Quality in local public transport - variability of assessments

Sjöstrand, Helena

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Paper 4

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Helena Sjöstrand (2001)

1 Introduction

When planning public transport route networks the planners aim to fulfil the passengers' needs while being restricted to given circumstances, such as budget constraints. It often leads to a goal conflict between qualities to satisfy the demand. A balance must be found between walking distances, in-vehicle times, service frequency, avoidance of transfers and transfer waiting time (see e.g., Bates, 1986). In addition, the public transport passengers constitute a complex group with different preferences and abilities, which affect their assessments of quality during the trip. Within the group some people primarily want short walking distances, while others prefer frequent buses, etc. Therefore all passengers' needs cannot be fulfilled to the same extent at the same time with the same route network. More knowledge about passengers' preferences and about the variability of preferences enable more cost efficient planning of the bus routes and the possibility to give favour to specific groups of passengers. The reasons why the preferences vary will be given three explanations described in the following.

First of all, the performed trip's characteristics have effect on the experienced travel utility. For example, the trip purpose has effect on how different parts of the trip is assessed (European Commission, 1998). So has the frequency of travelling by bus, that is if the trip is made often or only on one single occasion. Most often the value of shorter travel time is higher for commuter journeys than for leisure journeys (Wardman, 1998). Leisure transport differs in various aspects from the transportation of workers since during leisure hours, people have far more freedom of choice (Sinzing and Bieger, 2000).

Secondly, the preferences vary because of the passengers' characteristics. It has influence, whether the person is female or male, young or old, etc. These types of characteristics are often used as segmentation variables when for example estimating the value of time. Also when predicting number of bus trips, passengers' age has shown to have importance. Old people show high walk distance elasticity and low service headway elasticity, while young people show the opposite conditions (Stokes, 1988). These circumstances are explained by health conditions and by probable presence of time pressure. The variability due to these characteristics can likely explain some of the differences between traveller groups' preferences mentioned above.

Furthermore, previous studies have shown that the assessments vary depending on passengers' present conditions (e.g., Kjörstad and Renolen, 1996 or Sjöstrand, 1999a). Because of passengers' different experiences of for example travel time, bus frequency, access time and bus transfers quality is assessed differently. This, so called, state dependency effect can be observed either as inertia, that is the present conditions has a special value, or as general non-linearity. The effect has been given several explanations:

- A decrease in quality is often assessed higher than the corresponding increase (Ampt *et al.*, 1995), which can be a result of budget restrictions or justification.
- It may be difficult to imagine situations of which one has no experience (Widlert, 1994).
- There is a resistance against changes, a perceptual threshold (see Hultkrantz, 1998).
- Decreasing marginal utility (e.g., Hultkrantz and Mortazavi, 1998). A 10-minute reduction in the length of a journey means more if total travel time is 20 minutes, than if total travel time is 2 hours.
- Self selection bias: e.g., a person who finds the bus too slow therefore chooses not to use the bus, we will not be able to interview her or him on the bus.

As this effect has been shown earlier in various areas, there is likely an effect also in assessments of local public transport. It is interesting to investigate this effect more closely, how large it is and under which circumstances as a function of the basic trip characteristics.

There are two main reasons why the variability of preferences is interesting to investigate and describe. One of them concerns planning of public transport and the other one is a theoretical modelling problem.

The planning reason is important partially because of differentiation of route networks. In many cities some passenger groups have a bus network of their own, which is created to meet special needs of a specific traveller group. In Sweden, for example, it is common to have a special route network for elderly or disabled people (Ståhl *et al.*, 1993). These bus routes are characterised by short walking distances, low-floor buses and helpful drivers. Another group of passengers, who can have special bus routes and may be homogeneous, consists of work commuters. Many of them travel from the residence in the suburbs to the workplace in the city centre in the morning, and return in the afternoon. Bus routes suited for work commuters are often characterised by frequent services during morning and afternoon with nothing in-between, few bus stops leading to shorter in-vehicle times as well as longer walking distances. To enable the creation of separate route networks for separate groups it is essential to know each group's preferences regarding time spent at the different stages of the bus trip: walking, waiting, riding and transferring.

If a route network is planned to meet the demand of an average passenger, maybe no passenger gets really satisfied. An example will be given here to illustrate this problem. If 50% of the customers want ice cold water, while the remaining 50% want hot water, which kind of water should then be given? The average temperature of water wanted, which is lukewarm, will probably satisfy no one.

Also, when only one common network is planned for all passengers, it may be wanted either to favour a specific group of travellers, or to evaluate each passenger category's perceived travel utility separately. The selected group could for example consist of either work commuters or elderly passengers. The reason for a selection like this can be political or economical, for example an apportionment problem. To be able to make such a priority or evaluation, the planner has to know this group's preferences and how they differ from other passengers'. In addition it must also be considered that different groups have special origins and destinations (OD matrices). The political reasons may also concern genders or age groups. Therefore it is interesting to see how assessments vary with different demographic characteristics like gender and age, even if it is neither possible nor wanted to plan separate route networks for men and women. Moreover, the variability due to these characteristics can probably explain some of the differences between traveller groups' preferences, as described above.

The other reason for the variability of preferences being interesting, is related to the estimations needed to determine assessments from empirical data. In many cases, those estimations are based on a model in which the respondents (within defined segments) are assumed to have identical preferences concerning the basic properties of a trip. This is, for example, the case with the logit model, see section 2.5, which is frequently applied for the analyses. In the logit model, the variation between respondents is assumed to be captured by a random term, uncorrelated with the explanatory variables.

Thus, we may not trust estimation results in cases when preferences vary, since basic assumptions are then violated. According to theory, estimated preferences may then well be systematically different, not only from what is valid for specific groups, but also from the population average. Brundell-Freij (1995) has, for example, shown considerable estimation bias in some – but not all - such cases.

In recent years there has been an increased interest to treat heterogeneity of preferences. One of the developments is the so called mixed logit model, see e.g., Hensher (2001). However, mixed logit models can not relate assessments to specific groups of passengers, but only allows for the overall variability. Mixed logit models do not either take care of the fact that different passenger groups have different origin-destination matrices.

There are now many value of time surveys (Wardman, 2001). But, most of them do not study the variability of time values at all, or only distinguish between work and non-work time savings (Armstrong *et al.*, 2001).

As, so far, few, if any, assessment studies have be done where specific passenger groups' assessments in local public transport have been done, I find a need to do this. The studies performed are often specialised for only one group (work trips, Widlert *et al.*, 1989), for regional trips (Widlert, 1992a), for long distance travel (Algers *et al.*, 1995).

The aim of this paper is to describe how assessments of quality in local public transport vary among traveller groups, due to present quality conditions and personal characteristics. The qualities studied are walking time, in-vehicle time, headway, waiting time during transfer and transfer penalty.

2 Method

2.1 Measurement of assessments

Methods for estimating assessments of quality can mainly be divided into revealed preference methods (RP) and stated preference methods (SP). In RP methods people's real behaviour is studied, while in SP methods people state their preferences to hypothetical alternatives. Both sets of methods have their advantages and disadvantages (e.g., Hensher *et al.*, 1999). To assess quality in this study a SP method was used, because of the possibility to make people state their preferences to alternatives consisting of selected combinations of varying levels of the chosen attributes. One of the problems then faced is that the respondents may not react in reality as they say they would in the hypothetical questions. To increase the validity of the study efforts described further down were made to make the question context as realistic and understandable as possible.

2.2 Data collection

As the subject of the study was passengers' assessment of quality in local public transport, respondents were chosen among public transport travellers. Passengers were contacted on board buses in the city of Göteborg, Sweden's second largest city with almost 500 000 inhabitants. Göteborg's main local public transport consists of trams, but also buses constitute an important part of the system with 40% of the boarding passengers. Both trams and buses are parts of the same system, with the same fare system, common timetable, etc. Anyhow, it was chosen to interview only passengers on buses because a bus route network is more common in other cities than a mixed network, and the comfort on tram trips might be assessed differently, partly due to the "rail factor[1]". Besides, in a Stated Preference experiment, where the realism is important, it may be easier to imagine changed access times to bus stops than to tram stops. The reason for that is that a bus route is easier moved than a tram route with tracks. However, some of the respondents in this study have changed vehicles during their trip and their travel time include time both on bus and on tram. But the majority has only used bus. Hence, passengers were contacted on buses and invited to participate in a study on quality in public transport. Questionnaires were handed out directly after a short contact interview on the bus. The interview

[1] The rail factor indicates the fact that many studies have shown that passengers prefer rail bound modes in front of buses, if other conditions are equal (e.g. Stangeby and Norheim, 1995).

made it possible to customise the questionnaires to the passenger's conditions, since the personnel carried with them different sets of questionnaires intended for different in-vehicle times, bus headways and ticket types. As the answers from the contact interviews, as well as gender and roughly judged age were recorded, it was afterwards possible to control for bias in these respects between the three groups

- passengers on the bus
- passengers on the bus and willing to participate in the study
- passengers on the bus and willing to participate in the study and answering the questionnaire

The first group "passengers on the bus" includes those who participated, but also passengers refusing to participate, passengers who were sleeping, who didn't understand Swedish or who had already participated in the study. School pupils, however, were excluded from the population, as they get a free public transport ticket from the municipality of Göteborg and thus the choice between trips with different costs is irrelevant.

The distributed questionnaire letters, which should be mailed back, consisted of one sheet with background questions and one sheet with six binary choices in a Stated Preference game. Previous research (Sjöstrand, 1999a or b) has shown that a mail-back questionnaire containing binary choices can give reliable and valid estimates of quality in local public transport. While mail-back questionnaires were chosen, extra care was taken to make the questionnaire as short and clear as possible. The commonly given question of the person's income was excluded of two reasons. It was suspected that this question would decrease the response rate, and the use of the answer can be questioned as long as the person's other conditions, like family size and holdings, are unknown. The question about car availability was also left out. Often a clear difference is found between assessments of public transport passengers who "have to" use the public transport and of passengers who have chosen to use it (e.g., TRRL, 1980). This question is anyway not put in this study, because I think both the question and the answer can be considered diffuse.

Two separate data collections with the overall same aim were conducted. The chosen bus routes are operating in different parts of the city and meet different demands. Some are more like feeders to trams and some are trunk lines. Questionnaires were delivered both during peak hours, mornings and afternoons, and during off-peak hours, in the middle of the day, but only on weekdays. In this way passengers were automatically distributed over different trip purposes, in-vehicle times, access times and other characteristics.

The first data collection, made during the spring of 2000, included solely passengers on buses with headway of 15-20 minutes. This limitation was to avoid the need of adaptation of this attribute. Also the bus routes, or parts of bus routes, on which passengers were contacted, were chosen so that there were no parallel travel possibilities. Otherwise the knowledge of a person's headway quality would have been jeopardised.

The second data collection was made during the autumn of 2000. The aim was now to interview passengers travelling on buses with different headway, to investigate if the assessment of for example headway depends on actual headway.

2.2.1 Choice of attributes

This paper deals with variability of assessments of some characteristics often referred to as hard quality elements (European Commission, 1998). The attributes included are in-vehicle time, walking time to bus stop, bus headway, bus interchange and waiting time by interchange. Each alternative in the Stated Preference experiments was a bus trip described by four of these variables. These variables determine the basic form of a public transport network and are therefore important to study. The time and interchange elements are furthermore used as the input in traffic assignment models as VIPS and EMME/2. Examples of soft elements are information, vehicle standard and cleanliness. Some of these can of course be crucial for if some passengers can use public transport at all. For example, a disabled person has no possibility choosing public transport if the bus entrance is too narrow or too steep.

It has been recognised for a long time that time spent on different parts of a journey is differently comfortable assessed (e.g., PLANK, 1981). Generally the time spent inside the vehicle is considered most convenient, while time spent outside the vehicle, when getting to the bus stop and waiting for the service, is less convenient. If the headway is long and part of the waiting time is not spent at the bus stop, but e.g. at home or at work, the waiting time is normally not as high assessed as if it is spent on the bus stop (e.g., Holmberg, 1977 or Blomquist and Jansson, 1994).

2.2.2 Adaptation of attributes

As previously stated, in a Stated Preference experiment it is most important that the questions are considered realistic. For example, some of the attributes need adaptation to the respondent's conditions (Bradley, 1988). Therefore, in both data collections in this study adaptation is made to the passenger's travelling time. In the contact interview, the passenger stated the estimated travelling time between boarding the bus and alighting at the final bus stop. If there had been a bus transfer, the time spent between the vehicles would be included. Thus, travelling time, as defined in this study, is not always spent in a vehicle, and not always when in motion.

In both data collections, the adaptation of travelling time was made in the same way. There were five different travelling time classes, table 1. Each passenger's own travelling time on the trip with the contact interview determined from which bunch of questionnaires an envelope would be drawn. In the Stated Preference choices then both faster and slower alternatives were described.

Table 1 Presented levels of travel time depending on actual travel time on bus, in minutes.

actual travel time according to contact interview	travel time in SP alternatives: fast level	medium level	slow level
<15	5 or 8[1]	10	15
15-25	15	20	25
25-35	25	30	40
35-50	35	40	50
> 50	45	60	75

[1] in the first data collection, it was 5 minutes and in the second data collection it was 8 minutes

In the first data collection the adaptation according to bus headway was not relevant because all passengers were met on buses with 15-20 minutes' headway. But in the second data collection, the customisation of headway levels in Stated Choice alternatives was essential, table 2. Bus routes chosen for the study had headway of 8, 10, 30 and 60 minutes, because this was the variation of headway available in Göteborg.

Table 2 Presented levels of headway depending on actual headway, in minutes.

actual headway according to timetable	headway in SP alternatives: most frequent level	medium level	least frequent level
8	5	8	10
10	8	10	15
15-20 (data collection 1)	10	15	30
30	20	30	60
60	45	60	90

In the first data collection, walking time to bus stop was one of the attributes. As it was assumed that this variable would not vary very much among respondents, all questionnaires presented alternatives with walking times 2, 5 and 7 minutes. In the alternatives, describing a bus trip, this attribute is expressed as "walking time to bus stop". Of course also the walking time at the end of the trip is important for mode choice, choice of bus route and opinion of the trip's quality. But, to not make the questionnaire too complicated, only the walking in first part of the trip was included. Thus, walking time in the last end was assumed constant for all alternatives in the SP experiment.

