Conditional Choice Modelling of Time Allocation Among Spouses in Transport Settings.

Theory and Empirical Findings

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As part of a wider rule-based model of activity behaviour, this paper explores the possibility to build a suite of linked conditional choice models to predict the amount of time spouses in a household spend on a set of activities together and alone. First, a choice model is used to predict the probability and hence the amount of time the spouses spend together and alone. Conditional on the outcome of this choice model, a second model predicts the amount of time that is spent by each spouse separately on a set of activities, as a function of socio-demographics, car availability and work status. The model is estimated using a small sample in Hendrik-Ido-Ambacht and Zwijndrecht in the Netherlands. The results indicate the model to have face validity. Rho-square values are also high.

1. Introduction

Recently, the development of activity-based models has been advocated by an increasingly larger number of researchers in transportation research (see e.g. Timmermans, 2000). This plea for activity-based models is related to the understanding that discrete choice models, focusing on trips or tours rather than activities, have reached their limits (e.g., Axhausen and Gärling, 1992; Bhat and Koppelman, 1999). Several developments, including an increased participation of women in the workforce, changes in the institutional context and the colonisation of the night, potentially have a dramatic impact on activity-travel patterns. The mechanisms underlying such change cannot be easily captured by conventional discrete choice models, except if one is willing to make rather ad hoc, largely non-testable assumptions.

Task allocation among spouses is another important development in this regard. Changing role patterns may induce a change in the allocation of tasks with the household. Consequently, particular activities may be organised differently in time and space, potentially resulting in shifting travel patterns. An interesting study on the relationship between task allocation and aspects of mobility and travel patterns was conducted by BGC (1995). In particular, the authors examined the relationship between the number of tasks, defined as paid work, school, volunteer work and in-home maintenance, that are performed and aspects of travel patterns. They concluded that females who combine more tasks have a higher car ownership and car availability rate. There was also evidence that if individuals performed more tasks, their mobility was higher and their travel patterns were more complex. This relationship was especially strong for women. There is also consistent evidence that the work commute of women is shorter (see also Hanson and Hanson, 1980; Singell and Lillydahl, 1986; Gordon, *et al*., 1989; Turner and Niemeier, 1997).

In addition to this basically empirical, descriptive research, there have been some attempts of modelling activity participation and related travel of couples. For example, Golob and McNally (1997) used a structural equation model to investigate the relationship between activity participation and travel. Activities were classified into three categories: work, maintenance, and discretionary. The total out-of-home duration for these categories was calculated, as was total travel time. A series of household and personal characteristics was used as the exogenous variables of the model. They studied four types of direct effects: travel requirements of out-of-home activities, within-person activity interactions, within-person travel interactions, and cross-person interactions. One of the interesting results was that if the male increases his participation in work activities, their model predicts that the female's travel for maintenance activities increases more than proportionally to the increase in the female's participation in maintenance activities.

To further increase the relevance of activity-based models, a separate (sub)model of task or time allocation within households is required if one wishes to capture change in time allocation on activity-travel patterns. The current paper explores the possibility of developing such a model.

The paper is organised as follows. First, we will outline the theoretical underpinnings of the suggested approach, followed by a discussion of the specification of the model. This is followed by a discussion of the data collection. Next, we will discuss the results of the estimation. Finally, we draw some conclusions and discuss some avenues of future research.

2. Theory

Assume that spouses are faced with a set of activities that they need or wish to accomplish during a particular time horizon. Each activity takes a certain amount of time. Some activities are spent together by the spouses, while the remaining time is spent to conduct personal activities or fulfil household responsibilities. If we group the latter two categories, the problem can be conceptualised as a hierarchical choice process. First, a decision needs to be made regarding the amount of time spent together to conduct particular activities. This results in a number of hours left for each spouse to conduct mandatory and discretionary activities. Given the amount of time left, the time allocation of each spouse can be predicted by relating the time spent on various activities to a set of independent variables. Note that although we

used this hierarchical conceptualisation, this does not imply that the actual decision-making process also proceeds along these lines. It is primarily a convenient way to capture the empirical relations, if any, in the data.

