Willingness to accept commuting time for yourself and for your spouse: Empirical evidence from Swedish stated preference data

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Abstract

In this study, Swedish stated preference data is used to derive estimated values of commuting time (VOCT). Both spouses in two-earner households are individually making trade-offs between commuting time and wage; both with regard to their own commuting time and wage only, as well as when both their own commuting time and wage and their spouse's commuting time and wage are simultaneously changed. Thus, we are able to compare how male spouses and female spouses value each other's commuting time. When only ones own commuting time and wage are attributes, the empirical results show that the estimated VOCT is plausible with a tendency towards high values compared to other studies, and that VOCT does not differ significantly between men and women. When decisions affecting commuting time and wage of both spouses are analyzed, both spouses tend to value the commuting time of the wife highest. For policy implications, this study provides additional support for the practice of valuing commuting time higher than other private travel time. In addition, if VOCT were to be gender specific, the value might be higher for women than for men in two-earner households.

Keywords: Value of time; Commuting; Value of commuting time; Stated preferences; Two-earner households; Gender differences; Mixed logit

JEL codes: C25; H54; J16; J30; R41

1 Introduction

The value of time (VOT) has been analyzed or estimated in a large number of studies beginning with the seminal theoretical work of Becker (1965) followed by extensions by DeSerpa (1971) and Truong and Hensher (1985), for example. The policy interest of VOT in transportation analysis mainly originates from the large portion of benefits of transport infrastructure investment that is due to decreased travel time. In fact, up to 80 percent of the benefit side of a road investment may follow from travel time savings (Mackie et al., 2001).

Since there is no market for time, we cannot observe the VOT from a market price. Instead, other indirect methods have to be used to determine a valuation and, conventionally, the data sources for estimating the value of any non-market goods are categorized into two types. First, there is the method of revealed preferences (RP) where actual observed behavior is used to estimate an implicit value of the non-market good. Usually in RP, the inquired estimate is derived indirectly by using other types of real markets.

In the other method, subjects respond to hypothetical scenarios on how they would behave in a corresponding real environment. This type of data is then assumed to elicit the individuals' underlying preferences and hence measure the value of the particular non-market good. Advantages of the latter method, also known as stated preferences (SP), are opportunities to set relevant scenarios, control for correlated effects, and no endogeneity problems. In these aspects, RP usually has several problems with the data collection and structure, for example multicollinearity, undefined choice sets, and difficulties in isolating the effect under consideration.

The main criticism when it comes to SP valuation is its hypothetical nature and the fact that individuals tend to act differently in a real context as compared to their statements in an analogous hypothetical scenario. This phenomenon is referred to as hypothetical bias, which is claimed to be the most important issue to deal with in SP studies (Harrison, 2006). Empirical studies of fields other than VOT suggest that hypothetical bias might be a severe problem (e.g. Cummings et al., 1995; List and Gallet, 2001; Murphy et al., 2005), while studies of VOT have found mixed results regarding hypothetical bias (Brownstone and Small, 2005; Isacsson, 2007; Smith and Mansfield, 1998; Swärdh, 2008). In addition, a recent study finds that hypothetical bias exists when a public good is valued but is not a significant problem when a private good is valued (Johansson-Stenman and Svedsäter, 2008). However it is not clear whether this result can be generalized to the private good of time.

The empirical approach to estimating the value of travel time (VTT) is usually based on either between-mode choices or within-mode choices in a random utility framework. Between-mode choices reveal a trade-off between travel time and travel cost, for example between a car and a bus. Regarding within-mode choices, on the other hand, the mode is constant across alternatives and the trade-off between time and cost is revealed from different routes, lanes or destinations. Since these types of trade-offs exist in the real world, individuals are assumed to be familiar with them and therefore mode choices,

both as within- and between-, are frequently used as scenarios in SP surveys.

There are, however, trade-offs made in other markets which can be used to derive a value of a specific type of travel time. For commuting time, the trade-off between time and money, where the latter is measured as wage or housing costs, can be revealed in the labor market or in the housing market. In the housing market this trade-off is recognized since houses with greater distances to services, central business districts, and clusters of establishments have a lower price, ceteris paribus. Another related trade-off is found in the labor market, where workers who are willing to commute a greater distance are able to search for jobs in a larger geographical area and hence, with access to a larger number of potential employers, increase the probability of experiencing a better matching process. Estimated models of these kinds that derive an implicit value of commuting time (VOCT) are usually based on RP data (e.g. Isacsson and Swärdh, 2009; Rouwendal, 1999; Tse and Chan, 2003; Van Ommeren and Fosgerau, 2009; Van Ommeren et al., 2000; Van Ommeren et al., 2002).

In the present study, the estimated VOCT is based on stated choice experiments where the respondents receive offers including a longer commuting time and a higher wage compared to their present situation. The data is taken from a survey distributed in year 2005 to two-earner households in the Stockholm region of Sweden. This study contributes to the literature where VOCT is estimated through the trade-off between commuting time and wage in the labor market, in several different ways.

This study makes an important contribution in that we are able to analyze whether there are any gender difference in how the respondents value an increase in their own commuting time compared to how they value an increase in the commuting time of their spouse. This is possible since all respondents are parts of a two-earner household where both spouses individually answer separate parts of the questionnaire. In particular, the respondents are treated with two different stated choice experiments regarding the trade-off between wage and commuting time.

In the first choice experiment, respondents make choices on their willingness to accept longer commuting time for themselves, i.e. choose to accept or reject an offer where both wage and commuting time are increased. In the second choice experiment, respondents choose to accept or reject offers where both themselves and their spouse simultaneously receive wage increases as compensation for longer commuting times.

Another contribution is that to our knowledge no SP study of this type has been previously realized in Sweden and with an SP approach it is possible to control for effects that are not observable or are difficult to control for in RP studies. Especially the effect of residence-moving behavior, which is expected to cause an overestimation of VOCT if it is not taken into account (see Van Ommeren et al., 1997, p. 408).

Rouwendal and Meijer (2001) use Dutch SP data to estimate the trade-off between money and commuting time in both the housing market and the labor market. Their motivation for an SP approach is that choices in the labor and housing markets may have been dictated more by restrictions imposed in these markets than by individual preferences (Rouwendal and Meijer, 2001, p. 480). If these markets are out of equilib-

rium, it will be difficult to model economic behavior consistently and instead an SP experiment where all other effects are being held constant is an attractive alternative approach to estimating underlying preferences. The main drawback of SP data however, is its hypothetical nature and the prominent risk of hypothetical bias.

The rest of the paper is organized as follows. In section 2, a brief literature review of papers that estimate the trade-off between wage and commuting time is given. Subsequently, in section 3, the SP survey and the data are described. In section 4, the empirical models are presented. Section 5 consists of descriptive statistics and empirical results, followed by sensitivity analyses. Finally, a concluding discussion is presented in section 6.

2 Estimating the trade-off between wage and commuting time

By assuming that commuting time is a negative job attribute, the theory of compensating wage differentials, also known as equalizing differences [1], can be applied to estimate the value of commuting time (VOCT). According to this theory, a particular job is characterized by a number of attributes, some of which are propitious from the workers' aspect whereas others are not. In equilibrium, where workers are assumed to be homogeneous, negative working conditions must offer higher wages to compensate the workers, whereas jobs with positive working attributes will offer lower wages, ceteris paribus. In other words the assumption that commuting time is a negative job attribute means that workers require a higher wage to compensate for longer commuting time.

There are several previous studies of the labor market where VOCT is derived from the trade-off between wage and commuting time. Most relevant for our study is Rouwendal and Meijer (2001), to our knowledge the only study of this kind that is based on SP data. In the stated choice experiments of Rouwendal and Meijer (2001), commuting time is traded against both wage and housing attributes and analyzed by mixed logit models. Their empirical results suggest that a reduction in commuting time by one minute per trip would be worth almost 30 Dutch guilders (approximately 13.5 EUR) per month. Compared to the wage rate, this implies the somewhat high VOCT of 20 EUR per hour assuming 20 working days, thus 40 working trips per month.