In the second data collection, walking time was excluded, in favour of transfer and waiting time during transfer. The attribute had three levels; direct trip without transfer, trip with transfer and no waiting time, and trip with transfer and 5 or 10 minutes' waiting time depending on present travelling time, see table 3.

Table 3 Presented levels of transfer depending on actual travelling time.

actual travel time according to contact interview	transfer quality in SP alternative		
	best level	medium level	worst level
<15	direct trip without transfer	transfer without waiting time	transfer with 5 min waiting time
15-25	direct trip without transfer	transfer without waiting time	transfer with 5 min waiting time
25-35	direct trip without transfer	transfer without waiting time	transfer with 5 min waiting time
35-50	direct trip without transfer	transfer without waiting time	transfer with 10 min waiting time
> 50	direct trip without transfer	transfer without waiting time	transfer with 10 min waiting time

In the first data collection, the cost attribute was expressed in three different ways for passengers travelling with a period ticket. Questionnaires were randomly distributed among the respondents with the cost expressed either as per month cost, or a per trip cost at two different levels, see table 4 and Sjöstrand (2000).

Table 4 Presented levels of travel cost, SEK.

	cheapest level	medium level	most expensive level
cost per month	300	390	500
cost per trip, month cost level	5	6.50	8.50
cost per trip, trip cost level	8	10	13

About half the sample travelled with period tickets. The other half used either a prepaid discount card or paid cash and these respondents got questionnaires with costs per trip of 8, 10 or 13 SEK.

2.2.3 Stated Preferences design

In both data collections each respondent got one Stated Preference experiment with six binary choices. Each alternative described a bus trip with four attributes and the respondent's task was to choose the one of the two that they liked the most for such a trip that they were doing, when met on the bus. The respondent was asked to think of the same trip purpose, weather, time of day and other circumstances, as prevailing on the questionnaire delivery day.

Since all attributes in the study took three levels, in each data collection there were 3^4=81 possible alternatives. Alternatives were created, paired, and put together six by six to thousands of questionnaires at random. Each questionnaire thus had its own design and probably none looked exactly the same. Pairs containing a dominant alternative (that is when the choice was obvious, with one alternative both cheaper and faster in all respects, than the other alternative) were however rejected. By using the random design, observations for more level combinations have been collected, than if the same six were used for all questionnaires. But there is also a risk of getting an inefficient design when the rate of orthogonality is not known.

There are various demands on the experimental design of a Stated Preferences experiment. Demands are both because of cognition, it must be possible to rate, rank or choose between alternatives and because of model estimation when analysing the results. According to the cognition demand the attribute levels have to be realistic to the respondent (Bradley, 1988). The differences between the levels have to be big enough to indicate a quality distinction between them, but still be realistic. To improve model estimations the design should be balanced and orthogonal. Choice probabilities should have the most effective size. Those demands are difficult to combine.

The case of experimental design is discussed in Toner *et al.* (1999), who have tested a new design versus the traditional orthogonal design, with non-correlated attributes. It was found that choice probabilities of 50/50 are not always particularly desirable for efficiency. Also t-statistics can be improved with non-orthogonal designs, especially when obtaining monetary valuations, such as the value of time. Choice probabilities of 0.917/0.083 are recommended. When estimating coefficients for the purpose of forecasting, orthogonal designs should be used.

Before the second data collection in this study, simulations were made to estimate the number of needed observations with different sets of levels of the attributes and the used experimental design. These simulations were made based on preliminary expectation parameters from my own previous studies. After some adjustments of the experimental design and sample sizes it was found that the achieved quality of estimated would be good enough.

Examples of Stated Preference questionnaires from data collection 1 and 2 are shown in appendix 2.

2.2.4 Number of distributed questionnaires

The *first* data collection had three purposes

- verify if the ordering of attributes has any effect on assessments
- study how the trip cost shall be expressed among period ticket holders
- describe the variability of assessments of in-vehicle time, walking time, and headway

In this paper only results from the third point will be described, the others are described in papers 2 and 3. However, also the other points contributed in determining the number of distributed questionnaires.

The number of distributed questionnaires in the first data collection was determined by

- passengers with five different travelling times should be studied (10, 20, 30, 40, 60 minutes)
- passengers travelling with two different ticket types (period tickets, paying per trip)
- answers from 100 respondents in each group were desired
- the response rate was assumed to be 50%

Thus, the total number of delivered questionnaires was aimed to be
$N_1 = 5 * 2 * 100 * (1/0.50) = 2000$

Then, hopefully, while choosing to have 100 instead of 50, as earlier set as the minimum number of respondents per segment (Widlert, 1992b), the observations will get numerous enough to admit segmentation across various variables. Also, the distribution of travelling times was not known in advance, but with this amount of collected observations it was assumed to get enough responses for each time segment.

The *second* data collection had the purposes

- describe the variability of assessments depending on present headway
- contribute to the first data collection in describing the variability of assessments of time elements and of bus transfer

The number of distributed questionnaires was determined by

- four classes of headways should be studied (a bus every 8, 10, 30, 60 minutes)
- answers from 100 respondents per group were desired
- the response rate was assumed to be 50%

The total number of delivered questionnaires was aimed to be
$N_2 = 4 * 100 *(1/0.50) = 800$

2.3 Data description

In this section, the sample will be described. First, in table 5, the three groups

- passengers on the bus
- passengers on the bus and willing to participate in the study
- passengers on the bus and willing to participate in the study and answering the questionnaire, that is, respondents

will be compared for all variables that is known for all of them.

Table 5 Combination of persons in the three groups: passengers met on the bus, persons taking the questionnaire and respondents in the two data collections.

		Data collection 1			Data collection 2		
variable	group	on the bus	taking quest.	respondents	on the bus	taking quest.	respondents
gender	female	61%	63%	68%	68%	69%	74%
	male	39%	37%	32%	32%	31%	26%
age[1]	young (<25)	33%	34%	32%	34%	35%	30%
	middle	56%	56%	57%	51%	52%	54%
	old (>65)	11%	10%	11%	15%	13%	16%
ticket[2]	period ticket	60%	60%	58%	62%	61%	60%
	discount card	38%	38%	40%	35%	37%	37%
	paying cash	2%	2%	2%	3%	2%	3%
time[2]	10 min	22%	17%	16%	24%	23%	22%
	20 min	23%	24%	23%	19%	19%	19%
	30 min	22%	24%	24%	24%	24%	27%
	40 min	18%	18%	20%	18%	19%	17%
	60 min	15%	17%	17%	15%	15%	15%
headway[3]	8 min				30%	30%	31%
	10 min				44%	43%	40%
	15 min	88%	89%	89%			
	20 min	12%	11%	11%			
	30 min				18%	20%	20%
	60 min				8%	7%	9%
No. of persons		2506	1942	1074	496	425	225

[1] judged by the personnel
[2] asked in the contact interview, nb all passengers on the bus did not answer this question
[3] determined by on which bus route the person was met

As table 5 shows, it does not seem to be severe bias problems in the material. One tendency shown is that women both accept to take the questionnaire and answer to a larger degree than men do. The overall participation rate was 77-86%, and the response rate among those who said they were willing to participate was 53-55%. Considering that it was not possible to send out any reminders, the response rates were considered acceptable.

As described in section 2.2.4 the numbers of distributed questionnaires aimed to be 2000 in the first data collection and 800 in the second. In the first data collection this number was almost reached, whereas in the second data collection the number of delivered questionnaires was far away from the goal. The reason for this was a lack of passengers on buses with long headway.

The answers of the background questions on the first paper sheet will be described here, and can be seen as a background to the assessment results in the next chapter. The questionnaire is presented in appendix 1.

Table 6 Results from the background questions in both data collections.

		Data collection 1	Data collection 2
Where were you going from	from home	56%	64%
	from work or school	32%	21%
	from a shop or other service	5%	5%
	from something else	6%	9%
	no answer	1%	1%
Where were you going	to home	38%	25%
	to work or school	41%	41%
	to a shop or other service	6%	8%
	to something else	14%	25%
	no answer	1%	1%
Access mode	foot	94%	94%
	bike	1%	-
	car	1%	2%
	else	1%	-
	no answer	3%	4%
Number of transfers	0	37%	40%
	1	52%	47%
	2	9%	12%
	3	1%	-
	no answer	1%	1%
Seat on bus	all the trip	86%	85%
	part of the trip	11%	13%
	stood all the trip	2%	1%
	no answer	1%	1%
Ticket type	paid cash (16 SEK)	2%	2%
	bought discount card on bus (120 SEK)	1%	-
	discount card (100 SEK)	35%	35%
	monthly card, Göteborg (390/400 SEK)[1]	37%	35%
	monthly card, off peak traffic (240 SEK)	4%	6%
	monthly card, <20yrs (240 SEK)	1%	-
	other monthly ticket	5%	9%
	3 months ticket	2%	1%
	1 year ticket	2%	4%
	no answer	11%	8%

[1] during the summer of 2000 the cost for a monthly ticket was raised from 390 to 400 SEK

The table is continued on the next page.

Table 6 Results from the background questions in both data collections, continued.

		Data collection 1	Data collection 2
number of bus or tram trips per month	0-9	6%	4%
	10-19	8%	13%
	20-29	9%	11%
	30-39	12%	11%
	40-49	27%	24%
	50-59	15%	14%
	60-69	8%	10%
	70-79	1%	2%
	80-	3%	3%
	no answer	11%	8%
occupation	work	59%	56%
	retired	11%	17%
	study	17%	15%
	unemployed	1%	1%
	long-term sick-listed	1%	3%
	on military duty	1%	-
	no answer	10%	8%
born year	1900-1910	-	-
	1911-1920	2%	3%
	1921-1930	4%	7%
	1931-1940	10%	7%
	1941-1950	18%	18%
	1951-1960	13%	12%
	1961-1970	15%	17%
	1971-1980	26%	27%
	1981-	1%	1%
	no answer	11%	8%

The higher shares of "no answer" on the last questions are due to that they were on the back side of the paper sheet, and probably all respondent have not noticed them. See also table 5 for information about gender and travelling times.

2.4 Segmentation

As introduced in chapter 1 there are several ways of segmentation of local public transport passengers. Woodruff *et al.* (1981) describe how the selection of segmentation bases can be made. Segmentation can be based on either travel behaviour, socio-economic characteristics or product characteristics/ dimensions. Other bases of segmentation are attitudes, importances, usage and competitive markets according to Urban and Star (1991).

Following these bases of segmentation, some passenger groups were found interesting to be discussed further. Under the title of *travel behaviour* the assessments' relationship with trip frequency will be analysed, as will trip purpose and trip time of day. The variables available for *socioeconomic* segmentation in this study are gender and age. No segmentation will be made by *attitudes*, as no attitude questions were in the questionnaire. The same goes for *importance*. However, even though nothing is known about *competitive markets* on an individual level, an interesting segment consists of people who use public transport seldom, but work or study. Those probably use other travel modes frequently. They are interesting as a segment, as they might have preferences, which deviate from other passengers' preferences. If planners know more about their needs and adaptations can be done, some of them may switch mode from car to bus for a larger proportion of their trips. In this study it is unknown which alternative travel modes that are available for each person.

To show the variability of assessments among passengers estimations for segments of passengers will now be done. Comparisons of passenger groups in different dimensions will be performed. The dimensions can mainly be divided into

- groups interesting for planning
- demographic groups
- state dependency

These dimensions partly overlap as will be seen below, and one specific respondent will be found in several groups. Further, several dimensions are correlated (retired are mainly old, etc.). Thus, this study does not aim to determine the cause of preference differences. Rather, this study describes how assessments vary when passengers are classified into groups under these dimensions. The classifications will now be described further.

2.4.1 Traveller groups

Based on the answers on the questions ”Where were you going from when we met?” and “Where were you going?” in the questionnaire, the respondents’ trips were divided into three categories. The trip was categorised as being either a trip to or from work, study or leisure. The leisure category includes both trips to shops and service, as well as trips to visits, sports, etc. The number of observations from trips of each category is shown in table 7.

Table 7 Distribution of trip purposes.

	number of observations	estimated number of persons	share of trips
work trip	3954	659	54%
study trip	909	152	13%
leisure trip	2392	399	33%
total	7255	1210	100%

“Estimated number of persons” is calculated as “number of observations” divided by 6, which is the number of choices each respondent should make. All respondents have not, however, made all choices.

Since the work trips were many, it was possible and desirable to make a further segmentation of them. Segmentation of work trips was done according to gender, a special group for young persons, work trip passengers who seldom use bus, and a division between work trips during morning peak hours respective off peak hours. The number of observations from each of these segments is shown in table 8.

Table 8 Distribution of work trips.

	number of observations	estimated number of persons
work trip, women	2775	462
work trip, men	1173	196
work trip, <25 years	522	87
work trip, uses bus seldom	228	38
work trip at 7-9	1466	244
work trip at 9-15	404	67

2.4.2 Demographic groups

Possible demographic characteristics are only those registered in the contact interview or asked for in the questionnaire. Variables used are gender, age, occupation and frequency of using public transport. For age, the respondents were divided in four groups: 0-25, 26-40, 41-65 respective over 66 years old. The number of respondents older than 65 years was small leading to large standard errors and weaker significance.

2.4.3 State dependency

In sections below, differences of assessments that depend on respondents' present conditions will be presented. The conditions that will be studied are present in-vehicle time, present walking time to bus stop, present headway, presence of bus transfers and availability of seat on bus.

2.5 Analysis of results

Analysis of Stated Preference data relies on that simultaneous information about the choice and the level of each attribute (e.g., cost, walking time, in-vehicle time, etc.) for both chosen and non-chosen alternatives is given.

