6	8.2	10	8.4
Meeting	41	20.2	145	39.5	39	19.2	11	15.1	10	8.4
Work, local office	18	8.9	23	6.3	14	6.9	5	6.8	33	28.0
Others	49	24.1	45	12.3	40	19.7	17	23.3	7	5.9
Total	203	100.0	367	100.0	203	100.0	73	100.0	118	100.0

Table 9.5 shows the distribution of respondents by personal income and inter-urban travel modes for private travel. This table suggests that the average income of inter-urban travellers for private purposes by modes car and air is higher than bus and rail. Table 9.6 shows the distribution of respondents by income and inter-urban travel modes for business travel. This table shows similar pattern between income and travel mode as for private travel.

Table 9.5 Distribution of respondents by income and inter-urban travel modes, private travel

Mode	*Car*		*Air*		*Ferry*		*Bus*		*Rail*	
Income in NOK 1000	Count	%	Count	%	Count	%	Count	%	Count	%
Missing	3	0.4	1	0.4	12	4.2	25	5.7	20	2.9
<20	26	3.5	22	8.6	20	7.0	95	21.5	104	15.3
20-100	76	10.4	47	18.3	38	13.3	129	29.2	163	24.0
100-150	76	10.4	21	8.2	38	13.3	53	12.0	78	11.5
150-200	130	17.7	36	14.0	45	15.7	50	11.3	105	15.5
200-250	182	24.8	53	20.6	57	19.9	47	10.6	105	15.5
250-300	82	11.2	26	10.1	35	12.2	20	4.5	42	6.2
300-400	96	13.1	30	11.7	25	8.7	12	2.7	43	6.3
400-500	39	5.3	10	3.9	8	2.8	4	0.9	13	1.9
500+	23	3.1	11	4.3	8	2.8	7	1.6	5	0.7
Total	733	100.0	257	100.0	286	100.0	442	100.0	678	100.0

Table 9.6 Distribution of respondents by income and inter-urban travel modes, business travel

Mode	*Car*		*Air*		*Ferry*		*Bus*		*Rail*	
Income in NOK 1000	Count	%	Count	%	Count	%	Count	%	Count	%
Missing	5	2.5	5	1.4	12	5.9	4	5.5	4	2.7
<20	5	2.5	1	0.3	3	1.5	6	8.2	11	7.4
20-100	6	3.0	11	3.0	12	5.9	6	8.2	14	9.5
100-150	11	5.4	7	1.9	3	1.5	5	6.8	5	3.4
150-200	18	8.9	17	4.6	20	9.9	12	16.4	7	4.7
200-250	45	22.2	60	16.3	44	21.7	21	28.8	34	23.0
250-300	39	19.2	56	15.3	39	19.2	8	11.0	19	12.8
300-400	46	22.7	108	29.4	36	17.7	6	8.2	32	21.6
400-500	17	8.4	65	17.7	20	9.9	3	4.1	10	6.8
500+	11	5.4	37	10.1	14	6.9	2	2.7	12	8.1
Total	203	100.0	367	100.0	203	100.0	73	100.0	148	100.0

9.2 Short distance travel

Table 9.7 shows the distribution of respondents by travel distance and urban travel modes. This table shows that most trips by urban travel modes are less than 10 kilometres except for rail. The majority of trips with rail are over 20 kilometres.

Table 9.7 Distribution of respondents by travel distance and urban travel modes

	Car		*Subway*		*Tram*		*Bus*		*Rail*	
Distance	Count	%	Count	%	Count	%	Count	%	Count	%
2-4 km	350	23.4	40	19.8	47	54.7	163	33.5	2	1.4
5-7 km	305	20.4	65	32.2	26	30.2	124	25.5	6	4.1
8-10 km	237	15.9	61	30.2	9	10.5	85	17.5	14	9.5
11-13 km	94	6.3	12	5.9	2	2.3	28	5.7	11	7.5
14-16 km	123	8.2	12	5.9	1	1.2	24	4.9	20	13.6
17-19 km	34	2.3	0	0.0	0	0.0	9	1.8	7	4.8
20-29 km	150	10.0	10	5.0	1	1.2	32	6.6	49	33.3
30-39 km	82	5.5	2	1.0	0	0.0	11	2.3	17	11.6
40km and over	118	7.9	0	0.0	0	0.0	11	2.3	21	14.3
Total	1493	100.0	202	100.0	86	100.0	487	100.0	147	100.0

Table 9.8 shows the distribution of respondents by travel purpose and urban travel modes. For business, travellers use mainly car in urban area. It was not simple to recruit business travellers by subway, tram and bus.

Tables 9.9 shows the distribution of respondents by private travel purposes and urban travel modes. This table shows that commuting is the dominant private travel purposes in urban areas. Other important travel purposes are daily shopping, recreation and private visit.

Table 9.10 shows the distribution of respondents by business travel purposes and urban travel modes. This table suggests that the main business travel purposes in urban areas is customer visits. Attending meetings is also an impotent business travel purpose.

Table 9.8 Distribution of respondents by travel purpose by urban travel modes

	Car		*Subway*		*Tram*		*Bus*		*Rail*	
Purpose	Count	%	Count	%	Count	%	Count	%	Count	%
Private	1407	91.1	207	100	89	98.9	1743	98.5	254	96.2
Business	138	8.9	0	0	1	1.1	27	1.5	10	3.8
Total	1545	100.0	207	100	90	100.0	1770	100.0	264	100.0

Table 9.9 Distribution of respondents by private travel purposes and urban travel modes

	Car		*Subway*		*Tram*		*Bus*		*Rail*	
Private purpose	Count	%	Count	%	Count	%	Count	%	Count	%
Commuting	541	38.5	80	38.6	28	31.5	640	36.9	149	58.7
School	34	2.4	16	7.7	8	9.0	264	15.2	31	12.2
Daily shopping	231	16.4	26	12.6	18	20.2	117	6.7	7	2.8
Other shopping	31	2.2	2	1.0	1	1.1	110	6.3	1	0.4
Private business	105	7.5	11	5.3	6	6.7	277	16.0	14	5.5
Recreation	171	12.2	33	15.9	17	19.1	134	7.7	29	11.4
Private visit	165	11.7	31	15.0	9	10.1	135	7.8	18	7.1
Accompanying	95	6.8	4	1.9	1	1.1	10	0.6	0	0.0
Other purposes	34	2.4	4	1.9	1	1.1	48	2.8	5	2.0
Total	1407	100.0	207	100.0	89	100.0	1735	100.0	254	100.0

Table 9.10 Distribution of respondents by business travel purposes and urban travel modes

	Car		*Subway*		*Tram*		*Bus*		*Rail*	
Business purpose	Count	%	Count	%	Count	%	Count	%	Count	%
Conference, etc.	7	5.1			0	0	3	11.5	1	10.0
Study tour	3	2.2			0	0	1	3.8	0	0.0
Customer visit	49	35.5			1	100	2	7.7	0	0.0
Meeting	20	14.5			0	0	5	19.2	2	20.0
Work, local office	12	8.7			0	0	0	0.0	0	0.0
Others	47	34.1			0	0	15	57.7	7	70.0
Total	138	100.0			1	100.0	26	100.0	10	100.0

Table 9.11 shows the distribution of respondents by personal income and urban travel modes for private travel. This table suggests that the average income for private travellers is higher for car divers than for public transport.

Table 9.12 shows the distribution of respondents by personal income and urban travel purposes for business travel. The comparison of this table with table 9.11 suggests that for car travel, business travellers have higher income than travel for private purposes.

Table 9.11 Distribution of respondents by income and urban travel modes, private travel

	Car		*Subway*		*Tram*		*Bus*		*Rail*	
1000 NOK	Count	%	Count	%	Count	%	Count	%	Count	%
0-49	92	6.6	34	16.9	13	14.8	78	16.6	14	10.2
50-99	117	8.4	19	9.5	6	6.8	93	19.8	16	11.7
100-149	153	11.0	27	13.4	16	18.2	62	13.2	18	13.1
150-199	234	16.8	46	22.9	15	17.0	92	19.6	18	13.1
200-249	339	24.3	40	19.9	23	26.1	82	17.5	26	19.0
250-299	169	12.1	22	10.9	9	10.2	26	5.5	22	16.1
300-399	172	12.3	12	6.0	2	2.3	23	4.9	17	12.4
400-499	60	4.3	1	0.5	2	2.3	8	1.7	5	3.6
500 and more	57	4.1	0	0.0	2	2.3	5	1.1	1	0.7
Total	1393	100.0	201	100.0	88	100.0	469	100.0	137	100.0

Table 9.12 Distribution of respondents by income and urban travel modes, business travel

	Car		*Subway*		*Tram*		*Bus*		*Rail*	
1000 NOK	Count	%	Count	%	Count	%	Count	%	Count	%
0-49	6	4.3								
50-99	2	1.4								
100-149	6	4.3					2	16.7		
150-199	17	12.3					3	25.0	1	25.0
200-249	32	23.2					3	25.0		
250-299	29	21.0			1	100	2	16.7		
300-399	26	18.8					2	16.7	3	75.0
400-499	13	9.4								
500 and more	7	5.1								
Total	138	100.0			1	100	12	100.0	4	100.0

10 Results from SP study, private travel

The data for inter-urban private travel was analysed separately for the first wave, the second wave and then the total using different types of segmentation. For urban study the data from different studies were merged and analysed again using the different types of segmentations. Two paired choices among dominant alternatives were later simulated for each respondent and included in the data. The evaluation of the inclusion of the dominant alternatives was presented earlier under chapter 6.3.

For estimation with data from different sources a scaling procedure been used (Bradley and Daly, 1991). This procedure allows for the variances of the random components in the utility function to vary between the different data sets. For long distance travel data, from wave 1 and 2 are treated as two different data sources. For short distance travel data from four different sources have been used. In the modelling we have allowed for the scale parameters to vary in the utilities of different travel modes.

The types of segmentation are similar to those used in the Swedish *VoT* study (Algers, et al., 1995). The utility function of mode m is defined as follow

$$V_{im} = b_m \cdot C_{im} + \sum_t b_{tm} \cdot T_{imt} \qquad (17)$$

Where

V_{im} utility of alternative *i* for mode *m*
b_m parameter for cost for mode *m*
C_{im} cost of alternative *i* for mode *m*
b_{tm} parameter for time component *t* for mode *m*
T_{imt} time component *t* of alternative *i* for mode *m*

It should be emphasised that *VoT* derived from the estimates of cost and time parameters reflects the “subjective *VoT*” of the travellers and is equal to the amount she is prepared to pay to decrease travel time for use in an alternative activity such as leisure or work, etc.

10.1 Long distance travel

The Swedish *VoT* study (Algers, et al., 1995) shows that the *VoT* for short distance travel (less than 50 kilometres) are significantly lower than *VoT* for long distance travel. Algers et al., (1995) suggest various possible explanations. The differences can in fact represents the behavioural differences related to inter-urban and urban travel. The differences could also be explained by the fact that time savings as the same percentage of trip time for short distance travel is smaller than for long distance travel and smaller time savings could be valued less. Different evidence in the Swedish *VoT* supports that behavioural differences between inter-urban and urban travel is a more likely explanation.

A similar pattern is present in the Norwegian *VoT* study. The *VoT* for inter-urban travel is higher than *VoT* for urban travel. Different evidence points to behavioural differences in inter-urban travel and urban travel to explain the differences. As we show later, *VoT*'s for all travel modes decrease with distance for inter-urban travel, while for urban travel *VoT*'s increases with distance. The overall picture is that *VoT* increases with travel distance and after a threshold it decreases with distance. We will come back to this issue later.

Tables 10.1 show the *VoT*, in NOK/hr, for private travel. Note that the *VoT*'s for trips less than 50 kilometres are quite close to the corresponding travel modes in urban travel (compare with Table 10.11). It is appropriate to point out that the average industrial wage in Norway in 1995 was about 108 NOK/hr.

Table 10.1 Value of time for private inter-urban travel, NOK/hr

	Car	*Ferry*	*Rail*	*Bus*	*Air*
Trips < 50 km					
In vehicle time	38	71	54	31	120
Headway	-	30	16	1	45
Delay			6		
Trips> 50 km					
In vehicle time	86	75	54	48	163
95 confidence interval	±10	±13	±7	±8	±25
Headway	-	32	7	3	18
Delay			0		

See model SS2GP in Appendix III

Delay was only included as an attribute for travel mode rail. Our evaluation is that this attribute has not worked well for long distance travel. In the Swedish *VoT* study delay is only used as an attribute for long distance travel by rail. The value for delay is reported to be approximately 50% more than in-vehicle time.

The valuations of headway times are much lower than what would have been the expectation based on evidence from urban travel, except for ferry. The Swedish *VoT* study shows similar results. We will come back to this issue later.

Transfer was not used as an attribute in the Norwegian *VoT*. Transfer has actually two dimensions; number of transfers and transfer time. In the context of long distance travel, there might not be very many trips that require more than one transfer. However, transfer time is quite important. We recommend the *VoT* for transfer from the Swedish *VoT* study. The Swedish study reports the transfer *VoT* to be 40 percent to 140 percent higher than in-vehicle *VoT*. This study suggests that relative transfer *VoT* to in-vehicle *VoT* to be lowest for air and highest for rail and regional bus.

10.1.1 Headway time values

The Swedish study shows that the relative value *VoT* for headway decreases as headway increases. This is in accord to previous findings. The explanation is the greater possibility of utilisation of an extra minute of headway for longer headway. For the estimation of *VoT* for headway, the Swedish *VoT* study (Algers, et al., 1995) uses the following piecewise linear expression:

$$V_{im} = \ldots + b_{h1m} * \min(H_{im}, A) + b_{h2m} * \min(H_{im} - A, B - A | H_{im} > A) + b_{h3m} * (H_{im} - B | H_{im} > B) \quad (18)$$

Where

V_{im} utility of alternative i for mode m

b_{h1m} headway parameter of mode m, for the part less than A minutes

b_{h2m} headway parameter of mode m, for the part between A and B minutes

b_{h3m} headway parameter of mode m, for the part over B minutes

H_{im} headway of alternative i for mode m

The Swedish study reports that the headway *VoT's* for inter-urban travel are considerably lower than the conventional values. The conventional weight for valuing waiting time (twice the headway time) relative to in-vehicle time of about 2 is based on empirical studies of urban travel. Similar results are found in the Norwegian *VoT* study (see Table 10.1). The headway *VoT* relative to in-vehicle *VoT* is especially low for trips longer than 50 kilometres, with the exception of ferry. Algers et al., (1995) question whether the derived headway *VoT* in a SP study reflects the true value. They suggest that "Utilising a higher frequency implies that the respondent would think of using another departure, and if, by instructions, the respondents relate too close to the trip actually made, they would not be able to do so." This should be especially true in the context on inter-urban travel, where a passenger is only interested in a particular departure time, rather than frequency of service.

Table 10.2 shows the headway *VoT* for different headway intervals. This table shows that the relative headway *VoT* decreases as headway increases.

Table 10.3 shows the variation of headway *VoT* with headway interval and income for ferry. The examination of this table is of particular interest for ferry. These results are presented in Figure 10.1 and shows that the relative headway *VoT* decreases sharply after a headway interval of 30 minutes. However, the decrease is relatively less for longer headway intervals.

Table 10.2 Headway *VoT* in NOK/hr and headway interval, long distance travel

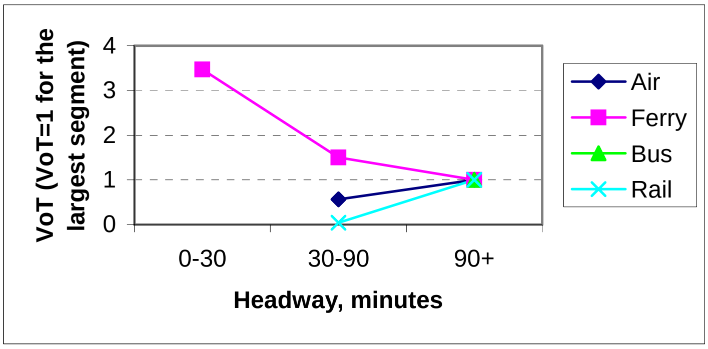
Headway interval, min	*Ferry*	*Rail*	*Bus*	*Air*
0-60	46	5	-	22
60-120	15	5	14	16
120+	19	7	3	16

Table 10.3 Distribution of headway *VoT* (NOK/hr) by headway interval and income for ferry, long distance travel

Income *Headway, minutes*	*0-100*	*101-200*	*201-300*	*301-400*	*400+*
<30	84	98	124	136	180
30-90	36	43	54	59	78
90+	24	28	36	39	52

See model 2GPF in Appendix III

Figure 10.1 Headway time value and headway interval, long distance travel



See model 2GPF in Appendix III

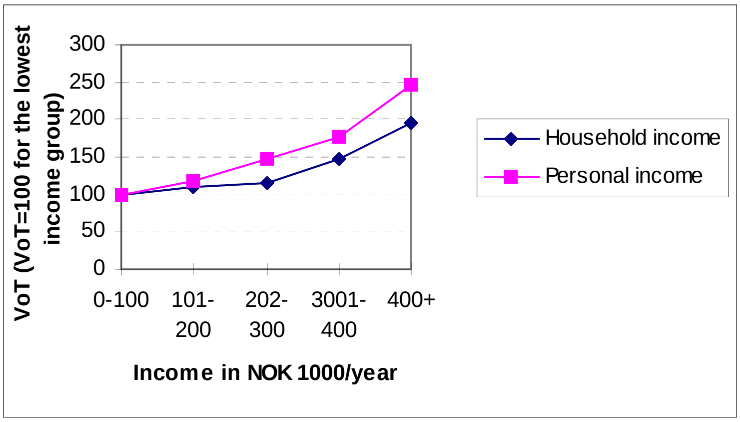
10.1.2 Value of time and income

The relationship between *VoT* and income is important for different reasons. A main issue is, of course, the equity aspect. Another issue is related to the adjustment of *VoT* for future economic growth.

As explained earlier, the two parameters that are relevant for the estimation of *VoT* are the marginal utility of cost (which by construct is equal to the marginal utility of income with a negative sign) and the marginal utility of time. Economic theory suggests that marginal utility of income decreases with income. On the other hand, it is possible that the marginal utility of time increases with income, since higher income might imply higher restrictions on time. A higher marginal utility of time and a lower marginal utility of income result in a higher *VoT*. Income is however, a difficult variable to measure. It is difficult to compare the relationship between *VoT* and the reported income between countries. This is due to the differences in allowances, taxation systems, social security systems, etc., between countries. Furthermore it is only possible to speculate if a particular behaviour is in response to the personal income or to the household income.

In the Norwegian *VoT* study data on gross (before tax) personal and household income were collected. Figure 10.2 shows the relationship between the *VoT* and personal and household incomes. Table 10.4 shows the same relation. This figure shows that *VoT* increases with both personal and household incomes, however, not in a proportional manner. Nevertheless, it is worthwhile to notice that *VoT* increases more with income in the context of inter-urban travel than urban travel (see section 10.2.2).

Figure 10.2 Variations in *VoT* for private long distance travel with household and personal incomes



See model 2GHI and 2GPI in Appendix III

We did not calculate the income elasticity of the *VoT*, since the data used in the Norwegian *VoT* study can not be considered representative. For the calculation of the income elasticity of *VoT* we would need to correctly weight the sample.

Table 10.4 *VoT* (in NOK/hr) for private long distance travel and household and personal income

Income, 1000/year	*0-100*	*101-200*	*201-300*	*301-400*	*400+*
			Car		
Household-income	62	67	71	92	120
Personal income	64	76	94	113	158
			Air		
Household-income	99	108	115	147	193
Personal income	125	149	183	222	310
			Ferry		
Household-income	55	60	64	82	107
Personal income	59	70	86	104	145
			Bus		
Household-income	37	41	43	55	73
Personal income	44	52	64	78	108
			Rail		
Household-income	34	37	39	50	66
Personal income	44	52	64	77	108

See models 2GHI and 2GPI in Appendix III

In the Swedish *VoT* study (Algers, et al., 1995) household composition were taken into account when looking at household income. Table 10.5 shows the relationship between *VoT* and income for different household compositions. The examination of this table suggests that the relationship between *VoT* and income is more transparent with personal income. This can have different explanations. The obvious one is that personal income is more consequential for determining behaviour in the context of long distance travel.

Table 10.5 *VoT* for different income groups, NOK/hr

Income	*Personal/Household*		*Personal*		*Household*	
Range, 1000 NOK/year	1 employed without children	1 employed with children	2 employed without children	2 employed with children	2 employed without children	2 employed with children
0-100	100	100	100	100	100	100
101-200	118	115	119	121	253	292
201-300	151	224	123	121	88	107
301-400	121	161	173	171	-	-
401-	300	250	233	203	525	372

10.1.3 Value of time and distance

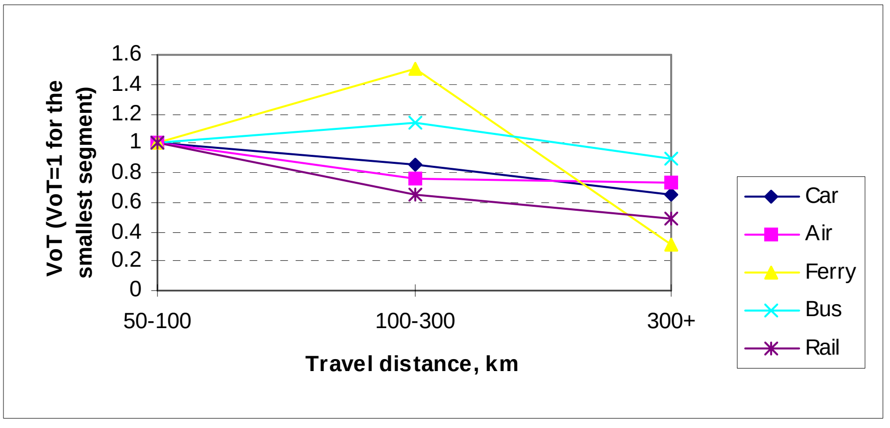
Trip duration and distance are quite correlated, except for travel by air. In the context of inter-urban travel we feel that there are different counteracting factors that contributes to the variation of *VoT* with distance. Obviously the further the destination from the origin, the higher is the individual's utility from the activity at that destination, otherwise she would have chosen a closer destination at less time and cost. HCG (1990) provides a theoretical framework under which *VoT* increases with the distance of destination from origin.

However, as travel distance increases, the scope of activities which can be undertaken during the journey and probably the perception of comfort change. There are differences in transport services that depend on travel distance. As an example for inter-urban travel with car, the proportion of driving on higher quality roads increases with travel distance. The differences in transport services that depend on travel distance are present in other modes of travel, i.e., air, rail and bus. Furthermore time constraint for shorter inter-urban trips could be more binding. Shorter inter-urban trip allows for the scheduling of outbound and inbound trips on the same day or the scheduling of an activity on the same day as inbound or outbound trip.

The results from the Swedish *VoT* study shows that journeys of less than 100 kilometres have in general lower *VoT* than longer journeys. Also *VoT* is lower for trips of 100-300 kilometres than trips over 300 kilometres for inter-city and high-speed rail. For other travel modes, i.e., car, regional rail and bus, *VoT* increases with distance, yet the increase decreases with distance.

Some of these results are also evident in the Norwegian *VoT* study. The *VoT* for urban trips are substantially lower than for longer inter-urban trips. However, the *VoT* decreases with travel distance after a certain threshold. Table 10.6 shows changes in *VoT* with trip distance. Table 10.7 shows distribution of *VoT* by trip distance and income. Figure 10.3 shows the changes in *VoT* with travel distance.

Figure 10.3 Changes in *VoT* for private long distance travel with trip distance



See model 2GPD in Appendix III

Table 10.6 *VoT* (in NOK/hr) for private long distance travel and trip distance

Trip distance, kilometres	*Car*	*Rail*	*Bus*	*Air*
50-100	101	108	51	172
100-300	97	68	53	170
300-	77	50	38	151

Table 10.7 Distribution of *VoT* (in NOK/hour) by trip distance and income

Income, 1000 NOK/year	*0-100*	*101-200*	*201-300*	*301-400*	*400+*
Distance, km			**Car**		
50-100	86	101	128	139	189
100-300	74	86	110	119	161
300+	57	66	84	91	124
			Air		
50-100	173	202	257	279	378
100-300	130	152	194	210	285
300+	126	148	188	203	276
			Ferry		
50-100	61	72	91	99	134
100-300	92	108	137	148	201
300+	19	23	29	31	43
			Bus		
50-100	29	34	43	46	63
100-300	33	39	49	53	72
300+	26	30	39	42	57
			Rail		
50-100	85	100	127	137	186
100-300	55	65	83	89	121
300+	42	49	63	68	92

See model 2GPD in Appendix III

10.1.4 VoT and size of time savings or losses

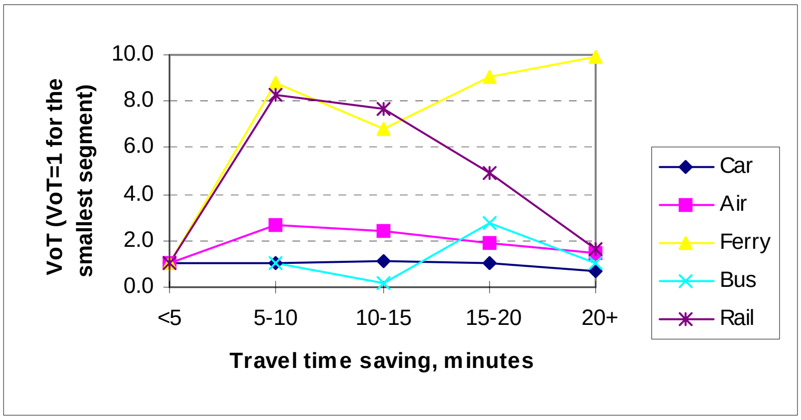
Earlier we briefly described the issues related to the controversies and debates on the valuation of small time savings. Table 10.8 shows the distribution of *VoT* by income and size of travel-time savings or losses. Figure 10.4 shows the changes in *VoT* with size of travel-time savings or losses. This figure suggests that *VoT* to be relatively lower for very small time savings (less than 5 minutes), for the modes rail and ferry. However, this table shows that *VoT* for this segment is not very reliable. This is due to the design of the SP study since very small time savings were deliberately avoided in the design. With the exclusion of *VoT* for the very small time savings (less than 5 minutes), it is not possible to detect any change in *VoT* with the size of time saving.