Van Ommeren et al. (2002) formulate a bivariate duration model for two-earner households including a mutual dependence of job mobility choice of the workers within a household. In the empirical application based on RP data, the most important finding is that the marginal willingness to pay for reduced commuting time is greater for two-earner households than for single-earner households. This result is consistent with the theory claiming that single-earner households are more flexible in choice situations in the housing market. Also, in Van Ommeren et al. (2002), the marginal willingness to pay for a reduction in commuting time is estimated to about 87 percent of the net wage rate.

[1] See Rosen (1986) for an overview of this theory.

Stutzer and Frey (2008), on the other hand, use German individual-level data to conclude that workers with longer commuting time tend to report lower subjective well-being. This finding is interpreted as a commuting paradox signifying that the commuting time is a disutility that is not compensated by other job attributes in the labor market. However, the analysis of Stutzer and Frey (2008) is based on a static framework, which assumes that the labor market is in equilibrium. This is a strong assumption that may affect the results considerably.

Another approach to estimating compensating wage differentials for commuting time is derived from duration analysis and has, to our knowledge, been performed in three applications; Van Ommeren et al. (2000), Van Ommeren and Fosgerau (2009) and Isacsson and Swärdh (2009). This framework is based on the result of Gronberg and Reed (1994), wherein the authors show that conventional hedonic wage regressions lead to biased estimates of job attribute compensations when the labor market is not in equilibrium. Instead, Gronberg and Reed (1994) develop an on-the-job search model where the duration of a job spell is determined by a vector of job attributes so that the marginal willingness to pay for a certain job attribute is given by the ratio of the parameter for this certain job attribute and the parameter of the wage.

Van Ommeren et al. (2000) apply this model to a sample that consists of 370 observations from a household survey in the Netherlands. Only males who worked on average more than 20 hours per week are included in the estimated model. Their result suggests that the marginal willingness to pay is about 0.40 Dutch guilders per commuting kilometer, which corresponds to approximately 3 EUR per commuting hour or about one-third of the pre-tax wage rate.

Isacsson and Swärdh (2009) perform a similar analysis on a sample of more than 100 000 observations taken from register data of the Swedish labor market. In contrast to Van Ommeren et al. (2000) where the commuting time is zero for about 40 percent of the sample, the commuting time in Isacsson and Swärdh (2009) is observed in more detail by using imputed travel times between the center points of small geographical homogeneous areas. Additionally in this application, only men are used, based on the argument that working time, which is not observable in data, is sufficiently homogeneous among men but is not among women. Furthermore, the estimated result of the model that mimics Van Ommeren et al. (2000) shows an average VOCT that is about 155 Swedish Crowns (SEK [2]) or about 1.8 times the *net* hourly wage rate.

In a recent study, Van Ommeren and Fosgerau (2009) in a similar approach use an on-the-job searching indicator and a job moving indicator as the dependent variable. Their estimated VOCTs are fairly high and about 17 EUR per hour on average, which is a VOCT that coincides with the estimates found in Isacsson and Swärdh (2009).

An SP study such as this one contributes to the literature since all attributes that are not included in the scenarios are assumed to be constant across the alternatives.

[2] 1 Euro is approximately equal to 10 SEK.

Hence, an SP study controls for all other effects that are influencing commuting choices. Still, as far as we are aware the only SP study, where the trade-off between wage and commuting time is analyzed, results in a VOCT that is high compared to most other studies (Rouwendal and Meijer, 2001). A source for the high VOCT in Rouwendal and Meijer (2001) may be that commuting time is valued higher than other private travel time. Compared to other travel purposes, commuting time might imply a larger disutility due to congestion and other bad travel conditions (see e.g. Wardman, 1998; Shires and De Jong, 2006).

3 Data

The data is taken from a postal questionnaire survey sent to 6000 randomly selected households in the Stockholm region of Sweden. The criteria for a household to be eligible were that; it would consist of a married couple of one woman and one man, each of the spouses had to be either employed or a student, one of the spouses would be between 25 and 50 years old, and in total 4000 spouses would have at least one child while the other spouses would have no children.

The questionnaire was sent out in April and May 2005. The total number of returned questionnaires was 2433, which implies a response rate of about 41 percent. Two reminders were sent out and a copy of the questionnaire was attached to the second reminder. Furthermore, no compensation was paid to the respondents.

The questionnaire was designed to study behavior, attitudes, and interactions between household members in their choice of transport journeys and modes. Since these interactions are difficult to study and generalize when data consists of answers from only one household member, this study questioned both spouses in the households. The questionnaire consisted of three different parts, where the first part collected background characteristics of the household. The second and third parts consisted of two separate but similar questionnaires, one of which was directed at the male spouse and the other at the female spouse. In the instructions, it was also stated that these second and third parts of the questionnaire should be answered individually by the man and the woman, respectively. In total, the questionnaire consisted of about 200 questions per household, which implies a somewhat heavy and time consuming exercise that may have affected the response rate negatively. However, the priority in the survey process was to increase the number of total respondents, which was why no drop-out analysis was carried out.

The motivation for sending the questionnaires only to households in the Stockholm region was that a sufficiently large number of the respondents would have access to public transport and consequently they would have a realistic choice between different transport modes. Stockholm is the largest urban area in Sweden with a population of approximately two million, most of whom have access to public transports.

A report including analysis of this survey can be found in Swedish (Transek, 2006).

In the survey, two stated choice experiments of the trade-off between wage and com-

muting time were included. In this study, these choice experiments are used for a more fundamental empirical analysis.

3.1 Stated choice experiments

In the first stated choice experiment, the respondents were given the hypothetical scenario that their workplace would be moved to a location that would imply a longer commuting time and that this disutility would be compensated by a higher monthly *net* wage. All other characteristics, including commuting cost, commuting mode, other work characteristics, and housing characteristics, were assumed to remain unchanged. [3] Two levels of each attribute were used in all possible combinations and always compared to the respondents' present situation. These levels were 10 minutes and 25 minutes per one-way commuting trip and 500 SEK [4] and 1000 SEK in net wage per month. Hence, this design implied four choice situations where two alternatives were available in each situation. Since the present situation in all cases was compared to an alternative where both commuting time and wage are increased, these scenarios measure the willingness to accept (WTA) commuting time. Furthermore, to calculate a commuting time measure that is comparable with the monthly wage, the usual number of working days per week stated by the respondents themselves is used. In addition, 4.33 weeks per month implies that a respondent who states five working days per week is assumed to have 43.3 working trips per month. [5]

In the second stated choice experiment, the respondents were given choice scenarios where four attributes in each alternative were changed compared to the present situation. These attributes were; own commuting time, own wage, the spouse's commuting time, and the spouse's wage. In these scenarios, both their own workplace and that of their spouse, were assumed to be relocated, which influences these four attributes but no other work characteristics. Note, however, that there is still an individual choice to accept or reject the offer.

The levels used in the second choice experiment were also 10 and 25 minutes with regard to the commuting time and 500 and 1000 SEK with regard to the monthly net wage. These attributes and levels were combined into nine different offers that were divided into two different questionnaire versions. Thus one of the questionnaire versions consisted of five choice situations while the other version consisted of four choice situations. Within a household, the man and the woman received different versions of

[3] That the commuting cost is unchanged when the commuting time is increased is realistic for public transport commuters who pay a fixed fee for a season ticket, but probably not realistic for car commuters. In subsection 5.3, the result is analyzed when the sample is split with respect to car commuters and non-car commuters, which is one way to check the sensitiveness of this assumption.

[4] 1 Euro is approximately equal to 10 SEK.

[5] As an example, the offer where commuting time is increased by 10 minutes implies in the case of five stated working days per week, a monthly commuting time increase of 433 minutes, i.e. 7 hours and 13 minutes. In the offer where this level of commuting time increase is combined with 500 SEK higher net wage, the VOCT offer is approximately 69.28 SEK per hour.

the second choice experiment. The procedure to calculate the monthly commuting time is the same as in the first choice experiment, which is described above.

The questionnaires included many questions and to answer these appropriately might have been a relatively heavy and time consuming exercise. This is a probable cause of the relatively low response rate but may also affect the quality of the completed answers. Fatigue effects during the completion process might lead to an "easy way out", which can be indicated for instance by some respondents always choosing the present situation or always choosing the alternative situation. However, we do not know if these respondents take the "easy way out" or actually make trade-offs between the wage and the commuting time. How to deal with these type of answers in the analysis is therefore not clear, although a straightforward way is to check the sensitiveness of excluding these respondents. This is done in the subsection 5.3, which deals with sensitivity analysis.