Often a linear utility model is formulated for each available alternative as

$$U = \Sigma (a_i * x_i) + \varepsilon \qquad (1)$$

where

U is the perceived utility of an alternative

a_i are the relative importance attached to each attribute (to be estimated)

x_i are the levels of each of the included attributes (known)

ε is the random or unobservable error effects associated with the utility of an alternative

For example, if the alternatives are described by cost, walking time to bus stop, in-vehicle time, headway, transfer (dummy variable) and transfer waiting time the utility for each alternative is formulated as

$$U = a_c * c + a_w * w + a_v * v + a_h * h + a_t * t + a_{tt} * tt + \varepsilon \qquad (2)$$

where

a_i are the relative importance attached to each attribute (cost, walking time to bus stop, in-vehicle time, headway, transfer and transfer waiting time) (parameters)

c, w, v, h, t, tt are the levels of cost, walking time to bus stop, in-vehicle time, headway, transfer (0/1-variable) and transfer waiting time actually presented in the SP experiment

ε is the random or unobservable error effects associated with the utility of an alternative

This is the model generally applied to obtain the result in chapter 3. A modified model was applied in section 3.7.

The probability to choose an alternative depends both on the utility of this alternative and of the other, competing alternatives. From the definition of utility we see that those utilities, on top of the level of attributes, and the importances attached to them, also depend on the distribution of ε. Common assumptions about these distributions give the multinomial logitmodel

$$P_1 = \frac{e^{(\Sigma a_i x_i)_1}}{\sum_j e^{(\Sigma a_i x_i)_j}} \qquad (3)$$

P_1 is the probability to choose alternative 1 among all alternatives j

We assume that each individual has chosen the alternative that gives him or her highest utility. Then, after having asked many respondents about their choices, we, intuitively, have many constraints on the U:s. Based on this information, the a_i:s may be estimated so that the constraints are fulfilled as well as possible. The parameters a_i of logitmodels are often estimated (maximum likelihood) by using the computer package Alogit (1992).

The a_i:s are then the basis for describing the assessments and express them as weights relative to either in-vehicle time or travel cost. Proceeding with the example in equation 2, an estimation of the value of in-vehicle time is calculated as

$$\text{v.o.t.} = \frac{a_v}{a_c} \qquad (4)$$

often expressed in "SEK per hour". Furthermore, for example the walking time weight, how inconvenient walking time is relative to in-vehicle time, is estimated as

$$\text{weight of walking time} = \frac{a_w}{a_v} \qquad (5)$$

If the weight of walking time is 1.0, it indicates that each minute spent walking to the bus stop is assessed as being just as comfortable or uncomfortable as one minute riding in the bus. If the weight is 1.5, 1 minute's walking time feels just as burdensome as 1.5 minutes riding in the bus.

When studying segments totally separate models have been estimated for each segment.

In addition to parameters a_i, Alogit also estimates (asymptotic) standard errors of parameters as well as correlation between parameters. Those standard errors and correlations are then used to estimate standard errors of the weights. Since the weights are ratios of estimates, the standard error of for example the value of time can be estimated as

$$\text{s.e.}\left(\frac{a_v^*}{a_c^*}\right) = \sqrt{\left(\frac{a_v^*}{a_c^*}\right)^2 \left(\frac{\text{var}(a_c^*)}{a_c^{*2}} + \frac{\text{var}(a_v^*)}{a_v^{*2}} - 2\,\frac{\text{cov}(a_c^*, a_v^*)}{a_c^* a_v^*}\right)} \qquad (6)$$

where a_c^* and a_v^* are the estimations of parameters of cost and in-vehicle time respectively. This equation for estimation of standard errors of assessments in a Stated Preference-survey has also been used by e.g. Kjörstad (1995).

To show the uncertainty of the results in the next chapter, estimates are presented together with 90% confidence intervals. Those intervals are computed as the estimate ± 1.64 * the estimated corresponding standard error, with 1.64 being the 95^{th} percentile of the standardised normal distribution.

The 90% confidence interval indicates that the "true values" are inside those intervals in 90% of all cases. On average, the true value is in the middle of the intervals. The choice of level of confidence, thus is a balance between certainty and ability to indicate differences. Higher confidence, say 95%, gives wider confidence intervals (± 1.96 * standard error).

To test the significance of the difference between corresponding weights (e.g. values of time) for two different segments (e.g. women and men) the following test-statistics has been used

$$T = \frac{v.o.t._f - v.o.t._m}{\sqrt{s.e.(v.o.t.)_f^2 + s.e.(v.o.t)_m^2}} \quad (7)$$

where the indexes f and m represent female and male.
Critical values for the test-statistics T has been obtained from the standardised normal distribution.

3 Results

3.1 Base model

Initially the utility model presented in section 2.5 was applied to the available 7447 observations (6180 from the first data collection and 1267 from the second data collection) to estimate all a_i.

The value of in-vehicle time was estimated to 17 SEK/h (± 1.10 SEK/h), which is quite similar to the 17 SEK per hour found in Jönköping (Sjöstrand, 1999a). Car drivers have generally larger values of time (see, e.g., Algers *et al.*, 1995 or Blomquist and Jansson, 1994).

The ratios a_w/a_v, a_h/a_v and a_{tt}/a_v shown in figure 1 indicate how high importance is put on out-of-vehicle time elements (walking time, headway time and transfer waiting time) compared to in-vehicle time.

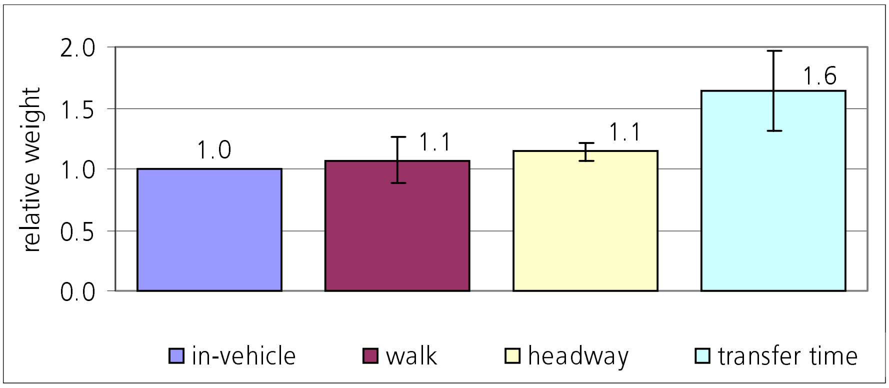

Figure 1 Relative time weights for all passengers in the study. Estimate and 90% confidence interval.

Both walking time to bus stop and headway time have about the same weight as in-vehicle time. However waiting time during transfer is considered significantly more uncomfortable than the other time elements, with a mean weight of 1.6. A study in Oslo indicated a walking time weight of 2.0, a headway weight of 1.7 and a transfer waiting time weight of 1.25 (Norheim and Stangeby, 1993).

Having to change buses during the trip was assessed equivalent to 12 in-vehicle minutes (± 2 min). This is considerable more than the transfer penalty suggested by Vägverket (1992) of 5 minutes and also more than the transfer penalty estimated in the study of public transport passengers in Oslo (Norheim and Stangeby, 1993). Passengers were there willing to accept 8 minutes longer travel time for a direct connection if they could choose between alternative connections with and without transfer.

The results in this section (3.1) must be handled with care. If we accept that the assessments are likely to vary in the population, representativity is important to estimate assessments. It may look like reported assessments represent the assessments of an average passenger. Within this sample that is true, but since not enough effort has been taken to make this total sample representative, these weights do not represent an average passenger in Göteborg. The sample was chosen to get a variety of passengers with different backgrounds and travel characteristics.

In the following sections the variation of assessments over segments will be described. An overview of these results is given in appendix 3.

3.2 Value of in-vehicle time

The value of in-vehicle time is calculated as a_v/a_c in equation 2 above. How the value of this ratio varies between segments of passengers will be described in this section.

3.2.1 Trip purpose

Figure 2 shows that on leisure trips the value of time is lower (p=0.001) than on work or study trips. Also in the report from European Commission (1998), where indications of heterogeneous preferences have been listed, it is stated that the value of time is higher for commuter journeys than for leisure journeys. Wardman (1998) specifies the difference in value of time between commuting and leisure travel to be that for commuting, the time is 25 per cent higher valued.

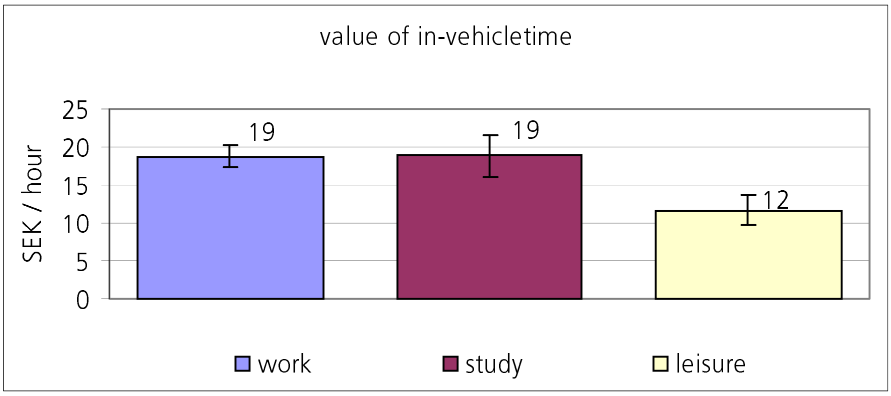

Figure 2 Estimated value of in-vehicle time, SEK/h, on trips to and from work, study respective leisure. Estimate with 90% confidence interval.

In a recent study among work commuters in Stockholm (Olsson *et al.*, 2001) the estimated value of time among bus passengers was 19-20 SEK/h, that is just about the same as in this study.

A group that normally has high values of time constitutes of business travellers (e.g., Algers *et al.*, 1995 or Wardman, 1998). Business travellers were far too few on buses in Göteborg to allow for separate estimations.

The value of time differs on work trips depending on the circumstances, figure 3. Men on work trips have a higher value of time than women on work trips have (p=0.10). Those who are making a work trip, but are using the bus seldom have a higher value of time, than others have. In a Dutch study of travel time savings (Gunn *et al.*, 1998) travellers during morning peak showed significantly higher value of time than the average. This study points in the same direction, but the difference between peak and off-peak travellers is not significant.

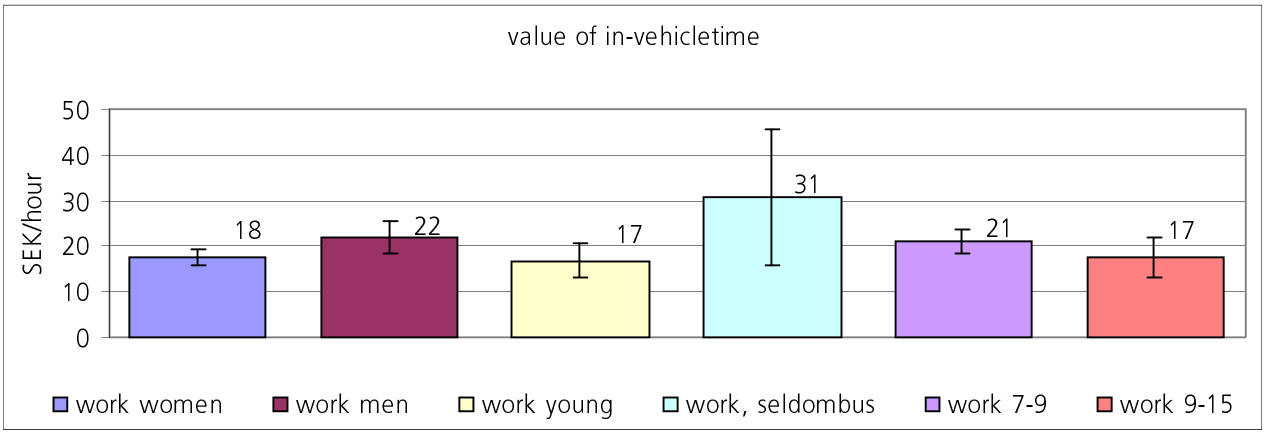

Figure 3 Estimated value of in-vehicle time, SEK/h, on trips to and from work for segments. Estimate with 90% confidence interval.

3.2.2 Demographic groups

A significant difference (p=0.02) is found between women's respective men's value of in-vehicle time, figure 4. Men have a higher value of time (19.80 SEK/h) than women have (15.50 SEK/h). This result is not surprising as it is found also in other studies (e.g., Pekkarinen, 1993). One explanation is that men often have higher income than women and therefore have more money to spend. Many studies (e.g., Kurri and Pursula, 1995, European Commission, 1998) have shown that value of time increases significantly with income.

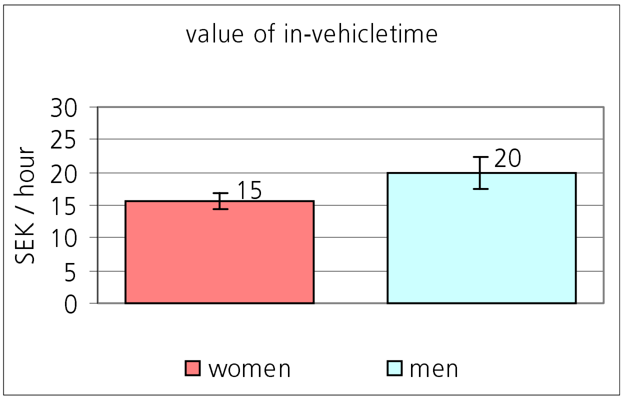

Figure 4 Estimated value of in-vehicle time, SEK/h, for women respective men. Estimate and 90% confidence interval.

Passengers older than 65 years have a significantly (p=0.10) lower value of time than other passengers have, figure 5. The highest value of time seems to exist among ages 26-40 years, while 41-65-year olds have a lower value of time (p=0.05). Also in Widlert *et al.*(1989) a lower value of time for older bus passengers is shown. European Commission (1998) refers to British and Dutch studies, which likewise have reported that the value of time decreases with age.