We conceptualise that various factors influence the time allocation to activities. In particular, we assume that the presence of children of various ages in the household, the socio-economic status of the household, age, car availability and work status of the spouses influence time allocation. We included the presence and age of children in the household because the presence of children, especially when they are young may induce particular activities, such as bringing/getting them to/from school. The socio-economic status of the household has been included in the model to examine the possibility that role patterns may vary across households of different socio-economic status. Age has been included primarily for the same reason, but also because the amount of time spent on particular activities may be partly age-dependent. The number of cars available in the household was included to reflect the notion that a spouse's flexibility to conduct a particular activity pattern within some space-time prism is influenced by the availability of a car. If a car is not available, and a spouse is dependent on other means of transportation, the possibilities to reach particular destinations and to become engaged in trip-chaining are reduced, resulting in a different activity pattern and associated time allocation. Finally, work status was included because the amount of time spouses have to spend on work, which is a mandatory activity, directly influences the time left for discretionary activities.

According to our conceptualisation, first we assume that spouses have to choose between spending time together and spending time alone and second, we assume that spouses have to choose on how to spend time among several activities. Therefore, the problem at hand is a choice problem. Multinomial logit models, including these variables as contextual effects, were used to predict time allocation by the two spouses on a set of activities. First, a binomial logit model was estimated to predict the amount of time spent together. This model is specified as follows:

$$p_{together} = \exp(V_{together}) / \exp(V_{together}) + \exp(V_{alone}) \quad (1)$$

where,

$p_{together}$ is the proportion of time spent together**;**
p_{alone} is the proportion of time spent alone**;**
$V_{together}$ is the structural utility of spending time together, defined as
$V_{together} = c_0 + \alpha \boldsymbol{X}$**;**
V_{alone} is the structural utility of spending time alone, defined as
$V_{alone} = 0.0$;
$\boldsymbol{X}$ represents the characteristics of the households and the spouses;
c_0 is a constant to be estimated;
α is a set of parameters to be estimated.

Note that the probability that spouses will spend time together has been directly related to the amount of time available during one week. The structural utility of spending time together depends on a set of characteristics of the household and the spouses.

Next, a conditional choice model was estimated to predict the time a spouse will spend on a particular activity. This multinomial logit model has the following form:

$$p_{as} = \exp(V_{as}) / \sum_{a'} \exp(V_{a's}) \qquad (2)$$

where,

p_{as} is the proportion of time spent on conducting activity a for spouse s**;**
V_{as} is the utility of spending time on activity a for spouse s, defined as
$V_{as} = c_{as} + \beta_{as}\boldsymbol{X}$**;**
c_{as} is a constant to be estimated for activity a and spouse s;
β_{as} is a set of parameters to be estimated for activity a and spouse s.

Because the total amount of time spent alone by spouse s is known (P_{alone}), these proportions can be translated into the time spent on particular activities. The utility of activity a is supposed to be a function of the set of characteristics $\boldsymbol{X}$. Note that the constant for one of the activities has to be set at zero.
Finally, a multinomial logit model was estimated to predict the time spent on each activity by both spouses together:

$$p_{a} = \exp(V_{a}) / \sum_{a'} \exp(V_{a'}) \qquad (3)$$

where,

p_a is the proportion of time spent on conducting activity a by both spouses together**;**
V_a is the utility of spending time on activity a by both spouses, defined as
$V_a = c_a + \gamma_a\boldsymbol{X}$**;**
c_a is a constant to be estimated for activity a;
γ_a is a set of parameters to be estimated for activity a.

Again, the proportion of time spent on activity a can be translated into the amount of time spent on activity a by multiplying P_a by the predicted time spent together $(P_{together})$.

3. Data collection

The data for the formulated model were collected in the Spring of 1998. This data collection was a follow-up of the collection of diary data, required to estimate the `Albatross` model (Arentze, et al, 2000). Respondents participating in the original data collection effort were asked if they were willing to participate in the collection of additional data. A total of 223 respondents agreed and these constitute the sampling frame for the present study. After a reminder, 75 two-person households and 33 single households returned the filled-out questionnaire, representing a response rate of 56% and 57% respectively. Of the latter group, 18 respondents were women and 15 men. However, these single household respondents were not used for the analysis reported in this article.
Respondents were requested to jointly express the amount of time they typically spend alone and together on a set of 27 different activities, which were later grouped into activity classes.