If the results are to be credible it is important that the scenarios seem realistic to the respondents. Since the choice experiments used in this study assume a relocation of the workplace, both spouses have to be employed to be included in the estimated models.

There was also an alternative labeled "equivalent" in both choice experiments. All observations where the respondent chose the equivalent option were excluded from the estimation samples.

The wording of these two stated choice experiments taken from one of the questionnaire versions, is given in the Appendix.

4 Empirical approach

The stated choice experiments of the trade-off between commuting time and wage, are analyzed within a random utility (RU) framework (McFadden, 1974). In the RU model, the individual is assumed to choose the alternative that gives her the highest utility, where the utility consists of a deterministic part and a stochastic part that is unobserved by the analyst. The utility of alternative k for individual i in choice situation t is formulated as

$$U_{ikt} = \mathbf{x}'_{ikt}\beta + \epsilon_{ikt}, \tag{1}$$

where $\mathbf{x}'_{ikt}\beta$ is the deterministic part and ϵ_{ikt} is the stochastic part. In this study, there are always two alternatives per choice situation, which means that $k = 1, 2$. The traditional way to estimate an RU model would therefore be a bivariate discrete choice model as logit or probit. However, in recent years, the mixed logit model[6] is most frequently used to estimate RU models (see e.g. Algers et al., 1998; Hensher and Greene, 2003; Hess et al., 2005). The first study that proposed this kind of model in transportation analysis was Ben-Akiva et al. (1993), while Revelt and Train (1998) extended the mixed logit model to take repeated choices from the same individual into

[6] Other terms for this type of model are random parameters logit or error components logit.

account. Contrary to the logit model, the parameter vector in mixed logit is individual-specific and the utility of model (1) is then reformulated as

$$U_{ikt} = \mathbf{x}'_{ikt}\beta_i + \epsilon_{ikt}. \tag{2}$$

The more flexible mixed logit model has several advantages over a conventional logit model. First, independence of irrelevant alternatives (IIA) does not have to be assumed, which is a restrictive assumption for the logit model. Furthermore, mixed logit models are more efficiently and accurately estimated on panel data since a mixed logit does not assume independence of choices within a panel. Finally, the individual-specific parameters imply that more heterogeneity is explained in the model. A drawback of mixed logit is that the integral that determines the unconditional probability cannot be calculated analytically, therefore the probability is approximated through simulation and the simulated log-likelihood function is maximized (Revelt and Train, 1998).

In the first choice experiment, individual i chooses between the present situation and a workplace relocation that would imply higher wage and longer commuting time. Hence, the only attributes in the model are wage, w; commuting time, τ; and an indicator variable for the reference alternative, i.e. the present situation, *ref*. The utility function can then be formulated as

$$U_{ikt} = \beta_i^{ref} ref_k + \beta_i^w w_{ikt} + \beta_i^\tau \tau_{ikt} + \epsilon_{ikt}. \tag{3}$$

In model (3), β_i^{ref} is capturing the inertia effect of the individuals' willingness to change from the present situation, β_i^w is the marginal utility of wage, and β_i^τ is the marginal utility of commuting time, where all of these parameters are individual-specific. Since wage is assumed to be a positive job attribute while commuting time is assumed to be a negative job attribute, β_i^w and β_i^τ are expected to be positive and negative, respectively. Therefore, the distributions of the wage parameter and the commuting time parameter are both assumed to be lognormally distributed. This means that the marginal utility of wage and commuting time is restricted to having its expected sign for all individuals. The inertia parameter is assumed to be normally distributed and can therefore take a positive or a negative value. Note also that economic theory suggests no inertia term, whereas most applications of VTT have found a positive inertia term (e.g. Algers et al., 1995; Hensher and Greene, 2003).

Meijer and Rouwendal (2006) recommend reporting the median of a lognormal distribution, since the mean may be inflated due to the heavily skewed characteristic of the lognormal distribution. Let β^w, and β^τ denote the estimated coefficients of the respective distribution, then the median of the underlying distribution and also what is interpreted as the estimated marginal utility of the corresponding variable is given by $\exp(\beta^w)$ and $\exp(\beta^\tau)$. The ratio of two lognormally distributed variables is also lognormally distributed and the median VOCT, defined as the marginal rate of substitution between wage and commuting time, is estimated according to

$$VOCT \equiv mrs_{w,\tau} = -\frac{\partial U}{\partial \tau} \Big/ \frac{\partial U}{\partial w} = \frac{\exp(\beta^{\tau})}{\exp(\beta^{w})} = \exp(\beta^{\tau} - \beta^{w}). \tag{4}$$

Note that the definition of VOCT in equation (4) is not based on a simulation approach to estimate the VOCT. According to Hensher and Greene (2003, p. 163), a simulation approach is preferred when valuation estimates are derived. However, the main objective of this study is not to establish VOCT for policy use, but to examine gender differences of VOCT. Also, generating random draws of β^{τ} and β^{w} for each observation and then calculating the VOCT for each individual, leads to a very similar result of the median VOCT, which holds for all estimated models.

An alternative approach would be to follow for example Fosgerau (2006) and estimate the model directly on the VOCT offer. If the main purpose is to estimate the willingness to accept commuting time, the model is preferably formulated directly in terms of willingness to accept. This means that the marginal utilities of commuting time and wage are not observable, instead the utility function in equation (2) can be written as

$$U_{ikt} = \beta^{ref} ref_k + \beta_i^{V} V_{ikt} + \epsilon_{ikt}, \tag{5}$$

where $V_{ikt} = \textit{VOCT-offer}_{ikt} = w_{ikt}/\tau_{ikt}$. Also in this model, a lognormal distribution is assumed for β_i^{V} since it is assumed to be strictly positive. The expected positive sign follows, since V is a WTA offer and the higher the compensation for increased commuting time, the higher the expected probability of accepting the offer. The VOCT of model (5) is derived as

$$VOCT = \frac{\beta^{ref}}{\exp(\beta^{V})}. \tag{6}$$

To analyze the second choice experiment where both spouses' commuting time and wage are affected, the individual wage and commuting time in the models above are at first replaced by the household values of these variables. The models will now be given as

$$U_{ikt} = \beta_i^{ref} ref_k + \beta_i^{w}(w_{ikt} + w_{jkt}) + \beta_i^{\tau}(\tau_{ikt} + \tau_{jkt}) + \epsilon_{ikt}, \tag{7}$$

and

$$U_{ikt} = \beta^{ref} ref_k + \beta_i^{V}(V_{ikt} + V_{jkt}) + \epsilon_{ikt}, \tag{8}$$

where j denotes i's spouse. In these cases, the estimated VOCT will be measuring a household effect and not an individual effect. Note, however, that this household-level VOCT will still be derived from individual i's utility function and preferences. Consequently, all stated choices are made at the individual level, although the wage and commuting time of the spouse are included as attributes in the choice sets. Also,

note that the VOCT derived from model (8) has to be divided by two since there is the sum of two VOCT offers included in the offer variable

$$VOCT^h = \frac{1}{2}\frac{\beta^{ref}}{\exp(\beta^V)}, \tag{9}$$

where h denotes the household level.

Finally, models are estimated with separate variables for the spouses, based on the second choice experiment. This alteration implies the opportunity to estimate the different preferences of men and women with respect to both their own VOCT and their spouse's VOCT. In these cases the utility functions will be formulated as

$$U_{ikt} = \beta_i^{ref} ref_k + \beta_i^{w,i} w_{ikt} + \beta_i^{w,j} w_{jkt} + \beta_i^{\tau,i} \tau_{ikt} + \beta_i^{\tau,j} \tau_{jkt} + \epsilon_{ikt}, \tag{10}$$

and

$$U_{ikt} = \beta^{ref} ref_k + \beta_i^{V,i} V_{ikt} + \beta_i^{V,j} V_{jkt} + \epsilon_{ikt}. \tag{11}$$

Here the median estimated VOCT for the individuals themselves based on model (10) is given by

$$VOCT^i = \exp(\beta^{\tau,i} - \beta^{w,i}), \tag{12}$$

and the median estimated VOCT for the spouse by

$$VOCT^j = \exp(\beta^{\tau,j} - \beta^{w,j}). \tag{13}$$

Based on model (11) and using the same argumentation as for model (8) [7], estimated VOCT for the individuals themselves is given by

$$VOCT^i = \frac{1}{2}\frac{\beta^{ref}}{\exp(\beta^{V,i})}, \tag{14}$$

and the estimated VOCT for the spouse by

$$VOCT^j = \frac{1}{2}\frac{\beta^{ref}}{\exp(\beta^{V,j})}. \tag{15}$$

[7] The difference between model (8) and model (11) is that in the former the parameters of own offer and spouse's offer are restricted to be equal. Hence, to be comparable the VOCTs of model (11) have also to be divided by two.