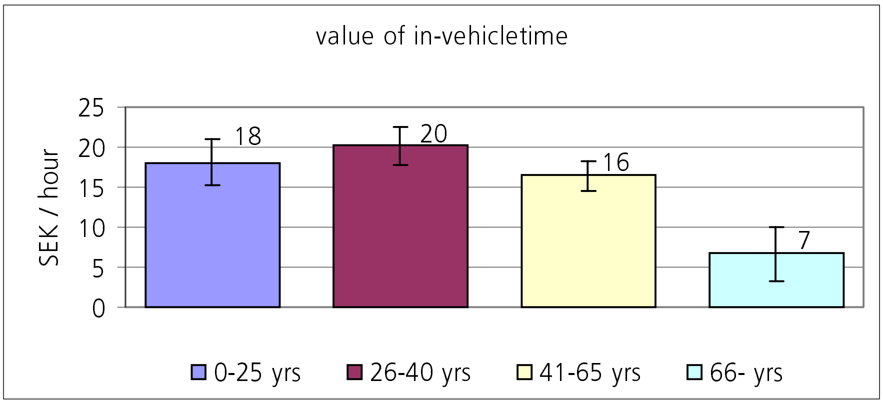

Figure 5 Estimated value of in-vehicle time, SEK/h, for passengers in different age groups. Estimate and 90% confidence interval.

The respondents were also classified into three occupations: student, worker and either retired or long-term sick-listed. Too few respondents have stated something else as occupation in the questionnaire to form a fourth group. The value of time can not be significantly separated for students respective workers, who have a value of in-vehicle time of 17-19 SEK/h, figure 6. Nevertheless, retired and long-term sick-listed persons have a lower (p=0.10) value of time, about 7 SEK/h. According to European Commission (1998) students have a lower value of time, because of their restricted income and less time constraints. But that result is not confirmed in this study, probably because students in Sweden have more money and more time constraints than students in other countries.

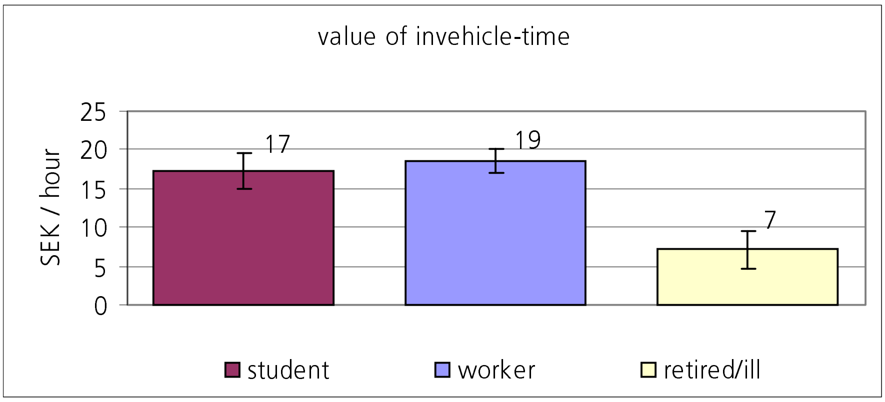

Figure 6 Estimated value of in-vehicle time, SEK/h, for students, workers respective retired or sick-listed persons. Estimate and 90% confidence interval.

The value of time appears to be about the same, irrespective of frequency of travel, 16-18 SEK/h.

3.2.3 State dependency

When segmenting the sample into groups with equal *in-vehicle times*, the highest value of time was found among respondents with an in-vehicle time of 16-25 minutes. Both for shorter and longer in-vehicle times, the value of time was lower (p=0.10), figure 7.

Stangeby and Norheim (1995) showed an increasing value of time, when travel time in bus increased. So did Widlert *et al.* (1989), but they also found decreasing value of time when travel time in *sub-way* increased.

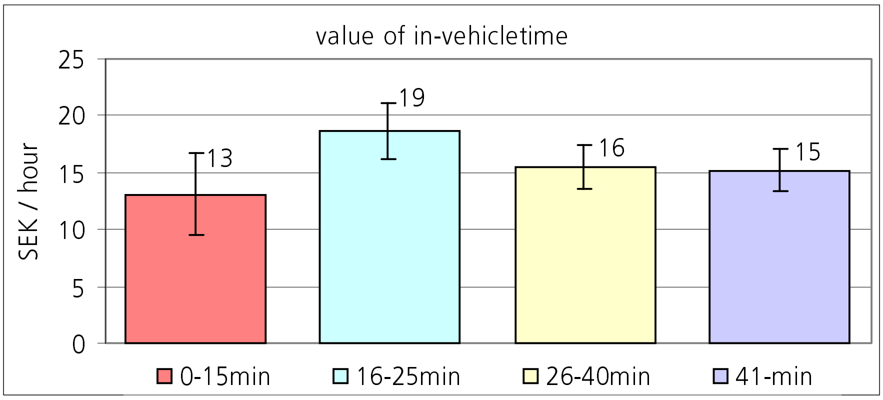

Figure 7 Estimation of value of in-vehicle time, SEK/h, for passengers with different travelling times. Estimate and 90% confidence interval.

When segmenting the respondents into groups with common *headway*, the highest value of time was found among respondents with ability to catch a bus every 8 minutes, figure 8. Between remaining groups no significant differences were shown, but passengers with the most frequent bus service are distinguished as being most ready to pay more to get a faster trip.

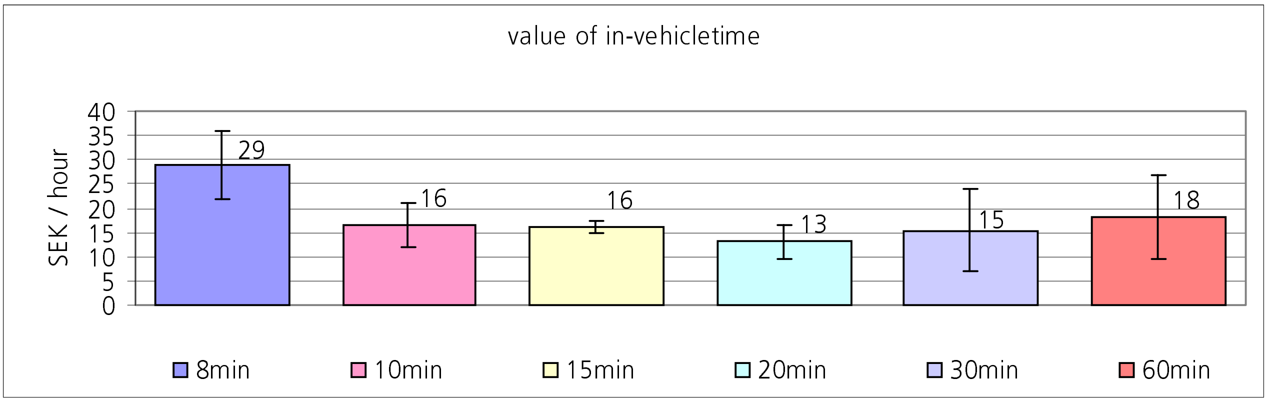

Figure 8 Estimated value of in-vehicle time, SEK/h, depending on headway. Estimate and 90% confidence interval.

No difference could be shown in valuation of time between the passengers who have to change buses during their trip and those, who can travel without having to change buses.

Neither was there a significant difference between passengers who had a seat on bus and those who had not. Previous research (Widlert *et al.*, 1989, Olsson *et al.*, 2001) has shown larger values of time for time standing than time sitting, but this study cannot confirm that result.

3.2.4 Value of time - summary

Groups that showed high values of time compared to their comparison groups were people who work but use bus seldom (31 SEK/h), men (20 SEK/h) and passengers on buses with the shortest headway (29 SEK/h). Groups that showed low values of time compared to their comparison groups were passengers on leisure trips (12 SEK/h), women (16 SEK/h), people older than 66 years (7 SEK/h) as well as retired or long-term sick-listed passengers (7 SEK/h).

3.3 Walking time

The assessment of walking time to bus stop will be presented as a ratio between walking time and in-vehicle time, a_w / a_v in equation 2 above. This ratio is also known as the "weight of walking time". Note that these are not assessments in SEK/h, but only relative to in-vehicle time.

3.3.1 Trip purpose

On leisure trips the walking time is assessed as being more inconvenient (p=0.20) than on trips to work or study, figure 9. This result is not surprising, as it is mentioned in for example The Canadian Transit Handbook (1993) that passengers on non-work journeys are more concerned about having to walk longer distances to bus stop. Norheim and Stangeby (1993), however, found no differences between work trips and other purposes when valuing walking time.

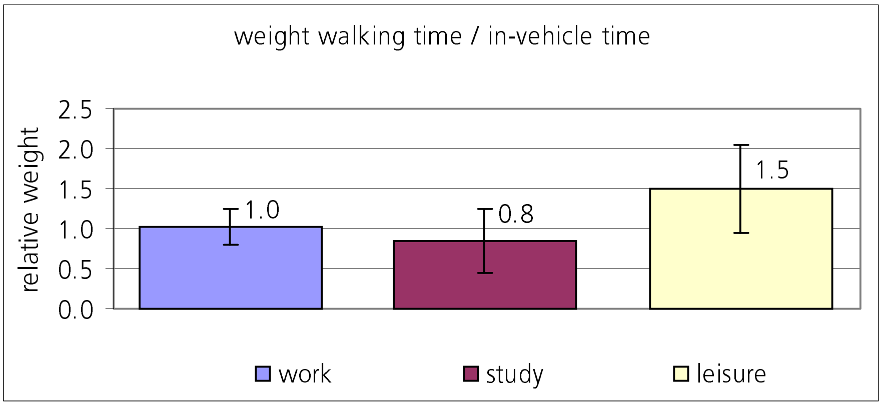

Figure 9 Relative weight walking time to bus stop / in-vehicle time for trips to and from work, study or leisure. Estimate and 90% confidence interval.

Both young persons on work trips and working people who use the bus seldom are distinguished for having a significantly larger (p=0.05) walking time weight than others, figure 10. The latter can be seen as a consequence of self selection. Those who assess the walking time as burdensome, seldom go by bus.

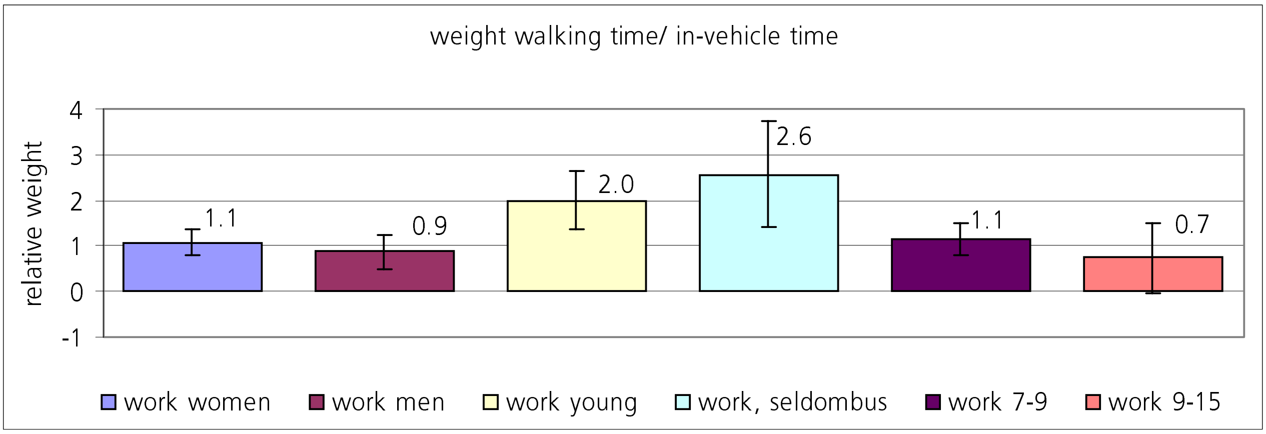

Figure 10 Relative weight walking time to bus stop / in-vehicle time for different work trips. Estimate and 90% confidence interval.

3.3.2 Demographic groups

Among the age groups it was shown that passengers, 41-65 years of age, can be significantly (p=0.20) separated from both younger groups, as having lower resistance against walking time, figure 11. The group with the oldest passengers was too little and/ or too heterogeneous in this respect to make it possible to show significant differences. Other studies (European Commission, 1998) report that older passengers assess walking time 150 per cent higher than travel time. In Oslo (European Commission, 1998) passengers older than 80 years assess shorter walking times twice as much as the average passenger, whereas younger pensioners do not differ markedly from the average.

That the assessments of the oldest group can not be significantly separated from others may stem from the design of this Stated Preference experiment. The walking times were expressed as 2, 5 or 7 minutes walk. It is possible that an elderly passenger is not threatened of a walking time of 7 minutes, which is not a long time for a person with low walking speed. Maybe a significant difference had be shown if the access had been expressed as a distance, in meters instead.

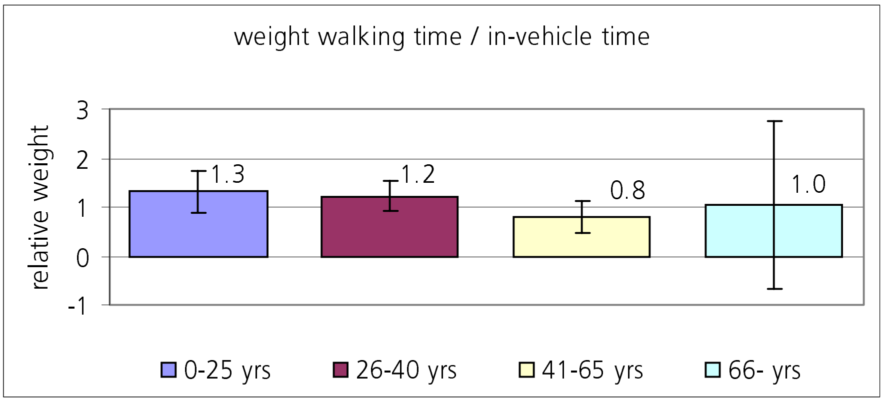

Figure 11 Relative weight walking time / in-vehicle time for four age groups. Estimate and 90% confidence interval.

Women's respective men's assessment of walking time relative to in-vehicle time can not be significantly separated.