Table 10.8 *VoT* (NOK/hr) by income and size of travel time savings/losses, private long distance travel

Time saving/loss, Min Income, 1000 NOK/year	<5	5-10	10-15	15-20	20+
			Car		
0-100	94*	95	104	96	64
101-200	110*	111	122	112	75
201-300	138*	139	153	141	94
301-400	152*	154	168	155	104
400+	199*	201	221	203	136
			Air		
0-100	81*	220	194	155	123
101-200	95*	258	228	182	144
201-300	120*	324	286	228	180
301-400	132*	358	316	252	199
400+	173*	468	413	330	261
			Ferry		
0-100	12*	105	82	108	119
101-200	14*	123	96	126	139
201-300	18*	155	120	159	175
301-400	19*	171	133	175	193
400+	25*	223	174	229	252
			Bus		
0-100		28*	5*	79	30
101-200		33*	5*	92	35
201-300		41*	7*	116	44
301-400		46*	7*	128	48
400+		60*	10*	167	63
			Rail		
0-100	27*	225	210	134	44
101-200	32*	264	246	157	51
201-300	40*	331	309	198	64
301-400	44*	365	341	218	71
400+	58*	478	446	286	93

* t-value for coefficient for time parameter not significant, see model 2GPST1in Appendix III

Figure 10.4 Changes in *VoT* with size of time savings/losses

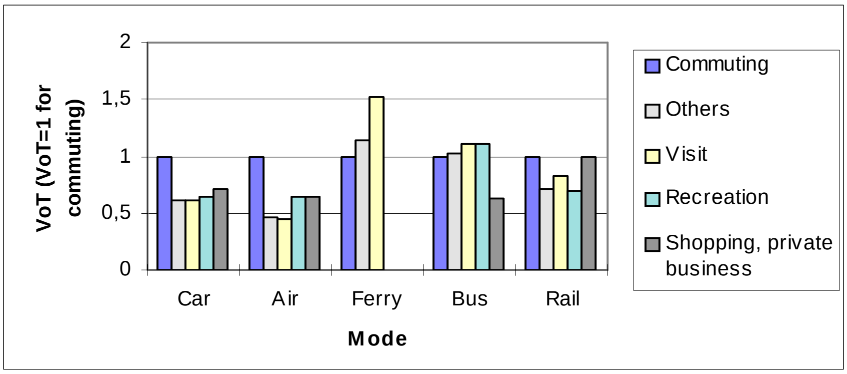


See model 2GPST1 in Appendix III

10.1.5 Value of time and travel purpose

Table 10.9 shows the *VoT* for private travel purposes by travel mode. This table shows that *VoT* is highest by air for all travel purposes. Furthermore *VoT* for commuting is higher than other travel purposes over all modes with a few exceptions. Figure 10.5 shows *VoT* for different travel purposes compared with *VoT* for commuting for each travel mode.

Figure 10.5 *VoT* and private travel purposes



See 2gpiarb, 2gpioth, 2gpioth2 in Appendix III

Table 10.9 Distribution of *VoT* (in NOK/hr) by travel purpose and personal income

Income, 1000/year	*Commuting*	*Others*	*Visit*	*Recreation*	*Shopping, private business, others*
			Car		
0-100	104	63	64	67	74
101-200	103	75	68	72	80
201-300	141	94	93	98	109
301-400	189	108	100	106	117
400+	156	166	182	192	213
			Air		
0-100	258	121	114	166	168
101-200	255	143	122	177	179
201-300	349	179	167	241	245
301-400	468	204	180	261	264
400+	387	315	327	473	480
			Ferry		
0-100	53	60	80		
101-200	52	71	86		
201-300	71	89	117		
301-400	95	102	126		
400+	79	157	229		
			Bus		
0-100	43	44	48	47	27
101-200	42	52	51	50	29
201-300	58	65	69	69	39
301-400	78	75	75	74	43
400+	64	115	136	135	77
			Rail		
0-100	60	43	49	42	59
101-200	59	51	53	45	63
201-300	81	63	72	61	86
301-400	109	72	77	66	93
400+	90	112	140	120	169

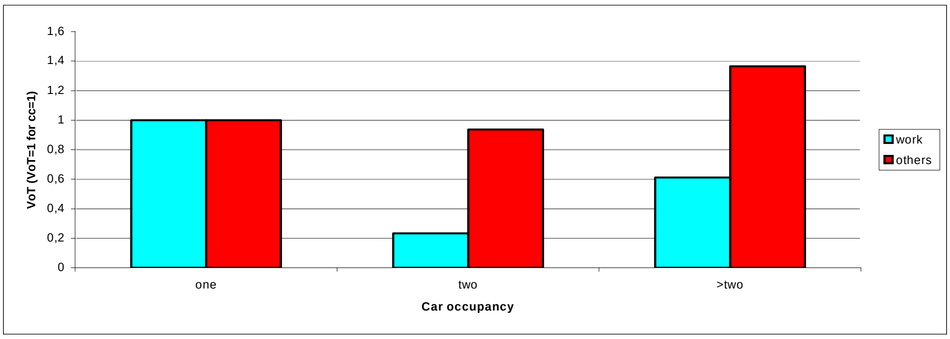
See 2gpiarb**,** 2gpioth, 2gpioth2 in Appendix III

10.1.5 Value of time and car occupancy

Figure 10.6 shows the variation of *VoT* for car driver with car occupancy and travel purpose. This figure shows that *VoT* for car drivers travelling for purpose work decreases with increase in car occupancy. This can be mainly explained by the higher income of the solo drivers who commute to work compared with the other groups. It is also possible that for travel purpose work the diver might enjoy the company of a passenger.

The *VoT* for car drivers for other purposes does not seem to change much with car occupancy. For other travel purposes the *VoT* for car driver decreases with one passenger and increases with more than one passenger. These results suggest that the car driver does not take into account the *VoT* of the passengers.

Figure 10.6 Variation of *VoT* of car driver with car occupancy and travel purpose



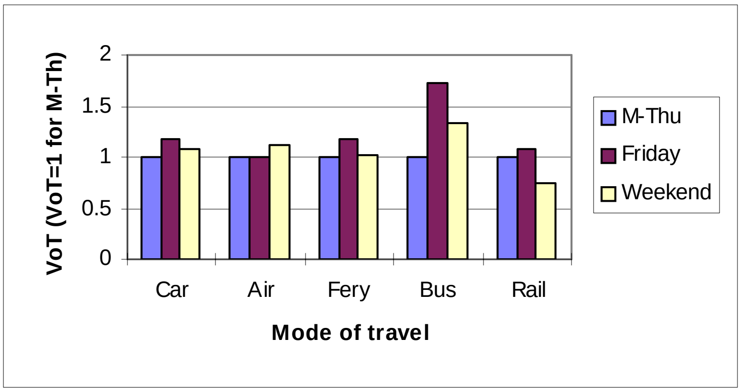
See model 2GPCOA and 2GPCOO in Appendix III

10.1.6 Other Factors

Day of the week

Table 10.7 shows the variation of *VoT* with day of the week. This table shows that *VoT* is higher for trips on Fridays than other days by all travel modes except for air.

Figure 10.7 *VoT* and day of the week

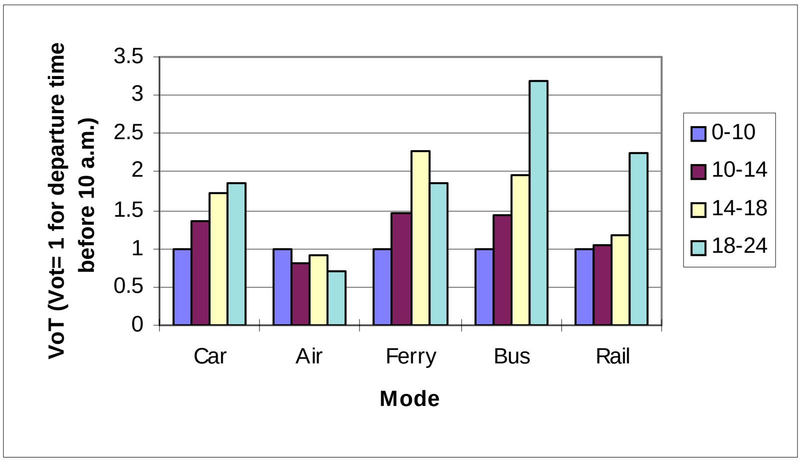


See model 2GPDA in Appendix III

Departure time

Figure 10.8 shows the variation of *VoT* by departure time. This figure shows that journeys with departure time after 18:00 have the highest *VoT* by all travel modes except for air.

Figure 10.8 *VoT* and departure time

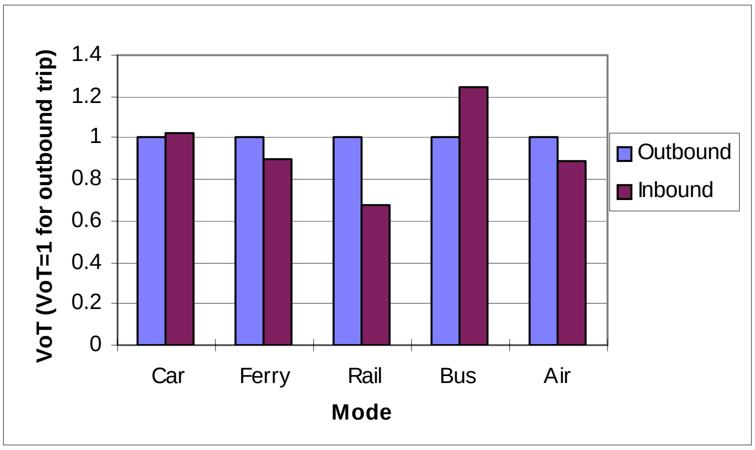


See model 2GPIFT in Appendix III

Direction of trip

Figure 10.9 shows differences in *VoT* for inbound and outbound journeys for different travel modes. The differences are large for private inter-urban travel.

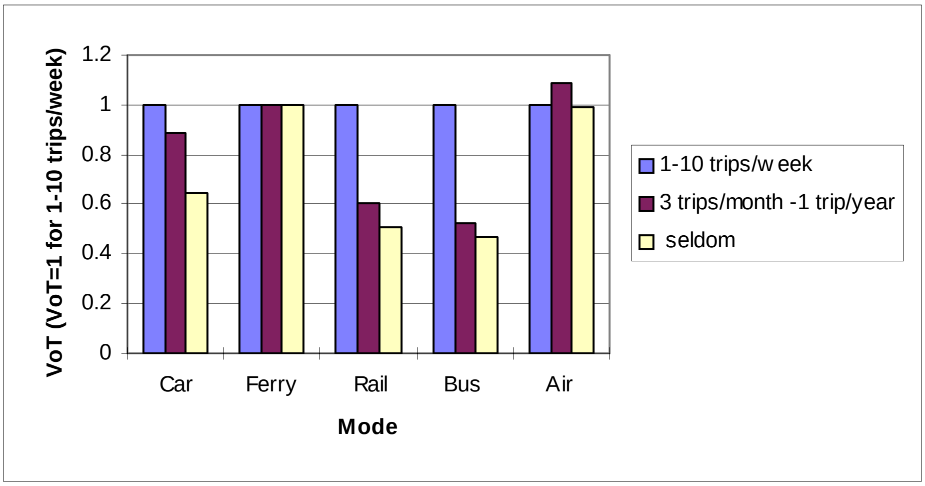
Figure 10.9 *VoT* and direction of trip



Trip Frequency

Figure 10.10 shows the variation of *VoT* with trip frequency. This figure suggests that the less frequent travellers have lower *VoT*. This could be partly explained by the income differences of travellers.

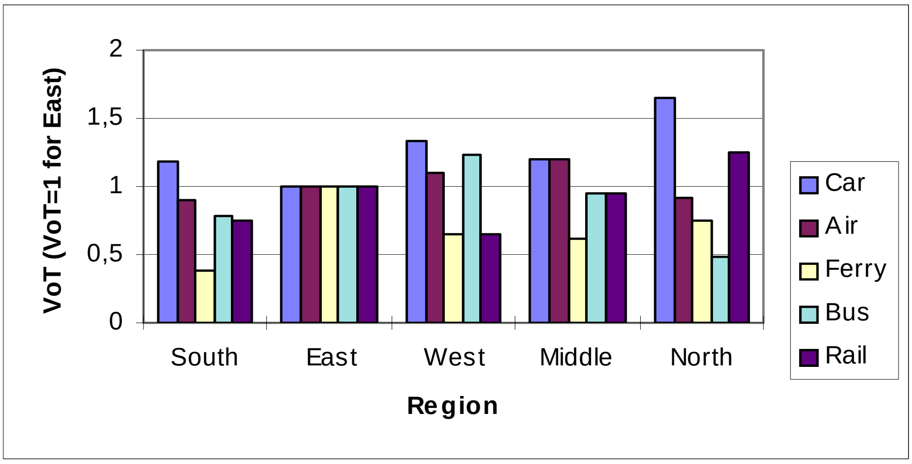
Figure 10.10 Trip frequency



Regional differences

Table 10.10 shows the distribution of *VoT* by regions in Norway and personal income by different modes of travel. Figure 10.11 shows these results. In this figure *VoT* for different travel modes in different regions are shown relative to *VoT* of these modes in "East".

Figure 10.11 Regional differences in *VoT*, corrected for personal income



See model 2GPG in Appendix III

Table 10.10 *VoT* (in NOK/hr) by regions in Norway and income

Region *Income, 1000 NOK/year*	*South*	*East*	*West*	*Centre*	*North*
			Car		
0-100	62	53	70	64	87
101-200	72	61	81	74	101
201-300	94	80	106	96	131
301-400	100	85	113	102	140
400+	131	111	148	134	183
			Air		
0-100	107	118	129	141	108
101-200	124	137	150	164	125
201-300	162	178	195	214	163
301-400	172	189	208	227	173
400+	225	248	272	297	227
			Ferry		
0-100	51	133	87	82	99
101-200	59	155	101	95	115
201-300	77	201	131	124	150
301-400	82	214	139	131	159
400+	108	280	183	172	208
			Bus		
0-100	26	32	40	31	16
101-200	30	37	46	35	18
201-300	39	49	60	46	24
301-400	41	52	64	49	25
400+	54	68	84	64	33
			Rail		
0-100	38	50	33	47	62
101-200	44	58	38	54	72
201-300	57	75	50	71	94
301-400	61	80	53	75	99
400+	79	105	69	99	130

See model 2GPG in Appendix III

Employment status

Figure 10.12 shows the variation of *VoT* with employment status. It should be reminded that respondents in this study were 18 or older. In this context students who drive car seem to have relatively high *VoT*. This result is confirmed when the variation of *VoT* with age is studied.

In general *VoT* for unemployed and retired is lower than for employed travellers, about 25% to 50% lower.

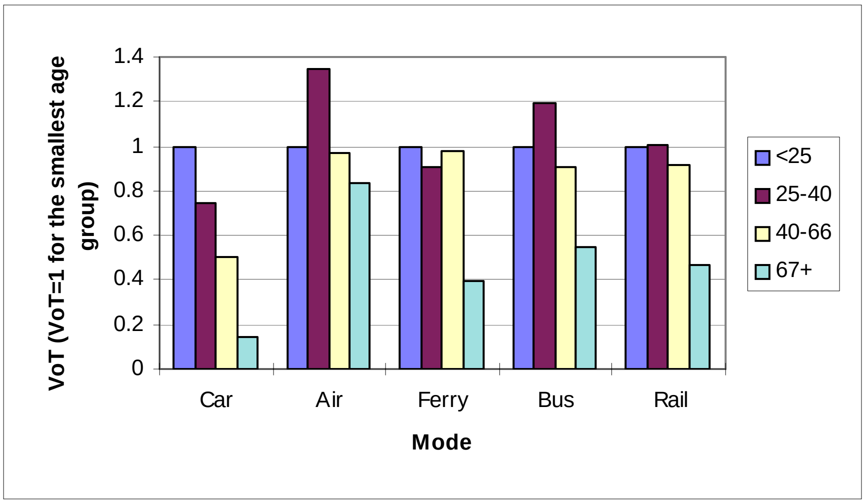
Figure 10.12 *VoT* and employment status, private long distance travel

See model 2GPIWS in Appendix III

Age

Figure 10.13 shows the variation of *VoT* with age. This figure suggests that *VoT* for travellers older than 67 (retirement age in Norway) considerably lower than other age groups. The age group 25-40 has the highest *VoT* for travel with all modes except for car where age group 18-25 has the highest *VoT*.

Figure 10.13 *VoT* and age, private long distance travel

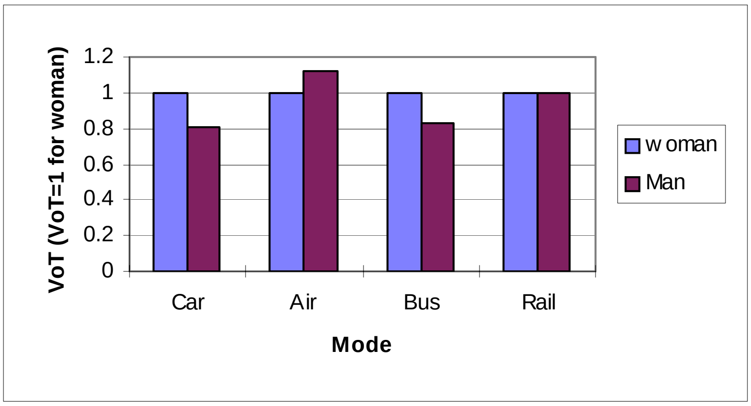


See model 2GPIA in Appendix III

Gender

Figure 10.14 shows the differences in *VoT* between men and women by different modes of travel. Except for travel mode air and rail, women have higher *VoT* than men. Income might explain the differences between men and women for travel with air. For other modes of travel the differences could be explained by differences in time constraints, comfort factors, etc., between men and women.

Figure 10.14 *VoT* and gender, private long distance travel



See model 2GPIK in Appendix III

10.1.7 A summary of results, private long distance travel

- The *VoT* is significantly lower for trips shorter than 50 kilometres especially with travel modes car and bus. The differences could be connected with the differences in time and money constraint connected with travel in these two segments. The *VoT*'s for car, bus and rail for trips shorter than 50 kilometres are similar to those for urban travel from some other studies (Ramjerdi, 1993). Trips shorter than 50 kilometres with car, bus and rail are assumed to belong to urban travel and will be analysed later with data on urban travel.
- The *VoT* decreases with trip distance. There could be different explanations for this. One explanation could be that longer journeys allow for larger scope of activities that can be undertaken while travelling. It could also be connected with the tighter time constraint for shorter inter-urban trips. Shorter inter-urban trips can allow for the scheduling of outbound and inbound trips on the same day or the scheduling of an activity on the same day as inbound or outbound trip.
- Piecewise linear models were used for the estimation of the value of headway. The relative value of headway decreases as headway increases. Furthermore, the *VoT*'s for headway are considerably lower than the reported values for urban conditions. Similar results were reported in the Swedish *VoT* study (Algers et al., 1995).
- The *VoT* increases with income. The relationship of *VoT* and income is more explicit when individual income is used. Similar results were reported in the Swedish *VoT* study.
- Very small time savings (less than 5 minutes) were deliberately avoided in the design. Consequently there were not enough observations with small time savings. The analysis of data suggests that *VoT* are lower for very small time savings (less than 5 minutes), however the estimates cannot be assumed quite

reliable. With the exclusion of *VoT* for the very small time savings (less than 5 minutes), it is not possible to detect any change in *VoT* with the size of time saving.

- The *VoT* for commuting is higher than other private travel purposes over all modes with a few exceptions.
- Evidence does not suggest that the *VoT* of car driver to account for the *VoT* of car passenger.
- The *VoT* is lower among retired and unemployed travellers.
- *VoT* varies over the geographical regions in Norway. This is partly explained by the variation of income in the different regions.

10.2 Short distance travel

A preliminary examination of the *VoT* for public transport suggests that the *VoT* for rail is significantly higher than other modes, i.e., subway, tram and bus. This can have different explanations. Trips by rail as an urban mode of travel are on the average longer than other public modes of transport. Another contributing factor is the higher average income of travellers by rail than by other public transport modes (see chapter 9). On the basis of this preliminary evaluation, all different public transport modes, except for rail, were put together under public transport for further evaluation.

Table 10.11 shows the *VoT* in NOK/hr, for private urban travel. The comparison of this table with table 10.11 shows that *VoT*'s for private urban travel is similar to the *VoT*'s for trips less than 50 kilometres.

Delay, in the context of private urban travel, is valued two to three times higher than in-vehicle time. As we mentioned earlier, the Swedish *VoT* study (Algers et al., 1995) reports that delay for high-speed rail to be about 50 percent higher than in-vehicle time.

The values of headway times are on the average much lower than the expectation based on evidence from other studies. However, as we shall see later, as was the case of inter-urban travel, the relative value of headway time decreases with the increase in headway interval. With the exclusion of headway interval longer than 30 minutes, the value of headway time is 50 to 60 percent higher than in-vehicle time.

Walking time relative to in-vehicle time is valued higher for car than for public transport. For car walking time is valued 50 percent more than in-vehicle time. For public transport walking time is valued slightly higher than in-vehicle time.

We mentioned earlier that the average wage of industrial workers in Norway in 1995 was about 108 NOK/year. The in-vehicle *VoT* for urban trips ranges between about 27 percent (public transport) to 45 percent of wage rate (rail).

Table 10.11 and figure 10.15 show the *VoT* for urban modes of travel.

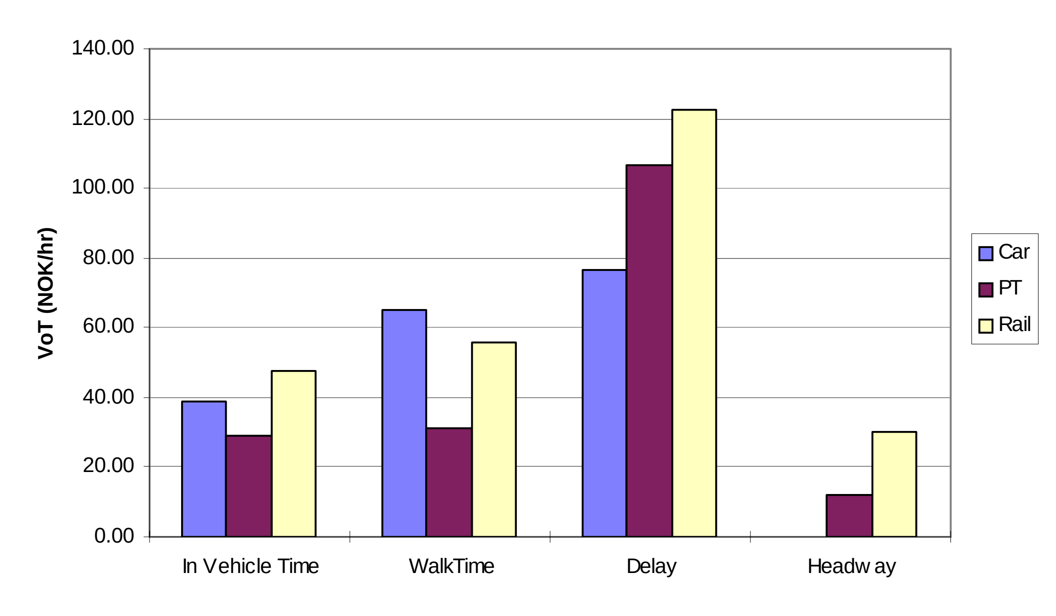
Table 10.11 Value of time for private urban travel, NOK/hr

	In Vehicle Time	*Walking Time*	*Delay*	*Headway*
Car	39 (4)[1]	65	77	
Public Transport	29 (4)	31	107	12
Rail	48 (14)	56	122	30

1 Value in the parenthesis is the 95% confidence interval

See model KPTSM1 in Appendix III

Figure 10.15 Value of time for private urban travel, NOK/hr



See model KPTSM1 in the Appendix III

10.2.1 Headway and delay

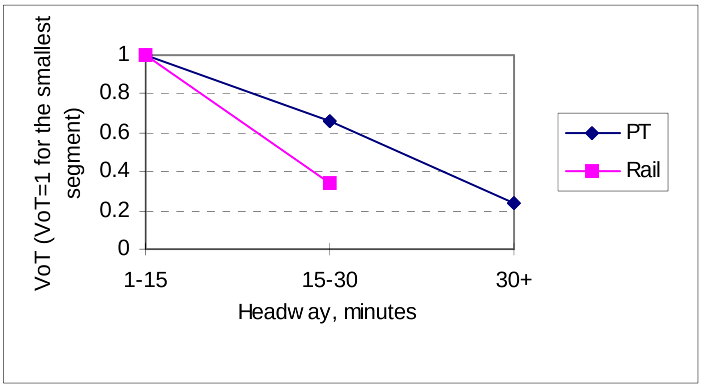
Piecewise linear models were used for the estimation of the value of headway. Table 10.12 shows the distribution of headway *VoT* by headway intervals and income. This table shows that the relative headway *VoT* decreases as headway increases. This table shows that the headway *VoT* decreases more sharply after a headway interval of 30 minutes. Similar result was reported earlier for ferry (see Table 10.2 and Figure 10.1).

Table 10.12 Distribution of headway *VoT* in NOK/hr and personal income, private short distance travel

Income	*0-100*	*101-200*	*201-300*	*301-400*	*400+*
Headway, minutes			**Bus**		
<15	24	25	28	27	33
15-30	16	17	19	18	22
30+	5	6	7	6	8
			Rail		
<15	48	51	58	56	68
15-30	17	18	20	19	23

Figure 10.16 Shows the variation of headway *VoT* with headway. Kjørstad (1995) reports similar results based on SP technique for some small towns in Norway (see Figure 10.17). Note that waiting *VoT* is twice the headway *VoT*.

Figure 10.16 Headway *VoT* and headway interval



See KPTMSPH0 in Appendix III

Figure 10.17 Waiting time relative to in-vehicle travel time (Kjørstad, 1995)

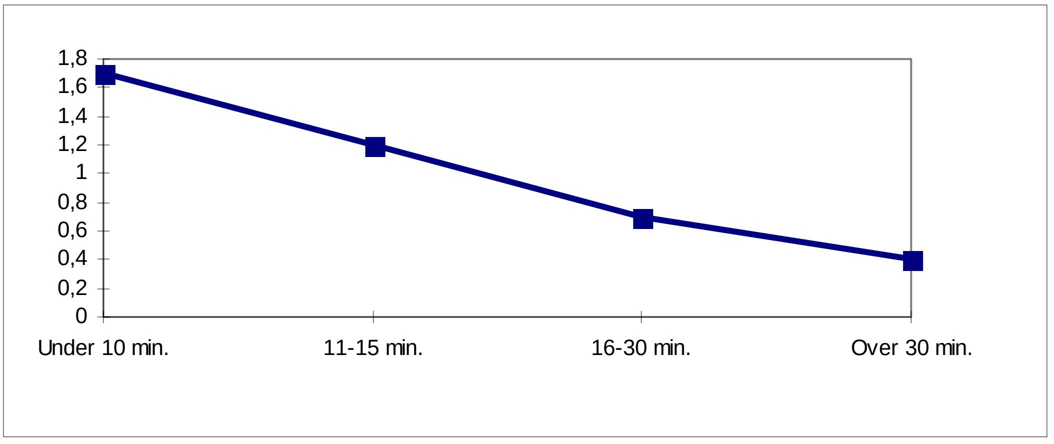


Table 10.13 shows that *VoT* for delay increases with size of delay and income. Figure 10.18 shows the variation in *VoT* for delay with size of delay.

It would be, however, worth while to examine the valuation of very small delays, less than 2 minutes. Very small delays (less than 2 minutes) are valued higher than twice the in-vehicle time. On this basis it might be difficult to justify a very low *VoT* for very small time savings/losses (say about 2 minutes).