The second choice experiment is primarily designed to analyze gender differences and not policy values of commuting time per se. However, there will be no opportunity to compare the marginal utilities between their own attributes and the attributes of their spouse in the second choice experiment when the model is formulated directly in terms of willingness to accept, as in model (11). On the other hand, for model (10) where the marginal utility of wage and the marginal utility of commuting time are estimated separately, tests of the following hypotheses are accomplished

$$\beta^{\tau,i} = \beta^{\tau,j}, \tag{16}$$

$$\beta^{w,i} = \beta^{w,j}, \tag{17}$$

i.e. if the individual experiences a difference between marginal utility of their own attributes and marginal utility of their spouse's attributes.

All models presented up to this point will be estimated in this study. In addition, as sensitivity analyses, different sample segmentations will be used for the models. These sensitivity analyses are described in subsection 5.3. Furthermore, the models are estimated in Stata by the mixlogit command (Hole, 2007). The bias of simulating the maximum likelihood is decreasing in the number of repetitions, therefore 500 Halton draws are used as recommended by Revelt and Train (1998). In Hensher and Greene (2003), the results are also found to be stabilized after about 500 Halton draws.

5 Results

5.1 Descriptive statistics

In Table 1, descriptive statistics of variables that are relevant for this study are presented. For the household-specific variables, the average number of children per household is about 1.6, while 54 percent of the households have at least one child aged 0-11. Furthermore, about 80 percent of the households claim to have a completely shared household economy.

Since the main objective of this study is to examine gender differences, descriptive statistics of variables that are individual-specific are presented separately for men and women.

The average age is about three years higher for men than for women, while the education level is on average slightly higher for women than for men. Furthermore, the wage class variables show that men on average belong to a higher monthly pre-tax wage class than women. Women are most frequent in the wage classes between 15 000 and 25 000 SEK per month, while men are most frequent in the wage classes between 20 000 and 40 000 SEK per month. Note also that about 12 percent of the men have a monthly pre-tax

Table 1
Descriptive statistics

Variable	**Household**	**Men**	**Women**
Number of children	1.608		
	(1.025)		
Children aged 0-11	0.543		
Shared household economy	0.801		
Age		43.20	40.24
		(8.582)	(7.062)
Education - compulsory school		0.107	0.074
Education - high school		0.316	0.303
Education - university		0.536	0.594
Monthly pre-tax wage < 7500		0.024	0.078
Monthly pre-tax wage 7500 - 15 000		0.050	0.118
Monthly pre-tax wage 15 000 - 20 000		0.102	0.198
Monthly pre-tax wage 20 000 - 25 000		0.206	0.229
Monthly pre-tax wage 25 000 - 30 000		0.166	0.162
Monthly pre-tax wage 30 000 - 40 000		0.206	0.129
Monthly pre-tax wage 40 000 - 50 000		0.102	0.038
Monthly pre-tax wage $>$ 50 000		0.119	0.026
Commuting time < 20		0.276	0.287
Commuting time $20 - 40$		0.424	0.394
Commuting time > 40		0.300	0.319
Mode - public transport		0.213	0.287
Mode - car driver		0.443	0.250
Mode - car passenger		0.010	0.022
Mode - car and public transport		0.018	0.017
Mode - motorcycle		0.005	0.002
Mode - bicycle		0.046	0.054
Mode - walking		0.028	0.064
Mode - home working		0.012	0.008
Accept offer - CE 1		0.270	0.280
Accept offer - CE 2		0.235	0.229
No of observations	2296	2296	2296

Note: The figures are mean values and in parenthesis standard deviations. Standard deviations of indicator variables are not shown since they are determined by the mean according to $\sqrt{\mu(1-\mu)}$, where μ is the mean. The figures of the income class variables are given in SEK. The figures of the commuting time class variables are minutes per working trip and based on a weighted average between both travels to work and travels from work based on public transport users and car users. Missing values are the reason that the sum of the means of the class variables in some cases do not add up to one.

wage of more than 50 000 SEK whereas only 2.6 percent of the women achieve this highest wage class.

Regarding commuting time, there does not seem to be a difference between men and women, which is a bit surprising since on average, men usually commute further than women in two-earner households. Nevertheless, the answer to this puzzle may be found in the data of travel mode for the commuting trip. Car driving is far more frequent among men than among women. Women, on the other hand, more frequently use public transport. Hence, the reason may be that women travel a shorter distance but use, on

average, more time consuming modes, which will result in similar commuting times across the genders. Another possible explanation is that more men than women have very long commuting times which is not observed in this data because all commuting times that are longer than 40 minutes per trip are brought together into the same class.

Finally, the offers of the first experiment are accepted in 27 percent of the choices by the men and in 28 percent of the choices by the women. In the second choice experiment, the corresponding figures are 24 percent for the men and 23 percent for the women. A lower acceptance rate in the second choice experiment is expected since it should be more difficult for a two-earner household to adjust to a new situation that implies increased commuting time for both spouses.

5.2 Estimated models

In Table 2, the results of the estimated models for the first choice experiment are presented. Keep in mind that this choice experiment means choices that only regard own commuting time and own wage. For the lognormally distributed variables, i.e. wage, commuting time, and VOCT offer, the presented coefficients are the medians of the distributions according to the recommendation of Meijer and Rouwendal (2006). Also, the variables of wage and commuting time are divided by 100 in all estimated models, which lead to a scale of the coefficients that is easy to interpret.

The estimated results of model (3) are found in columns 2 and 3 of Table 2. The commuting time and wage coefficients are highly significant for both men and women. Furthermore, the reference alternative coefficient is significantly positive, although only at the ten percent level for women, which indicates inertia effects in these cases. The VOCT based on the median values of the distributions of the commuting time and wage coefficients is estimated to about 93 SEK per hour for men and about 97 SEK per hour for women. These estimates of VOCT are not significantly different from each other.

Regarding the distribution of the estimated parameters, both commuting time and the reference alternative are significantly different from a fixed parameter specification, whereas wage is not. Also, a chi-square test of the model fit compared to a conditional logit model is highly significant in favor of the mixed logit specification[8]. This last finding also holds for all forthcoming models and will not be specifically indicated hereafter.

In columns 4 and 5 of Table 2, the estimated results of model (5) are given, i.e. the model where the VOCT offer appears directly as one explanatory variable. The coefficient of VOCT offer is strongly significant and also varies significantly across the individuals. Estimated VOCT are found to be 118 SEK per hour for men and 115 SEK per hour for women. These estimates are significantly higher than the estimates of model (3).

Presented in Table 3 are the estimated results of models (7) and (8), i.e. where com-

[8] These tests are not presented in the tables.

Table 2
Estimates of own VOCT

Variable	**Model 3**		**Model 5**	
	Men	**Women**	**Men**	**Women**
Median/Mean				
Wage	0.501**	0.561**		
	(0.027)	(0.029)		
Commuting time	-0.774**	-0.910**		
	(0.047)	(0.066)		
VOCT offer			2.81**	3.16**
			(0.119)	(0.124)
Reference alternative	0.671**	0.441†	5.54**	6.05**
	(0.196)	(0.262)	(0.186)	(0.193)
Standard deviation				
Wage	<0.001	0.018		
	(0.005)	(0.018)		
Commuting time	0.333**	0.343**		
	(0.043)	(0.066)		
VOCT offer			2.31**	2.34**
			(0.152)	(0.141)
Reference alternative	2.09**	2.20**		
	(0.141)	(0.168)		
VOCT - SEK per hour	92.7	97.3	118	115
	(4.13)	(5.34)	(2.31)	(2.06)
No of observations	6671	6799	6671	6799
Simulated log-likelihood	-2634	-2618	-2645	-2642

Note: Standard errors are given in parenthesis. For the coefficients, **, * and † denote significance at the one five and ten percent level respectively. The parameters of wage, commuting time, and VOCT offer are lognormally distributed whereas the parameter of the reference alternative is normally distributed. The coefficients of the lognormally distributed variables are the medians and the coefficient of the normal distributed variable is the mean. VOCT is calculated according to $\exp(\beta^{\tau} - \beta^{w}) \times 60$ and $(\beta^{ref}/\exp(\beta^{V})) \times 60$, respectively and their standard errors according to the delta method. The variables of commuting time and wage are divided by 100 before the estimation.

muting time and wage variables are given at the household level. Here, the variables are defined at the household level so the estimated effects are restricted so as to be equal for both spouses.