The following activity classes were distinguished: (1) sleep, eat, drink and personal care; (2) work out of home, including travel time; (3) shopping, services, including travel time; (4) in-home non-leisure; (5) in-home leisure; (6) out-of-home leisure; (7) bring/get activities, and (8) other. Respondents had to express the amount of time in a free format, e.g. minutes per day or hours per week. All time expenditure data were re-coded into the number of hours per week.

4. Analysis and results

Because we assume that the probability that a particular task will be conducted by the spouses can be described by multinomial logit models, standard methods of estimating multinomial logit choice models may be used to estimate the model. In this particular study, iterative re-weighted regression analysis was applied, which produces maximum likelihood estimates. The observed time expenditures for each activity constitute the dependent variable. The effects of the independent variables were estimated by coding the implied categories as a series of dummy-coded indicator variables. This implies that each variable with say L categories or levels, is coded as L - 1 indicator variables. One of the categories or levels is chosen as a base and coded 0 on all indicator variables. Each indicator variable corresponds with a specific category or level as indicated by a code of 1, while all other categories are coded 0 on that variable. When interpreting the following results, it should be remembered that all effects describe the differences between the corresponding activity and socio-demographic group and the time spent on the “other” activity class by young households of lower social-economic status with one car, without children between 4 and 18 years of age, and both spouse working less than 4 hours per week.

Figure 1 presents the categorisation and labels of the independent variables. Note that the categorisation of the presence of children is based on the age at which children go to primary and secondary school. Socio-economic status was measured by means of household income. High socio-economic class was defined as twice the modal income level; low socio-economic status was defined as lower than modal income, and medium socio-economic class was defined in between. The categorisation of age was set at 50 years of age to represent the before and after WW-II generations. The work status was defined as ‘no work’ (max. 4 hours per week), ‘part-time’ (5-32 hours) and ‘full-time’ (more than 32 hour per week).

As explained in the theory section, we have conceptualised the modelling process of time allocation by spouses to a set of activities in terms of a suite of linked choice models. A first model predicts the amount of time spent by both spouses together. This model will result in a predicted amount of time left for each spouse to spend on activities by themselves. The allocation of this time to a set of activities is predicted by another set of choice models, one for men and one for women. Finally, time spent by men and women together will be allocated to the activities. The results are reported next.

Table 1. Categorisation of independent variables

Variable	Label	Categories
Presence of children	-----	no children
	child_1	children aged between 4 and 12 present in household
	child_2	children aged between 13 and 18 present in household
Socio-economic status	-----	low socio-economic status
	soc/ec_1	medium socio-economic status
	soc/ec_2	high socio-economic status
Cars	-----	one car available in household
	cars	2 or more cars available in household
Age	----	oldest person in household is under 50 years of age
	age	oldest person in household is older than 50
Work status	-----	both spouses do not work (< 4 hours/week)
	work man_1	man works part-time (5-32 hrs/week)
	work man_2	man works full-time (> 32 hrs/week)
	work fem_1	woman works part-time (5-32 hrs/week)
	work fem_2	woman works full-time (> 32 hrs/week)

4.1 Amount of time spent together vs. alone

Table 2 presents the result of the model estimating the effects of the selected independent variables on the probability that spouses spend time together or alone.

Table 2. Effects of the independent variables on probability of spending time together or alone

Variable	Estimated effect	Significance
Constant	-1.04	**
Child_1	-0.01	
Child_2	0.35	**
soc/ec_1	0.06	
soc/ec_2	0.18	*
Cars	0.06	
Age	0.16	*
Work man_1	-1.54	**
Work man_2	-0.64	**
Work fem_1	-0.22	**
Work fem_2	-0.17	**

significance: ** 95%; * 90%

Table 2 demonstrates that young spouses without children between 4 and 18 years of age, low socio-economic status, only one car available, under 50 years of age and without work spend less time together than alone as indicated by the negative constant. The utility of ‘time spent alone’ was arbitrarily set equal to zero. If an older child is present in the household, the amount of time spent together significantly increases. A similar effect is found for households of a higher socio-economic status, although this effect is only significant at the 90% probability level. All work status effects are significantly and negative, suggesting that less time is spent together if either spouse works. These effects are stronger for part-time workers

than for full-time workers, and higher for men than for women. The predicted ability of the estimated choice model is high as indicated by a Rho-square of 0.89.