The walking time weight could not be significantly separated among passengers with different occupations. Neither could the weight put on walking time be shown to depend upon how often a person uses public transport.

3.3.3 State dependency

Assessment of *walking time* relative to in-vehicle time is clearly affected of how long walking time a passenger has to a bus stop, figure 12. Each walking time minute gets less and less important the longer the walking time (p=0.05). This is a clear evidence of state dependency. Those who find it hard to walk for 10 minutes are not travelling by public transport if they live that far away from a bus stop. The consequence of this, so called, "self selection bias" is that there are no respondents with high walking time weight among those who walk long distances.

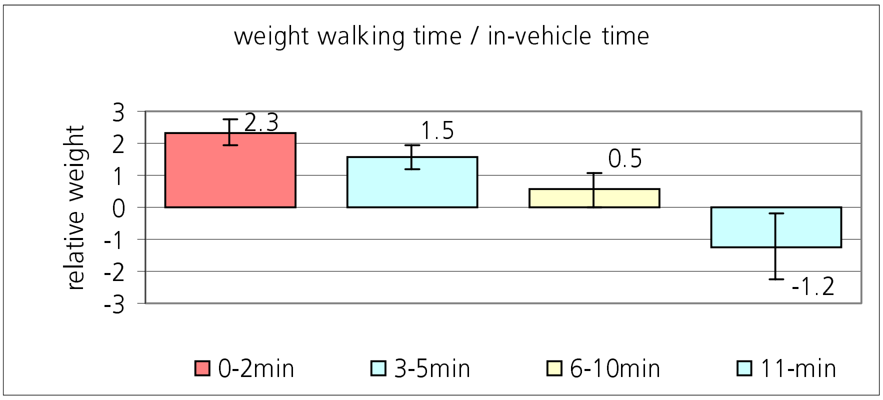

Figure 12 Relative weight walking time / in-vehicle time by walking time. Estimate and 90% confidence interval.

Also how long the actual *travel time* on bus is influences the assessment of walking time, figure 13. The assessment of walking time relative to in-vehicle time decreases with longer travelling times (p=0.05).

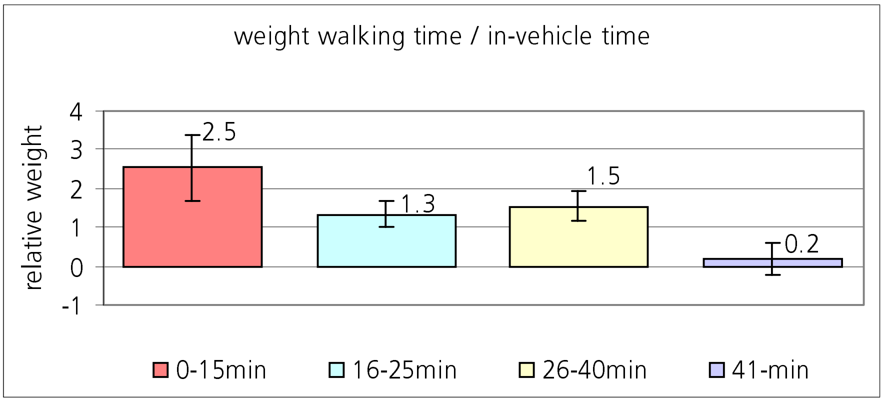

Figure 13 Relative weight walking time / in-vehicle time by length of in-vehicle time. Estimate and 90% confidence interval.

Neither the presence of transfer in the trip nor the availability of seat influenced the walking time weight.

3.3.4 Assessment of walking time to bus stop – summary

Groups that have high walking time weights are passengers on leisure trips (1.5), young people on work trips (2.0), people who work but use bus seldom (2.6), retired or long-term sick-listed persons (1.5), people with very short walking times (2.3), and people with short in-vehicle times (2.5). Groups that have low assessment of walking time, that is do have little against walking, are people who go to work during off-peak hours (0.7), people who have long walking times (-1.2), and people with long in-vehicle times (0.2).

3.4 Headway

3.4.1 Trip purpose

On leisure trips the headway time is higher (p=0.01) assessed than on trips to work or study, figure 14. In the Oslo study (Norheim and Stangeby, 1993) no difference was found between work trips and other trips when valuing shorter headway.

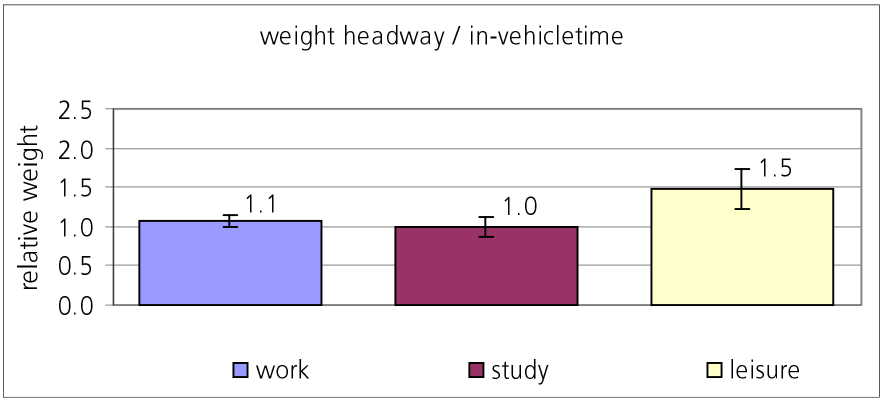

Figure 14 Relative weight headway / in-vehicle time by trip purpose. Estimate and 90% confidence interval.

A significant difference was found between assessments of headway for work trips of women respective men. Women assess the headway as more (p=0.001) important than men do on work trips, figure 15. Men's bus headway weight is even smaller than 1, meaning that the in-vehicle time is more important to reduce than the headway on trips to work for the same time reduction.

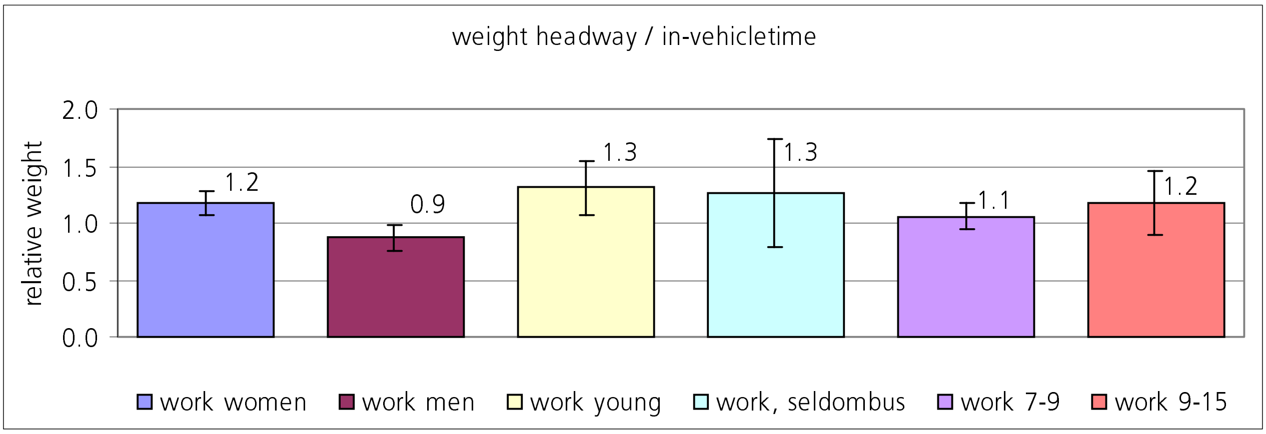

Figure 15 Relative weight headway / in-vehicle time for different work trips. Estimate and 90% confidence interval.

3.4.2 Demographic groups

Both women and men assess the headway as being somewhat more inconvenient than the in-vehicle time. Assessments of women are slightly higher (p=0.20) than assessments of men, 1.2 compared to 1.1.

Passengers older than 65 years old assess the headway higher than younger passengers do (p=0.20), figure 16. This result agrees with the result of a telephone survey by Ståhl *et al.* (1993). Their study showed that increased bus frequency is by far the commonest desire among elderly and disabled when respondents were asked to name one single improvement they would like to see in public transport. Assessments of headway of young passengers can not be significantly separated from assessments of the middle aged.

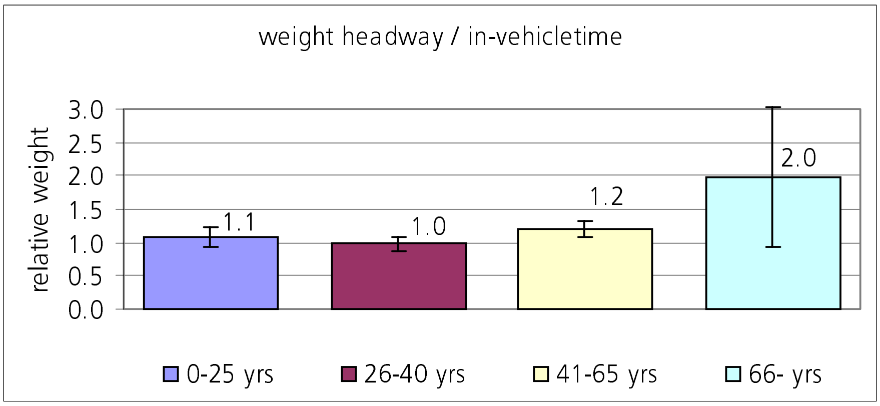

Figure 16 Relative weight headway / in-vehicle time for age groups. Estimate and 90% confidence interval.

When the respondent's occupation is used as segmentation basis instead, the same pattern is shown, figure 17. The retired and long-term sick-listed persons have a higher relative assessment of headway than students and workers have (p=0.10).

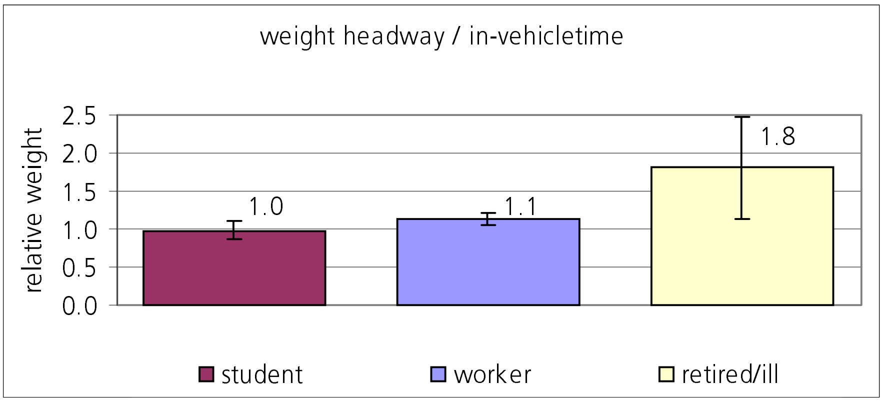

Figure 17 Relative weight headway / in-vehicle time for occupations. Estimate and 90% confidence interval.

There is a weak tendency that headway gets more important relative to in-vehicle time, the more trips a passenger makes per month, figure 18. But the only statistically significant (p=0.20) difference is that passengers who make 40-59 trips per month have a higher weight, than passengers who make less than 39 trips per month.

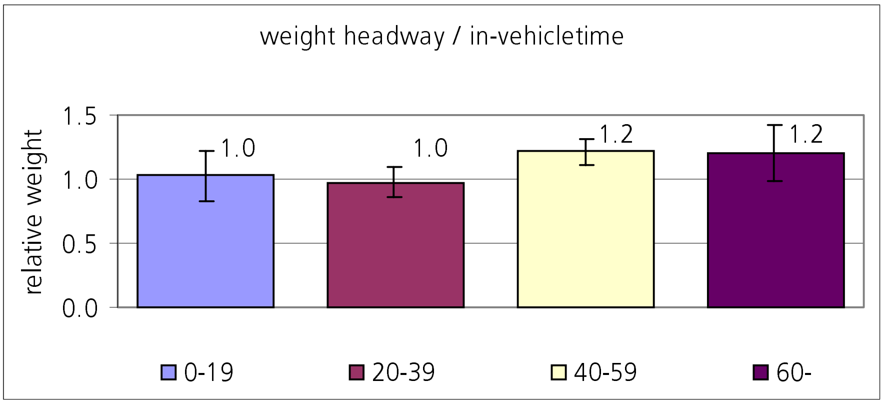

Figure 18 Relative weight headway / in-vehicle time depending on trips per month. Estimate and 90% confidence interval.

3.4.3 State dependency

Which *headway* a passenger has access to today affects the assessment of headway, figure 19. The main reason why the confidence interval is smaller for 15 minutes' headway is the high number of respondents in this group. The weight of headway is lowest for the shortest (8 minutes) and the longest (60 minutes) headway. Stangeby and Norheim (1995) show lower assessments of headway the longer the headway is. The same relationship is shown by Blomquist and Jansson (1994), but only for passengers knowing the timetable. In contrast, for passengers who did not know the timetable, the relative weight of headway increased with longer headway.

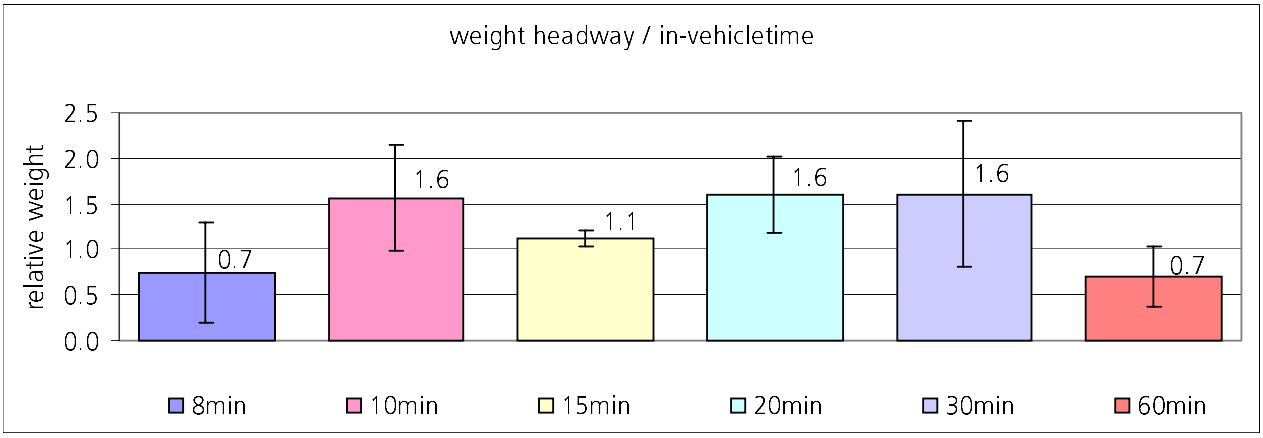

Figure 19 Relative weight headway / in-vehicle time depending on headway. Estimate and 90% confidence interval.