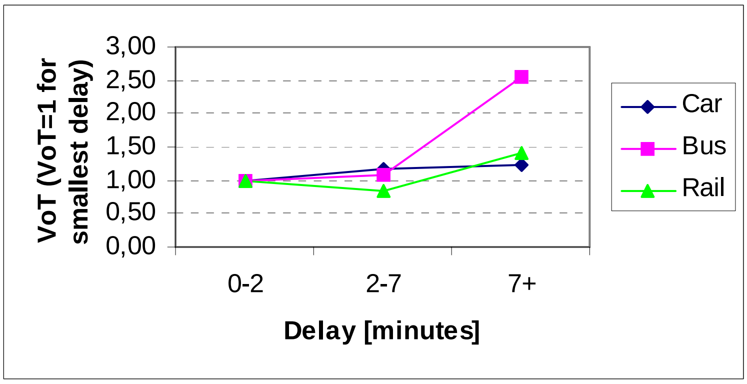
Table 10.13 Distribution of *VoT* (NOK/hr) for delay with size of delay and income

Personal income, 1000 NOK/year	*0-100*	*101-200*	*201-300*	*301-400*	*400+*
Delay , Minutes			**Car**		
<2	61	78	85	81	82
2-7	71	91	99	94	95
7+	75	95	104	98	100
			Bus		
<2	92	118	128	121	123
2-7	100	128	139	132	134
7+	234	299	327	309	313
			Rail		
<2	209	266	291	275	279
2-7	172*	220*	240*	227*	230*
7+	294	376	410	388	393

* Not significant

See model KPTMSHF0 in Appendix III

Figure 10.18 Variation of *VoT* for delay with size of delay

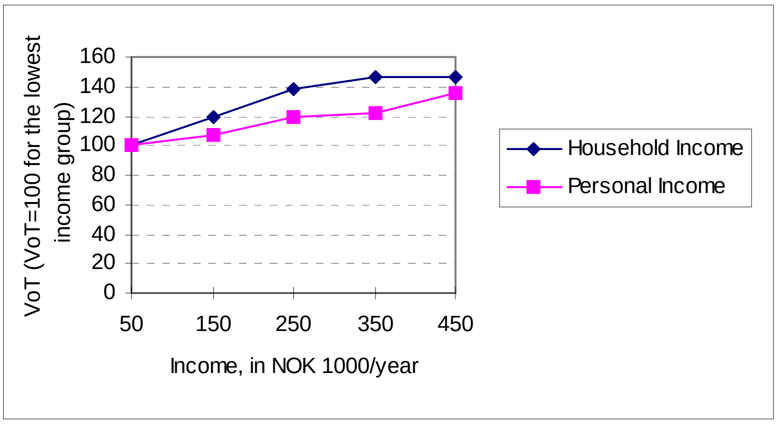


See KPTMSHF0 in Appendix III

10.2.2 Value of time and income

Figure 10.19 shows the variations in the *VoT* with household incomes and personal income. The comparison of this figure with Figure 10.2 suggests that the increase in *VoT* with income in the context of urban travel is not as large as inter-urban travel. This comparison suggests a higher income elasticity of *VoT* for inter-urban than urban travel. It should be pointed out that similar pattern for values of income elasticity of travel demand has been reported earlier (Ramjerdi and Rand, 1993). Table 10.14 shows the variations of *VoT* with personal and household incomes.

Figure 10.19 Variations in *VoT* with household and personal incomes



See KPTMS2H and KPTMS2P in Appendix III

Table 10.14 *VoT* (in NOK/hr) and household and personal income

Income, 1000/year	*0-100*	*101-200*	*201-300*	*301-400*	*400+*
			Car		
Household Income	30	36	41	43	43
Personal Income	34	37	41	42	47
			Bus		
Household Income	25	30	34	36	36
Personal Income	27	29	32	33	36
			Rail		
Household Income	34	40	47	49	49
Personal Income	52	56	62	64	71

10.2.3 Value of travel time and distance

Table 10.15 shows the variation of *VoT* with trip distance for short distance travel. It is interesting to compare of the results presented here and the results for long distance travel presented earlier under section 10.1.3.

VoT's for both car and bus increase with travel distance for urban travel. It appears that *VoT* with car increase with distance up to a threshold after which it begins to decrease. This could be the threshold that separates urban from inter-urban travel.

For rail, however, the *VoT* decreases with travel distance for both urban and inter-urban travel. This might be explained by the differences in the scope of activities which can be undertaken during journey be rail with distance for both urban and inter-urban travel.

Table 10.15 Distribution of *VoT* (in NOK/hour) by trip distance and income

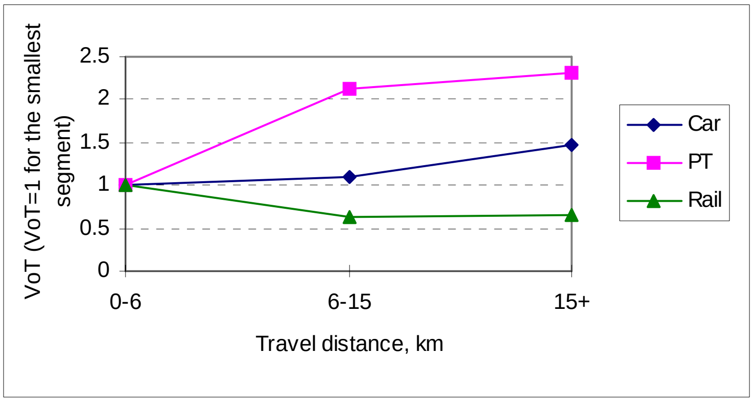
Income, 1000/year	*0-100*	*101-200*	*201-300*	*301-400*	*400+*
Distance, km			Car		
<6	28	29	32	33	37
6-15	30	32	35	36	40
15+	40	43	47	48	53
			Bus		
<6	15	16	18	18	20
6-15	32	34	38	38	43
15+	35	37	41	42	47
			Rail		
<6	81	86	94	96	108
6-15	52	55	60	61	69
15+	53	56	61	62	70

See KPTMSPD0 in Appendix III

Figure 10.20 shows the changes in *VoT* with travel distance. This figure shows that *VoT*'s for car and public transport increase with travel distance, while *VoT* for rail decreases with travel distance.

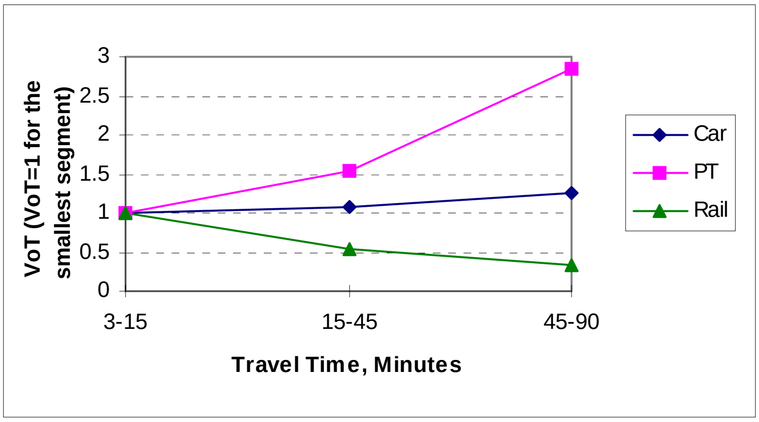
Figure 10.21 shows the changes in *VoT* with travel time. This figure shows similar pattern as that in Figure 10.20.

Figure 10.20 Changes in VoT with travel distance



See KPTMSPD0 in Appendix III

Figure 10.21 Changes in *VoT* and travel time

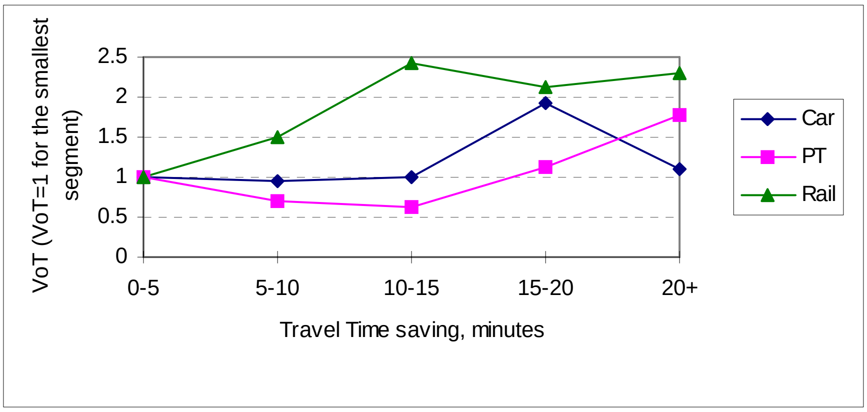


See KPTMSHD0 in Appendix III

10.2.4 Size of time savings or losses

Figure 10.22 shows the changes in *VoT* with size of travel-time savings or losses. With the exception of rail, it is difficult to conclude that that the size of the time saving has any effect on *VoT*.

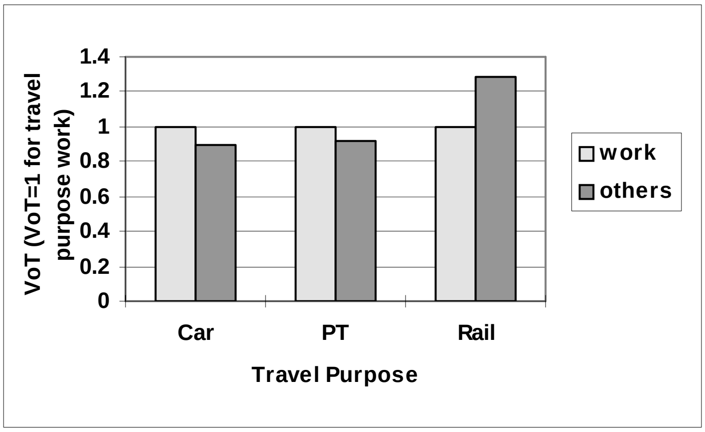
Figure 10.22 Changes in *VoT* with size of time savings/losses



10.2.5 Travel Purpose

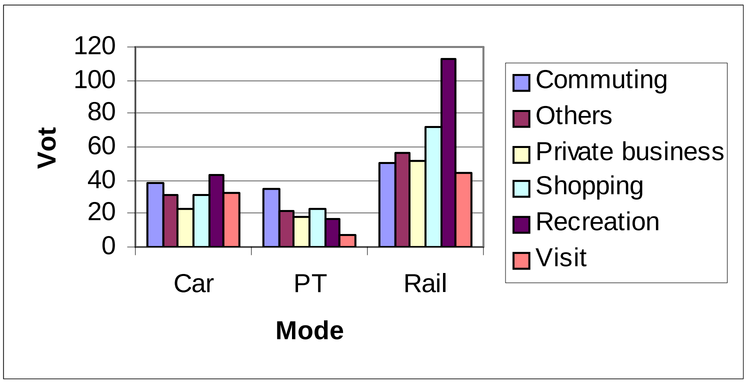
Figure 10.23 shows the *VoT* for work and other private travel purposes. This figure suggests that the *VoT* for work by car and public transport is on the average 10 percent higher for work than for other private travel purposes. For rail, however, the *VoT* for work is about 30 percent lower than for other private purposes. Figure 10.24 shows the variations in *VoT* by private travel purposes including work.

Figure 10.23 *VoT* and travel purpose work and others



See KPTMSHW in Appendix III

Figure 10.24 Variations in *VoT* by private travel purposes



See Kppiarb, Kppioth2 and Kppioth2 in Appendix III

10.2.5 Value of time and car occupancy

Figure 10.25 shows the changes in the *VoT* of car driver with car occupancy. Figure 10.26 shows the variation of *VoT* of car driver with car occupancy and travel purpose. This pattern is very similar to that for inter-urban travel (see Figure 10.6). The evaluations of these figures does not suggests that car driver accounts for the *VoT* of car passenger.

Figure 10.25 Variation of *VoT* for car drivers with car occupancies

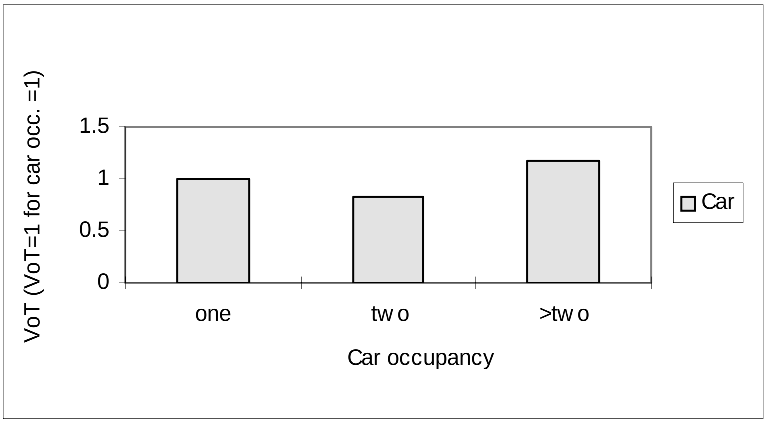
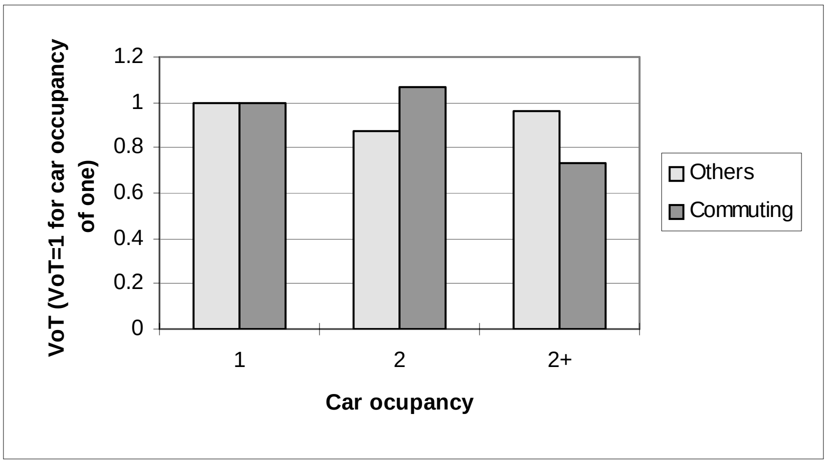


Figure 10.26 Variation of *VoT* of car driver with car occupancy and travel purpose



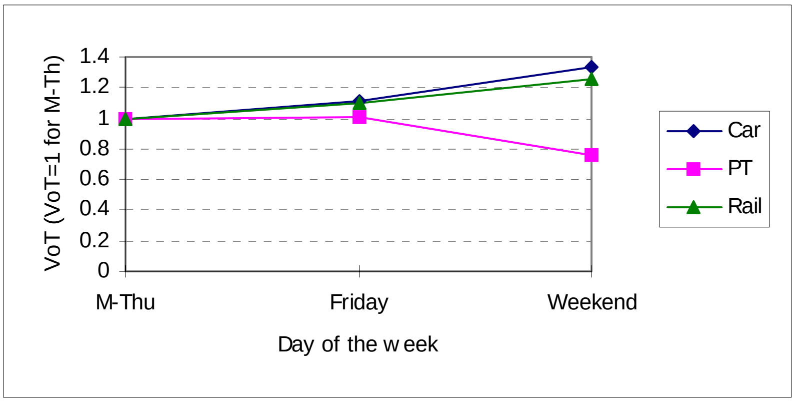
See KPTMSHCA and KPTMSHCO in Appendix III

10.2.6 Other factors

Day of the week

Figure 10.27 shows that variation of the *VoT* with day of the week. The variations of the *VoT* by day of the week by different modes of travel can be partly explained by the composition of travel purpose during these days (see Figure 10.24). This figure shows that *VoT* with car and rail is higher on weekends than other days, while it is the opposite for public transport.

Figure 10.27 *VoT* and day of the week

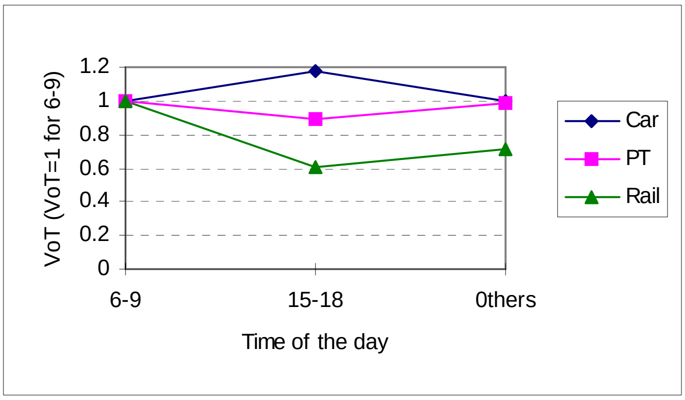


See KPTMSHT in Appendix III

Departure time

Figure 10.28 shows the variation of *VoT* by departure time. This figure suggests that *VoT* is the highest during the afternoon peak-hours for car. For rail, however, the *VoT* is the highest during the morning peak-hours and lowest during the afternoon peak hours.

Figure 10.28 *VoT* and departure time

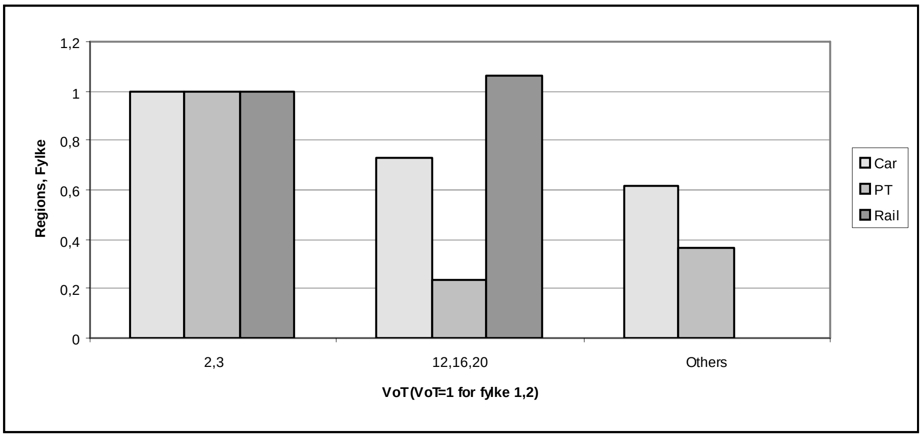


See KPTMSHT2 in Appendix III

Regional differences

Figure 10.29 shows the regional differences in *VoT*. *VoT* is on the average higher in counties 2 and 3 (corresponding to Akershus and Oslo).

Figure 10.29 Regional differences in *VoT*

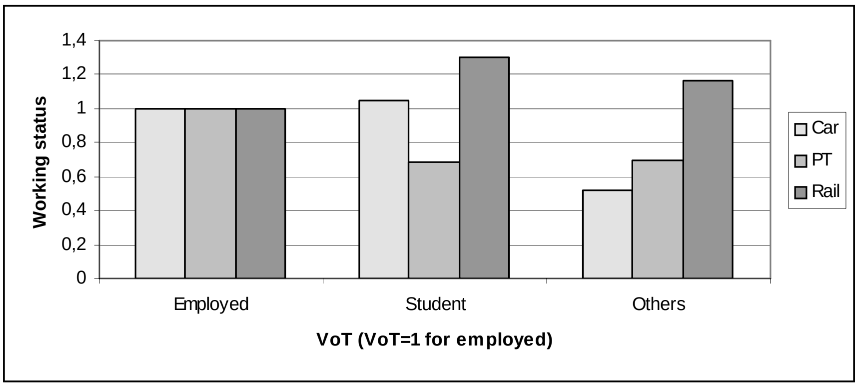


See KPTMSHG in Appendix III

Employment Status

Figure 10.30 shows the variation of *VoT* with employment status. Note that respondents in this study were 18 or older. In this context students who drive cars seem to have a higher *VoT* compared with other groups. In general *VoT* for unemployed and retired is lower than for employed travellers, about 30% to 50% lower, except for travel with rail.

Figure 10.30 *VoT* and employment status

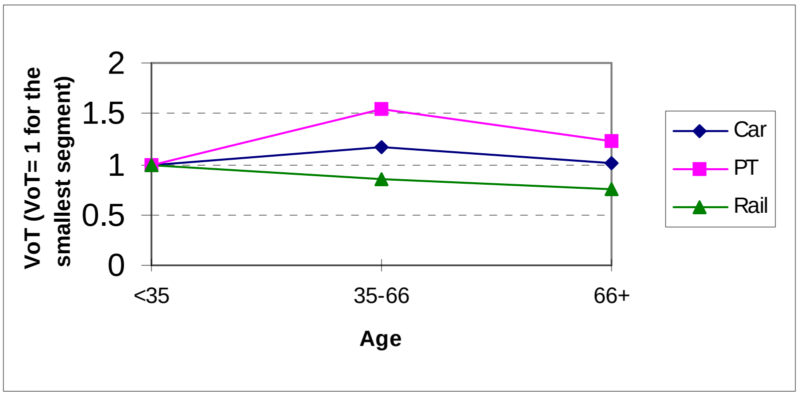


See KPTMSHSE in Appendix III

Age

Figure 10.31 shows the variation of *VoT* with age. This figure suggests that the *VoT* for age group 35-67 is higher than other age groups and lowest for travellers older than 67 (retirement age in Norway) by all modes of travel, with some exceptions.

Figure 10.31 *VoT* and age

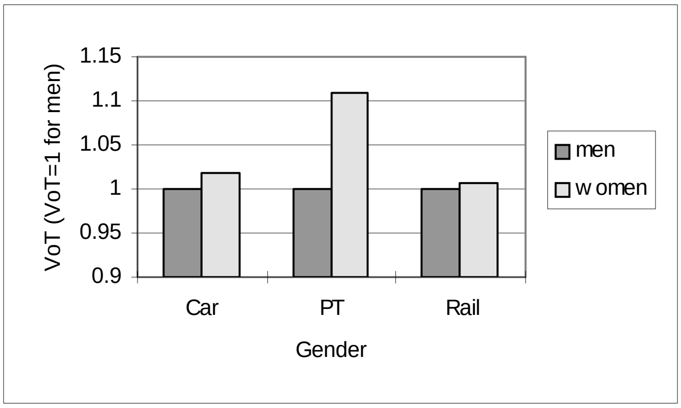


See KPTHSA2 in Appendix III

Gender

Figure 10.22 shows the differences in *VoT* between men and women by different modes of travel. Women have slightly higher *VoT* than men, however, the differences are not significant.

Figure 10.32 *VoT* and gender

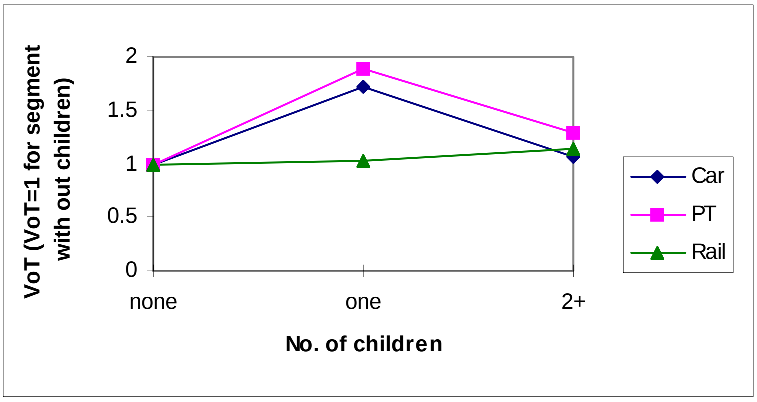


See KPTMSHSK in Appendix III

Number of Children

Figure 10.33 shows the variation of *VoT* with number of children. This figure suggest that *VoT* in the context of urban travel is higher among travellers with children.

Figure 10.33 *VoT* and number of children

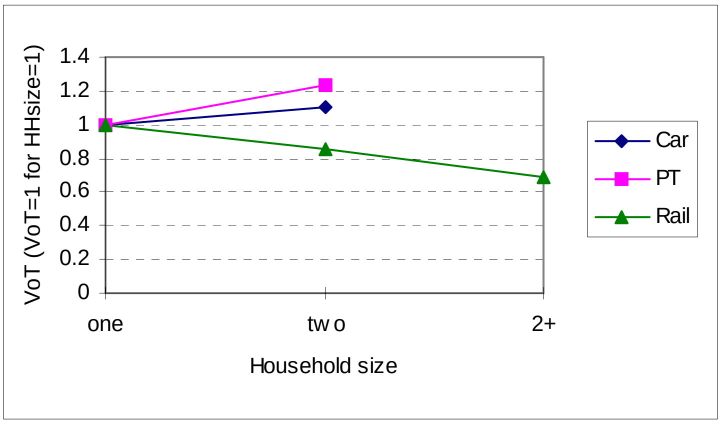


See KPTMSHSB in Appendix III

Household size

Figure 10.34 shows the variation of *VoT* with household size.

Figure 10.34 *VoT* and household size



See KPTMSHSH in Appendix III

10.2.7 A summary of results

- The *VoT* for urban travel is significantly lower than for inter-urban travel, especially for with travel modes car and public transport. *VoT* for travel with rail is significantly higher than other urban travel modes. The in-vehicle *VoT* for urban trips ranges between about 27 percent (public transport) to 45 percent of the wage rate (rail).
- Walking time relative to in-vehicle time is valued higher for car than for public transport. For car walking time is valued 50 percent higher than in-vehicle time. For public transport walking time is valued slightly higher than in-vehicle time.
- Delay, in the context of urban travel, is valued two to three times higher than in-vehicle time.
- Piecewise linear models were used for the estimation of the value of headway. The relative value of headway time decreases with the increase in headway interval. With the exclusion of headway interval longer than 30 minutes, the value of headway time is 50 to 60 percent higher than in-vehicle time.
- *VoT* increases with trip distance for travel modes car and public transport. For travel with rail, *VoT* decreases with distance.
- *VoT* increases with income, however, not as much as inter-urban travel.
- It is not possible to detect any change in *VoT* with the size of time saving. The design of the SP study does not allow the evaluation of *VoT* for small time savings (less than 2 minutes). However, delays less than 2 minutes are valued higher than twice the in-vehicle time.
- *VoT* for commuting to work is higher (about 10 percent) than other private travel purposes over all modes with the exception of rail.
- Evidence does not suggest that the *VoT* of car drivers to include the *VoT* of car passenger.
- VoT is highest during the afternoon peak for car. For rail, however, the *VoT* is the highest during the morning peak-hours.
- In general *VoT* for students, unemployed and retired is lower than for employed travellers for all modes of travel, about 30% to 50% lower, with some exceptions. *VoT* varies over the geographical regions in Norway. This is also partly explained by the variation of income in the different regions.

11 Results from SP study, business travel

For the estimation of the *VoT* for business travel we have used a revised Hensher's approach. Equation (1) shows Hensher's formula. In this equation *MP* is the marginal product of labour. As explained earlier, traditionally this value was used as an approximation to the *VoT* for business travel. If a business trip takes place during the normal working hours, and "as long as the time savings during working hours affects neither the quality nor the duration of working time, this saving should be valued at the wage rate plus the marginal wage increment" (Bruzelius, 1978, p. 5).

However, very often business trips do not entirely occur during normal working hours. Often part or all of the business trip, especially inter-urban business trip, can be outside normal working hours. Different employers have different rules connected to the compensation of their employees travel time outside the normal working hours[1]. The compensation could be in the form of monetary payment, or time. If the compensation is in the form of reducing work time to compensate for time taken for travelling, then *MP* should be valued at the wage rate plus the marginal wage increment. However, if the compensation were in the form of a payment then *MP* should relate to a corresponding hourly payment.