4.2 Time spent on activities by men

The next model estimates the effects of the household characteristics on the time allocation of men to activities. The results are listed in Table 3. Rho-square is 0.79, which is high. The first column of parameters of Table 3 depicts the effects on sleeping, eating and drinking and personal care. When interpreting the results, remember that time spent on 'other activities' served as the base in the estimation. Thus, the positive constant indicates that men spend more time on sleeping, eating, drinking and personal care than on this category. Time spent on sleeping, eating, drinking and personal care is significantly less when there are older children in the household, and two or more cars are available in the household. The first finding may indicate that men have less time for themselves as the children grow older. The interpretation of the latter effect is less evident, but might indicate that the availability of a second car induces them to spend more time on activities that require a second car, or at least are stimulated by the availability of a second car.

The effects for the work status of the spouse are both negative, indicating that the amount of time on sleeping, eating, drinking and personal care by men is less if their spouses have a part-time or full-time job, but only one of these effects is significant and then only at the 90% probability level. If men have a part-time job, their time allocation to sleeping, eating, drinking and personal care is higher. In contrast, it is significantly less if they have a full time job, which might suggest that personal care is especially important if they need to go to work, and they fall into a "take it easy"-mode when they don't have to go to work. Men in households of a medium and high socio-economic status appear to spend significantly more time on sleeping, eating, drinking and personal care than men in household of a low socio-economic status, which might reflect differences in life style. Older men also spend more time on sleeping, eating, drinking and personal care, which is what one would expect for this age cohort.

The second column of parameters reports similar effects for out-of-home work. The amount of time spent on this activity class is significantly higher for the medium and higher socio-economic groups. It is also significantly higher if men work. If their spouse works part-time, then the men tend to work less, which might indicate that they share certain tasks at home. If their spouse works full-time, the estimated coefficient is also negative, but not significant, which might indicate that dual-earner, no kids households are more represented by this group.

The third column of parameters reports the estimated effects for shopping and related activities. The amount of time spent on shopping is less than the amount of time spent on the base activity as indicated by the negative constant. The presence and age of children in the household does not have a significant effect on the time spent on shopping.

Table 3. Effects of the independent variables on the time allocation of men

Variable	Care	Work out-of-home	Shopping	Non-leisure in-home	Leisure in-home	Leisure out-of-home	Bring/ get
Constant	**1.46**	-0.17	**-1.83**	**-0.65**	**-0.67**	**-1.73**	---
child_1	0.19	0.23	0.05	0.24	0.35	0.21	**1.68**
child_2	**-0.39**	-0.23	-0.55	**-0.53**	**-0.95**	-0.07	0.50
soc/ec_1	**1.11**	**0.75**	**1.88**	**1.51**	**2.27**	**1.00**	---
soc/ec_2	**1.05**	**0.92**	**1.63**	**1.35**	**1.46**	**1.33**	---
Cars	**-0.46**	*-0.25*	-0.16	**-0.57**	**-1.15**	*-0.48*	0.75
Age	**0.36**	-0.03	0.20	**0.76**	**0.99**	-0.13	---
work man_1	**1.25**	**2.45**	**2.17**	0.64	**2.96**	**2.49**	---
work man_2	-0.18	**1.49**	**-1.85**	**-0.80**	**-0.82**	0.16	---
work fem_1	-0.10	**-0.45**	*0.74*	**0.98**	0.09	-0.35	-0.66
work fem_2	*-0.28*	-0.18	0.19	0.19	**-0.71**	-0.03	---

significance: bold 95%; italics 90%

In contrast, the socio-economic status of the household does have a significant impact, the effect increasing with a decreasing socio-economic status (from high to medium). This may reflect a difference in lifestyle or time pressure of the higher socio-economic group. As expected men working part-time spend more hours on shopping, while men working full-time spend less time on shopping. If spouses work, men tend to shop more, but this effect is only significant if their spouses work part-time, and then the effect is only significant at the 90% probability level.