The importance of frequent bus services is largest (p=0.20) for passengers with the *shortest trips*, figure 20. The explanation may be that passengers do not want to spend longer time waiting for the bus, than riding on the bus, and most passengers have a headway shorter than 20 minutes.

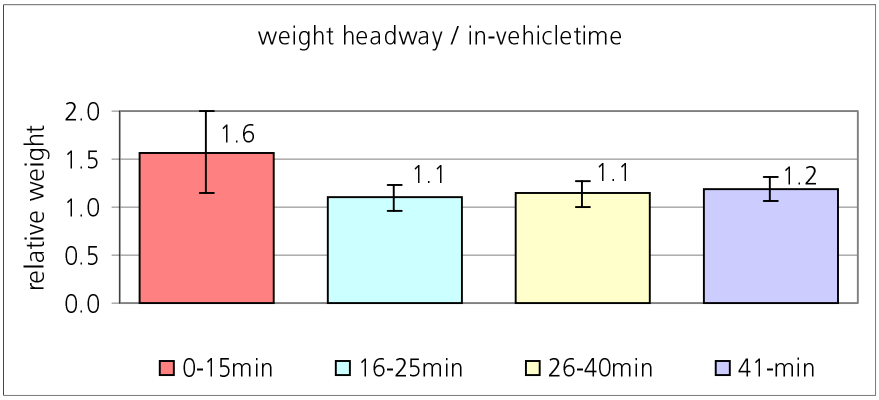

Figure 20 Relative weight headway / in-vehicle time depending on in-vehicle time. Estimate and 90% confidence interval.

Neither the presence of transfer in the trip nor the availability of seat influenced the headway weight.

3.4.4 Assessment of headway – summary

Instead of waiting time, which is often used as a quality variable in public transport studies, in this study headway was used as a measure of the quality of a bus route. A deterioration of the headway is easier for respondents to imagine than an increased waiting (Bradley, 1988). It is also the headway that the bus company planner can plan, not the waiting time. Assuming random passenger arrivals and constant bus headway, the average passenger wait time at the bus stop is equal to half the headway (e.g., Kaysi and Bassil, 1995).

Headway minutes are assessed high compared to in-vehicle time on leisure trips (1.5), by working women (1.2), by passengers older than 66 and retired (1.8-2.0), and when in-vehicle time is short (1.6). Short headway is not assessed being so important for working men (0.9) and passengers who have either very short headway (8 minutes) (0.7) or very long headway (60 minutes) (0.7).

3.5 Bus transfer

The assessment of a transfer will here be expressed in in-vehicle time minutes. The corresponding in-vehicle time minutes express how many extra minutes a passenger can spend in the bus, if a transfer is avoided. The amount is also known as a transfer penalty.

3.5.1 Trip purposes

When comparing how a bus transfer is assessed on trips to work, study or leisure, significant differences were found, figure 21. On work trips and leisure trips, a transfer is clearly higher (p=0.01) assessed than on trips to school. While travelling to school, passengers' assessment of the inconvenience of having to change buses can not be separated from zero.

This result clearly differs from the previous recommended transfer penalty in Sweden of 5 minutes (Vägverket, 1992). Norheim and Stangeby (1993) have reported somewhat higher transfer penalties of 8-10 minutes from studies in Norway.

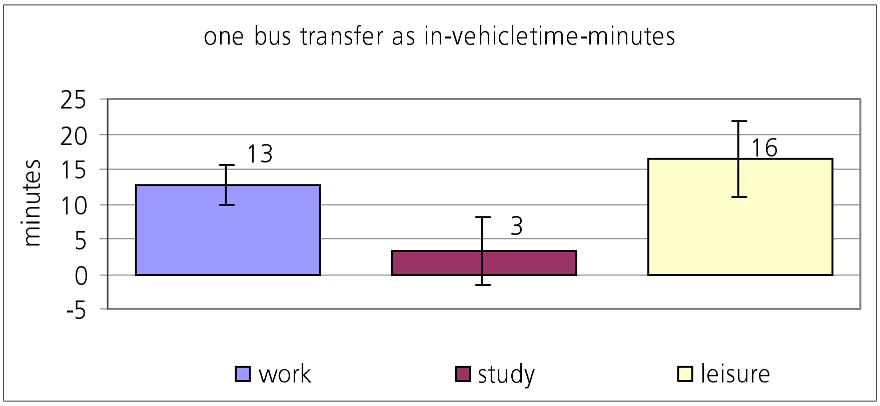

Figure 21 A bus transfer expressed as in-vehicle time minutes for different trip purposes. Estimate and 90% confidence interval.

The work trips were split up to sub-segments to see if any variations could be found between categories of work trips. One significant difference shown was that during off peak hours is a transfer higher weighted (p=0.20), than during peak hours, figure 22.

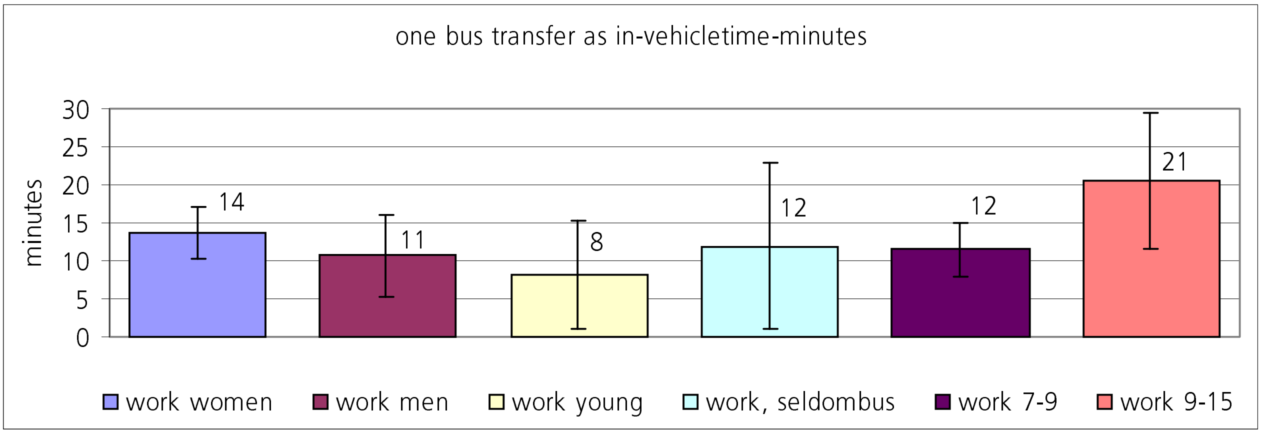

Figure 22 A bus transfer expressed as in-vehicle time minutes for different work trips. Estimate and 90% confidence interval.

3.5.2 Demographic groups

Women's respective men's assessments of bus transfer could not be significantly separated from each other. The transfer penalty in both groups was about 10-12 minutes.

Young people have the smallest resistance against a bus transfer, figure 23. The assessment of a bus transfer increases when passengers get older (p=0.10). The number of respondents older than 66 years were unfortunately too few to give a clear assessment. However, it is shown that 41-65 year olds have higher assessments, than people who are younger than 40.

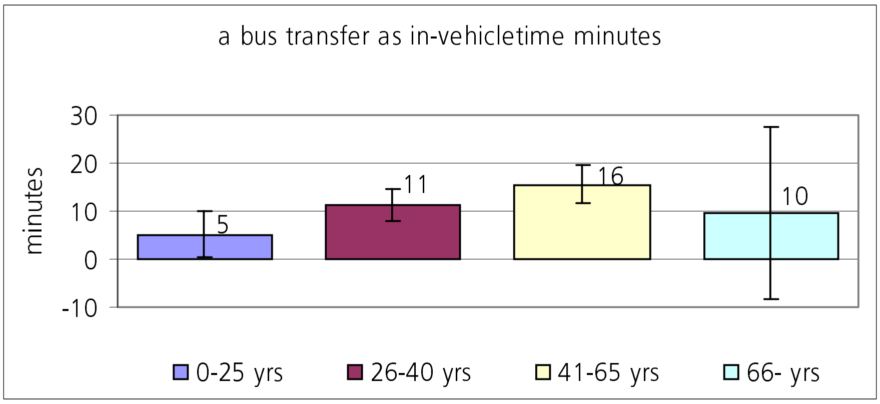

Figure 23 A bus transfer expressed in in-vehicle time minutes for age groups. Estimate and 90% confidence interval.

Students do not mind changing buses during a trip, figure 24. The estimated assessment is 3 in-vehicle minutes and the estimate can not be significantly separated from 0. Both workers and retired and long-term sick-listed persons have higher resistance against a bus transfer (p=0.05), with an average estimate of 14 respective 21 in-vehicle minutes.

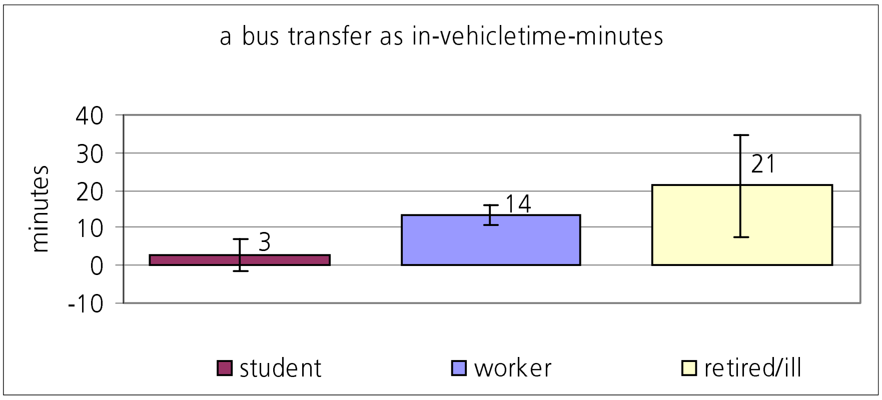

Figure 24 A bus transfer expressed as in-vehicle time minutes for occupations. Estimate and 90% confidence interval.

No significant differences were found in assessment of a bus transfer depending on how many trips per month a passenger does.

3.5.3 State dependency

Bus passengers who have to *change buses* during their trip assess a bus transfer lower (p=0.02), than passengers who do not have to change buses, figure 25. This is a clear example of that "willingness to pay" is lower than "willingness to accept" and has also been shown in for example Widlert *et al.*(1989) and Sjöstrand (1999a).

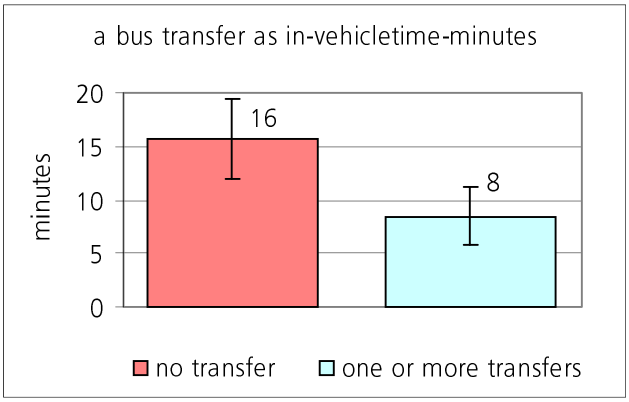

Figure 25 A bus transfer expressed as in-vehicle time minutes depending on present conditions. Estimate and 90% confidence interval.

As seen in figure 26, the resistance against having a bus transfer is highest (p=0.01) among passengers with short *travelling times*. The explanation is as above, that the passengers with short travelling times do probably not have to change buses now and a bus transfer involves deterioration for them.

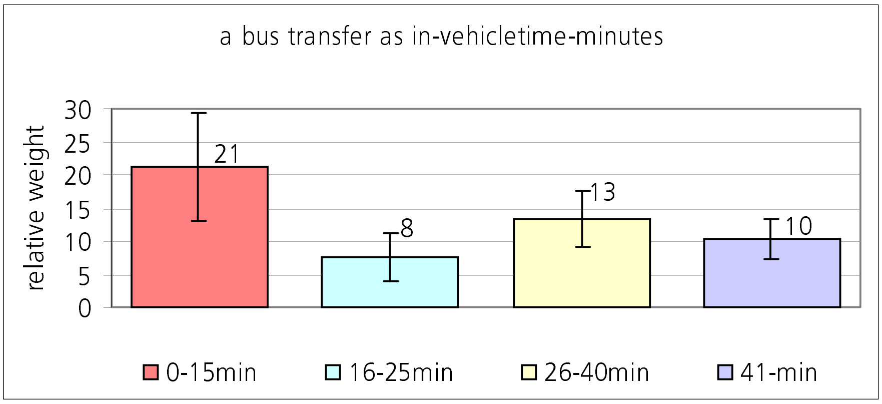

Figure 26 A bus transfer expressed as in-vehicle time minutes depending on present conditions. Estimate and 90% confidence interval.

The transfer assessment did not depend on seat availability.

3.5.4 Assessment of bus transfer - summary

The assessment of a transfer is expressed in in-vehicle minutes. The corresponding in-vehicle time minutes express how many extra minutes a passenger can spend in the bus, if a transfer is avoided. The amount is also known as a transfer penalty.

The transfer penalty is high for work trips during off-peak hours (21 min), for retired (21 min), for passengers who currently do not need to transfer (16 min) and for passengers with short travel time. On the other hand, students (3 min) and passengers younger than 25 (5 min) do not have large resistance against a bus transfer.