First of all, the result shows no significant difference across the genders, which holds for both of the model formulations. Furthermore, for the model with separate wage and commuting time variables, the result is higher VOCT on the household level compared to the results of the models based on own commuting time and wage, although only at the ten percent significance level for women. For the model estimated directly on the offer, there is no significant difference between the household-level model and the individual-level model.

In particular, the estimated household-level VOCT is 137 SEK per hour for men and 125 SEK per hour for women in model (7) and 118 SEK per hour for men and 111 SEK per hour for women in model (8). The result of the model with separate attributes might

Table 3
Estimates of household VOCT

Variable	**Model 7**		**Model 8**	
	Men	**Women**	**Men**	**Women**
Median/Mean				
Wage	0.271**	0.314**		
	(0.029)	(0.023)		
Commuting time	-0.621**	-0.655**		
	(0.044)	(0.032)		
VOCT offer			1.84**	1.99**
			(0.105)	(0.090)
Reference alternative	-0.952*	-1.31**	7.20**	7.34**
	(0.428)	(0.366)	(0.318)	(0.265)
Standard deviation				
Wage	0.173**	0.003		
	(0.020)	(0.007)		
Commuting time	0.185**	0.216**		
	(0.044)	(0.024)		
VOCT offer			1.12**	0.951**
			(0.064)	(0.047)
Reference alternative	1.42**	1.86**		
	(0.259)	(0.166)		
VOCT - SEK per hour	137	125	118	111
	(13.7)	(9.11)	(2.37)	(1.76)
No of observations	6456	7390	6456	7390
Simulated log-likelihood	-2498	-2811	-2711	-3083

Note: Standard errors are given in parenthesis. For the coefficients, **, * and † denote significance at the one five and ten percent level respectively. The parameters of wage, commuting time, and VOCT offer are lognormally distributed whereas the parameter of the reference alternative is normally distributed. The coefficients of the lognormally distributed variables are the medians and the coefficient of the normal distributed variable is the mean. VOCT is calculated according to $\exp(\beta^{\tau} - \beta^{w}) \times 60$ and $(\beta^{ref}/\exp(\beta^{V})) \times 60/2$, respectively and their standard errors according to the delta method. The variables of commuting time and wage are divided by 100 before the estimation.

be viewed as support for the result of Van Ommeren et al. (2002), where two-earner households are found to have a higher VOCT than single-earner households. Still, the choices that influence only own commuting time and wage are made by members of a two-earner household and therefore may not be completely comparable with choices of individuals in single-earner households. Intuitively, however, it would be easier for a two-earner household to adjust to a situation where only one of the spouses increases his/her commuting time compared to both spouses increasing their commuting time.

Interestingly, the parameter of the reference alternative in model (7) has a negative estimated mean for both men and women, which is not the expected sign of an inertia effect. However, the estimated standard deviations are large and highly significant which indicates strong heterogeneity of these parameters. The wage and commuting time coefficients have significant standard deviations in these models, except the wage coefficient for women.

Next, the results of models (10) and (11) are presented. Here, the commuting time and wage variables are treated separately with the consequence that the respondent's valuation of their own VOCT and their spouse's VOCT are allowed to be different. Keep in mind however, that this second choice experiment is not explicitly designed to derive policy values of commuting time. Instead, the focus of the analysis of the second choice experiment is more on analyzing differences across the genders.

Columns two and three of Table 4 show the estimated results of model (10), where the wage and commuting time variables appear separately. The marginal utility is significantly higher for own wage than for the spouse's wage and this result holds for both men and women. One reason for this result may be that a higher wage does not only imply a utility effect from the opportunity to increase consumption per se, but also a utility effect from the increased status of a higher wage or from greater bargaining power within the household.

More interesting, though, is that for men the marginal disutility is significantly higher for the spouse's commuting time compared to own commuting time. Women, on the other hand, do not experience significantly different marginal disutility of own commuting time and spouse's commuting time. This result means that men would rather increase their own commuting time than that of their spouse. A possible interpretation might be that on average, women within a two-earner household take more responsibility for household work as cooking, cleaning, and accompanying children to school.

Also in model (10), the inertia effect has the non-expected negative sign and most of the commuting time and wage coefficients have a significant standard deviation.

For model (11), the results of which are presented in columns 4 and 5, the distributions of the parameters of own VOCT offer and the spouse's VOCT offer are allowed to be correlated. This estimated correlation is positive and significant for both men and women, which means that if the respondent places a relatively high value on their own commuting time, the respondent will also place a high value on the commuting time of their spouse, and vice versa.

Furthermore the results show that their own VOCT is significantly higher than the spouse's VOCT for women, whereas there is no such difference for men. Hence, there is support for the interpretation that both men and women tend to experience a higher marginal disutility from the commuting time of the female spouse. However, this result is not consistent across both model formulations (10) and (11) and will therefore be further analyzed in the sensitivity analyses regarding the second choice experiment.

5.3 Sensitivity analyses

In this subsection, sensitivity analyses by splitting the sample into different subsamples, are described. None of these estimated results are presented in tables but can be provided by the authors on request. The focus here is to compare the results of the estimated VOCT regarding the first choice experiment and to compare the results of the tests of different marginal utilities regarding the second choice experiment.

Table 4
Estimates of own and the spouse's VOCT

Variable	**Model 10**		**Model 11**	
	Men	**Women**	**Men**	**Women**
Median/Mean				
Wage - own	0.304**	0.354**		
	(0.030)	(0.031)		
Wage - spouse	0.086*	0.147*		
	(0.035)	(0.059)		
Commuting time - own	-0.549**	-0.798**		
	(0.074)	(0.068)		
Commuting time - spouse	-0.681**	-0.709**		
	(0.054)	(0.062)		
VOCT offer - own			1.79**	1.92**
			(0.109)	(0.097)
VOCT offer - spouse			1.88**	2.17**
			(0.118)	(0.101)
Reference alternative	-1.81**	-2.79**	7.20**	7.54**
	(0.636)	(0.484)	(0.318)	(0.274)
Standard deviation				
Wage - own	0.003	0.006		
	(0.050)	(0.011)		
Wage - spouse	0.550**	0.433**		
	(0.195)	(0.119)		
Commuting time - own	0.100	0.312**		
	(0.154)	(0.078)		
Commuting time - spouse	0.225**	0.389**		
	(0.056)	(0.113)		
VOCT offer - own			1.17**	1.52**
			(0.108)	(0.126)
VOCT offer - spouse			0.054	0.003
			(0.113)	(0.008)
Correlation VOCT offers			0.485**	0.220**
			(0.035)	(0.033)
Reference alternative	2.06**	0.350		
	(0.262)	(0.530)		
VOCT - own	108	135	121	118
	(15.0)	(11.8)	(3.83)	(3.39)
VOCT - spouse	473	289	115	105
	(199)	(114)	(3.37)	(1.91)
Eq. MU of wage	<0.001	<0.001		
Eq. MU of com. time	0.034	0.350		
No of observations	6456	7390	6456	7390
Simulated log-likelihood	-2493	-2779	-2768	-3060

Note: Standard errors are given in parenthesis. For the coefficients, **, * and † denote significance at the one five and ten percent level respectively. The parameters of wage, commuting time, and VOCT offer are lognormally distributed whereas the parameter of the reference alternative is normally distributed. The coefficients of the lognormally distributed variables are the medians and the coefficient of the normal distributed variable is the mean. VOCT is calculated according to $\exp(\beta^{\tau} - \beta^{w}) \times 60$ and $(\beta^{ref}/\exp(\beta^{V})) \times 60/2$, respectively and their standard errors according to the delta method. The variables of commuting time and wage are divided by 100 before the estimation.