The next column of Table 3 concerns the estimated effects for in-home non-leisure activities. Most variables, except the presence of children in the younger age cohort, men working part-time and women working full-time has a significant impact on the time allocation of men to this activity class. The presence of younger children tends to increase the time spent on in-home work, but not significantly. In contrast, if there are older children in the household, the amount of time spent by men on in-home non-leisure activities is less, which might suggest either that the older children are performing some of these tasks, or as we have already seen that more time spent with these children on other activities. As expected, the amount of time spent on in-home work activities gradually increases with decreasing socio-economic status, from high to medium. It suggest that the household belonging to the medium socio-economic status perform more DIY-activities. If there are more cars in the households, the amount of time spent on this class of activity is less, which might be explained by the same reasoning as in the case of personal care. Older people also allocate more time to in-home non-leisure activities, which is again consistent with expectations. The effects for the work status variables are interesting. If men work part-time, they tend to also spent more time on in-home work activities, but the effect is not significant. If the work full-time, the allocate significantly less time to in-home work. If their spouses work, men also tend to spend more time on in-home work activities, but this effect is only significant if their spouses work part-time.

Column 5 of Table 3 reports the estimated effects on in-home leisure activities by men. If there are young children in the household, men tend to stay at home more, but once the children grow older they allocate significantly less time to in-home leisure activities. As one would anticipate, the amount of time spent on in-home leisure activities monotonically increases with decreasing socio-economic status, from high to medium. To the extent there is

a correlation between higher socio-economic status and the availability of more than one car, the finding that time allocation to in-home leisure activities is less for household with more than one car is consistent with the estimated effects for socio-economic status. The face validity of the estimated models is further substantiated by the finding that the amount of time spent on in-home leisure by men increases if both they and their spouse work part-time, and decrease if they work full-time. The estimated effects are higher for men than for women, which is also what one would expect.

The next column concerns out-of-home leisure activities. The lower size of the parameters suggest that households tend to spend more on leisure in-home than out-of-home. The sign of the estimated effects is largely consistent with the estimated effects for in-home leisure activities, and hence similar explanations can be brought forward. There are a few exceptions however. First, the estimated parameter for age now is negative. Hence, this suggest that older people tend to avoid going out and spend more time at home. Secondly, the effect estimated for men working full-time is now positive, albeit non-significant, implying that men with a full-time job allocate slightly more time to out-of-home leisure activities. This might be explained by a more extensive network of work relations and the social responsibilities that come with a full-time job. The estimated effects for the work status of their spouses are not significant. Both parameter are negative, suggesting that men spend less time on out-of-home leisure activities if their spouses have either a part-time or full-time job.

The final activity class concerns bring/get activities. Overall, the amount of time involved is rather small, and therefore it was not possible to estimate the effects of all selected independent variables. Table 3 shows that only the effect of the presence of children in the young age cohort is significant at the conventional 95% probability level, the positive sign indicating that men spend more time on bringing/taking their children, which is almost tautological. Although not significant, the allocation of time to this activity class by men increases if there is a second car available and decreases if their spouse works part-time.

4.3 Time spent on activities by women

Table 4 reports the same effect as Table 3, but now for the women. Again, the Rho-square of 0.78 suggests that the estimated choice model predicts the data quite well. A comparison of the constants of the two models suggests that, compared to men, women spend less time on out-of-home leisure activities and more time on most other activities. As far as sleeping, eating, drinking and personal care is concerned, Table 4 demonstrates that women with older children in the household and more than one car in the household spend less time on this activity class. Similar effects are observed for women whose spouses work. In contrast, time allocation to this activity class is significantly higher with decreasing socio-economic status (from high to medium), older age, and if the women work, although the latter effect is only significant is they work part-time. Overall, the pattern of signs is very similar between men and women.