3.6 Waiting time during transfer

In the same way as walking time and headway are treated above, the assessment of waiting time during bus transfer, is calculated as a_{tt} / a_v from equation 2. The transfer waiting time weight was estimated to 2.3-4.3 in 5 Norwegian cities (Kjörstad, 1995). No segmentation on different travellers was made in that study.

3.6.1 Trip purpose

On leisure trips waiting time during bus transfer is higher (p=0.10) assessed than on trips to work or study, figure 27.

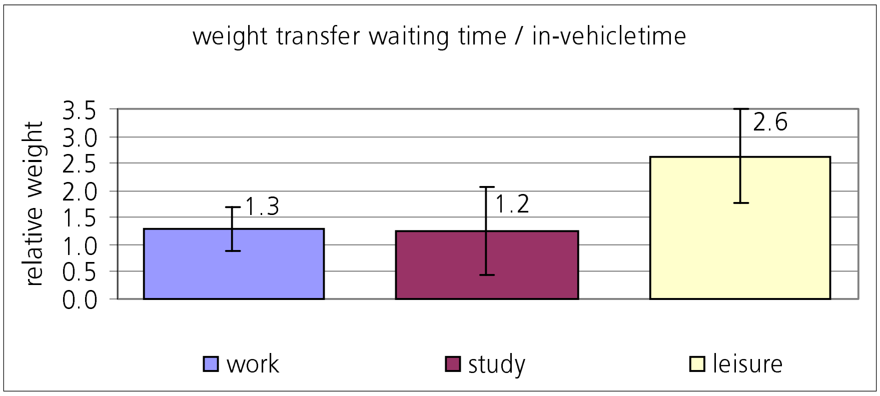

Figure 27 Relative weight transfer waiting time / in-vehicle time by trip purposes. Estimate and 90% confidence interval.

Segmentation of work trips did not show any differences between groups.

3.6.2 Demographic groups

Old people assess the waiting time during bus transfer as being relatively more inconvenient (p=0.20), than younger passengers do, figure 28. Among the younger groups, no variation of transfer time weight assessment could be seen.

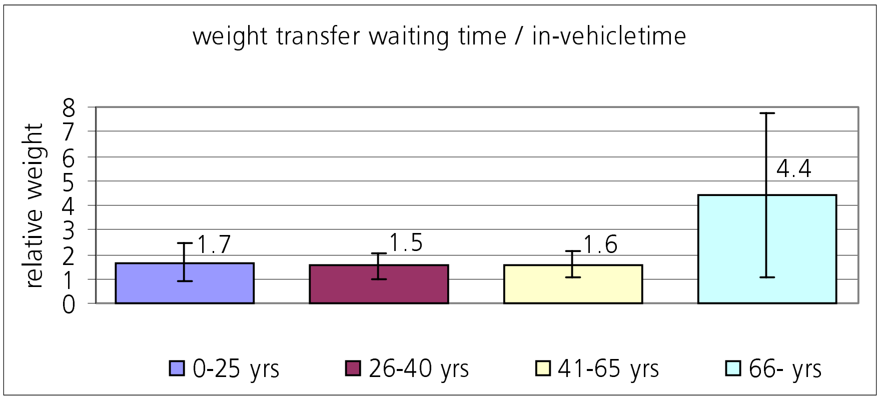

Figure 28 Relative weight transfer waiting time / in-vehicle time by age group. Estimate and 90% confidence interval.

As figure 29 shows, retired and long-term sick-listed persons have a higher (p=0.20) assessment of transfer waiting time, than workers have. Of course, many of these persons are identical with "passengers over 66 years old", whose assessments were shown above.

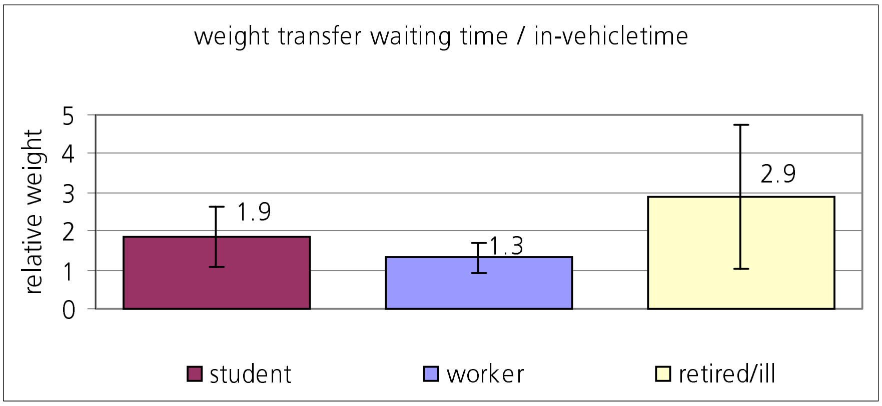

Figure 29 Relative weight transfer waiting time / in-vehicle time by occupation.

There is a clear tendency that assessment of transfer waiting time decreases the more trips a passenger does per month, figure 30.

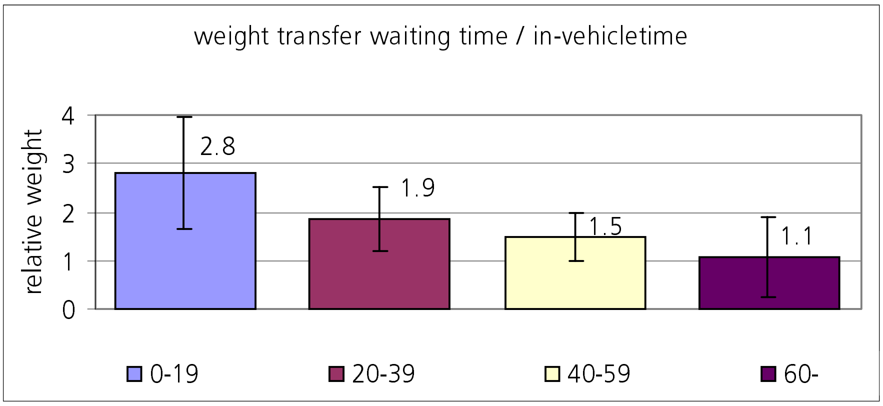

Figure 30 Relative weight transfer waiting time / in-vehicle time by number of trips per month.

No significant difference between women's respective men's transfer time weight could be shown.

3.6.3 State dependency

The transfer waiting time weight could not be significantly separated neither depending on if the passenger's trip contained a bus transfer or not, nor on actual in-vehicle time.

3.6.4 Assessment of waiting time during transfer - summary

The waiting time during transfer is high assessed relative to in-vehicle time on leisure trips (2.6), by passengers older than 66 (4.4), by retired or long-term sick-listed passengers (2.9), and for people making few bus trips per month (2.8). The waiting time during transfer is low assessed among passengers who make many trips (more than 60) per month (1.1).

3.7 Interaction between time elements

As mentioned above state dependency include both inertia effects and non-linearity effects. In this section effects of inertia are excluded when it is analysed if the assessment of any of the time parameters depended on the present level of any of the other time parameters in the alternatives. It is possible that, for example, the assessment of walking time to bus stop is influenced by the contemporary level of in-vehicle time. Therefore, a number of new parameters were created and tested for significance one at a time in the above described model. The model was defined as before, but with one additional term:

$$U = a_c * c + a_w * w + a_v * v + a_h * h + a_t * t + a_{tt} * tt + \mathbf{a_{xy} * x * y} + \varepsilon \qquad (8)$$

where

a_i and c, w, v, h, t, tt and ε as above

a_{xy} is the presumed extra contribution to the x time parameter, when y is high, or the reverse
x and y are alternately walking time to bus stop, in-vehicle time, headway and transfer waiting time

If a_{xy} can be significantly separated from 0, the assessment of x-time is affected by the level of y-time. Table 9 shows which combinations of a_i that gave correlation and to which extent a_{xy} could be separated from 0.

Table 9 Estimations of a_{xy} with t-statistics in parentheses

	walk	in-vehicle	headway	transfer waiting
walk	-0.0117 (-1.6)	0.0020 (3.7)	0.0003 (0.3)	not relevant [1]
in-vehicle	0.0020 (3.7)	-0.0001 (-0.7)	0.0002 (1.7)	0.0008 (1.0)
headway	0.0003 (0.3)	0.0002 (1.7)	0.0002 (2.1)	0.0001 (0.1)
transfer waiting	not relevant [1]	0.0008 (1.0)	0.0001 (0.1)	-0.0054 (-0.9)

[1] the interaction between walking time and transfer waiting time was not possible to estimate as these attributes were not present in the same experiment

Note that this is not the same issue as has been investigated under "state dependency" in sections 3.3-3.4. In those sections the assessment depended on how long walking time, in-vehicle time and headway people actually have. Now we study if assessments depend on which levels of walking time, in-vehicle time, headway and transfer waiting time that were presented in the SP-experiment, thus inertia effects are excluded.

Equation 8 and these estimates give an opportunity to estimate the relative weight to in-vehicle time of x for a specific y as

$$\frac{a_x}{a_v} = \frac{a_x + a_{xy} * y}{a_v} \qquad (9)$$

where

a_x/a_v is the weight of x-time relative to in-vehicle time

a_x is the parameter of x-time (either in-vehicle, walking, headway or transfer waiting time)

a_{xy} is the presumed extra contribution to the x time parameter, when y is high, or the reverse
y is alternately walking time to bus stop, in-vehicle time, headway and transfer waiting time

a_v is the parameter for in-vehicle time

As can be seen in table 9, there is an interaction such that walking time to bus stop is higher assessed when presented walking time levels are large (p=0.10). The relation is shown also in figure 31. The interaction indicates that the walking time to bus stop is not inconvenient (relative to in-vehicle time) with the levels of walking time presented in the study.

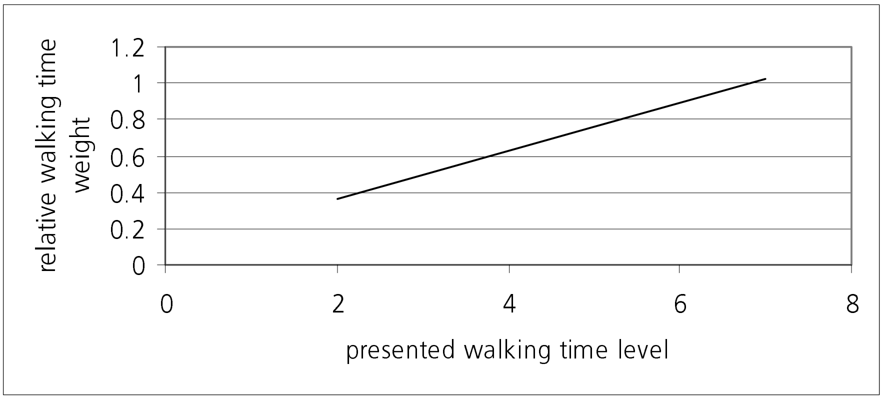

Figure 31 Relative weight walking time / in-vehicle time depending on presented walking time.

The next interaction tells that there is a correlation between walking time and in-vehicle time (p=0.05) such that when either of them is large, the other one is low assessed. The opposite is also possible, that when either of them is small, the other one is high assessed. Thus, the assessment of in-vehicle time decreases with longer walking distances or the assessment of walking time decreases with longer in-vehicle times. Figure 32 shows how the walking time weight depends on presented in-vehicle time.

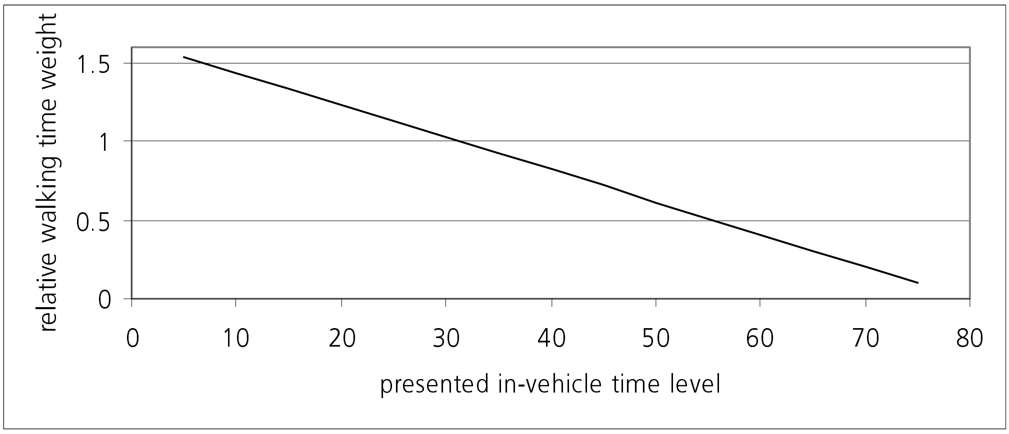

Figure 32 Relative weight walking time / in-vehicle time depending on presented in-vehicle time.

In-vehicle time is also negatively correlated (p=0.10) with the level of headway. When presented in-vehicle time gets longer the assessment of headway gets lower, and vice versa. The relation is shown in figure 33 for presented in-vehicle times of 5-75 minutes.

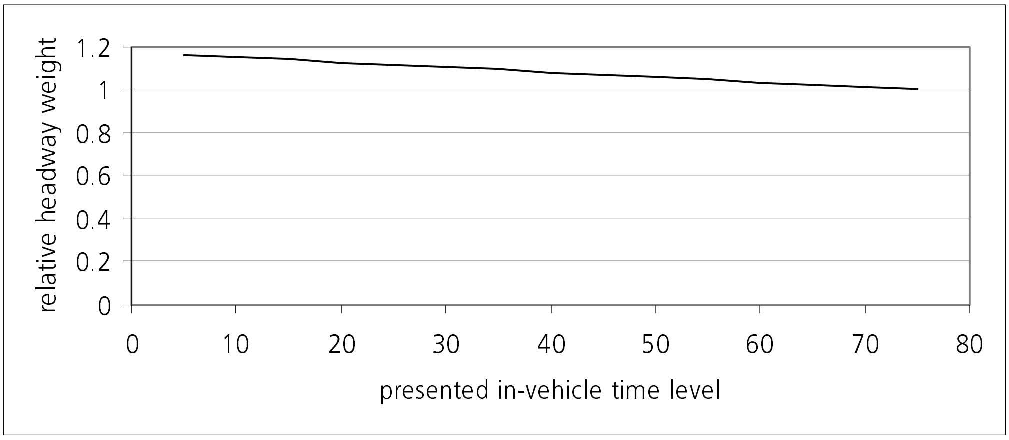

Figure 33 Relative weight headway / in-vehicle time depending on presented in-vehicle time.