It is also possible that the employee accepts some form of compensation lower than his wage or is not compensated at all for the travel time outside working hours. That implies that the employee has accepted a contract to travel outside the working hours with a lower payment than his normal wage or without any payment. There are different incentives for the employee to accept these terms. There is also allowance for the costs of subsistence and accommodation that could become an incentive for accepting such terms. The other possibility is the expectation of promotion in a job. It is also possible that the employee agrees to a lower payment than his wage while travelling, since he accepts that his wage should cover the extra time than his normal working hours he is expected to travel for the employer. Consequently it is difficult to justify a zero value for *MP* when there is no compensation for travel time outside normal working hours. Similarly it is difficult to assert a value for *MP* when the compensation is lower than the

[1] Out of 20 employers at TØI who took part in a pilot SP study, only one person knew about the institute's policy on the compensation for travel time outside normal working hours. In Norway the government uses defined rules for compensations for travel time outside working hours and most private companies use the same rules.

wage rate. As pointed out earlier, even under such circumstances, when the employee is not explicitly paid for the travel time outside the normal working hours, there is an implicit payment connected with that time. The point by raising these issues is to show the problems connected with the calculation of *MP* related to a trip outside the working hours.

In summary, it is rational to assume that both the employee and the employer could benefits from the travel-time savings. In that case, the employee could identify what portion of the travel-time savings is used for leisure (*r*) and what proportion is used for work (*1-r*).

For the private travel purposes, it is not necessary to identify the alternative use of travel-time savings. In this case the travel-time savings could be allocated to work, leisure or a combination of these. Furthermore the travellers can have different monetary values for the alternative uses of the travel-time savings.

For the business travel purposes it is necessary to specify the alternative use of the travel-time savings, since the employer benefits from part of the travel-time savings (*1-r*) and the employee from the rest.

The private *VoT* for employees is estimated the same way as for private travel. In Equation (1) "*vl*" is the monetary value to the employee of leisure compared to travel time. Travel time in this case could have a very different content that for travellers for private purposes. A traveller for private travel purposes does not earn a wage while travelling. For business travel purposes the traveller is earning a wage while travelling, implicitly or explicitly. If indeed a business trip is outside the working hours and the traveller is explicitly or implicitly compensated for time while travelling, one can argue that "*vl*" is not quite similar to the private *VoT*. Under these conditions "*vl*" could become close to the wage rate since leisure is a "demanded leisure". Even a value higher than the wage rate can be considered theoretically "correct" since one can argue that the person is constrained to work more than he actually wants (see Moses and Williamson, 1963).

The monetary value to the employee of work time while in office (earning a wage paid by the employer that is already captured by *MP*) compared to travel time is "*vw*". Like "*vl*", "*vw*" can have a higher value that the *VoT* for private travel purposes. If "*vw*" arises from earning a wage then *MP* already captures this value. However, one can argue that "*vw*" is related to some relative preference for working in the office and earning a wage and travelling and earning a wage. We suggest that at the equilibrium *MP* should capture this value, since wage is negotiated under all these conditions.

As we shall see later it is possible to get an estimate of "*vw*". However, we believe this value is captured by *MP* and a form of double counting occurs by including "vw" for the calculation of the business *VoT*, *Vtts*. Consequently we recommend to revise the Hensher's formula as follows:

$$Vtts = (1-r-pq)*MP + r*vl + MPF \qquad (19)$$

See section 3.1 for the definition of the variables in Equation 19.

In Hensher's formula "*r*" is the proportion of travel-time savings that is used for leisure. Hence, this proportion of travel-time savings should be valued at the private value of time of employee's, *vl*, and (*1-r*) should be valued at the marginal product of labour, *MP*.

What happens if the employee can use some of the travel time, *p*, for productive work? This creates a problem, since it is not simple to assert who would benefit from the work, employer or employee and furthermore what is the productivity of the activities that are described as work. Carruthers and Hensher (1976) suggest that an average value should be assumed for productive work that is performed while travelling.

If the employer benefits from the work, then the proportion of travel time saving that employers benefit from, i.e., *(1-r)* should be adjusted for the proportion of this time that could have been used to work, *p*. This implies that $(1-r-p) \geq 0$. Furthermore *p* should be adjusted by the relative productivity of work done while travelling compared with the equivalent work done in the office, *q*. Hence the benefit from travel-time savings for the employer will be (*1-r-pq*). The value of *q* has been constrained to have a maximum value of one. This is to acknowledge that the perception of a higher productivity than what would have been possible to achieve in the office or other environments is not connected to the mode of transport.

We have assumed that the value of extra output generated due to reduced fatigue, *MPF*, to be negligible.

11.1 Long distance travel

11.1.1 Private *VoT, vl*

One explanation for a higher (private) *VoT* among business travellers than those who are travelling for private travel purpose could be related to budget constraints. In both cases the evaluations of alternatives are based on price differences of the alternatives that are borne by the travellers. However, those who are travelling for private travel purposes have to pay the full price of the chosen alternative. This is not the case for the business travellers. They have to pay for the difference in the price of their chosen alternative and their present price (that is borne by the business). Hence the price for business travellers is only a fraction of the price of the private travellers.

The private *VoT* for employees is estimated the same way as for private travel. Table 11.1 shows the results for wave 1 and 2 for alternative model specification using different types of segmentation.

The examination of the results (see table 11.1) suggests that there are significant differences between values of time in wave 1 and wave 2. Furthermore, these values are larger than private *VoT*'s. These differences could have been caused by the differences in the design of SP study in wave 1 and wave 2.

In the design of the first wave, we had assumed a maximum *VoT* of 300-350 NOK/hr while in the second study we increased this value to 600. A sensitivity analysis (see Figure 6.1) shows that the maximum *VoT* used in the design affects the estimated value of time. Figure 6.1 shows that the differences between design *VoT*'s used in the waves 1 and 2 can't be explain the differences in the *VoT* between the two waves.

In wave 1, the design is such that a traveller sees the total price. It was emphasised that the part of the cost she or he will save (or pocket) is the difference between the present cost (borne by the business) and the cost of the alternative. In wave 2 the traveller does not see the total price of the alternatives, only what she or he has to pay or pocket. Notice that this amounts to two different methods of presentations. Under both methods, the traveller is faced with exactly the same difference in costs of the two alternatives. It is possible that in wave 1 a traveller takes note of the total cost of the alternatives as well as her own share. This would result in a lower *VoT* in wave 1 than in wave 2.

As table 11.1 shows the *VoT*'s based on wave 2 are higher than *VoT*'s based on wave 1. The difference is especially significant for air. One explanation is the differences in the design range of *VoT*. However, as Figure 6.1 shows, the design *VoT* does not explain all. The difference in the method of presentation of the price between the two waves contributes to the differences.

Table 11.1 Value of time for business travel (private valuation), NOK/hr

	Car	*Ferry*	*Rail*	*Bus*	*Air*
Trips < 50					
In vehicle time	131	76	124	-	151
Headway	-	70	55	-	85
Delay			0		
Trips> 50					
In vehicle time					
Wave 1 + Wave 2	262	112	163	121	353
95 confidence interval	63	40	57	44	111
Wave 1	185	102	118	59	313
95 confidence interval	41	44	28	21	67
Wave 2	283	80	195	152	415
Headway (wave 1)	-	70	13	9	67
Delay (wave 1)			0		

On the basis of the discussions presented above, we feel that the *VoT*'s based on wave 1 is more acceptable that based on wave 2.

The valuations of headway times compared with in-vehicle time are much lower than expected, except for ferry. This is exactly the same situation as for private inter-urban travel.

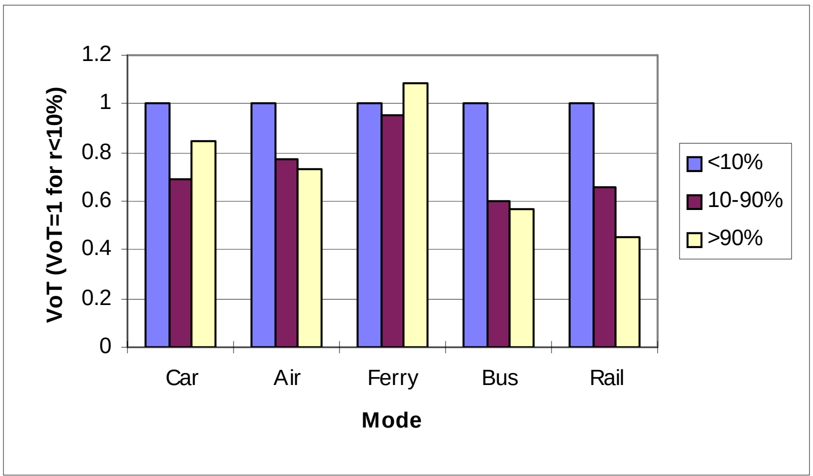
Transfer time was not evaluated in the Norwegian *VoT* study and we recommend the values from the Swedish *VoT* study. Delay did not work well in our study. This was also the situation for inter-urban private travel. Again we recommend the Swedish *VoT* study for the *VoT* for delay.

11.1.2 Differences between "vw" and "vl"

In the SP games, the business travellers are asked to evaluate paired alternatives and state their choice. It is stated clearly that they will have to pay (or pocket) the difference in price of the alternatives and their present price (that is borne by the business). However, it is not stated who will benefit from the time saving. If it was made clear that they could use the time saving for leisure then their valuation is related to "*vl*". If it was made clear that they could use the time saving only for work then their valuation is related to "*vw*".

It is not possible to know what the respondents had assumed about how they will use the time saving for (for leisure or for work). However, we could assume that when "*r*" (proportion of travel time saved which is used for leisure) is small it is more likely that the respondent's response is related to "*vw*". Conversely, when "*r*" (proportion of travel time saved which is used for leisure) is large it is more likely that the respondent's response is related to "vl". The resulting *VoT*'s from appropriate segmentation (r = 0.1, 0.1 < r < 0.9, r <0.9) are shown in Figure 11.1. This figure suggests that it is likely that "*vl*" is smaller than "*vw*".

Figure 11.1 Percentage of travel time saved which is used for leisure

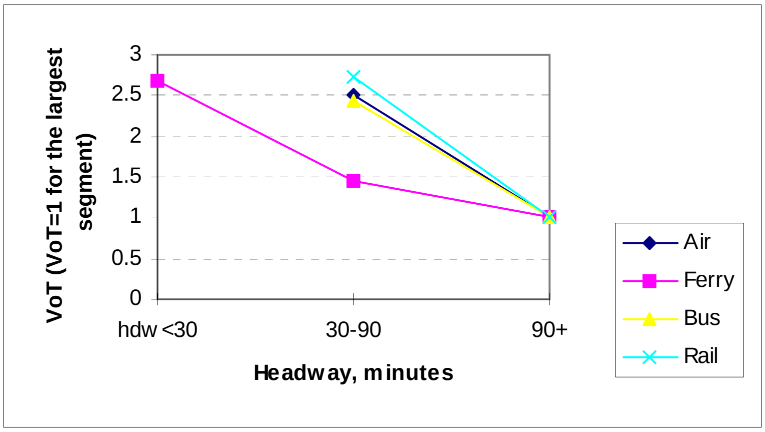


See model 2Gpafri in Appendix III

11.1.3 Headway time values

Figure 11.2 shows the changes in headway *VoT* with headway interval. This suggests a similar pattern for business inter-urban travel as for private inter-urban travel. The relative value of headway *VoT* decreases with headway interval. Furthermore, with the exception of ferry, the headway *VoT* relative to in-vehicle *VoT* is low compared to urban travel.

Figure 11.2 Headway *VoT* and headway interval



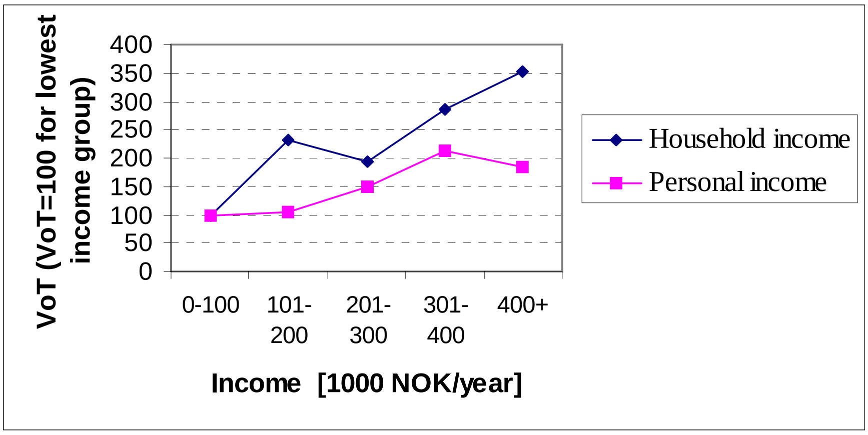
See model BGPF in Appendix III

11.1.3 Value of time and income

Figure 11.3 shows the variation of *VoT* with household and personal incomes. This figure shows that *VoT* increases with both personal and household incomes. It is also important to notice that *VoT* increases more with income in the context of inter-urban travel than urban travel.

Table 11.2 shows the relationship between *VoT* and income for different household compositions. The examination of this table as well as Figure 11.3 suggest that the relationship between *VoT* and income for business travel is not as smooth as that for private travel.

Figure 11.3 Changes in *VoT* with household and personal income



See models bgHI and bgPI in Appendix III

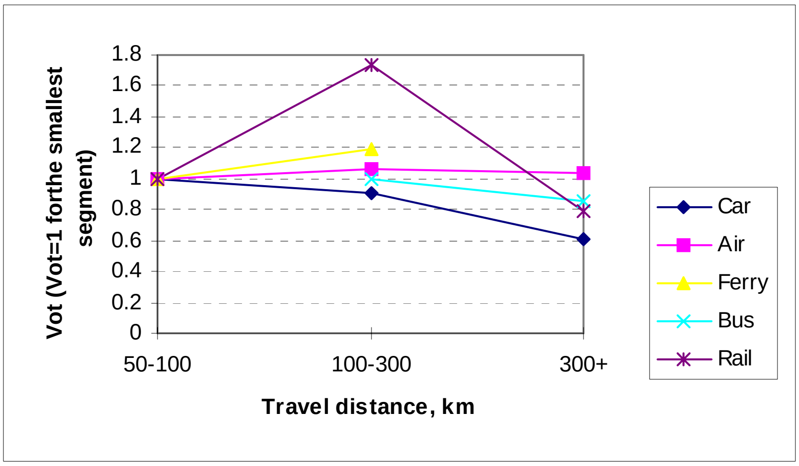
Table 11.2 Value of time for different income groups

Income	*Personal/Household*		*Personal*		*Household*	
Range,1000 NOK/year	1 employed without children	1 employed with children	2 employed without children	2 employed with children	2 employed without children	2 employed with children
0-100	-	-	100	100	100	100
101-200	100	100	131	102	267	103
201-300	274	278	202	249	424	403
301-400	149	143	175	260	-	-
401-	63	345	331	259	199	153

11.1.4 Value of time and distance

Figure 11.4 shows the changes in *VoT* with travel distance. *VoT* decreases with distance for travel modes car and bus. *VoT* for rail increases with travel distance and after a certain threshold decrease with travel distance.

Figure 11.4 Changes in *VoT* and trip distance by travel mode

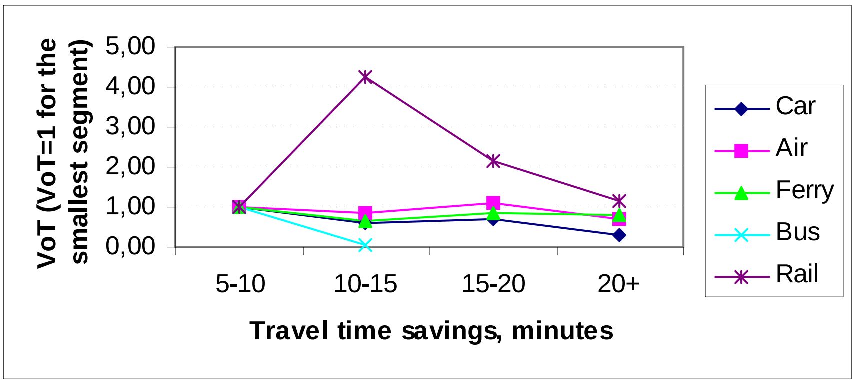


See model bgPD in Appendix III

11.1.5 Size of time savings or losses

Figure 11.5 shows the changes in *VoT* with size of time savings/losses. Again, as was the case for private travel, based on this study, it is not possible to conclude that *VoT* changes with the size of time savings/losses.

Figure 11.5 Changes in *VoT* with size of time savings/losses



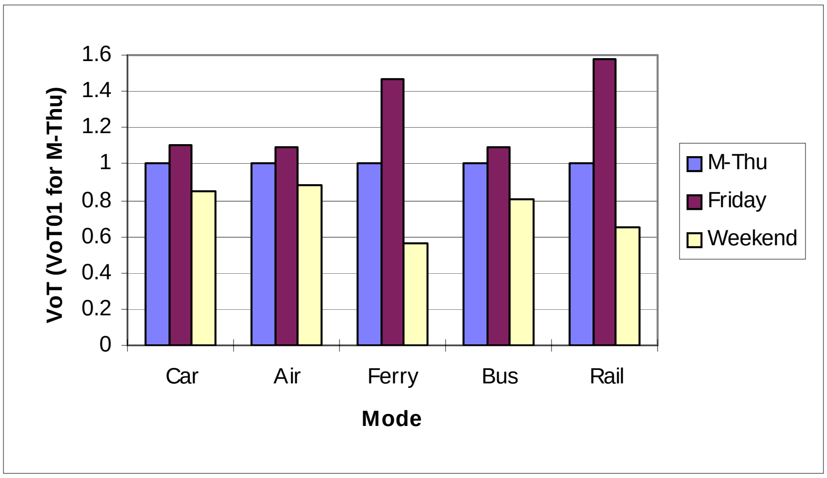
See model bgPST1 in Appendix III

11.1.6 Other factors

Day of the week

Figure 11.6 shows the variation of the *VoT* with day of the week. The *VoT* for business travel is higher on Fridays than other days as it was for private travel. *VoT* is lower on weekends than other days.

Figure 11.6 *VoT* and day of the week



See model BGPDA in Appendix III

Value of time and trip direction

Table 11.3 shows the variation of *VoT* and trip direction. *VoT* for outbound trips is highest when a business is scheduled on the same day as trip. However, *VoT* for inbound trip is higher than outbound trip when a business is scheduled on the day after the outbound trip.

Table 11.3 Value of time and trip direction, NOK/hr

Direction of trip	*Car*	*Ferry <50 km*	*Ferry >50 km*	*Rail*	*Bus*	*Air*
Outbound: Business scheduled on the same day	264			160	78	415
Outbound: Business scheduled on the day after	157	59	95	95	46	246
Inbound	207	82	133	126	61	326

See models TILFRA in Appendix III

Value of time and trip frequency

Table 11.4 shows the changes in *VoT* and trip frequency. The examination of this table does not suggest any clear pattern between *VoT* and trip frequency.

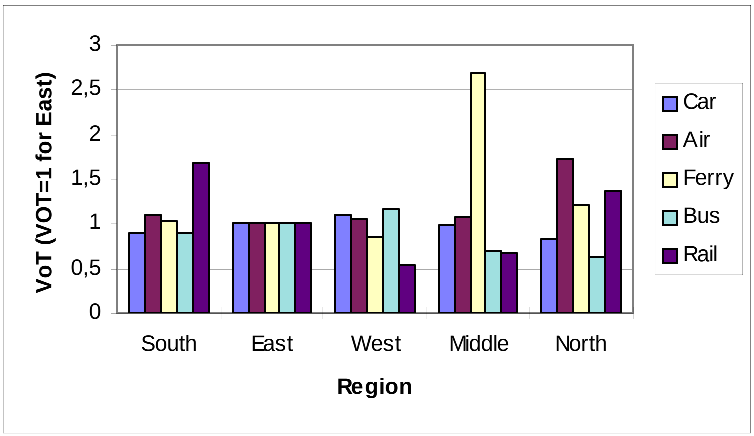
Table 11.4 Value of time and trip frequency, NOK/hr

Trip frequency	*Car*	*Ferry*	*Rail*	*Bus*	*Air*
1 – 10 trips a week	230	94	97	90	317
3 trips a month - 1 trip a year	143	-	144	54	267
Seldom	377	123	91	30	326

Regional differences

Figure 11.7 show the distribution of *VoT* by regions in Norway and income by different travel modes. In this figure *VoT* for different modes of travel in different regions are shown relative to *VoT* of these modes in "East". This figure suggests similar regional differences in *VoT* as for private *VoT*, however, not as clear.

Figure 11.7 Regional differences in *VoT*



See model BGPG in Appendix III

11.1.5 Productivity effect

Table 11.5 shows the mean values for components of the Hensher's formula (Equation 1). In this table the *VoT*'s for business travel under different assumptions are presented. These assumptions are:

- The private *VoT*'s for a business traveller, *vl*, is the same as the non-business *VoT* using the revised Hensher's formula (Equation 19)

- The private *VoT* for a business traveller, *vl*, is the same as non-business *VoT* and *vw* is equal to *vl*, using the Hensher's formula (Equation 1)
- The private *VoT*'s for a business traveller, *vl*, is different from non-business *VoT* and is based on wave 1 and using the revised Hensher's formula (Equation 19)
- The private *VoT*'s for a business traveller, *vl*, is different from non-business *VoT* and is based on wave 1 and of and *vw* is equal to *vl*, using the Hensher's formula (Equation 1)

Table 11.5 shows that business *VoT*'s are significantly different under different assumptions stated above. It is obvious that the business *VoT's* with the revised Hensher's formula (Equation 19) are lower than those with Hensher's formula (Equation 1) are. Furthermore, business *VoT*'s are lower under the assumption that "*vl*" is the same as the non-business *VoT*.

Our recommendation is to use the revised Hensher's approach for the calculation of the business *VoT*. Furthermore, with the acknowledgement of problems in measuring "*vl*", we suggest to use "*vl*" rather than the non-business *VoT* in the revised Hensher's formula. However, as table 11.5 shows, the business *VoT* for air is higher than *MP* since "*vl*" is higher than *MP*.

Table 11.5 Value of time for business travel

							Business *VoT*, *Hensher's approach*			
					vl	*vl*	***vl* (private)**		***vl* (wave 1)**	
Mode	*r*	*q*	*p*	***MP***	private	wave 1	***Eq. 19***	***Eq. 1***	***Eq. 19***	***Eq. 1***
Car	.57	.32	.03	**185**	86	185	**127**	**164**	**181**	**259**
Air	.64	.28	.07	**201**	155	313	**168**	**224**	**267**	**379**
Rail	.72	.39	.18	**153**	54	118	**71**	**86**	**116**	**148**
Bus	.74	.20	.06	**132**	48	59	**68**	**80**	**75**	**90**
Ferry	.63	.19	.03	**161**	83	102	**111**	**142**	**130**	**172**

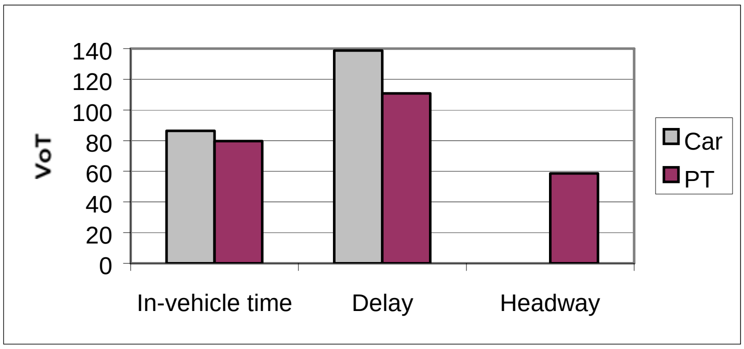
11.2 Short distance travel

As pointed out earlier, the urban study was conducted after the inter-urban study. The design of the SP games was slightly changed for the urban study. In the SP games, the business travellers were asked to evaluate the paired alternatives and state their choice. It is stated clearly that they will have to pay (or pocket) the difference in price of the alternatives and their present price (that is borne by the business). However, in the urban study, half of the respondents could use the time saving for leisure. The valuation in this case is then related to "*vl*". The other half could use the time saving only for work. The valuation in this case is then related to "*vw*".

11.2.1 Private *VoT*, *vl*

Figure 11.8 and table 11.6 show *VoT* for business travel purposes in urban areas. In-vehicle *VoT* is significantly higher for business travel than for private travel purposes. Delay is valued about 70 percent higher than in-vehicle time. Headway time is valued much higher than headway in an inter-urban context. Again, the main reason is shorter average headway time in an urban context than in inter-urban context.

Figure 11.8 Value of time for business travel (NOK/hr), urban travel



See model KBTMS1 in Appendix

Table **11.6** *VoT*, NOK/hr

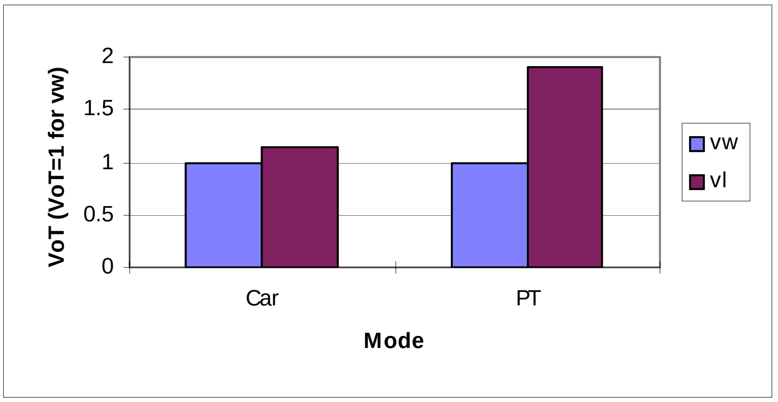
Mode	*In-vehicle VoT*	*Delay*	*Headway*
Car	87 (27)	139	-
Public transport	80 (48)	111	59

Numbers in parenthesis shows the 95% confidence intervals

11.2.2 Differences between vw and *vl*

As stated earlier, the design of the urban study allows for the estimation of "*vl*" and "*vw*". Figure 11.9 shows a comparison of these values. This figure shows that "*vw*" is smaller than "*vl*", however, the difference for car is not significant.

Figure 11.9 Comparison of "*vl*" and "*vw*"



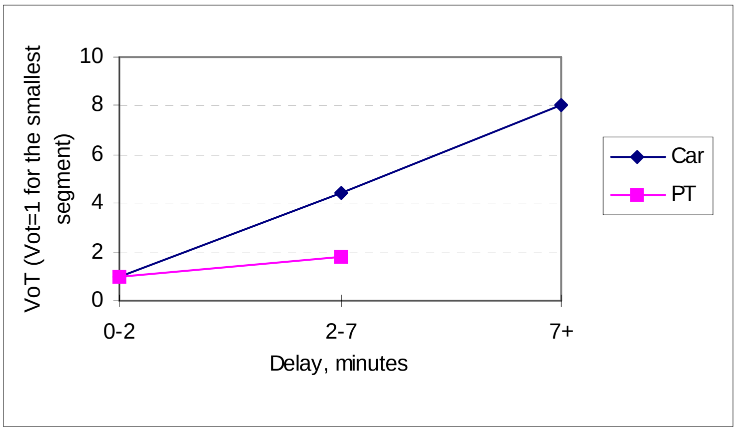
See model Kbpsta in Appendix III

11.2.3 Headway time value and delay

There were not enough observations with public transport and rail for business travel purpose to make it possible to evaluate the variation of headway *VoT* with duration of headway.