The first choice experiment is sensitivity analyzed with respect to "yes" and "no" respondents and travel mode. Respondents that always accept or always reject the offer might be a problem in stated choice experiments. One problem is that we do not know whether these respondents are actually making trade-offs with respect to the attributes or answer in the same way to all scenarios due to other reasons, such as fatigue, or to protest against the scenarios. In the first choice experiment, 33 percent of the men and 31 percent of the women are "yes" or "no" respondents and of these, 87 percent of the men and 88 percent of the women always choose the present situation, i.e. always reject the offer of a higher wage as a compensation for longer commuting time.

How to deal with individuals that always accept or reject the offer in the analysis, varies in the literature. Furthermore, in this study the offer vector is relatively narrow which means that some respondents might have a VOCT that is lower than the lowest VOCT offer or higher than the highest VOCT offer. Nevertheless, models that exclude these respondents are estimated. The results show that the VOCT is lower for both men and women compared to the model where these individuals are included. This result follows, since a large majority of the excluded respondents choose the present situation.

The first choice experiment is also analyzed separately for car commuters and non-car commuters. The reason is that the assumption of the same monetary commuting cost when the commuting time increases, seems unrealistic for car commuters. However, the estimated results for both men and women shows no difference in VOCT for car commuters and non-car commuters.

The second choice experiment is sensitivity analyzed with respect to "yes" and "no" respondents, shared household economy, young children, income, female spouses in full-time work, the number of Halton draws used for the maximum simulated likelihood, and correlation structure.

Here also the sensitivity of excluding "yes" and "no" respondents is analyzed. In the second choice experiment 22 percent of the men and 18 percent of the women belong to this group and of these, 84 percent of the men and 86 percent of the women always choose the present situation. Thus a lower portion are "yes" or "no" respondents in the second choice experiment than in the first choice experiment. The only difference in this estimated model compared to the one presented in table 4 is that men experience no significant difference between own commuting time and the spouse's commuting time.

Another sensitivity analysis is to include only spouses who claim to have a shared household economy. This exercise is undertaken with the objective of exploring whether spouses with separated household economy have caused the gap between marginal utility of own wage and marginal utility of the spouse's wage. For women, this sample restriction has only negligible effects of the results and the marginal utility is still higher for own wage compared to the spouse's wage. For men, however, the expected result occurs and there is no longer a significant difference between the marginal utility of own wage and the marginal utility of the spouse's wage.

Next, the sample is split with respect to young children in the household. When the

sample consists of spouses with at least one child that is younger than twelve years old, men do not experience a higher marginal disutility of the spouse's commuting time than for own commuting time. On the other hand, when the estimated sample is spouses without children aged between zero and eleven, the result for men is similar to the model with young children. Hence, the effect that men experience a higher marginal disutility of the spouse's commuting time does not seem to be driven by young children in the household. For women, however, there is a significantly higher marginal utility of own commuting time compared to the marginal utility of the spouse's commuting time when there are no young children in the household, whereas this difference is nonsignificant for the women with young children.

Usually, VOCT is found to be positively related to income. To test this, the sample is split into four subsamples which are defined as all combinations between low-wage and high-wage men and low-wage and high-wage women. High wage is defined as individuals who have a pre-tax wage of at least 25 000 SEK per month. The most striking result here is that in the group of low-wage men and low-wage women, both men and women experience a higher marginal disutility of the commuting time of the female spouse compared to the marginal disutility of the commuting time of the male spouse.

Whether the female spouse works full-time or part-time might influence the tests of equal marginal (dis)utilities of wage and commuting time. However, the difference is negligible and men still experience a higher marginal disutility of the spouse's commuting time compared to the marginal disutility of own commuting time, whereas there is no such significant difference for women.

Finally, the sensitivity with respect to two different mixed logit model specifications is checked. First, the results when 2000 Halton draws instead of 500 Halton draws are used for the maximum simulated likelihood are only slightly changed. In fact, the estimated VOCT changes by only a few SEK per hour. Including a correlation structure of the parameter distributions in model (10) is also tested, which unfortunately has difficulties in converging. In fact when the model converges for women, there is strong correlation between most of the attribute coefficients. The correlation between the coefficients of own wage and the spouse's wage as well as the correlation between the coefficients of own commuting time and the spouse's commuting time are positive, which seems plausible. However, the results of the tests of equal marginal (dis)utilities are not changed when a correlation structure is included in the model.

6 Concluding discussion

In this paper, the objective was to estimate the value of commuting time (VOCT) based on stated choice experiments where the respondents receive offers comprising of a longer commuting time and a higher wage as compared to their present situation. Two choice experiments were given to all respondents; one where own commuting time and own wage were attributes, and another where own commuting time, own wage, the spouse's commuting time and the spouse's wage were attributes. Mixed logit models were estimated, both in a model formulation with separate wage and commuting time

variables and in another model formulation with the VOCT offers directly as explanatory variables. The results show that mixed logit models are significantly better than conventional logit models in all model specifications.

The results of the first choice experiment show that, in general, the estimated VOCT is plausible with a tendency towards high values compared to most other studies of VTT. In particular, Small (1992) argues that a reasonable estimate of the average VTT is around 50 percent of the gross hourly wage rate. Small (1992) also claims that the average value varies across different studies within a range of 20 and 100 percent of the gross hourly wage rate.

To calculate an approximate VOCT share of the wage rate in this paper, assume that the average monthly pre-tax wage for the men in this sample is 28 500 SEK. As given by the income class variables in Table 1, a monthly pre-tax income of 25 000 SEK corresponds to the 38th percentile while 30 000 SEK corresponds to the 55th percentile, therefore this is a reasonable assumption. By further assuming an average of 181 working hours per month derived from the average of the self-reported working hours per week multiplied by 4.33, the average pre-tax hourly wage rate for men in this sample is approximately 157 SEK. Estimated VOCT for men based on the first choice experiment, i.e. from scenarios that affect only own commuting time and wage, is found to be between 93 and 118 SEK. In other words, this means a share of 59 - 75 percent of the gross wage rate. [9]

Which characteristics of this study would have important influence on the estimated VOCT and in what direction are the VOCT estimates expected to be influenced? One characteristic is that VOCT in this study is measured in the willingness to accept (WTA) context. There is strong evidence in the literature of non-market goods valuation that WTA values exceed willingness to pay (WTP) values (see e.g. Horowitz and McConell, 2002). This pattern is also found in most value of time studies (e.g. Algers et al., 1995; De Borger and Fosgerau, 2008; Hultkrantz and Mortazavi, 2001).

Another characteristic is the hypothetical nature, which in most studies of valuation contexts other than time, lead to a positive hypothetical bias (e.g. Cummings et al., 1995; List and Gallet, 2001; Murphy et al., 2005). However, of the small number of value of time experiments that test this issue, a negative hypothetical bias is the most frequent result (Brownstone and Small, 2005; Isacsson, 2007). Note also that the interpretation of this negative hypothetical bias are scheduling constraints. Scheduling constraints may not be that important when decisions of commuting time and wages based on workplace relocations are analyzed because these types of choices are probably made with a more distant time horizon in mind and individuals should have better opportunities to reschedule in the long-run than in the short-run. Thus the direction of any hypothetical bias is unclear although previous studies suggest a negative bias.

The SP study of Rouwendal and Meijer (2001) results in a relatively high VOCT that is equivalent to approximately 220 SEK per hour. A similarity between the present study

[9] By assuming an average monthly pre-tax wage of 22 000 and an average of 161 working hours per month, similar patterns occur for women with a VOCT share of about 71 - 84 percent of the gross wage rate.

and Rouwendal and Meijer (2001) is that the alternatives of the hypothetical choices are based on trade-offs between wage and commuting time. One source of relatively high VOCT may therefore be that the valuation is derived from choices incorporating the wage, and not the cost of travel time, which is most frequently used to estimate VOCT. In scenarios based on wage, the respondents might be well aware that the change is persistent and these new commuting times may be difficult to incorporate in their daily life. For the respondents, this understanding may not be complete if only a mode or route choice scenario of a single trip is used.