The fourth and last correlation found between the time elements concerns assessment of headway time depending on presented headway. When the presented headway is long, each minute is not as high assessed as if the presented headway is short. As figure 34 shows, the decrease is almost invisible. But, according to the interaction analyse the decrease is significantly separated from 0 ($p=0.05$).

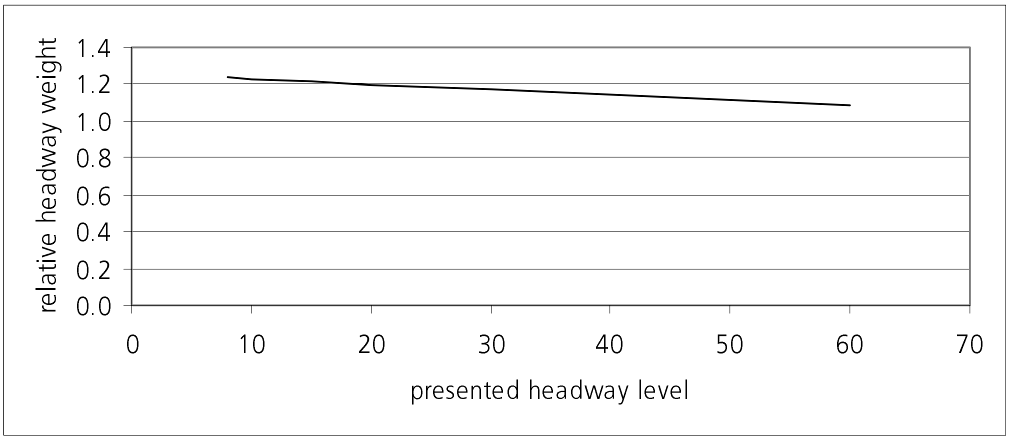

Figure 34 Relative weight headway / in-vehicle time depending on presented headway.

4 Conclusion

This study was carried out with the aim of describing how assessments of quality in local public transport vary among travellers groups and on different trips. The qualities studied are walking time, in-vehicle time, headway, transfer and transfer waiting time. The detailed result is presented in chapter 3 and an overview is presented in appendix 3.

This study has showed that assessments vary between groups. A very significant difference was that young people and students do not mind changing buses, while other groups find it very inconvenient to have to transfer. Another remarkable result was that walking time to bus stop is not assessed that inconvenient, as has previously been believed.

On work trips neither walking time nor headway are assessed with higher weight than in-vehicle time, but a transfer is assessed to corresponding 13 minutes. A passenger on the way to work will rather walk or wait a little longer to catch a bus that gives a direct trip than catch the closest bus, if it implies a bus transfer. To give work commuters the lowest generalised time, that is best quality, the route network should supply direct trips, while the bus stops being close to destinations is of lesser importance.

A bus route network adapted to students' assessments may include both transfers and some walking distances, as long as there is no waiting time between buses. The transfer waiting time is assessed quite negatively of this group.

When segmenting according to demographic variables, they naturally correlate with trip purpose, as, for example, almost all study trips are made by young people.

For elderly passengers there are larger variations between how different parts of the trip is assessed. Headway of buses is very important relative to in-vehicle time and also the waiting time during transfer. The walking time to bus stop is also quite burdensome, and a bus transfer is equivalent to spending 20 additional minutes on the bus. A bus network customised for elderly passengers shall be well covering, that is providing short walking distances and direct trips. Moreover, bus service shall be frequent.

On leisure trips, assessments are about the same, as for elderly passengers thus the same route network fits leisure travellers. One difference though is the value of time, which is higher for leisure travellers than for the elderly. That implies that on leisure trips passengers are ready to pay more to travel faster, than elderly are. But neither of these groups have such a high value of time as workers or students.

A segmentation basis sometimes discussed, is whether there is a difference between men's respective women's assessments. This study can not show any significant differences, except for the value of time. Like previous studies have shown, men have a larger value of time than women have. A route network planned to fit men, will also fit women. The only difference is that men are ready to pay more to get faster to their destinations.

One reason for segmentation, mentioned above, was competitive markets. Although only bus passengers were included in the study, some information about users of other modes could anyway be analysed as "workers who use bus seldom". To make them travel more often by bus, the walking distances shall be short and transfers avoided, but short headway is not that important. Anyway, the most important quality to improve is to shorten the actual in-vehicle time since these passengers have a high value of time.

This thesis has shown that irrespective of whether the purpose for segmentation of passengers was

- to plan different route networks for different groups, because of varying assessments or different origin-destination matrices
- to customise bus routes for a particular group for political reasons, or
- to make public transport a competitive alternative for frequent car users

there are relevant passenger groups who have assessments that differ significantly from those of average passengers.

As assessments vary significantly among groups, it would be misleading to use average assessments in the planning process. This could potentially lead to inefficient planning decisions.

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Några frågor om resan du gjorde när vi träffade dig i bussen

Varifrån kom du när vi träffades?	☐ hemifrån ☐ från jobbet eller skolan ☐ från affär eller annan service ☐ från något annat…………………

Vart skulle du åka när vi träffades?	☐ hem ☐ till jobbet eller skolan ☐ till affär eller annan service ☐ till något annat……………………

Hur kom du till hållplatsen? *(där resan startade)*	☐ jag gick, det tog……….…minuter ☐ jag cyklade, det tog………minuter ☐ jag åkte bil, det tog……....minuter ☐ ……………………………………

Bytte du buss eller spårvagn under resan?

☐ nej

☐ ja, på……………..…………………………………………………*(hållplatsens namn)*

Bytte du fler gånger?

☐ ja, på……………..…………………………………………………*(hållplatsens namn)*

Vilken buss- eller spårvagnslinje åkte du med? *(flera om du bytte)*

Linjenummer……………………………………………..

Hur lång tid tog hela resan från starthållplats till sluthållplats?
Räkna med tiden vid byte också, om du åkt flera bussar och/eller spårvagnar

……………………………….minuter

Fick du sittplats under resan?	☐ ja, hela resan ☐ delar av resan ☐ stod upp hela resan

Glöm inte frågorna på andra sidan!

Vilken typ av biljett hade du på resan?	☐ köpte enkelbiljett av föraren 16 kr ☐ Rabattkort 120 kr (köpt på bussen) ☐ Rabattkort 50 kr ☐ Maxirabatt 100 kr ☐ Månadskort Göteborg, 390 kr ☐ Månadskort, lågtrafik, 240 kr ☐ Månadskort, ungdom, 240 kr ☐ annat månadskort ☐ Kvartalskort Göteborg ☐ Årskort Göteborg ☐ Skolkort ☐ Färdtjänstbevis ☐ annan.......................................

Slutligen några frågor om dig själv

Hur många gånger åker du buss och/eller spårvagn under en månad?

ange antal enkelresor, men räkna inte som två resor om du bara byter linje
(om du bara åker till och från jobbet varje vardag blir det ca 40 resor)

ca……………….

Vad är din huvudsysselsättning?	☐ arbetar ☐ pensionär ☐ studerar ☐ arbetslös ☐ barnledig / tjänstledig ☐ långtidssjukskriven ☐ värnpliktig ☐ annat………………………………

Vilket år är du född?
…..……………………..

Övriga synpunkter eller annat som påverkar ditt resande:

……………………..……….........……………………………………………………

………………………………………………………………………………………

Välj ett av de två alternativen i varje par!

Din bussresa kostar 13 kr	Din bussresa kostar 10 kr
Din bussresa tar 15 minuter	Din bussresa tar 20 minuter
Bussen går var 15:e minut	Bussen går var 15:e minut
Du måste byta buss, 5 min väntetid	Du måste byta buss, ingen väntetid
Jag väljer ☐	☐

Din bussresa kostar 13 kr	Din bussresa kostar 10 kr
Din bussresa tar 20 minuter	Din bussresa tar 20 minuter
Bussen går var 8:e minut	Bussen går var 15:e minut
Du måste byta buss, 5 min väntetid	Direktresa utan byte
Jag väljer ☐	☐

Din bussresa kostar 10 kr	Din bussresa kostar 13 kr
Din bussresa tar 25 minuter	Din bussresa tar 25 minuter
Bussen går var 10:e minut	Bussen går var 15:e minut
Du måste byta buss, 5 min väntetid	Direktresa utan byte
Jag väljer ☐	☐

Din bussresa kostar 7 kr	Din bussresa kostar 10 kr
Din bussresa tar 20 minuter	Din bussresa tar 15 minuter
Bussen går var 10:e minut	Bussen går var 8:e minut
Du måste byta buss, ingen väntetid	Direktresa utan byte
Jag väljer ☐	☐

Din bussresa kostar 15 kr	Din bussresa kostar 15 kr
Din bussresa tar 15 minuter	Din bussresa tar 20 minuter
Bussen går var 15:e minut	Bussen går var 8:e minut
Direktresa utan byte	Du måste byta buss, 5 min väntetid
Jag väljer ☐	☐

Din bussresa kostar 15 kr	Din bussresa kostar 7 kr
Din bussresa tar 15 minuter	Din bussresa tar 25 minuter
Bussen går var 8:e minut	Bussen går var 10:e minut
Du måste byta buss, ingen väntetid	Du måste byta buss, ingen väntetid
Jag väljer ☐	☐

Välj ett av de två alternativen i varje par!

Din bussresa tar 75 minuter Bussen går var 10:e minut Du har månadskort som kostar 390 kr Det tar 2 min att gå till hållplatsen	Din bussresa tar 50 minuter Bussen går var 30:e minut Du har månadskort som kostar 390 kr Det tar 5 min att gå till hållplatsen
Jag väljer ☐	☐

Din bussresa tar 75 minuter Bussen går var 15:e minut Du har månadskort som kostar 300 kr Det tar 2 min att gå till hållplatsen	Din bussresa tar 50 minuter Bussen går var 15:e minut Du har månadskort som kostar 390 kr Det tar 5 min att gå till hållplatsen
Jag väljer ☐	☐

Din bussresa tar 60 minuter Bussen går var 30:e minut Du har månadskort som kostar 390 kr Det tar 2 min att gå till hållplatsen	Din bussresa tar 50 minuter Bussen går var 10:e minut Du har månadskort som kostar 390 kr Det tar 7 min att gå till hållplatsen
Jag väljer ☐	☐

Din bussresa tar 50 minuter Bussen går var 10:e minut Du har månadskort som kostar 300 kr Det tar 7 min att gå till hållplatsen	Din bussresa tar 50 minuter Bussen går var 15:e minut Du har månadskort som kostar 500 kr Det tar 5 min att gå till hållplatsen
Jag väljer ☐	☐

Din bussresa tar 60 minuter Bussen går var 15:e minut Du har månadskort som kostar 390 kr Det tar 2 min att gå till hållplatsen	Din bussresa tar 60 minuter Bussen går var 10:e minut Du har månadskort som kostar 390 kr Det tar 7 min att gå till hållplatsen
Jag väljer ☐	☐

Din bussresa tar 60 minuter Bussen går var 30:e minut Du har månadskort som kostar 300 kr Det tar 2 min att gå till hållplatsen	Din bussresa tar 50 minuter Bussen går var 10:e minut Du har månadskort som kostar 390 kr Det tar 7 min att gå till hållplatsen
Jag väljer ☐	☐

Summary of results from SP-studies, estimated assessments

	v.o.t. (SEK/ hour)	walk time weight	headway weight	transfer penalty (minutes)	transfer waiting time weight
all	17	1,1	1,1	12	1,6
work trip	19	1,0	1,1	13	1,3
study trip	19	0,8	1,0	3	1,2
leisure trip	12	1,5	1,5	16	2,6
work woman	18	1,1	1,2	14	1,3
work man	22	0,9	0,9	11	1,3
work young	17	2,0	1,3	8	0,7
work, bus seldom	31	2,6	1,3	12	2,1
work peak hours	21	1,1	1,1	12	1,2
work off-peak hours	17	0,7	1,2	21	1,1
woman	16	1,0	1,2	12	1,7
man	20	1,2	1,1	10	1,4
0-25 years	18	1,3	1,1	5	1,7
26-40 years	20	1,2	1,0	11	1,5
41-65 years	16	0,8	1,2	16	1,6
66- years	7	1,0	2,0	10	4,4
student	17	1,2	1,0	3	1,9
worker	19	1,1	1,1	14	1,3
retired / sick-listed	7	1,5	1,8	21	2,9
0-19 trips per month	18	1,4	1,0	14	2,8
20-39 trips per month	18	1,1	1,0	13	1,9
40-59 trips per month	16	1,0	1,2	10	1,5
60- trips per month	16	1,4	1,2	11	1,1
in-vehicle time 0-15 min	13	2,5	1,6	21	2,6
in-vehicle time 16-25 min	19	1,3	1,1	8	1,9
in-vehicle time 26-40 min	16	1,5	1,1	13	1,8
in-vehicle time 41- min	15	0,2	1,2	10	1,8
headway 8 min	29	-	0,7	11	0,9
headway 10 min	16	-	1,6	11	1,9
headway 15 min	16	1,2	1,1	-	-
headway 20 min	13	0,7	1,6	-	-
headway 30 min	15	-	1,6	14	1,5
headway 60 min	18	-	0,7	4	2,4
walking time 0-2 min	15	2,3	1,2	15	2,1
walking time 3-5 min	16	1,5	1,1	13	1,8
walking time 6-10 min	15	0,5	1,1	13	1,4
walking time 11- min	19	-1,2	0,6	18	2,8