Figure 11.10 shows the variation of the *VoT* for delay with size of the delay. This figure suggests that *VoT* for delay increase with the size of the delay. This figure is very similar to Figure 10.18 that shows the variation of *VoT* for delay with size of delay for private short distance travel.

Figure 11.10 Variation of *VoT* for delay with size of delay.

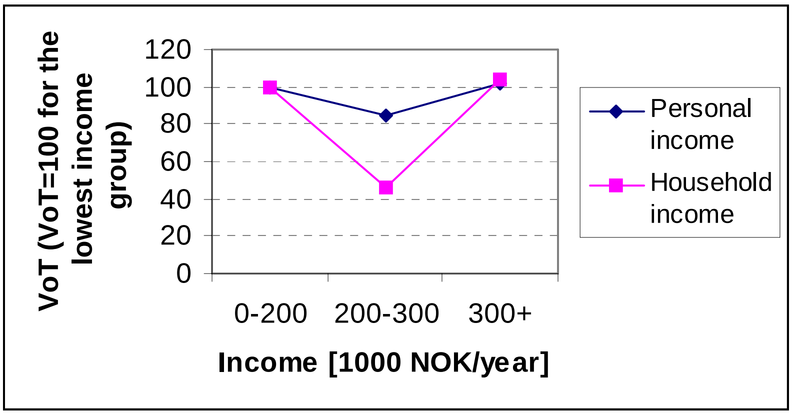


See model KBTMSPF0 in Appendix

11.2.4 Variation of VoT and income

Contrary to all other cases, i.e., inter-urban travel for private or business purposes and urban travel for private purposes, *VoT* for business urban travel does not seem to vary with income. Figure 11.11 shows the variation in *VoT* with personal income. The variation of *VoT* with household income exhibits the same pattern.

Figure 11.11 Variations in *VoT* with income

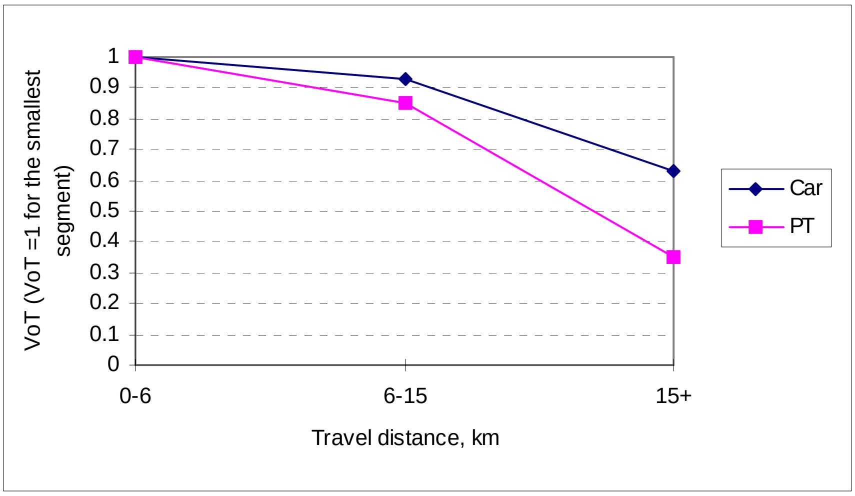


See models KBTMS2P and KBTMS2H in Appendix

11.2.5 Value of time and distance

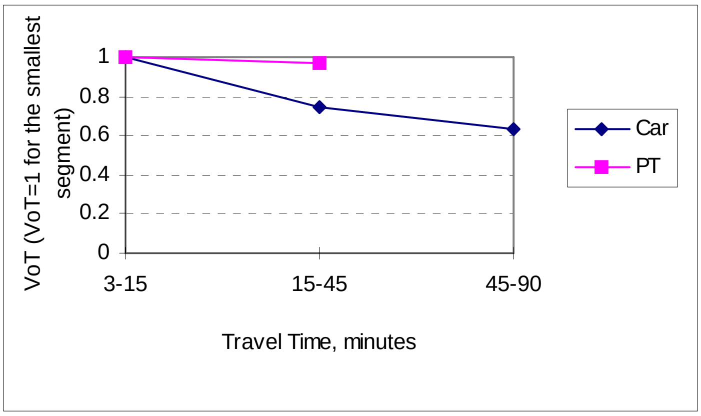
Figure 11.12 shows the changes in *VoT* with travel distance, while Figure 11.13 shows the changes in *VoT* with travel time. These figures show that *VoT* decrease with travel distance and travel time.

Figure 11.12 Changes in *VoT* with travel distance



See model KBTMSPD0 in Appendix

Figure 11.13 Changes in *VoT* with travel time

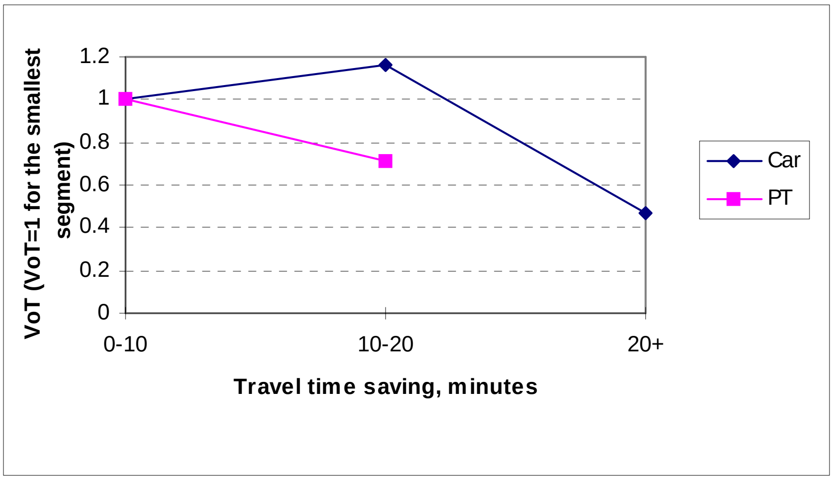


See model KBTMSPD1 in Appendix

11.2.6 Size of time savings or losses

Figure 11.14 shows the changes in *VoT* with size of time savings/losses. It is difficult to conclude that that the size of the time savings has any effect on the *VoT*.

Figure 11.14 Changes in *VoT* with size of time savings/losses



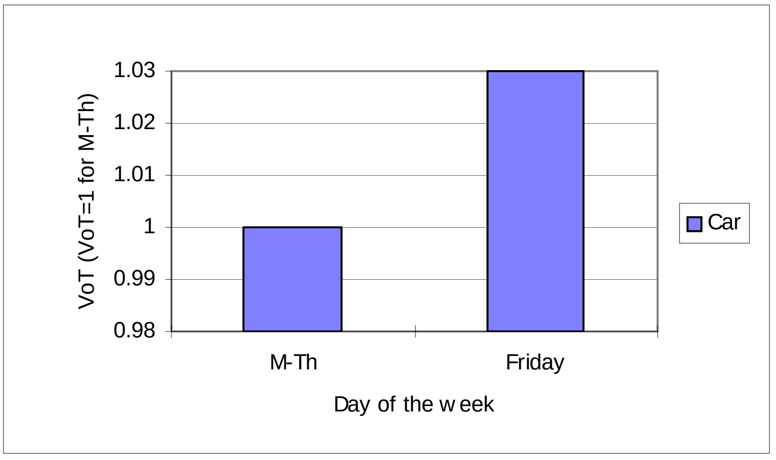
See model KBTMSPT0 in Appendix

11.2.7 Other Factors

Day of the Week

Figure 11.15 shows that variation of *VoT* with day of the week. This figure shows that *VoT* with car is higher on Fridays than other days of the week. The difference is, however, not significant.

Figure 11.15 *VoT* and day of the week

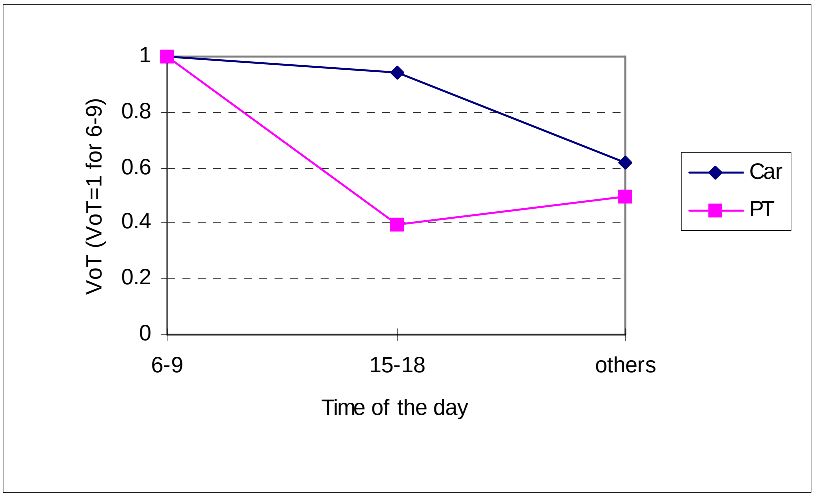


See model KBTMSPHT in Appendix III

Departure time

Figure 11.16 shows the variation of *VoT* by departure time. This figure suggests that *VoT* is the highest during the morning peak-hours.

Figure 11.16 *VoT* and departure time

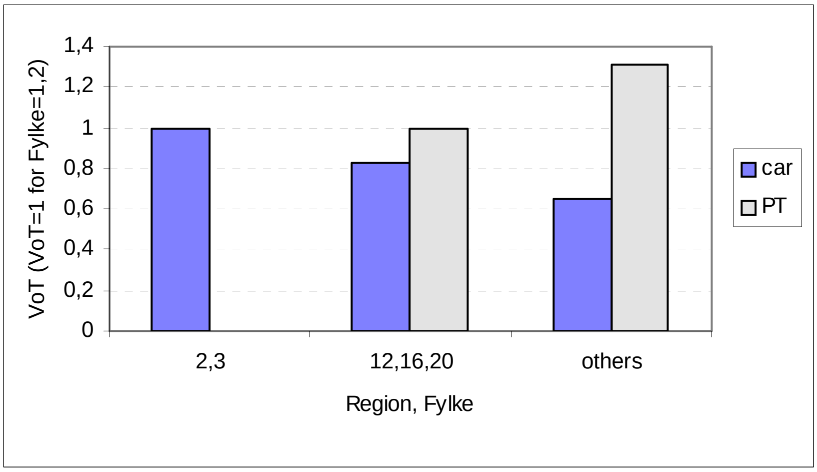


See model KBTMSPTS in Appendix III

Regional differences

Figure 11.17 shows the regional differences in *VoT*. *VoT* for car is on the average higher in counties 2 and 3 (corresponding to Akershus and Oslo) than other regions.

Figure 11.17 Regional differences in *VoT*

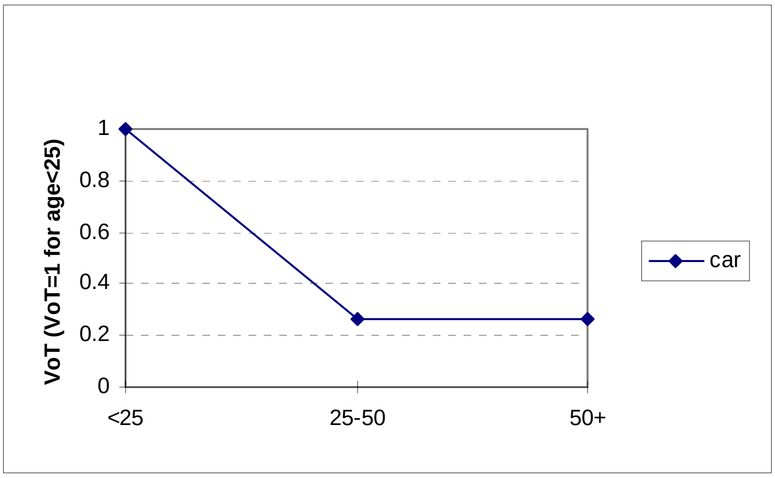


See model KBTMSPG in Appendix III

Age

Figure 11.18 shows the variation of *VoT* with Age. This figure suggests that *VoT* for is highest for young drivers, younger than 25.

Figure 11.18 *VoT* and age

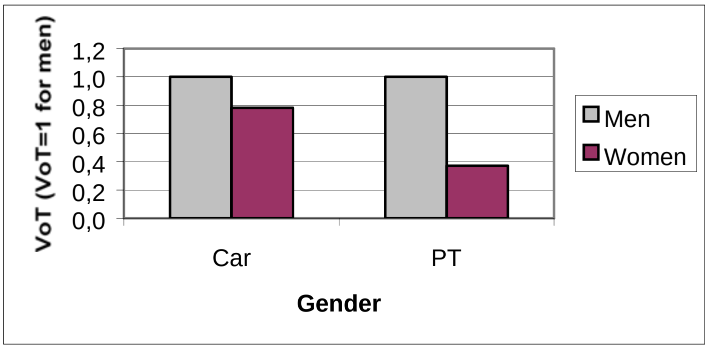


See model KBTMSPSA in Appendix III

Gender

Figure 11.19 shows the differences in *VoT* between men and women by different modes of travel. In an urban context women have lower *VoT* than men for business travel. The differences are significant.

Figure 11.19 *VoT* and gender

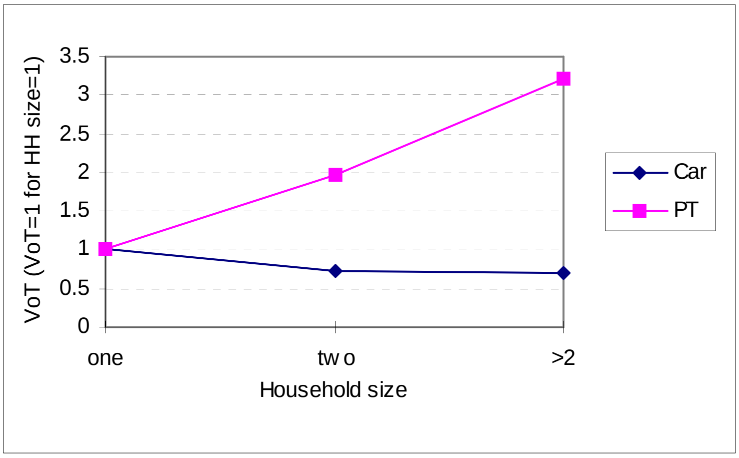


See model KBTMSPSK in Appendix III

Household size

Figure 11.20 shows the variation of VoT with household size.

Figure 11.20 Variations in *VoT* and household size

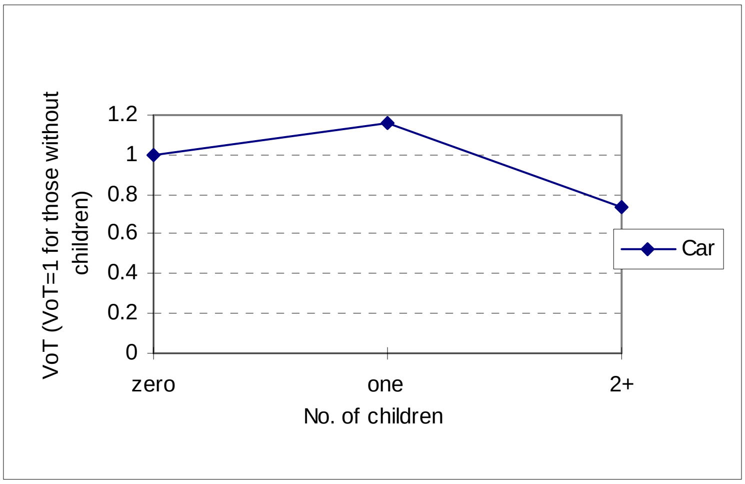


See model KBTMSPSH in Appendix III

Number of children

Figure 11.21 shows the variation of *VoT* with number of children.

Figure 11.21 Variations in *VoT* with number of children



See model KBTMSPSB in Appendix III

11.2.8 Productivity effect

Table 11.7 shows the mean values for components of the Hensher's formula and the revised formula (Equations 1 and 19). In this table the values of time for business travel under different assumptions are presented. These assumptions are:

- *MP* is assumed to be equal to the wage plus overhead using the revised Hensher's formula (Equation 19)
- *MP* is assumed to be equal to the wage plus overhead and with the assumption that "*vw* =*vl*", using the Hensher's formula (Equation 1)
- *MP* is calculated on the basis of information provided by business travellers on the type of compensation they received for travelling outside working hours, using the revised Hensher's formula (Equation 19)
- *MP* is calculated on the basis of information provided by business travellers on the type of compensation they received for travelling outside working hours and with the assumption that "*vw* =*vl*", using the Hensher's formula (Equation 1)

Table 11.7 shows that the business *VoT*'s based on the Hensher's formula (Equation 1) are higher than those based on the revised Hensher's formula (Equation 19). Furthermore, *MP* is lower based on information provided by business travellers on the type of compensation they received for travelling outside working hours, resulting in lower business *VoT's*.

Our recommendation is to use the revised Hensher's formula according to Equation (19). Furthermore we recommend *MP* based on wage rate, i.e., MP_1.

Table 11.7 Value of time for business travel

Mode	*r*	*q*	*p*	MP_1	MP_2	*vl*	**Business *VoT***			
							MP_1		MP_2	
							Eq. 19	***Eq. 1***	***Eq. 19***	***Eq.1***
Car	.39	.02	.21	170	148	87	**137**	**190**	**124**	**177**
PT	.43	.07	.30	131	87	80	**106**	**152**	**82**	**128**

PT stands for public transport

11.3 Some conclusions on the business *VoT*

In the context of inter-urban and urban travel, when employees benefit from a portion of the travel-time savings, it might be expected that the *VoT* for business travel should be lower than marginal product of labour, *MP*, given the private *VoT* is lower than *MP*.

In theory, Hensher suggests a correct approach for the calculation of the *VoT* for business travel. However, in the above sections we pointed out a source of double counting, and consequently proposed a revision of Hensher's formula according to Equation (19).

We suggested that the private *VoT*, or "*vl*" could in theory be higher than wage rate. However, we also pointed to difficulties connected with the measuring the variables in the revised Hensher's formula, i.e., *MP*, *r*, *p*, *q* and *vl*.

Table 11.7 shows the comparison of two alternative approaches for the calculation of *MP*. One, on the basis of wage rate, another on the basis of the wage rate and the additional information that the travellers had provided on the type of compensation they received for travelling outside working hours. These values are different. Our recommendation is to rely only on wage rate for the calculation of *MP*.

Another issue is the difficulties in assertion of the stability of these variables over time. The comparison of the Swedish and the Norwegian studies suggests that the values of "*r*", "*p*", and "*q*" are different enough to call for caution in the assumption of stability of these values over time.

Table 11.8 shows the business *VoT* according to the revised Hensher's formula (see Equation 19) for inter-urban and urban travel. This table shows that for inter-urban travel "*vl*" for travel modes car and especially air is valued higher than wage rate (compare with the corresponding *MP*).

We suggested earlier that a value higher than wage rate is justifiable for "*vl*". The high values of "vl" for travel modes air and inter-urban travel with car can be justified on theoretical grounds. A traveller with these modes is usually constrained to have longer days connected to work, including travelling and hence it is likely to have higher value for leisure time. It is exactly for these two travel modes, i.e., air and inter-urban travel with car that business *VoT's* are equal to or higher than their corresponding *MP's*. The issue that arises is whether such high private *VoT*, i.e., "*vl*" should be socially valued. As we pointed out earlier the differences can be explained by the problems related to resource allocation in the labour market and the correct values for economic analysis are the behavioural values.

However, we would recommend using the lowest value among *MP* and business *VoT*. This conservative recommendation seems appropriate until further research on *VoT* for business travel purposes. Especially for transport modes rail, bus and ferry the *VoT* according to the revised Henshers's formula seem appropriate. For inter-urban business *VoT* for travel modes car and air we would like to recommend *MP*.

Table 11.8 Business VoT according to the revised Hensher's formula

Mode	*r*	*Q*	*p*	*MP*	*vl*	**Business *VoT***
Inter-urban travel						
Car	.57	.32	.03	185	185	**181**
Air	.64	.28	.07	201	313	**267**
Rail	.72	.39	.18	153	118	**116**
Bus	.74	.20	.06	132	59	**75**
Ferry	.63	.19	.03	161	102	**130**
Urban travel						
Car	.39	.02	.21	170	87	**137**
Public transport	.43	.07	.30	131	80	**106**

The private *VoT* for business travellers, i.e., "*vl*", is significantly lower for trips by car shorter than 50 (see table 11.1). As for the case of private travel purposes, trips shorter than 50 with car, bus and rail are assumed to belong to urban travel and will be analysed later with data on urban study.

The private *VoT* for business travellers exhibits similar pattern as *VoT* for private travel purposes. *VoT* decreases with trip distance for inter-urban travel. The relative value of headway decreases as headway increases. *VoT* increases with income.

12 Results from the transfer price (TP) study

The focus of this chapter is on the analysis and the evaluation of the transfer price (TP) questions. It was emphasised earlier that the Norwegian *VoT* study relies mainly on the stated preference (SP) technique. However, the TP approach has been investigated in the Norwegian *VoT* study. The main purpose for this investigation is the evaluation of the technique. This technique was explored early in *VoT* studies in the 80's (see MVA et al., 1987). However, the SP technique became dominant in *VoT* studies. This was due to the poor performance of early TP approach as well as the advancements in SP techniques. More recently the TP approach in the context of *VoT* studies has been getting some attention. One advantage of the TP technique is that the distribution of the value of time can be addressed without having to resort to more advanced econometrics that SP data demands. Another purpose of the TP study will be to address the differences between willingness to pay (*WtP*) and willingness to accept (*WtA*).

This chapter focuses on the evaluation of part of the TP data. Some of the data collected in this study will be evaluated in connection with another research study.

We pointed out earlier that the TP questions were asked after the SP exercise. The main reason for selecting this order of presenting the questions was to assure a high quality of the SP data. However, our evaluation is that this order of presentation of data has contributed to a better quality of TP data. The SP exercise has probably helped the respondents to have more qualified answers to TP questions, or probably more consistent with SP exercise.

As stated before, in the TP study data on willingness to pay or accept (save) for specific improvements (reduced travel time, no transfer, reduction in headway) or willingness to take a reduction in price to compensate for an increase in travel time of the respondents were collected. The respondents were constrained to give at least as high a price for an improvement in transport services as they were already paying and vice versa.

For further research purposes, the short distance travel *VoT* questionnaire includes questions on willingness to pay for reduced accident rate and improved environment. This research is not part of the Norwegian *VoT* study and will be addressed in another study.

12.1 Descriptive analysis of data

The first two questions have been used to compute the willingness to pay for a 25% and a 10% reduction of travel time (in the following denoted WtP_{25} and WtP_{10} respectively), and from question 3 we computed the willingness to accept a 25% increase in travel time (denoted WtA_{25}).

These variables are continuos and defined as follows:

$$WtP = \frac{P_n - P_a}{T_a - T_n} \cdot 60 \tag{18}$$

$$WtA = \frac{P_a - P_n}{T_n - T_a} \cdot 60 \tag{19}$$

P_n is the price (in NOK) the respondent is willing to pay for a given change in travel time,

P_a is the amount (in NOK) that was actually paid for a particular trip

T_a is the actual travel time (in vehicle time, in minutes), for that particular trip

T_n is the new travel time in minutes.

The units for *WtP* and *WtA* are NOK/hour.

12.1.2 Long distance travel

In chapter 9 the description of data was given. In total there were 3 400 respondents who took part in the long distance *VoT* study, distributed over different travel modes as follows.

Mode	No. of interview
Air,	350
Air, STOL	150
Rail, long distance	450
Rail, regional	450
Bus, regional	250
Bus, long distance	250
Ferry	600
Car	900

Table 12.1 and 12.2 show the percentage of respondents who had stated a zero *WtP* and *WtA* for a 25 percent change in travel time. Table 12.3 shows the percentage of respondents who had stated a zero *WtP* for a 10 percent decrease in travel time. These tables suggest that the percentage of the respondents with $WtP_{25} = 0$ is larger than the percentage of the respondents with $WtA_{25} = 0$ and the differences are significant. The segmentation of the SP data shows that those who

had stated zero *WtP* or *WtA* in the TP study had in fact a lower *VoT* than the rest. This could be one explanation for the differences between the responses of men and women in the TP study. The examination of these two tables suggests that the percentage of men and women with zero *WtA* are similar, however, a higher percentage of women had zero *WtP* than men. The differences between the responses of men and women could partly be explained by the differences in their income.

The comparison of tables 12.2 and 12.3 shows that the percentage of respondents with *WtP* = 0 increases significantly when travel-time savings are reduced from 25 percent of travel time to 10 percent.

Table 12.1 Distribution of respondents by WtA_{25}, gender and travel purpose

	Private		Business		Total		
	WtA=0	*WtA*>0	*WtA*=0	*WtA*>0	*WtA*=0	*WtA*>0	Total
Men	29.9	70.1	27.9	72.1	29.2	70.8	64.5
Women	32.2	67.8	22.4	77.6	30.5	69.5	35.5
Total	30.8	69.2	26.8	73.2	29.7	70.3	100.0

Table 12.2 Distribution of respondents WtP_{25}, gender and travel purpose

	Private		Business		Total		
	WtP=0	*WtP*>0	*WtP*=0	*WtP*>0	*WtP*=0	*WtP*>0	Total
Men	39.1	60.9	41.2	58.8	39.8	60.2	64.5
Women	44.4	55.6	34.7	65.3	42.7	57.3	35.5
Total	41.3	58.7	39.8	60.2	40.8	59.2	100.0

Table 12.3 Distribution of respondents WtP_{10}, gender and travel purpose

	Private		Business		Total		
	WtP=0	*WtP*>0	*WtP*=0	*WtP*>0	*WtP*=0	*WtP*>0	Total
Men	66.7	33.3	73.1	26.9	69.1	30.9	66.4
Women	73.2	26.8	71.0	29.0	72.8	27.2	33.6
Total	69.3	30.7	72.7	27.3	70.4	29.6	100.0

Table 12.4 shows the average *VoT*. in terms of *WtP* or *WtA*. in NOK/hour. for different segmentations of the data used in Tables 12.1 to 12.3.

Tables 12.1 to 12.3 also shows that the percentage of respondents with zero WtP_{25} is higher than the percentage of respondents with zero WtA_{25}. It also shows that the percentage of respondents with zero WtP_{10} is significantly higher than the percentage of respondents with zero WtP_{25}. Table 12.4 also suggests that WtP_{25} is lower than WtA_{25} for almost all the segments. This is in line with underlying economic theories.

Another interesting observation from table 12.4 is the relation of WtP_{25} and WtP_{10}. WtP_{10} is significantly lower than WtP_{25} for all segments expect for the segment where $WtP_{10}>0$, where WtP_{10} is significantly larger than WtP_{25}. It should be also noted that for this segment the difference between WtP_{25} and WtA_{25} is not significant. This implies that the respondents in this segment have higher willingness to pay for small travel-time savings than large travel-time savings.