The use of a wage variable may also imply the opposite effect of decreased VOCT if the individuals' marginal utility of wage is inflated by the increased status of a higher wage. However, the marginal utility of some travel cost attributes may also be affected by sources other than pure marginal utility of income. For example, car drivers might be more willing to pay driving costs than toll costs.

Empirical results of VTT studies suggest that in-vehicle time is valued lower than walking time and waiting time (see e.g. Mackie et al., 2001; Perez et al., 2003). In this study, the commuting time for some respondents consists of a mixture of these different types of time. In the choice experiment scenarios, it is stated that the additional commuting time is assumed to be additional time in the mode that is currently used but this may still be misinterpreted by the respondents. However this effect is probably not influential in this study since the sensitivity analysis done by splitting the sample with respect to commuting mode, shows no difference in the estimated VOCT.

Finally, another characteristic is that commuting time might be valued higher than other private time, which is a result found in some meta studies of estimated VTT (see e.g. Wardman, 1998; Shires and De Jong, 2006). This interpretation is also supported by other recent studies such as Isacsson et al. (2008), Isacsson and Swärdh (2009), Van Ommeren and Fosgerau (2009), and Vredin Johansson et al. (2006). Note, however, that the result of these latter studies is relatively high VOCT compared to the VTT of other studies and that these studies do not perform intra-study comparisons between VOCT and the VTT of other private trips. Furthermore, a calculation exercise in Stutzer and Frey (2008, p. 355) suggests that complete compensation for one hour of commuting time would be equivalent to approximately 300 SEK. Thus these results together support the argument that commuting time has a higher value than other private travel time.

To summarize this particular discussion, there are several characteristics that are expected to influence the estimates of VOCT. Here, we have listed four reasons why the VOCT is expected to be relatively high and two reasons why the VOCT is expected to be relatively low in this study. Without discussing the magnitude of these effects, estimated values of commuting time that are slightly higher than the expected average of values of travel time according to Small (1992), seem adequate.

The results from the second choice experiment show that in one of the model specifications the estimated household-level VOCT is significantly higher as compared to the individual-level VOCT. This result can be interpreted as it being easier to adjust

commuting time upwards for an individual than for both individuals of a two-earner household.

When different VOCTs of the spouses are allowed, the most interesting result is that both men and women, based on individual preferences, tend to value the woman's commuting time higher than the man's commuting time. As stated earlier, the most likely explanation for this result is that women take a larger responsibility for household work in two-earner households, which is a finding that can be viewed as a confirmation of the household responsibility hypothesis (HRH). According to Turner and Niemeier (1997, p. 398-99), HRH entails that employed women tend to have greater household and child care responsibilities and, as a result, face greater time constraints and ultimately choose shorter commutes than employed men. In this study, greater time constraints for women is exactly what is found, and furthermore, this view holds from the perspective of both men and women.

Sensitivity analyses of the estimated results with respect to different subsamples show that the estimated VOCTs of the first stated choice experiment seem relatively robust. For the second choice experiment, however, there is more variation in the results. To sum up, there is still a tendency that both men and women value the commuting time of the female spouse highest, but this result is not consistent across all estimated models.

An important consideration is that the respondents answer these stated choice experiments at the individual level. This means that it is individual i's preferences based on their own utility function that are estimated in all cases. Furthermore, all estimated marginal utilities and VOCTs from the second choice experiment should be interpreted as if individual i has the right to determine both own commuting time and spouse's commuting time. As a critique against this assumption of the decision process, this is unlikely to be the case in reality where these types of choices, are most likely made at the household level. However, choices where only own commuting time and wage are attributes, as in the first choice experiment, will in reality be decisions that are probably also based on household bargaining. Hence, all previous studies of individual value of time, based on individual hypothetical choices where the individual is a part of a two-earner household, might be criticized in the same way. Also, one of the most interesting results of this study shows that men and women seem to agree that increased commuting time of the female spouse is valued higher than increased commuting time of the male spouse. Thus decisions made by bargaining at the household level will probably not lead to a different result in this aspect.

A policy suggestion from this study is that VTT recommended in cost benefit analysis (CBA) today may be too low, especially with regard to commuting time. For example, Swedish policy recommends in-vehicle VTT of 51 SEK per hour in the price level of 2006 for all private trips, including commuting trips, shorter than 100 kilometers (SIKA, 2008). By using the 2006 Swedish average monthly wage of about 25 000 SEK provided by Statistics Sweden and by assuming 171 working hours per month, this implies a VOCT to wage ratio of about 35 percent, which is in the low tail of plausible VTT-shares of the wage according to Small (1992) as well as much lower than the VOCT estimates of this study.

Finally, relying on the analyses of the second choice experiment where both spouses' commuting time and wage are included as attributes, gender-specific VOCT may imply a higher value for women than men in two-earner households. Since this type of VTT distinction with respect to gender is seldom the practice in CBA, a realization of this type will increase the benefits of public transport investment relative to the benefits of road investment given that women are more frequent users of public transport than men.

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Appendix

Here, the parts of the questionnaire that are used in this empirical analysis of this paper are reproduced freely translated from Swedish.

Choice experiment 1

In the following questions you are required to choose between alternative locations of your workplace. Assume that your employer is considering moving to another location - how would you prefer your employer to choose in the following choice scenarios?

Assume that you would still use your present mode of transport to travel to work and that access to public transport and car communications are similar to those at your present workplace.

You are to choose between two alternatives per choice scenario. Imagine that these alternatives only differ with respect to what is given in the scenarios and that they are equivalent in all other aspects.

The alternatives differ with respect to:

- Travel time - one-way trip
- Wage

Choose the alternative that you prefer and want your employer to choose.

1. Which alternative would you prefer for the location of your workplace?

Alternative 1	**Alternative 2**
Present travel time	10 minutes longer travel time than today
Present wage	1000 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

2. Which alternative would you prefer for the location of your workplace?

Alternative 1	**Alternative 2**
Present travel time	25 minutes longer travel time than today
Present wage	1000 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

3. Which alternative would you prefer for the location of your workplace?

Alternative 1	**Alternative 2**
Present travel time	10 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

4. Which alternative would you prefer for the location of your workplace?

Alternative 1	**Alternative 2**
Present travel time	25 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

Choice experiment 2

In the following questions you are required to choose between alternative locations of both your workplace and your spouse's workplace. Assume that both your employer and your spouse's employer are considering moving to another location - how would you prefer your employers to choose in the following choice scenarios?

Assume that you and your spouse would still use your present mode of transport to travel to work and that access to public transport and car communications are similar to those at your present workplaces.

You are to choose between two alternatives per choice scenario. Imagine that these alternatives only differ with respect to what is given in the scenarios and that they are equivalent in all other aspects.

The alternatives differ with respect to:

- Travel time - one-way trip
- Wage

Choose the alternative that you prefer and want your employers to choose.

1. Which alternative would you prefer for the location of your workplaces?

Alternative 1	**Alternative 2**
You	*You*
Present travel time	10 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today
Your spouse	*Your spouse*
Present travel time	10 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

2. Which alternative would you prefer for the location of your workplaces?

Alternative 1	**Alternative 2**
You	*You*
Present travel time	25 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today
Your spouse	*Your spouse*
Present travel time	10 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

3. Which alternative would you prefer for the location of your workplaces?

Alternative 1	**Alternative 2**
You	*You*
Present travel time	10 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today
Your spouse	*Your spouse*
Present travel time	25 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

4. Which alternative would you prefer for the location of your workplaces?

Alternative 1	**Alternative 2**
You	*You*
Present travel time	10 minutes longer travel time than today
Present wage	1000 SEK higher net wage per month than today
Your spouse	*Your spouse*
Present travel time	10 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

5. Which alternative would you prefer for the location of your workplaces?

Alternative 1	**Alternative 2**
You	*You*
Present travel time	25 minutes longer travel time than today
Present wage	1000 SEK higher net wage per month than today
Your spouse	*Your spouse*
Present travel time	10 minutes longer travel time than today
Present wage	500 SEK higher net wage per month than today

◯ Alternative 1 ◯ Alternative 2

◯ Equivalent alternatives

References

Algers, S., P. Bergström, M. Dahlberg, and J. Lindqvist Dillén: 1998, 'Mixed logit estimation of the value of travel time'. Working Paper Series 1998:15, Department of Economics, Uppsala University.