Table 12.4 *WtP* and *WtA* for different segments, NOK/hour

	Total	$WtP_{25}>0$	$WtP_{10}>0$	$WtA_{25}>0$	$WtP_{25}>0$ & $WtA_{25}>0$
No. of obs.	*3040*	*1802*	*460*	*2137*	*1552*
Percentage of obs.	100	59	30	70	51
WtP_{25}	67.8	113.4	115.8	80.4	110.4
WtP_{10}	40.8	68.4	136.2	45.0	64.2
WtA_{25}	107.4	109.2	111.0	152.4	127.2

Haneman (1991) suggests that the differences between *WtP* and *WtA* can be explained by income and substitution possibilities. Table 12.5 shows some descriptive analysis of data for the segmentations presented in Table 12.4. Table 12.5 shows that the average income is higher among the respondents with $WtP_{25}>0$ than $WtA_{25}>0$. It also seems that the average travel time is longer among the respondents with $WtP_{25}>0$ than $WtA_{25}>0$. Even though travel time and distance are correlated, there is not as clear pattern between travel distance and *WtA* and *WtP*. It is also important to note that there is not a very large difference between the average income among the respondents with $WtP_{25}>0$ than $WtA_{10}>0$.

A major part of respondents with zero *WtP* and *WtA* face an absolute change in travel time of less than 30 minutes.

Table 12.5 Average travel time travel distance and income

		WtP_{25}		WtP_{10}		WtA_{25}	
	Total	$WtP_{25}=0$	$WtP_{25}>0$	$WtP_{10}=0$	$WtP_{10}>0$	$WtA_{25}=0$	$WtA_{25}>0$
Travel time, min	162.4	128.1	185.9	142.1	221.0	131.3	175.5
Travel distance, km	289.3	285.3	292.3	297.0	313.0	259.8	302.2
Personal income[1]	215.3	194.2	229.8	219.8	224.7	216.2	215.1

1 personal income in 1000 NOK/year

12.1.3 Short distance travel

Table 12.6 shows the percentage respondents with zero WtP_{25} and WtA_{25}. The percentage of respondents stating zero WtP_{25} or WtA_{25}, is much higher than it was with long distance travels. The percentage of respondents with zero WtP_{25} or WtA_{25} is slightly higher for private than business travel.

This table also shows that the percentage of respondents stating zero *WtP* increases from 65.9 to 85.5 when the time savings decreases from 25 to 10 percent. This suggests that for small time savings, the respondents are less willing to state a non-zero value for *WtP* than for larger time savings.

About half of the respondent state zero WtA_{25}.

Table 12.6 Percentage of respondents with zero value for *WtP* or *WtA*

	WtP_{25}		WtP_{10}		WtA_{25}	
Purpose	WtP_{25}=0	WtP_{25}>0	WtP_{10}=0	WtP_{10}>0	WtA_{25}=0	WtA_{25}>0
Private (n=842)	68.2	31.8	86.2	13.8	52.5	47.5
Business (n=155)	53.5	46.5	81.3	18.7	50.3	49.7
Total (n=997)	65.9	34.1	85.5	14.5	52.2	47.8

Table 12.7 shows a comparison of the averages of some essential variables for the different sub-samples of zero and non-zero respondents.

Table 12.7 Average values of some essential variables

	WtP_{25}		WtP_{10}		WtA_{25}	
Variable	WtP_{25}=0	WtP_{25}>0	WtP_{10}=0	WtP_{10}>0	WtA_{25}=0	WtA_{25}>0
Travel time, min	17.85	25.16	19.15	27.38	17.69	23.23
Travel distance, km	9.60	15.61	10.79	16.70	9.79	13.66
Personal income[1]	202.34	256.01	220.23	223.10	204.89	237.82

1 personal income in 1000 NOK/year

The table shows that respondents with zero *WtP* in general have lower personal income, and shorter travels both in time and distance than those with non-zero *WtP*. Hence, they also have less potential for saving time.

For *WtA*, we see a similar pattern: those who stated zero *WtA* have less personal income, and shorter travels (both in the sense of travel time and distance), than those who stated non-zero *WtA*.

The objective is to evaluate *WtP* and *WtA* for short-distance travel. Consequently the percentage of respondents with zero values will influence the estimated values for *WtP* and *WtA*. Table 12.8 presents how the average values varies between different sub-samples.

Table 12.8 The average *WtP* and *WtA* in NOK/hr for different segmentations

	All	WtP_{25}>0	WtP_{10}>0	WtA_{25}>0	WtA_{25}>0 & WtP_{25}>0
No. of Obs.	997	340	145	477	262
WtP_{25}	19.95	58.50	78.33	29.94	54.51
WtP_{10}	14.56	42.68	100.08	19.02	34.62
WtA_{25}	21.80	32.86	34.61	45.56	42.65

The economic theory suggests *WtA* to be larger than *WtP*. This is true for all observations when zero-values for *WtP* and *WtA* are included. The same appears if we study the segment of data for respondents with WtA_{25}>0.

For other segments, i.e., the segments with respondents with WtP_{25}>0, with WtP_{10}>0 and finally with WtP_{25}>0 and WtA_{25}>0, WtP_{25} is larger than WtA_{25}, contrary to the expectation.

Figures 12.3 to 12.5 are histograms showing the distribution of the changes in travel time for the different segments of respondents with zero *WtP* and *WtA*. This figures shows that the major part of these respondents face a very small change in travel time. This is probably the main reason why most of the respondents are indifferent to the changes, and state zero *WtP* or *WtA* .

Figure 12.3 Time change, in minutes, for a 25 decrease in travel time for the respondents with zero WtP_{25}

Figure 12.4 Time change, in minutes, for a 10 decrease in travel time for the respondents with zero WtP_{10}

Figure 12.5 Time change, in minutes, for a 25% increase in travel time for the respondents with zero WtA_{25}

12.2 Respondents with zero *WtP* and *WtA*

The analysis of the factors that influence respondents to state a zero value for *WtP* or *WtA* is important. As it was presented above the number of observations with zero *WtP* or *WtA* is quite high. For this purpose a logistic regression model is estimated for each of the three measures WtP_{25}, WtP_{10} and WtA_{25}. In a logistic regression model, the dependent variable is dichotomous; here: 0 for the respondents with zero-value and 1 for the respondents with positive values of the dependent variable.

12.2.1 Long distance travel

Table 12.9 shows the logistic regression model for WtP_{25}. This model indicates that the probability of having a non-zero value of WtP_{25} increases with increase in travel distance and income. Travel purpose business increases the possibility of a non-zero WtP_{25}. Compared with car drivers, respondents travelling by all other modes of travel, with the exception of bus, are more likely to have zero *WtP*.

Table 12.9 Logistic model for WtP_{25}

	Original model			*Final model*		
No. of obs.		2954			2955	
-2LL		3784.2			3785.4	
Variable	ß	Wald statistics	Sign. level	ß	Wald statistics	sign. level
Travel distance	0.0009	26.678	0.00	0.0009	26.796	0.00
Income[1]	0.0016	24.774	0.00	0.0016	27.182	0.00
Male	-0.0176	0.040	0.84			
Business	0.2383	5.782	0.02	0.2417	6.018	0.01
Air	-1.3694	97.352	0.00	-1.3740	99.375	0.00
Ferry	-0.5598	20.025	0.00	-0.5651	20.457	0.00
Bus	0.6496	24.423	0.00	0.6469	24.554	0.00
Rail	-0.1164	1.126	0.29	-0.1187	1.183	0.28
Constant	0.0104	0.009	0.93	0.0007	0.000	0.99

1 Annual personal income in 1000 NOK/year

Table 12.10 shows the logistic model for WtP_{10}. This model is based on larger number of observations with zero value for *WtP*. This model indicates that the probability of having a non-zero value of WtP_{10} increases with increase in travel distance. However, income was not significant in this model.

Table 12.10 Logistic model for WtP_{10}

	Original model			*Final model*		
Natal obs.		1488			1524	
-2LL		1701.6			1753.5	
Variable	ß	Wald statistics	Sign. level	ß	Wald statistics	sign. level
Travel distance	0.0008	16.114	0.00	0.0008	14.497	0.00
Income[1]	0.0001	0.541	0.46			
Male	-0.4072	9.401	0.00	-0.4345	11.039	0.00
Business	0.1648	1.302	0.25	0.2783	3.929	0.05
Air	-1.1861	30.517	0.00	-1.1971	32.532	0.00
Ferry	-1.2662	32.125	0.00	-1.3288	35.641	0.00
Bus	0.7592	20.457	0.00	0.6073	14.355	0.00
Rail	0.0647	0.158	0.69	-0.0216	0.019	0.89
Constant	-0.8417	42.847	0.00	-0.9077	62.194	0.00

1 Personal income in 1000 NOK/year

Travel purpose business increases the possibility of a non-zero WtP_{10}. Compared to women, men have lower probability of a non-zero WtP_{10}. Compared with car drivers, respondents travelling by all other modes of travel, with the exception of bus, are more likely to have zero *WtP*.

Table 12.11 shows the logistic model for WtA_{25}. This model indicates that the probability of having a non-zero value of WtA_{25} increases with increase in travel distance. Travel purpose business increases the possibility of a non-zero WtP_{10}.

Compared to car drivers, respondents travelling by all other modes of travel, with the exception of bus, are more likely to have zeros *WtA*. Note that the signs for modes of travel are the same in all these three models.

Table 12.11 Logistic model for WtA_{25}

	Original model			*Final model*		
No. of obs.	2954			3023		
-2LL	3484.7			3570.9		
Variable	ß	Wald statistics	Sign. Level	ß	Wald statistics	sign. level
Travel distance	0.0008	20.568	0.00	0.0009	22.698	0.00
Income[1]	-0.00004	0.149	0.70			
Male	0.0136	0.023	0.88			
Business	0.3770	13.474	0.00	0.3661	13.554	0.00
Air	-0.9955	47.223	0.00	-0.9977	48.528	0.00
Ferry	-0.4581	11.268	0.00	-0.4749	12.584	0.00
Bus	0.0434	0.099	0.75	0.0172	0.017	0.90
Rail	-0.7091	37.489	0.00	-0.7052	38.601	0.00
Constant	0.9679	00.854	0.00	0.9577	13.884	0.00

1 Personal income in 1000 NOK/year

12.2.2 Short distance travel

Each of the logistic models is based on the whole sample, that is 997 observations.

Table 12.12 shows the logistic regression model for WtP_{25}. The model indicates that the probability of having a non-zero value of WtP_{25} increase with travel distance. Men have a higher possibility of a non-zero WtP_{25} than women do. The probability of having a non-zero WtP_{25} increases for trips that are made during the peak periods or for business purpose. Unlike long distance travel, travel purpose business does not influence a non-zero response.

Compared to car drivers, respondents travelling by public transport and rail are more likely to have zeros WtP_{25}.

Table 12.13 shows the logistic regression model for WtP_{10}. This model contains a larger amount of zero-observations than the previous one, as the number of respondents stating zero WtP_{10} is larger than the number stating zero WtP_{25}.

Similar to the previous model, the probability of a non-zero *WtP* increases with travel distance, for men and during peak periods. Travellers with public transport or rail have lower possibility of stating zero WtP_{10} than car drivers do.

Table 12.12 Logistic regression for WtP_{25}

	Original model			*Final model*		
-2 LL		1182.3			1185.904	
Variable	ß	Wald statistics	Sign. level	ß	Wald statistics	sign. level
Distance. km	0.047	42.706	0.00	0.049	45.960	0.00
Income[1]	0.002	1.180	0.28			
Male	0.285	3.677	0.06	0.329	5.040	0.02
Peak period	0.424	3.677	0.00	0.397	7.299	0.01
Business	0.282	2.058	0.15			
Public transport	-0.447	6.788	0.06	-0.500	8.770	0.00
Rail	-0.091	0.085	0.66	-0.145	0.230	0.63
Constant	-1.815	77.127	0.00	-1.549	74.807	0.00

1 Personal income in 1000 NOK /year

Table 12.13 Logistic regression model for WtP_{10}

	Original model			*Final model*		
-2 LL		771.174			771.760	
Variable	ß	Wald statistics	Sign. level	ß	Wald statistics	sign. level
Distance. km	0.036	21.791	0.00	0.036	24.947	0.00
Income[1]	-0.003	0.322	0.57			
Male	0.346	2.872	0.09	0.319	2.537	0.11
Peak period	0.385	3.794	0.05	0.389	3.919	0.05
Business	-0.049	0.038	0.85			
Public transport	-0.953	12.539	0.00	-0.928	12.178	0.00
Rail	-0.334	0.772	0.38	-0.322	0.724	0.39
Constant	-2.418	91.886	0.00	-2.474	108.029	0.00

1 Personal income in 1000 NOK /year

Table 12.14 shows the logistic regression model for WtA_{25}. This model suggests that the probability of a non-zero *WtA* increase with travel distance. Note that the signs for each of the modes public transport and rail are positive compared to car. That implies that travellers using public transport or rail are more likely to state non-zero willingness to accept than car drivers.

Table 12.14 Logistic regression model for WtA_{25}

	Original model			*Final model*		
-2 LL	1333.152			1337.671		
Variable	ß	Wald statistics	Sign. Level	ß	Wald statistics	Sign. level
Distance. km	0.040	31.505	0.00	0.039	31.878	0.00
Income[1]	0.001	1.466	0.23			
Male	-0.047	0.118	0.73			
Peak period	0.185	1.874	0.17			
Business	-0.007	0.001	0.97			
Public transport	0.152	1.286	0.26	0.391	7.165	0.07
Rail	0.100	0.243	0.62	0.383	1.602	0.21
Constant	-0.596	10.31	0.00	-0.678	33.348	0.00

1 Personal income in 1000 NOK /year

12.3 Regression models for *WtP* and *WtA*, long distance travel

Least square method was used for the estimation of *WtP*, *WtA*, ln*WtP* and ln*WtA*. It is assumed that the independent variable has a normal distribution. The normalised plots of the results of estimations are shown in Figures 12.6 to 12.9. The examination of these figures suggests that the *WtP* and *WtA* have a lognormal distribution.

To estimate the model all observations with zero value for *WtP* and *WtA* are excluded. The regression model used for the estimation of *WtP* and *WtA* are the following:

$$\ln(WtP) = c + a\ln(D) + b\ln(W) + d_1 Air + d_2 Ferry + d_3 Bus + d_4 Rail + u \qquad (20)$$

$$\ln(WtA) = c + a\ln(D) + b\ln(W) + d_1 Air + d_2 Ferry + d_3 Bus + d_4 Rail + u \qquad (21)$$

where

WtP willingness to pay for a decrease in travel time, NOK/hr

WtA willingness to accept an increase in travel time, NOK/hr

D travel distance in kilometres

W the average hourly wage

Air is equal to 1 if air is the mode of travel, otherwise equals to 0

Ferry is equal to 1 if ferry is the mode of travel, otherwise equals to 0

Bus is equal to 1 if bus is the mode of travel, otherwise equals to 0

Rail is equal to 1 if rail is the mode of travel, otherwise equals to 0

u is the error term

a, *b*, *c*, d_1, d_2, d_3 and d_4 are model parameters

Tables 12.15 and 12.16 show the average values of the variables that have been used for the estimation of WtP_{25} and WtA_{25}. These tables show that WtP_{25} and WtA_{25} are significantly different for different modes and travel purpose.

Table 12.15 Average values of the explanatory variables for WtP_{25}

	Mode of travel					
	Car	*Air*	*Ferry*	*Bus*	*Rail*	*Total*
Private trips						
WtP_{25}, NOK/t	79.8	273.6	85.2	64.2	61.8	84.6
Distance, km	213.6	596.0		191.0	318.8	265.5
Hourly wage, NOK	126.2	241.3	109.3	73.7	96.0	111.8
Business trips						
WtP_{25}, NOK/hr	112.8	432.0	109.8	66.0	100.8	187.2
Distance, km	242.8	591.3		262.7	290.4	366.7
Hourly wage, NOK	154.7	178.2	164.8	116.5	156.3	158.4

Table 12.16 Average values of the explanatory variables for WtA_{25}

	Mode of travel					
	Car	*Air*	*Ferry*	*Bus*	*Rail*	*Total*
Private trips						
WtA_{25}, NOK/t	100.2	342.0	134.4	51.0	75.6	108.0
Distance, km	211.1	607.3		199.4	305.0	270.8
Hourly wage. NOK	1223.0	152.6	107.5	69.4	76.6	101.1
Business trips						
WtA_{25}, NOK/hr	143.4	423.8	180.6	75.6	94.8	259.8
Distance, km	226.9	575.3		274.9	296.2	385.0
Hourly wage, NOK	147.5	174.8	152.6	113.3	153.9	155.2

Figure 12.6 Normalised plot for WtA_{25}

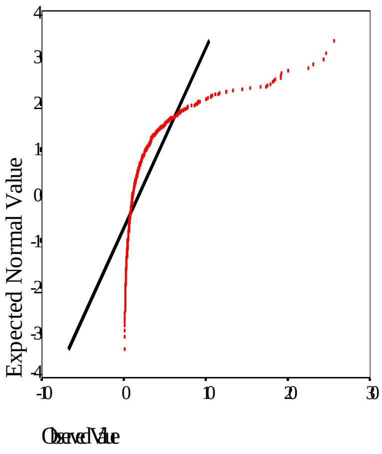


Figure 12.8 Normalised plot for WtA_{25}

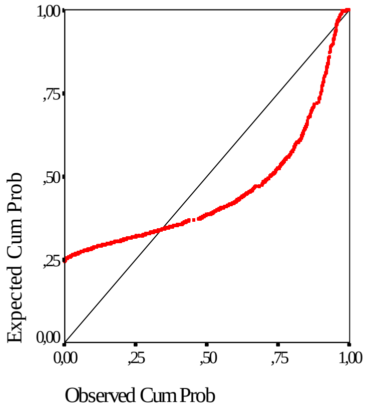


Figure12.7 Normalised plot for ln(WtA_{25})

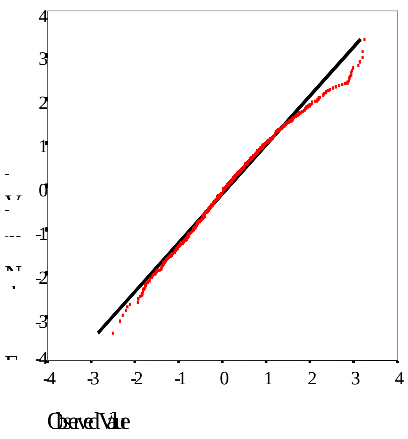
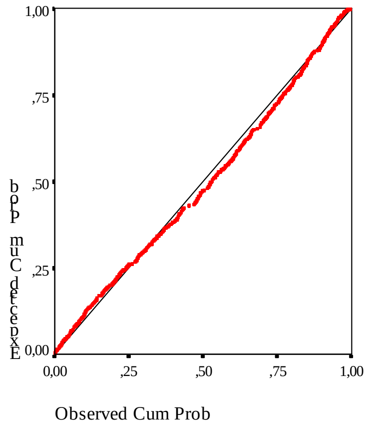


Figure 12.9 Normalised plot for ln(WtA_{25})



Since travel time and distance were correlated, travel time was not included in the regression models for the estimation of WtP_{25} and WtA_{25}. The estimation is based on trips longer than 30 kilometres.

Tables 12.17 and 12.18 show the regression models for WtP_{25} and WtA_{25} for private travel purposes. These models suggest that both WtP_{25} and WtA_{25} increase with travel distance and income. Compared with car drivers, the respondents travelling by bus and rail have a lower WtP_{25} and WtA_{25} while the respondents travelling by air have a higher WtP_{25} and WtA_{25}. For ferry WtP_{25} is similar to that of car while WtA_{25} is higher than car.

Table 12.17 Regression model for WtP_{25}. private travel

	Total		*Wave 1*		*Wave 2*	
No. of obs.	1113		565		548	
R^2	23.16		22.02		26.35	
Adjusted R^2	22.74		21.18		25.53	
	ß	t-value	ß	t-value	ß	t-value
Constant	-0.925	-4.63	-1.182	-3.89	-0.557	-2.14
ln(D)	0.095	3.00	0.107	2.16	0.063	1.58
ln(W)	0.107	4.68	0.144	3.97	0.069	2.45
Air	1.118	11.80	1.198	7.79	1.051	9.23
Ferry	-0.012	-0.15	-0.165	-1.30	0.106	1.11
Bus	-0.273	-4.42	-0.288	-2.98	-0.270	-3.52
Rail	-0.224	-3.79	-0.201	-2.21	-0.255	-3.35

Tables 12.19 and 12.20 show the regression models for WtP_{25} and WtA_{25} for business travel purposes. These models suggest that both WtP_{25} and WtA_{25} increase with travel distance and income. Compared with car drivers, the respondents travelling by bus and rail have a lower WtP_{25} and WtA_{25} while the respondents travelling by air have a higher WtP_{25} and WtA_{25}. For ferry WtA_{25} is similar to that of car while WtP_{25} is higher than car.

Table 12.18 Regression model for WtA_{25}. private travel

	Total		*Wave 1*		*Wave 2*	
No. of obs.	1273		630		643	
R^2	33.87		31.54		38.25	
Adjusted R^2	33.56		30.88		37.67	
	ß	t-value	ß	t-value	ß	t-value
Constant	-0.811	-4.35	-1.290	-4.77	-0.280	-1.09
ln(D)	0.072	2.50	0.110	2.56	0.023	0.58
ln(W)	0.153	6.81	0.197	5.78	0.113	3.78
Air	1.063	13.21	1.177	9.79	0.960	8.99
Ferry	0.323	4.65	0.305	2.95	0.343	3.71
Bus	-0.569	-9.60	-0.337	-3.81	-0.780	-9.92
Rail	-0.265	-4.70	-0.182	-2.24	-0.360	-4.58

Table 12.19 Regression model for WtP_{25}. business travel

	Total		*Wave 1*		*Wave 2*	
No. of obs.	461		206		255	
R^2	46.41		42.23		50.74	
Adjusted R^2	45.71		40.49		49.55	
	ß	t-value	ß	t-value	ß	t-value
Constant	-1.703	-4.20	-1.892	-2.81	-1.512	-3.04
ln(D)	0.169	3.35	0.066	0.77	0.220	3.55
ln(W)	0.248	4.09	0.373	3.85	0.173	2.24
Air	1.074	9.73	1.249	6.56	0.970	7.22
Ferry	-0.439	-3.79	-0.578	-3.29	-0.335	-2.20
Bus	-0.465	-3.60	-0.361	-1.75	-0.559	-3.42
Rail	-0.131	-1.19	0.080	0.49	-0.304	-2.01

Table 12.20 Regression model for $WtA_{25.}$ business travel

	Total		*Wave 1*		*Wave 2*	
No. of obs.	566		229		337	
R^2	48.64		47.50		53.03	
Adjusted R^2	48.09		46.09		52.17	
	ß	t-value	ß	t-value	ß	t-value
Constant	-0.719	-1.89	-0.797	-1.28	-0.663	-1.41
ln(D)	0.146	3.09	0.061	0.78	0.178	3.09
ln(W)	0.130	2.26	0.222	2.45	0.094	1.30
Air	1.059	10.50	1.238	7.70	0.965	7.60
Ferry	-0.023	-0.21	-0.347	-2.08	0.158	1.15
Bus	-0.808	-6.10	-0.571	-2.81	-0.979	-5.76
Rail	-0.622	-5.68	-0.267	-1.74	-1.001	-6.51

Table 12.21 shows the regression models for WtP_{10} for private and business travel purposes. The results of the estimation can be compared with Tables 12.17 and 12.19 wave2. The size and the sign of the coefficients, except for ferry, in regression models for WtP_{10} is quite comparable with WtP_{25}.

Table 12.21 Regression models for WtP_{10}

	Private Travel		*Business travel*	
No. of obs.	291		121	
R^2	29.35		43.42	
Adjusted R^2	27.86		40.52	
	ß	t-value	ß	t-value
Constant	-0.527	-1.17	-1.939	-2.47
ln(D)	0.046	0.66	0.241	2.11
ln(W)	0.097	2.27	0.234	2.07
Air	1.534	7.18	0.938	4.17
Ferry	0.456	2.20	-0.028	-0.10
Bus	-0.406	-3.50	-0.617	-2.62
Rail	-0.326	-2.70	-0.235	-0.90

Tables 12.22 and 12.23 show the average value of WtP_{25} and WtA_{25} for different travel modes and for private and business travel purposes. These averages are based on the average values of the dependent variables.

The comparison of Tables 12.22 and 12.23 show *WtP* and *WtA* are lower for private travel than for business travel except for bus and ferry. For travel modes bus and ferry the WtP_{25} and WtA_{25} for private and business travel are quite similar. Bus is not a favoured mode for business travel and there was relatively little observation in the data in this category.

Another observation is that WtP_{25} is generally lower than WtP_{25}. Again travel mode bus has been an exception where WtP_{25} and WtA_{25} are not significantly different.

Table 12.22 Average WtA_{25} and WtP_{25}. private travel. NOK/hr

	Car		Air		Ferry		Bus		Rail	
	WtA	*WtP*	*WtA*	*WtP*	*WtA*	*WtP*	*WtA*	*WtP*	*WtA*	*WtP*
Total	78.8	63.6	236.2	208.1	106.3	62.0	39.4	44.3	56.4	48.9
Wave 1	71.5	61.5	252.1	222.6	91.8	50.0	43.6	41.1	56.0	48.5
Wave 2	86.1	65.9	222.1	195.6	120.2	73.1	36.1	47.4	56.3	49.3

Table 12.23 Average WtA_{25} and WtP_{25}. business travel. NOK/hr

	Car		Air		Ferry		Bus		Rail	
	WtA	*WtP*	*WtA*	*WtP*	*WtA*	*WtP*	*WtA*	*WtP*	*WtA*	*WtP*
Total	113.0	82.6	364.3	268.9	108.7	51.4	45.2	42.3	58.3	65.6
Wave 1	103.1	71.2	365.0	249.7	68.8	36.4	48.6	36.6	71.8	64.9
Wave 2	121.7	93.5	365.0	285.8	143.4	67.0	41.9	45.9	43.0	63.5

Table 12.24 shows WtP_{10} for different modes and private and business travel. The values in this table should be compared with WtP_{25} for wave 2 in Tables 12.22 and 12.23. For travel modes car, bus and rail WtP_{10} and WtP_{25} are not significantly different, even though WtP_{10} is slightly higher than WtP_{25} for modes car and rail. For travel mode ferry WtP_{10} is larger than WtP_{25}. For air WtP_{10} is larger than WtP_{25} for private travel while WtP_{10} is smaller than WtP_{25} for business travel. It is possible to justify a higher WtP_{10} than WtP_{25}, since as we explained earlier a much larger part of the respondents had stated zero for WtP_{10} than for WtP_{25}. In the estimation of the regression models the zero observations are not included. This introduces bias in the data, since the estimation of the regression model for WtP_{10} is based on a sample that has a higher value of time than the sample that was used for the estimation of the regression model for WtP_{25}.

Table 12.24 Average WtP_{10}, NOK/hr

	Car	*Air*	*Ferry*	*Bus*	*Rail*
Private travel	69.2	313.2	103.4	44.6	49.5
Business Travel	96.5	213.3	73.3	43.5	67.9

12.3.1 Comparison of TP and SP studies

Tables 12.25 and 12.26 show the comparisons of results from TP and SP studies for private and business trips. In these tables WtP_{25} and WtA_{25} are the values from Tables 12.22 and 12.23. The examination of these tables suggests that WtP_{25} is significantly lower than WtA_{25}.

It was mentioned earlier that the percentage of the respondents with $WtP = 0$ increased when the travel time saving was decreased from 25 percent to 10 percent. It was also mentioned that the segmentation of the SP data shows that those who had stated zero *WtP* in the TP study had a lower *VoT* than the rest. This explains for WtP_{10} to be higher than for WtP_{25}.

Tables 12.25 and 12.26 show that the *VoT*'s from the SP and TP studies are comparable. In most cases the *VoT*'s from the SP study are in fact between WtP_{25} and WtA_{25} from the TP study.

It was explained earlier that the TP questions came right after the SP games. It is possible that this occurrence has helped the respondents in the TP study and some of the problems connected with TP studies have been avoided. However, the comparability of the results from the SP and the TP parts is such that it demands further studies to confirm this.

Table 12.25 Value of time for private trip. NOK/hr

	TP			SP
Mode	WtA_{25}	WtP_{25}	WtP_{10}	*VoT*
Car	79	64	69	86
Ferry	106	62	103	83
Rail	56	49	49	54
Bus	39	44	45	48
Air	236	208	313	155

Table 12.26 Value of time for business trip. private valuation. NOK/hr

	TP			SP[1]
Mode	WtA_{25}	WtP_{25}	WtP_{10}	*VoT*
Car	113	83	97	185
Ferry	109	51	73	102
Rail	58	66	68	118
Bus	45	42	44	59
Air	364	269	213	313

[1] based on the first wave

12.3.2 Tobit models

The observed data on *WtP* and *WtA* contain a cluster of zeros. In the Least Square (LS) models presented earlier, the zero observations were not included in the estimation of the parameters. Here different Tobit models with different values for left censoring will be estimated and compared with the least square model.

The structure of Tobit model used here has the following (LIMDEP maunal, version 7.0).

Latent underlying regression:

$$y_i^* = \beta' x_i + \varepsilon_i, \varepsilon_i \approx N(0, \sigma^2)$$

Observed dependent variable:

if $y_i^* \le L_i$, then $y_i^* = L_i$ or unobserved (lower tail censoring or truncation)

if $y_i^* \succ L_i$, then $y_i^* = \beta^{'} x_i + \varepsilon_i$

The values assumed for *L* are -4, -2.5, -0.7 and 0. The estimations are based on data for WtA_{25}, wave 2.

Figure 12.10 shows the comparison of the estimated parameters of different Tobit models with the LS model from Table 12.18. The examination of this figure suggests that the value assumed for *L* have significant effect on the estimated value of the parameters. It also can be observed that estimated parameters in the LS model are closer in value to a Tobit model with *L = 0* and *L = -0.7*, Note that *L = 0* is equivalent to a WtA_{25} of 60 NOK/hr.

Figure 12.10 Comparison of the estimated parameters, WtP_{25}, private travel

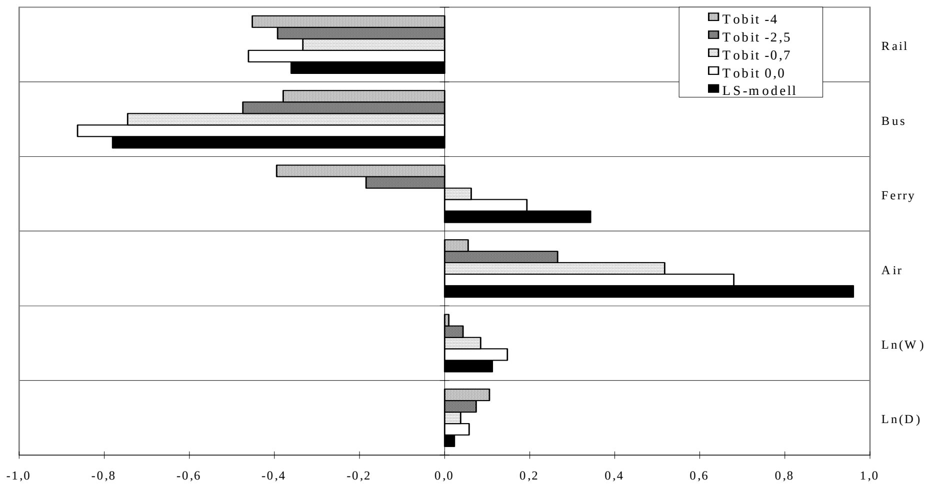


Figure 12.11 shows the loglikelihood values of the different models. The number of variables is the same in all these models. Tobit models are all based on the same number of observatione (884). Figure 12.11 suggests that the loglikelihood decreases with a decrease in *L*, i.e., the Tobit model with *L = -4* has a better fit than the Tobit model with *L = 0*. The loglikelihood for the LS model is lower than other models. However, the LS models are based on a smaller number of observations (645).

Figure 12.12 shows the average WtA_{25} based on different models. This figure shows that the WtA_{25} decreases with a decrease in *L*. This is of course according to the expectation. However, the WtP_{25} based on LS model is closest in value to that of Tobit where *L = 0*.

Figure 12.11 Comparison of log likelihood values of different models

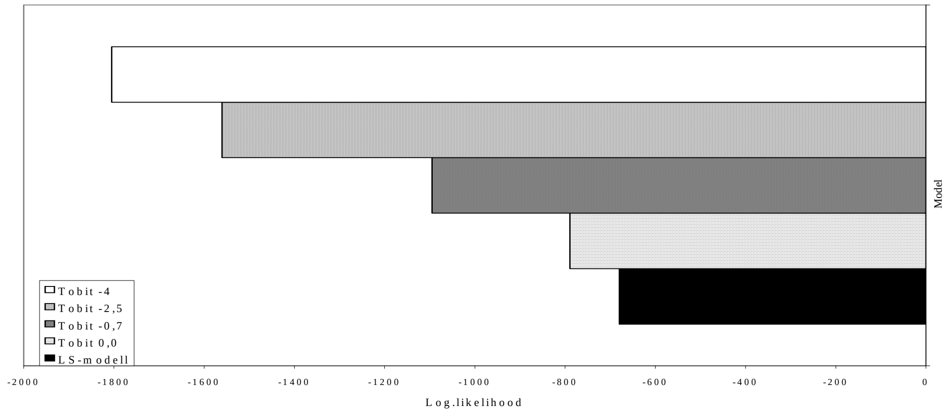
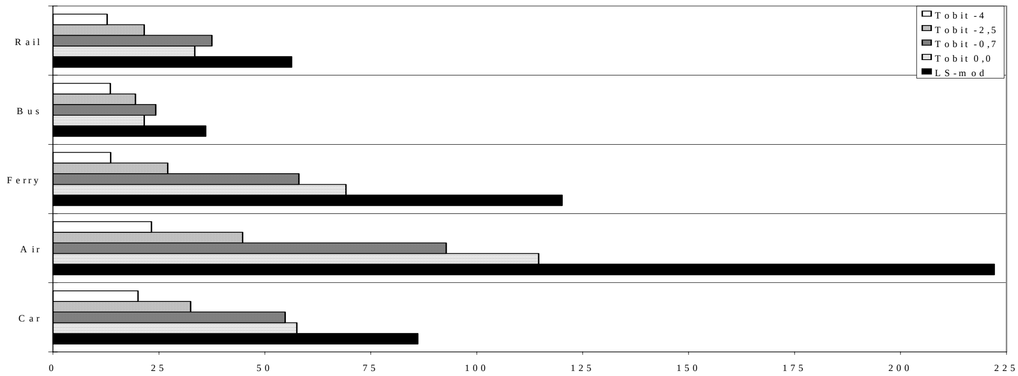


Figure 12.12 *WtA*$_{25}$ based on different models in NOK/hr



12.3.3 The difference between *WtP* and *WtA*

Economic theory suggests that *WtA* should be larger than *WtP*. Furthermore, it has been suggested that the difference should increase with income and the possibilities of substitution (Hanemann, 1991). Table 12.27 shows a regression model for the difference between WtA_{25} and WtP_{25} for long distance travel. The estimation of this model is based on responses with both WtP_{25} >0 and WtA_{25} >0.

Table 12.27 suggest that (WtA_{25}-WtP_{25}) increases with (hourly wage)^2, and travel distance.

There are some mode specific differences. Compared with car, (WtA_{25}-WtP_{25}) is less for bus and rail. The difference compared with car is not significant for the other modes. Travel purpose does not seem to affect (WtA_{25}-WtP_{25}) significantly.

Table 12.27 Regression model for (WtA_{25}-WtP_{25})

No. of obs.	1652		
R^2	0.01710		
Adjusted R^2	0.01231		
Variable		ß	t-value
(Hourly wage)^2		1.92E-07	2.283
Travel time. Min		9.81E-04	2.062
Ferry		0.2913	1.294
Buss		-0.6846	3.705
Rail		-0.3255	1.857
Air		0.1889	0.850
Business travel		0.0277	0.188
Commuting		0.3047	1.156
Constant		0.1791	1.195

12.4 Regression models for *WtP* and *WtA*. short distance travel

Normalised plots shown in Figures 12.13 to 12.18, suggest that the WtP_{25}, WtP_{10} and WtA_{25} have a lognormal distribution. To estimate lognormal models the zero observations have to be excluded.

The models are based on all observations with non-zero values for the dependent variable (WtP_{25}, WtA_{25} and WtP_{10}). This implies that the samples for the different models will be of different size according to Tables 12.6 and 12.7.

Figure 12.13 Normalised plot for WtP_{25}

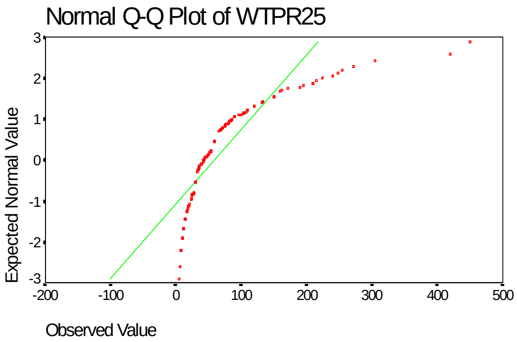


Figure 12.14 Normalised plot for WtP_{10}

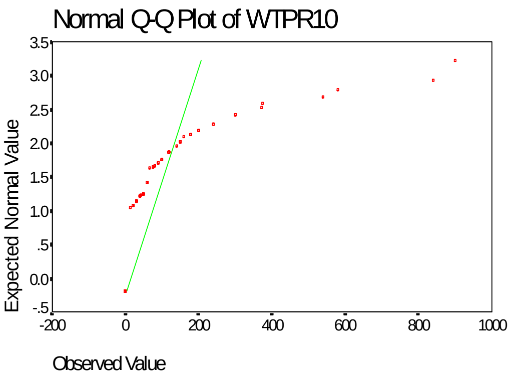


Figure 12.15 Normalised plot for WtA_{25}

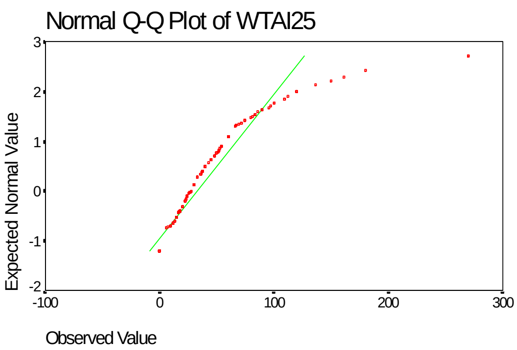


Figure 12.16 Normalised plot for $\ln(WtP_{25})$

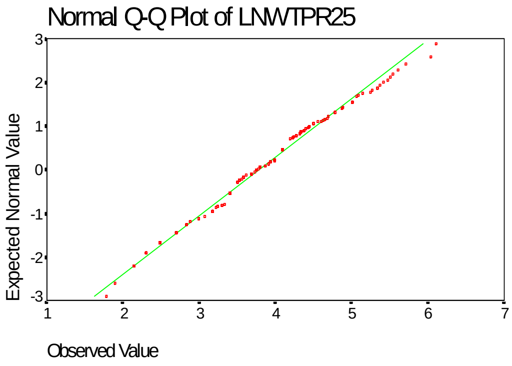


Figure 12.17 Normalised plot for $\ln(WtP_{10})$

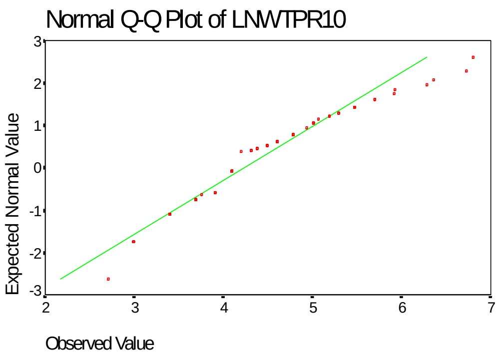
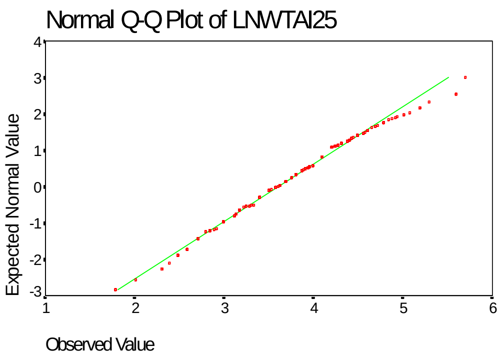


Figure 12.18 Normalised plot for $\ln(WtA_{25})$



For short distance travel, separate models for business and private travel were not estimated as for the case of long distance travel. The number of observations for short distance travel is much smaller than for long distance travel. Nonetheless, travel purpose business is used as a dummy variable in the regression models. Travel purpose commuting could have been another explanatory variable to include in the models. However, all the non-zero observations among the private travel were commuting.

Table 12.27 shows the estimated models for the WtP_{25}. Travel time and distance are correlated. Models with travel time instead of travel distance were quite similar to the models presented here. The models with travel distance are slightly better.

The models in Table 12.27 show that WtP_{25} increases with the travel distance and personal income. The WtP_{25} is higher for business travels than for private travel. Compared to mode car, WtP_{25} is lower for modes rail or public transport. The coefficient for dummy variables male or peak periods did not turn out to be significant.

Table 12.27 Regression model for the WtP_{25}

	Original model		*Final model*	
Variable	ß	t-value	ß	t-value
ln(D)	0.098	2.007	0.097	2.007
ln(I)	0.070	1.547	0.079	1.776
Male	0.053	0.628		
Business	0.233	2.356	0.228	2.352
Peak period	0.082	1.000		
Public transport	-0.440	-4.293	-0.431	-4.227
Rail	-0.332	-2.159	-0.312	-2.047
Constant	3.160	11.572	3.201	11.868
R square	0.137		0.133	

D is distance in km, and I is the personal income in 1000 NOK/year

Table 12.28 shows the models for WtP_{10}.These models are based on substantially fewer observations than the models for WtP_{25} as the percentage of zero observations was larger for WtP_{10} than WtP_{25}. This is probably the main reason why so few of the coefficients turned significant. The only significant effect here is connected to travel mode public transport. The final model also indicates that WtP_{10} increases with increase in personal income.

Table 12.29 shows the models for WtA_{25}. This table shows that WtA_{25} increases with the travel distance. The coefficient for personal income was not significant. The WtA_{25} is higher for business travels than for private travel. Compared to travel by car WtA_{25} is lower for rail and higher for public transport. Neither of them are statistically significant. The coefficient for dummy variables male or peak period is not significant either.

Table 12.28 Regression model for WtP_{10}

	Original		*Final*	
Variable	ß	t-value	ß	t-value
ln(D)	-0.094	-1.159		
ln(I)	0.088	1.024	0.121	1.509
Male	0.163	1.100		
Business	0.079	0.466		
Peak period	-0.047	-0.333		
Public transport	-0.656	-3.368	-0.647	-3.365
Rail	-0.145	-0.563	-0.182	-0.745
Constant	4.013	8.141	3.706	8.533
R square	0.132		0.116	

Table 12.29 Regression model for WtA_{25}

	Original		*Final*	
Variable	ß	t-value	ß	t-value
ln(D)	0.138	3.580	0.132	3.495
ln(I)	-0.006	-0.157		
Male	-0.087	-1.413		
Business	0.178	2.119	0.176	2.177
Peak period	-0.048	-0.760		
Public transport	0.020	0.278	0.045	0.678
Rail	-0.137	-1.153	-0.132	-1.150
Constant	3.370	16.709	3.271	33.795
R square	0.051		0.043	

12.4.1 Comparison of TP and SP studies

From the regression models presented above and the mean values of the variables for the whole sample we have computed mode specific values of WtP_{25} and WtA_{25} and WtP_{10}. Tables 12.30 and 12.31 shows the comparison of these values with the value of time from SP the study.

For private travel, the values are quite similar for WtP_{25} and *VoT*, WtA_{25} is a little lower for car and rail and a little higher for public transport.

Table 12.30 shows that the *VoT* from the SP study is quite similar to WtP_{25} and WtA_{25}. However, for business travel the *VoT* from the SP study is significantly larger than WtP_{25} and WtA_{25}.

These tables suggest that WtP_{25} is smaller than WtP_{10}. Even more pronounced than the case of long distance travel, the percentage of the respondents with zero value for WtP_{10} is much larger than for WtP_{25}. The segmentation of the SP data shows that those who had stated zero *WtP* in the TP study had a lower *VoT* than the rest. This explains for WtP_{10} to be higher than for WtP_{25}.

The economic theory suggests a higher *WtA* than *WtP*. The results presented in Tables 12.30 and 12.31 suggest the contrary.

Table 12.30 *VoT* for private trips, NOK/hr

Mode		*TP*		**SP**
	WtP_{25}	WtA_{25}	WtP_{10}	**VoT**
Car	44.7	34.6	74.9	38.6
Public transport	29.0	36.2	39.2	29.1
Rail	32.7	30.3	62.4	47.8

Table 12.31 *VoT* for business trips (private valuation), NOK/hr

Mode		*TP*		**SP**
	WtP_{25}	WtA_{25}	WtP_{10}	**VoT**
Car	62.2	36.4	78.9	87.0
Public transport	40.4	38.1	41.3	80.0
Rail	45.5	31.9	65.8	- *

* Not enough observations to calculate any *VoT*

The exercise in the context of long distance travel showed that Tobit models were quite sensitive to the number of zero observations and the choice of lower limit and for short distance travel we have chosen not to estimate Tobit model.

12.4.2 Willingness to pay for reducing transfer time

The respondents who had a transfer were asked for their willingness to pay to avoid transfer. Only 25 out of the 997 observations had transfer. Among these 23 were private travel and 2 were business travel.

Transfer is obviously another problematic variable for measurement. There is a disutility associted with transfer, since it takes time to transfer from one vehicle to another and it is not convenient, irrespective of length of time one has to take at the terminal, waiting for arrival of the next vehicle. There is also a disutility connected time waiting for the arrival of the next vehicle.

Table 12.32 Distribution of respondents by modes

Mode	*No. of obs.*
Public transport	22
Rail	3
Total	25

The willingness to pay for reducing transfer time is calculated as following:

$$WtP_T = \frac{Newprice - Actual\ \ price}{transfer\ time} \cdot 60$$

Newprice is the maximum price the respondent is willing to pay given no transfer. *Actual price* is the amount that was actually paid, *transfer time* is the time spent on transfer. The unit for WtP_T is NOK per hour.

Three of the 25 had no registered transfer time and they were excluded. Of the 22 remaining respondents only 14 stated a non-zero willingness to pay for not having a transfer. Table 12.33 shows the average value of willingness to pay to avoid transfer among all respondents and the sub-sample consisting of only the non-zero respondents.

Table 12.33 Average WtP_T (NOK per hour)

	All (n = 22)	WtP_T >0 (n = 12)
WtP_T	22.3	40.9

12.4.3 Willingness to pay for a 50 percent reduction in headway

Only 349 respondents answered the question concerning their *WtP* for a 50% increase in frequency. Of these, only 17 were travelling for business purpose.

Table 12.34 Distribution of respondents by travel mode

Mode	*N*
Public	295
Rail	54
Total	349

Table 12.35 shows the average values for some of the essential variables. We see that in average public transport is 5 NOK cheaper than rail and travellers using public transport are less willing to pay for a 50% reduction in headway than those using rail are. The average headway is about the same for public transport and rail, both around 26 minutes.

Table 12.35 Descriptions of some essential variables

Mode:		*New price (NOK)*	*Actual price (NOK)*	*Actual headway (min)*
Public transport	(n=295)	16.1	15.0	26.2
Rail	(n=54)	23.4	20.7	26.9
All	(n=349)	17.2	15.9	26.4

WtP for reducing headway was calculated using the following relationship.

$$WtP = \frac{Newprice - Actual\ \ price}{(time\ \ between\ \ departures\,/\,2)} * 60$$

Newprice is the maximum price the respondent is willing to pay given the change. *Actual price* is the amount that was actually paid. The unit for *WtP* is NOK per hour.

Similar to the previous measures there were many zero-responses here as well. Out of the 349 respondents 223 had zero *WtP* for reducing the headway. The average *WtP*'s for increase in frequency for the two actual modes, public transport and rail, are shown in the table below.

Table 12.36 *WtP* for a 50% increase in frequency, NOK/hr (no. of observations in parenthesis)

	All respondents (n=349)	*Non-zero respondents (n=126)*
Public transport	6.67 (295)	19.28 (102)
Rail	11.80 (54)	26.54 (24)
All modes	7.46	20.66

12.5.4 Package effect

The respondents who had used public transport or rail were asked how much they were willing to pay for a package consisting of:

- 25% decrease in travel time
- no transfer (for those who had transfer)
- 50% decrease in headway

Altogether 350 respondents answered this question. Everyone was offered a package consisting of a 25% decrease in travel time and a 50% decrease in headway. For the respondents with a transfer the package included no transfers as well. That means that these two groups of respondents were not offered the same package and we have chosen to analyse them separately.

Tables 12.37 and 12.38 show the distributions of respondents with and without transfer by travel mode and purpose. Tables 12.39 and 12.40 show the percentage of respondents with zero *WtP* for these two groups.

Table 12.37 Distribution of respondents without transfer by travel mode and purpose

	Public transport	*Rail*	*Total*
Private	262	47	309
Business	11	4	15
Total	273	51	324

Table 12.38 Distribution of respondents with transfer by travel mode and purpose

	Public transport	*Rail*	*Total*
Private	21	3	24
Business	2		2
Total	23	3	26

Table 12.39 Percentage of respondents without transfer with zero *WtP*

	WtP = 0 (n=164)	*WtP*>0 (n=160)
Private (n=309)	52.1	47.9
Business (n=15)	20.0	80.0
Total (n=324)	50.6	49.4

Table 12.40 Percentage of respondents with transfer with zero *WtP*

	WtP = 0 (n=8)	*WtP*>0 (n=18)
Private (n=24)	29.2	70.8
Business (n=2)	50.0	50.0
Total (n=26)	30.8	69.2

The percentage of non-zero response was higher among respondents with transfers. About 50% of those without transfer had a non-zero *WtP* compared with 70% for those with transfer.

Table 12.41 shows the average values of some of the essential variables.

Table 12.41 Mean values for some essential variables

Variable	Without transfers: *WtP*=0 (n=164)	Without transfers: *WtP*>0 (n=160)	Without transfers: All (n=324)	With transfers: *WtP*=0 (n=8)	With transfers: *WtP*>0 (n=18)	With transfers: All (n=26)
WtP (NOK)	14.13	21.76	17.90	20.00	22.50	21.73
Actual price (NOK)	14.13	17.43	15.76	20.00	16.22	17.38
25% travel time (min)	4.37	5.16	4.76	7.87	7.44	7.58
Transfer time (min)	-	-	-	8.13	7.78	7.88
Headway (min)	23.94	28.96	26.42	20.63	27.22	25.19
Income (1000 NOK)	159.63	167.81	163.67	177.25	160.33	165.54

The respondents were asked to give an estimate of the amount they paid to reduce travel time. This question was of course only answered by those who had stated a *WtP* greater than zero for the package. This produces *WtP* to reduce travel time by 25% and is calculated as follows

We computed the willingness to pay in (NOK/h) from the following formula:

$$WtP_P = \frac{amount\ stated}{25\%\ of\ the\ travel\ time} *60$$

Table 12.42 shows the comparison of WtP_P in the package and WtP_{25} for the same respondents from the previous exercise.

Table 12.42 Comparison of WtP_P in the package and WtP_{25} for the same respondents from the previous exercise.

Variable	Without transfer: *WtP*>0 (n=160)	Without transfer: All (n=324)	With transfer: *WtP*>0 (n=18)	With transfer: All (n=26)
WtP_P (NOK/h)	21.7	10.7	21.4	14.8
WtP_{25} (NOK/h)	18.2	9.9	26.5	18.3

This table shows that for the sample without transfer, $WtP > WtP_{25}$, while for the sample with transfer $WtP_{25} > WtP_{25\ package}$, however, they are quite close.

12.5 Conclusion

Transfer Price technique for urban travel has not worked out as well as for inter-urban travel. We have estimated some models that give reasonable results according to theory. But the conclusions from the work is not very clear and the large amount of respondents stating zero willingness to pay and/or zero willingness to accept makes the estimation difficult.

The potential time savings (for the questions of *WtP*) or money savings (for the questions of *WtA*) are probably too small for transfer price analysis to be successful for urban travels. The results for inter-urban travel are however quite clear.

For inter-urban travel the analysis suggests that *WtP* is larger than *WtA*. On the average the difference is larger for business travel than private travel. The difference between *WtP* and *WtA* is largest for ferry, *WtA* is about 70 percent higher than *WtP* for private travel, compared with 100 percent for business travel. The difference between *WtP* and *WtA* for trip with bus is almost negligible. The differences for the other travel modes, i.e., car, air, and rail ranges between 15 to 37 percent.

Our analysis suggests that the differences between *WtP* and *WtA* increase with travel distance and with income.

The distribution of *VoT* for both urban and inter-urban travel is best described by lognormal di WtP_T stribution.

13 Alternative travel mode

Each respondent was given two SP games. The SP games were based on "within-mode" choice context. The first game was related to a particular trip that the respondent had reported and the chosen mode of travel for that trip. In the second game the respondents were asked to relate to the same trip, but to consider an alternative travel mode other that they had chosen.

It is worthwhile to bear in mind that none of the studies that were used for urban travel except for the *VoT* study (see sections 5.2 and 6.2) had a SP game related to alternative travel mode. Table 5.7 shows that only 363 of the respondents in the *VoT* study had chosen public transport, while 793 of the respondents had chosen car for their reported trips.

Table 13.1 shows the comparisons of *VoT*'s for alternative and the chosen travel modes in the context of urban travel for private purpose. This table shows that in-vehicle *VoT* is higher when car is the chosen travel mode than when car is chosen as the alternative travel mode. This can be explained by the income differences of these two groups.

Delay with car has, however, a lower *VoT* when car is the chosen mode than when car is chosen as the alternative mode. This can be explained in the context of the trips that were reported by respondents who had chosen public transport. Most of these trips were made during peak-periods, when delays are expected to be longer. As we showed earlier the *VoT* for delay increases with delay time.