Algers, S., B. Hugosson, and J. Lindqvist Dillén: 1995, '1994-års tidsvärdesstudie'. Final report, Transek AB, Solna, Sweden.

Becker, G. S.: 1965, 'A theory of the allocation of time'. *Economic Journal* **75**(299), 493–517.

Ben-Akiva, M., D. Bolduc, and M. Bradley: 1993, 'Estimation of travel choice models with randomly distributed values of time'. *Transportation Research Record* **1413**, 88–97.

Brownstone, D. and K. A. Small: 2005, 'Valuing time and reliability: Assessing the evidence from road pricing demonstrations'. *Transportation Research Part A: Policy and Practice* **39**(4), 279–293.

Cummings, R. G., G. W. Harrison, and E. E. Rutström: 1995, 'Homegrown values and hypothetical surveys: Is the dichotomous choice approach incentive-compatible?'. *American Economic Review* **85**(1), 260–266.

De Borger, B. and M. Fosgerau: 2008, 'The trade-off between money and travel time: A test of the theory of reference-dependent preferences'. *Journal of Urban Economics* **64**(1), 101–115.

DeSerpa, A. C.: 1971, 'A theory of the allocation of time'. *Economic Journal* **81**(324), 828–846.

Fosgerau, M.: 2006, 'Investigating the distribution of the value of travel time savings'. *Transportation Research Part B: Methodological* **40**(8), 688–707.

Gronberg, T. J. and W. R. Reed: 1994, 'Estimating workers' marginal willingness to pay for job attributes using duration data'. *Journal of Human Resources* **29**(3), 911–931.

Harrison, G. W.: 2006, 'Experimental evidence on alternative environmental valuation methods'. *Environmental and Resource Economics* **34**(1), 125–162.

Hensher, D. A. and W. H. Greene: 2003, 'The mixed logit model: The state of practice'. *Transportation* **30**(2), 133–176.

Hess, S., M. Bierlaire, and J. W. Polak: 2005, 'Estimation of value of travel-time savings

using mixed logit models'. *Transportation Research Part A: Policy and Practice* **39**(2-3), 221–236.

Hole, A. R.: 2007, 'Fitting mixed logit models by using maximum simulated likelihood'. *Stata Journal* **7**(3), 388–401.

Horowitz, J. K. and K. E. McConell: 2002, 'A review of WTA/WTP studies'. *Journal of Environmental Economics and Management* **44**(3), 426–447.

Hultkrantz, L. and R. Mortazavi: 2001, 'Anomalies in the value of travel-time changes'. *Journal of Transport Economics and Policy* **35**(2), 285–300.

Isacsson, G.: 2007, 'The trade off between time and money: Is there a difference between real and hypothetical choices?'. Working Paper 2007:3, Swedish National Road and Transport Research Institute (VTI), Sweden. Available at http://swopec.hhs.se/vtiwps/.

Isacsson, G., A. Karlström, and J.-E. Swärdh: 2008, 'The value of time from subjective data on life satisfaction and job satisfaction: An empirical assessment'. Working Paper 2008:2, Swedish National Road and Transport Research Institute (VTI). Available at http://swopec.hhs.se/vtiwps/.

Isacsson, G. and J.-E. Swärdh: 2009, 'The value of commuting time in an empirical on-the-job search model - Swedish evidence based on linked employee-establishment data'. Working Paper, Swedish National Road and Transport Research Institute (VTI).

Johansson-Stenman, O. and H. Svedsäter: 2008, 'Self-image and valuation of moral goods: Stated versus real willingness to pay'. Conference paper at IAREP/SABE world meeting 2008 in Rome.

List, J. A. and C. A. Gallet: 2001, 'What experimental protocol influence disparities between actual and hypothetical stated values?'. *Environmental and Resource Economics* **20**(3), 241–254.

Mackie, P. J., S. Jara-Díaz, and A. Fowkes: 2001, 'The value of travel time savings in evaluation'. *Transportation Research Part E: Logistics and Transportation Review* **37**(2-3), 91–106.

McFadden, D.: 1974, *Frontiers in Econometrics*, Chapt. Conditional Logit Analysis of Qualitative Choice Behavior. New York: Academic Press.

Meijer, E. and J. Rouwendal: 2006, 'Measuring welfare effects in models with random coefficients'. *Journal of Applied Econometrics* **21**(2), 227–244.

Murphy, J. J., P. G. Allen, T. H. Stevens, and D. Weatherhead: 2005, 'A meta-analysis of hypothetical bias in stated preference valuation'. *Environmental and Resource Economics* **30**(3), 313–325.

Perez, P. E., F. J. Martinez, and J. de Dios Ortuzar: 2003, 'Microeconomic formulation and estimation of a residential location choice model: Implications for the value of time'. *Journal of Regional Science* **43**(4), 771–789.

Revelt, D. and K. Train: 1998, 'Mixed logit with repeated choices: Households' choices of appliance efficiency level'. *Review of Economics and Statistics* **80**(4), 647–657.

Rosen, S.: 1986, *Handbook of Labor Economics*, Vol. 1, Chapt. The Theory of Equalizing Differences, pp. 641–692. Amsterdam: Elsevier North-Holland.

Rouwendal, J.: 1999, 'Spatial job search and commuting distances'. *Regional Science and Urban Economics* **29**(4), 491–517.

Rouwendal, J. and E. Meijer: 2001, 'Preferences for housing, jobs and commuting: A mixed logit analysis'. *Journal of Regional Science* **41**(3), 475–505.

Shires, J. D. and G. C. De Jong: 2006, 'An international meta-analysis of values of time'. Heatco report, Annex A.

SIKA: 2008, 'Samhällsekonomiska principer och kalkylvärden för transportsektorn: ASEK 4'. Report 2008:3, Swedish Institute for Transport and Communications Analysis (SIKA), Östersund, Sweden.

Small, K. A.: 1992, *Urban Transportation Economics*. Reading: Harwood Academic Publishers.

Smith, V. K. and C. Mansfield: 1998, 'Buying time: Real and hypothetical offers'. *Journal of Environmental Economics and Management* **36**(3), 209–224.

Stutzer, A. and B. S. Frey: 2008, 'Stress that doesn't pay: The commuting paradox'. *Scandinavian Journal of Economics* **110**(2), 339–366.

Swärdh, J.-E.: 2008, 'Hypothetical bias and certainty calibration in a value of time experiment'. Working Paper 2008:7, Swedish National Road and Transport Research Institute (VTI). Available at http://swopec.hhs.se/vtiwps/.

Transek: 2006, 'Jämställdhet vid val av transportmedel'. Final report 2006:22, Transek AB, Solna, Sweden.

Truong, T. P. and D. A. Hensher: 1985, 'Meaurement of travel time values and opportunity cost from a discrete-choice model'. *Economic Journal* **95**(378), 438–451.

Tse, C. Y. and A. W. Chan: 2003, 'Estimating the commuting cost and commuting time property price gradients'. *Regional Science and Urban Economics* **33**(6), 745–767.

Turner, T. and D. Niemeier: 1997, 'Travel to work and household responsibility: New evidence'. *Transportation* **24**(4), 397–419.

Van Ommeren, J. and M. Fosgerau: 2009, 'Workers' marginal costs of commuting'. *Journal of Urban Economics* **65**(1), 38–47.

Van Ommeren, J., P. Rietveld, and P. Nijkamp: 1997, 'Commuting: In search of jobs and residences'. *Journal of Urban Economics* **42**(3), 402–421.

Van Ommeren, J., P. Rietveld, and P. Nijkamp: 2002, 'A bivariate duration model for job mobility of two-earner households'. *European Journal of Operational Research* **137**(3), 574–587.

Van Ommeren, J., G. J. Van Den Berg, and C. Gorter: 2000, 'Estimating marginal willingness to pay for commuting'. *Journal of Regional Science* **40**(3), 541–563.

Vredin Johansson, M., T. Heldt, and P. Johansson: 2006, 'The effects of attitudes and personality traits on mode choice'. *Transportation Research Part A: Policy and Practice* **40**(6), 507–525.

Wardman, M.: 1998, 'The value of travel time: A review of British evidence'. *Journal of Transport Economics and Policy* **32**(3), 285–316.