Table 13.1 shows that in-vehicle *VoT* is lower when public transport is the chosen mode than in-vehicle *VoT* for public transport as the alternative mode. However, headway *VoT* is valued significantly different. Headway *VoT* for public transport as an alternative mode is almost twice as high as *VoT* for headway for public transport as the chosen mode.

Table 13.1 *VoT*'s (NOK/hr) for alternative and chosen modes, private urban travel

	Alternative mode			*Chosen mode*		
	In-vehicle	Delay	Headway	In-vehicle	Delay	Headway
Car	33	142		39	77	
Public transport	35		21	29		12

Table 13.2 shows the comparisons of *VoT*'s for alternative and the chosen travel modes in the context of inter-urban travel for private purpose. This table shows that the in-vehicle *VoT* for all modes except for air is higher as an alternative

mode. Travel distance and income can explain the differences between *VoT* of the chosen and alternative travel modes.

The headway *VoT*'s for the scheduled modes are similar in value except for air. Headway *VoT* is higher for air as a chosen mode than as an alternative mode. This could be explained by the variation of headway *VoT* with headway interval. As an alternative mode, the average headway interval is longer.

Table 13.2 *VoT*'s (NOK/hr) for alternative and chosen modes, private inter-urban travel

	Alternative travel mode		*Chosen travel mode*	
	In-vehicle	Headway	In-vehicle	Headway
Car	90		86	
Air	97	7	163	18
Bus	78	5	48	3
Rail	95	8	54	7

14 Comparison of short and long distance *VoT*

The comparison of results from the urban and inter-urban studies suggests that *VoT*'s for these two markets are very different. Different explanations can explain the differences. One is the supply of transport services in these markets that are very different. Another explanation is that the differences in the behaviour of travellers in these two markets can partly be explained by the differences in associated money and time constraints.

In the following we compare the *VoT*'s for private and business travel purposes in these two markets.

14.1 Private travel

In-vehicle VoT

Figure 14.1 shows the in-vehicle *VoT*'s from urban and inter-urban studies. The in-vehicle *VoT*'s for inter-urban travel (greater than 50 km) with car and bus are about twice the corresponding *VoT*'s for urban travel. The *VoT*'s for trips of less than 50 kilometres are quite similar to *VoT*'s for urban travel. Table 14.1 shows the comparison of the in-vehicle *VoT*'s. This table also shows the results form the Swedish *VoT* (Algers, et al., 1995) for inter-urban travel. The *VoT*'s for inter-urban travel with car and bus are quite comparable in Norway and Sweden.

The in-vehicle *VoT* for rail is 65 percent higher than public transport in the context of urban travel. The differences can be explained by the differences in income and travel distance. However, in-vehicle *VoT* for inter-urban travel with rail is only 13 percent higher than *VoT* for urban travel. The in-vehicle *VoT* for rail is about 30 percent higher in Sweden than in Norway. The differences in supply of rail services can explain the differences in *VoT* for rail in Norway and Sweden.

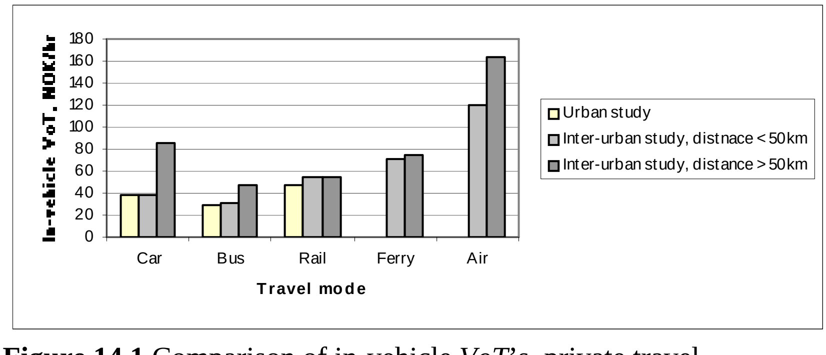


Figure 14.1 Comparison of in-vehicle *VoT*'s, private travel

Table 14.1 Comparison of in-vehicle *VoT*'s, NOK/hr and SEK/hr, private travel

	Urban study	*Inter-urban study, trip dis. <50 km*	*Inter-urban study, trip dis. > 50 km*	*Swedish VoT study (inter-urban)*
Car	39	38	86	81
Bus	29	31	48	57*
Rail	48	54	54	72*
X2000 (high speed rail)				102
Ferry		71	75	
Air		120	163	88

* Average value for regional and long distance

It is important to point to a relatively higher *VoT* with X2000 rail service (high-speed train) than other travel modes, even, air in Sweden. This type of rail service is not yet available in Norway.

The in-vehicle *VoT* for ferry for trips longer than 50 kilometres (from origin to destination) is only slightly higher than *VoT* for trips shorter than 50 kilometres. The in-vehicle *VoT* for ferry is about 13 percent lower than *VoT* for inter-urban travel with car.

The in-vehicle *VoT* for air is much higher than other travel modes. Notice that trips less than 50 kilometres with air is with STOL. The in-vehicle *VoT* for air with STOL is lower than ordinary services. Note that the in-vehicle *VoT* for air in the Norwegian study is about 85 percent higher than the Swedish study.

Delay

For inter-urban travel, delay was only included for rail. However, this attribute did not work well in the SP games. The Swedish *VoT* study has evaluated delay for long distance rail only. The Swedish study shows that delay *VoT* is approximately 50 percent higher than in-vehicle time.

For urban travel, the relative delay *VoT* to in-vehicle *VoT* is two to three. Furthermore the analysis shows that the *VoT* for delay increases with increase in delay time (see Figure 10.18).

Transfer time

Transfer time was not evaluated in the Norwegian study. The Swedish study reports the transfer *VoT* to be 40 percent to 140 percent higher than in-vehicle *VoT*, dependent of mode. The Swedish study suggests that relative transfer *VoT* to in-vehicle *VoT* to be lowest for air and highest for rail and regional bus.

Headway

The *VoT* for headway for inter-urban travel are much lower than urban travel, except for ferry. Further evaluation shows that headway *VoT* for headway intervals of over 30 minutes are significantly lower than headway *VoT* for headway intervals of less than 30 minutes. Furthermore, headway *VoT* decreases with increase in headway interval. All inter-urban scheduled modes of travel, except for ferry, have longer headway intervals than 30 minutes.

A similar result emerges for urban travel, i.e., headway *VoT* for headway intervals of longer than 30 minutes are much lower than headway *VoT* for headway intervals of less than 30 minutes. With the exclusion of headway interval longer than 30 minutes, the *VoT* for headway is 50 to 60 percent higher than in-vehicle time.

Walking time

In the context of urban travel, walking time to relative to in-vehicle time is valued higher for car than for public transport. For car walking time is valued more than 50 percent higher than in-vehicle time. For public transport walking time is valued slightly higher than in-vehicle time.

Variation of *VoT* with income

VoT increase with income, personal or household. The variation of *VoT* with personal income seems to show a clearer pattern (compare Figures 14.2 and 14.3).

Figures 14.2 and 14.3 show the variations of *VoT* and personal and household incomes. These figures suggest that the increase in *VoT* with income is higher for inter-urban travel than for urban travel.

Figure 14.2 Personal income and *VoT*

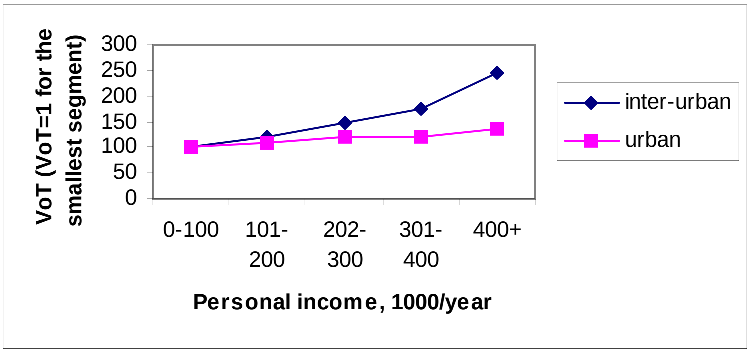
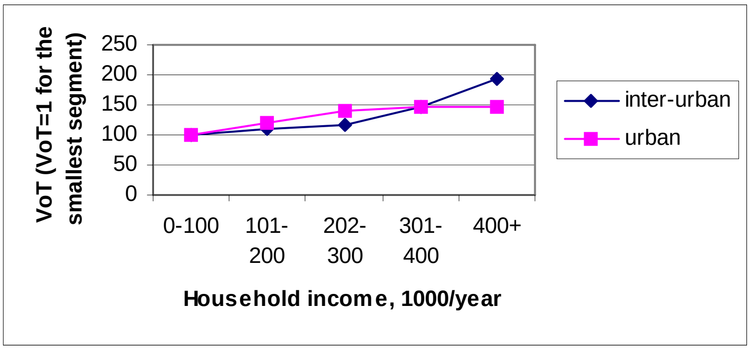


Figure 14.3 Household income and *VoT*

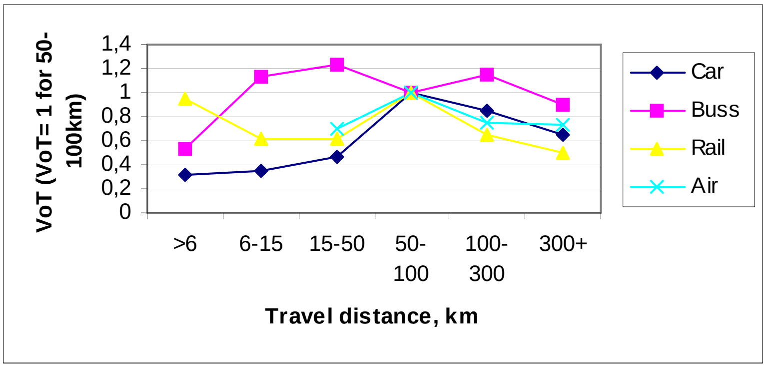


Value of time and travel distance

Figure 14.4 shows the variation of *VoT* with trip distance for different modes of travel. Note that in this figure *VoT*'s from urban and inter-urban studies are put together. *VoT*'s for the first three trips segments (d < 6, 6-15 and 15-50) are taken from the urban study, except for air. For air the *VoT* for trips distances of less than 50 kilometres (STOL services) comes from inter-urban study.

VoT for all modes of travel seem to increase with trip distance up to a threshold travel distance after which *VoT* decreases with trip distance. The only exception is rail, for which the *VoT* decreases with trip distance in both urban and inter-urban market.

Figure 14.4 *VoT* and trip distance



Size of travel-time savings or losses

The design of the SP study has been such to avoid very small time savings or losses (less than 2 minutes for urban travel and less than 5 minutes for inter-urban travel). Consequently it is not possible to estimate the *VoT* for very small time savings or losses with a high level of confidence.

Figure 14.5 and 14.6 show the variations in the *VoT* with the size of travel-time savings or losses for inter-urban and urban travel. The comparison of these two figures suggests that small travel-time savings or losses (less than 5 minutes) might be valued less (relatively) in the context of inter-urban travel than in the context of urban travels. This suggests that *VoT* for small time savings or losses should be evaluated in relation to travel time. A reduction of travel time of 5 minutes might be valued differently for a trip that takes 10 minutes with car in an urban context and a trip that takes two to three hours in an inter-urban context.

We realise that *VoT* for delay has a very different interpretation than *VoT* for in-vehicle time. Most studies suggest that *VoT* for delay is more than in-vehicle *VoT*. It is, however, interesting to examine Table 10.13 and Figure 10.18 that show the variation of delay *VoT* with size of delay for urban travel. This table and figure show that *VoT* for delay increase with size of delay, suggesting a discounted unit value (*DUV*) is more correct than a constant unit value (*CUV*) for delay time. However, delays of less than 2 minutes are valued much higher than in-vehicle *VoT*. Consequently it might be difficult to justify that very small travel-time savings/losses (say about 2 minutes) do not have a value in an urban context.

Figure 14.5 *VoT* and size of time savings/losses, inter-urban travel

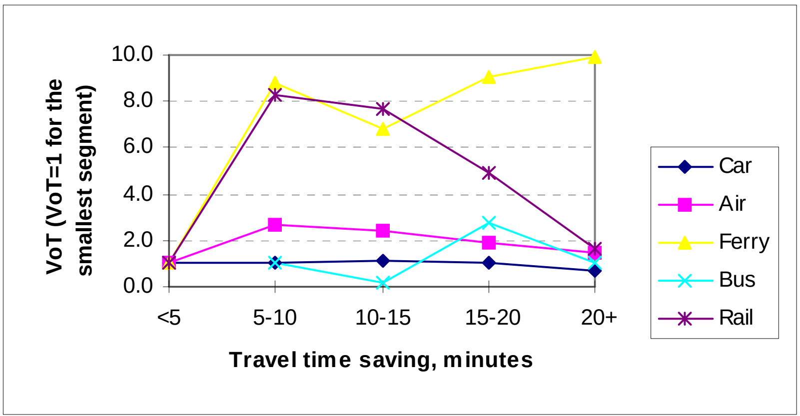
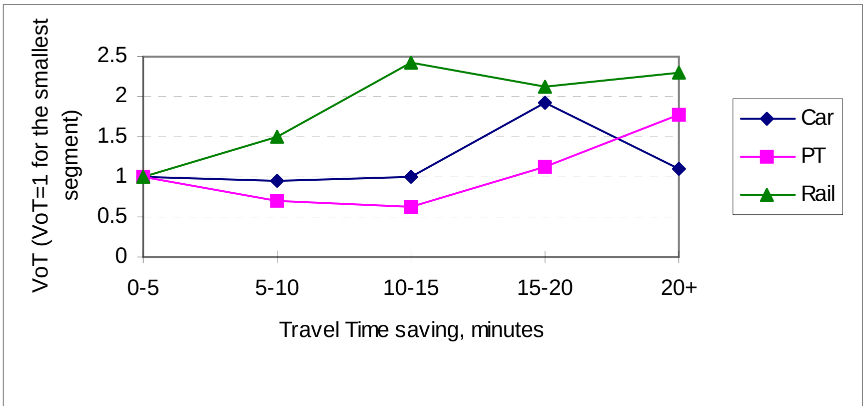


Figure 14.6 *VoT* and size of time savings/losses, urban travel



Direction, time loss versus time gain (*WtP* versus *WtA*)

The results from the TP study shows that willingness to pay (*WtP*) for travel time savings is lower than the willingness to accept a reduction in cost of travel (*WtA*) for an increase in travel time. The difference is only significant for inter-urban travel. Furthermore the differences between *WtP* and *WtA* increase with income and travel distance.

Travel purpose

Figure 10.5 shows the variations in *VoT* with inter-urban travel purpose and travel mode, while Figure 10.23 and 10.24 shows these variations for urban travel. These figures show that *VoT* varies by travel purpose, however, the variations depend on mode of travel. In general *VoT* is higher for commuting to work both in an urban and inter-urban context.

Car occupancy

The variation of *VoT* of car driver with car occupancy suggests that car drivers do not account for the *VoT* of car passengers.

Day of the week/ time of the day

Variations of *VoT* with day of the week and time of the day suggests that inter-urban travel and urban travel are quite different.

For inter-urban travel *VoT* is highest for trips scheduled on Fridays (see Figure 10.7). Trips with departure time after 18:00 have the highest *VoT* (see Figure 10.8).

For urban travel the variations of *VoT* with day of the week is not as pronounced as inter-urban travel. However, *VoT* seem to be higher on weekends than other days (see Figure 10.27). Trips with departure times during morning and afternoon peak have higher *VoT* than other periods (see Figure 10.28).

Regional Differences

There are regional differences in *VoT* in Norway that can be partly explained by income, however, not totally (see Figure 10.11 and 10.29).

Employment status

The evaluation of the variations of *VoT* with employment status, both in the context of urban and inter-urban travel, suggest that employed travellers have a higher *VoT* than others (see Figures 10.13 and 10.30).

Age

The travellers older than the retirement age (over 66 years old) have lower *VoT* than other age groups (see Figures 10.14 and 10.31). In the *VoT* study the respondents were restricted to 18 years or older, with an understanding of the difficulties of evaluating a willingness to pay for those who do not earn an income. It is not possible to make conclude for *VoT* for children in this study.

Gender

There is not significant difference between *VoT* for women and men in the context of urban travel (see Figure 10.22). The differences in the context of inter-urban travel is more and man exhibits a higher *VoT* for travel with air while women exhibit a higher *VoT* with other modes of travel (see Figure 10.15).

Other factors

The variations of *VoT* with some other factors such as number of children and household size have been examined (see Figures 10.33 and 10.34). There is not a clear relation between these factors and *VoT*.

14.2 Business travel

For *VoT* for business travel we suggest to revise Hensher's formula (compare Equation 1 and 19). The main reason for suggesting a revision is that we believe that the original formula includes some double counting.

In this approach, the marginal product of labour, the traditional value for business *VoT* is adjusted to account for both the employee and employer's valuations of travel-time savings in a business trip. The employees' valuations of travel-time savings in a business trip are based on SP study. We call this the private *VoT* of business travellers. In the following we summarise the results related to the private *VoT* of business travellers based on Hensher's approach.

In-vehicle *VoT*

Figure 14.7 shows the in-vehicle *VoT*'s from urban and inter-urban studies. For inter-urban business travel the *VoT* from wave 1 is used. The *VoT*'s for business travel are considerably higher than *VoT* for private travel for all modes of travel (compare with Figure 14.1). The *VoT* for inter-urban business travellers is much higher than the average industrial wage in Norway (108 NOK/hr in 1995). The average wage of the inter-urban business travellers is, however, higher than the average industrial wage. The *VoT*'s compared to the average wage are especially high for long distance trips with car and air. We suggested that even a value higher than the wage rate can be considered theoretically "correct" in this case (see chapter 11).

The *VoT*'s for trips less than 50 kilometres are less than the *VoT*'s for urban travel and *VoT*'s for trips over 50 kilometres, with the exception of bus. For urban business travel with bus and rail we have estimated just one value since there were not many business trips with public transport. Table 14.2 shows the comparison of the in-vehicle *VoT*'s. This table also shows the results form the Swedish *VoT* (Algers, et al., 1995) for inter-urban travel. Note that the Swedish *VoT*'s are considerably lower than the Norwegian values. They are more similar in size to the Norwegian *VoT*'s for shorter distance business trips.

Figure 14.7 Comparison of in-vehicle *VoT*'s, business travel

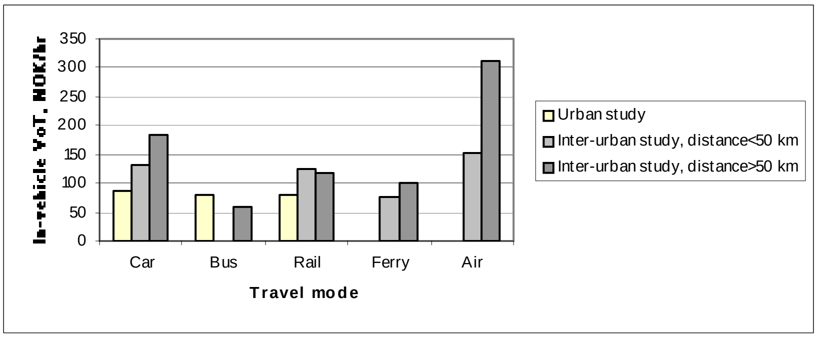


Table 14.2 Comparison of in-vehicle *VoT*'s, (NOK/hr and SEK/hr), business travel

	Urban study	*Inter-urban study, trip dis. <50 km*	*Inter-urban study, Trip dis. > 50 km*	*Swedish VoT study (inter-urban)*
Car	87	131	185	104
Bus	80		59	
Rail	80	124	118	104
X2000 (high speed rail)				113
Ferry		76	102	
Air		151	313	118

* Average value for regional and long distance

The in-vehicle *VoT* for air is much higher than other travel modes. Notice that trips less than 50 kilometres with air is with STOL. The in-vehicle *VoT* for air with STOL is lower than ordinary services.

Delay

For inter-urban travel, delay was only included for rail. However, as it was the case for private travel purposes, this attribute did not work well in the SP games. The Swedish *VoT* study has evaluated delay for long distance rail only. This study show that delay *VoT* to be approximately 70 percent higher than in-vehicle time.

For urban travel, delay *VoT* is approximately 70 percent higher than in-vehicle time (see Table 11.7). Furthermore the analysis shows that the *VoT* for delay increases with increase in delay time (see Figure 11.10).

Transfer time

Transfer time was not evaluated in the Norwegian study. The Swedish study reports transfer *VoT* to be valued twice the in-vehicle *VoT* with the exception of air where the difference between transfer *VoT* and in-vehicle *VoT* is very small.

Headway

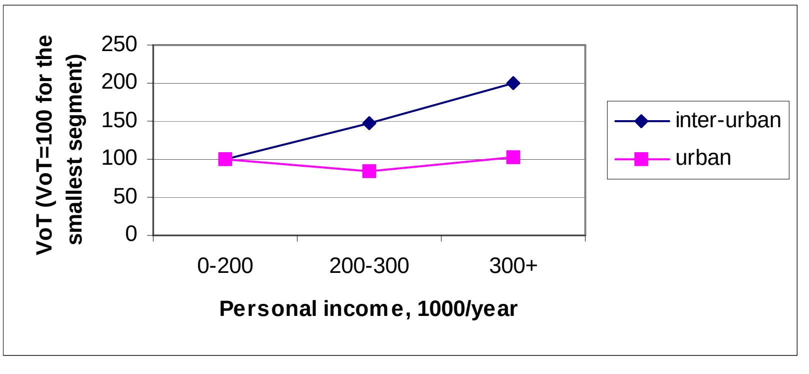
The *VoT* for headway in the context of inter-urban travel are much lower than for urban travel, except for ferry. As it was reported for the case of private travel purpose headway *VoT* for headway intervals of over 30 minutes are significantly lower than headway *VoT* for headway intervals of less than 30 minutes (see Figure 11.2).

It was not possible to evaluate the variation of headway *VoT* with headway intervals in the urban study for business travel, since there were not enough business travellers with scheduled modes of travel.

Variation of *VoT* with income

The variation of *VoT* with personal income seems to show a clear pattern. Figure 14.8 shows the variations of *VoT* and personal income. This figure shows that the increase in *VoT* with income for urban travel is not significant.

Figure 14.8 Personal income and *VoT*



Other factors

The variations of *VoT* with other factors are quite similar to those presented earlier for private travel purposes.

VoT for business travel, Hensher's approach

Table 14.3 shows the estimates of the different variables in Hensher's formula. "*r*" is the proportion of travel time saved which is used for leisure. "*p*" is the proportion of travel time saved at the expense of work done while travelling. "*q*" is the relative productivity of work done while travelling compared with the equivalent work in the office. "*MP*" is the marginal product of labour.

Note that compared to the business urban travellers, the inter-urban travellers would allocate a higher proportion of travel time saved to leisure (*r*) and the have a higher estimate of their relative productivity of work done while travelling (*q*) compared to equivalent work in the office. *MP*, calculated on the basis of hourly wage, is higher for inter-urban travellers than for urban travellers. However, it is only for inter-urban travel with air that *VoT*, i.e., *Vtts*, is higher than *MP*.

Table 14.3 Business *VoT* according to the revised Hensher's formula

Mode	*r*	*q*	*p*	*MP*	*vl*	**Business *VoT* = *vtts***
Inter-urban travel						
Car	.57	.32	.03	185	185	**181**
Air	.64	.28	.07	201	313	**267**
Rail	.72	.39	.18	153	118	**116**
Bus	.74	.20	.06	132	59	**75**
Ferry	.63	.19	.03	161	102	**130**
Urban travel						
Car	.39	.02	.21	170	87	**137**
Public transport	.43	.07	.30	131	80	**106**

15 Proposal for further research and study

A relatively large ground has been covered through the analysis of data collected in the Norwegian *VoT* study and presented in this report. However, more can be done with the data collected in this study. There are many potentials that can be explored by the merging the Norwegian and Swedish data.

We pointed out to some of these issues related to the *VoT* for business travel. It is obvious that in some context, one has to deviate from the use of marginal product of labour as a proxy for the business *VoT*. We have suggested a revised Hensher's approach for the calculation of the business *VoT*. However, we also have pointed out different issues connected with the measurement of the necessary variables as well as issues such as the stability of these variables over time. We propose to examine these variables closer. Different types of segmentations should provide grounds for better understanding of the behaviour of these variables as well as improvements in the results. The comparison of the Swedish and Norwegian data in this context is of great value.

In this study we have not addressed the values of income elasticity of *VoT*. The reason is that the data collected in this study is not representative. To calculate the values of income elasticity, the data needs to be weighted using the corresponding National Travel Surveys for inter-urban and urban travel.

Another issue is the distribution of the *VoT*. In the context of some important policies such as pricing it is quite important to have the distribution of *VoT*. We have addressed the distribution of the *VoT* through the analysis of the transfer price (TP) data. However, there exist more potentials in further evaluation of the TP data for this purpose. Furthermore, more advanced econometrics is necessary for addressing the distribution of *VoT* using the Stated Preference (SP) data. This should also be explored.

The comparison of results from alternative model specifications should also receive some attention. There are great potentials from benefiting from the more recent developments in discrete choice modelling. This is one area of research that has received attention in research that has proceeded the Swedish *VoT* study.

The differences between willingness to pay and willingness to accept have been addressed to some extent in this study. However, it needs further research. In the Norwegian study these differences were evaluated based on TP data. There are potentials in evaluating this data further. It would be important to explore the SP data for the comparison of results with those from TP techniques.

One issue related to SP technique is the inter-correlation of the repeated measure from an individual. Even though evidence suggests that the estimates of coefficients, and in this particular case the estimate of *VoT*, are not affected by this problem for practical purposes, the estimate of the errors of the estimates will be affected. There are different techniques that can address the problems related to repeated measures. We propose to include this issue in an agenda for further research on *VoT*.

“Small time savings” is another issue that deserves attention. We realise the difficulties related to this subject. It is not a simple task to address this issue theoretically. However, it is as difficult to address this issue empirically. This subject deserves some though on both levels.

The relation of VoT with distance should be examined further.

Glossary

VoT	Value of time
SVT	Subjective value of time
WtP	Willingness to pay
WtA	Willingness to accept
SP	Stated preference
RP	Revealed preference
TP	Transfer price
Vtts	value of travel-time savings for business travel, in Hensher's Formula
r	proportion of travel time saved, which is used for leisure, in Hensher's Formula
p	proportion of travel time saved at the expense of work done while travelling, in Hensher's Formula
q	relative productivity of work done while travelling compared with the equivalent work in the office, in Hensher's Formula
MP	the marginal product of labour, in Hensher's Formula
vl	the monetary value to the employee of leisure compared to travel time, in Hensher's Formula
vw	the monetary value to the employee of work time while in office compared to travel time, in Hensher's Formula
MPF	the value of extra output generated due to reduced fatigue, in Hensher's Formula
STOL	short take-off and landing
CUV	Constant unit value for time savings
DUV	Discounted unit value for time savings
CV	The Hicksian compensation variation measure of consumer surplus
DV	The Hicksian equivalent variation measure of consumer surplus

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