If we examine the second column of parameters, it seems that women spend more time on out-of-home work activities if they belong to a medium or lower socio-economic class, regardless whether they work part-time or full-time. Significant negative effects are estimated for the “more than one car”-variables. If the age of the oldest person in the household is higher, women also tend to work less, which is what we would expect. The effects for children in the household are also negative, but only the one for the older children is

significant at the 90% probability level. This may be a cohort effect. The sign of the estimated parameter is largely congruent between men and women, except for the presence of young children, suggesting that child raising is still primarily a task for women.
Column 3 reports the estimated effects on time allocation to shopping by women. The presence of children does not seem to have a significant impact in this regard. Women of medium and higher socio-economic status tend to spend significantly more time on shopping. The same is true if the oldest person in the household is older than 50. If the household has more than one car, women spend less time on shopping and related activities. If their spouses have a full-time or part-time job, women allocate less time to shopping, which is especially true if their spouse works part-time. This result might reflect a shift in the over all activity pattern in the sense that they may spend more time together on other activities. The impact of the work status of the women themselves is such that working women spend less time on shopping, but this effect is only significant if they work full-time, and then only at the 90% probability level. Time pressure might be the reason for this finding. The pattern of the signs of the work status variables is interesting. Compared to the reference household, time allocation of men to shopping tends to increase if their spouse work, suggesting that men take over some of the shopping responsibilities of their spouses. This is supported by the negative effects of the work status of their spouses for the model estimated for women.
The next column of Table 4 concerns in-home non-leisure activities. Women tend to spend more time on this activity class if they have young children and less time if they have older children compared to the situation where there are no children in the household. This seems to indicate that older children help out. Time allocation to in-home work activities by women is highest in households of a medium socio-economic status and lowest for households of a low socio-economic status.

Table 4. Effects of the independent variables on the time allocation of women

Variable	Care	Work out-of-home	Shopping	Non-leisure in-home	Leisure in-home	Leisure out-of-home	Bring/ get
Constant	**1.78**	-0.23	**-1.30**	*0.40*	-0.16	**-1.86**	**-3.91**
Child_1	0.22	-0.04	0.23	**0.53**	0.15	**0.48**	**1.37**
Child_2	*-0.28*	*-0.36*	-0.24	-0.17	**-1.31**	-0.38	*-2.27*
soc/ec_1	**1.63**	**1.26**	**1.81**	**1.74**	**2.52**	**1.11**	-1.42
soc/ec_2	**0.83**	**0.68**	**1.18**	**0.73**	**1.26**	**0.64**	1.24
Cars	**-0.86**	**-0.44**	**-0.77**	**-0.82**	**-1.94**	**-0.47**	0.15
Age	**0.43**	-0.26	**0.96**	**0.56**	**0.54**	0.23	---
work man_1	**-1.07**	---	**-2.16**	**-3.53**	**1.07**	0.37	---
work man_2	**-0.92**	**-1.45**	*-0.47*	**-0.44**	**-1.15**	0.32	0.03
work fem_1	**0.38**	**2.12**	-0.30	0.12	**0.80**	0.11	-0.10
work fem_2	0.25	**2.65**	*-0.52*	**-1.10**	-0.32	0.16	---

significance: bold 95%; italics 90%

Women spend significantly less time on in-home work activities if there are more than two cars in the household, and more time if the oldest person in the household is older than 50. There is evidence of task assignment in the sense that women spend less time on in-home work activities if their spouses have a part-time or full-time job. This effect is strongest if their spouses work part-time. If women only work part-time, they tend to spend slightly more

time (the effect is not significant at conventional probability levels) on in-home work activities compared to women who do not work, but the time allocation to in-home work activities is significantly lower if women work full-time.
As far as in-home leisure activities are concerned, women tend to spend less time on this activity class if they have older children, and if more than one car is available in the household. Time allocation to this activity class is significantly higher for medium and high socio-economic class households, and older persons. Hence, the signs and hence the interpretation is the same for women and men. This is also observed for the work status variables. Time spent on in-home leisure activities is lower for women if they work full-time, and higher if they work part-time. If their spouse works part-time, women spend more time on this activity class, if they work full-time, they spend less time on in-home leisure activities. Note that we found the same pattern for men.
Time spent on out-of-home leisure activities by women tends to increase if they have young children and decrease if they have older children, although the latter effect is not significant. Households of a medium or high socio-economic class spend more time on out-of-home leisure activities. If there are two or more cars in the household, women spend less time on this activity class, but this effect is only significant at the 90% probability level. None of the effects of the other independent variables, including the work status of men and women, is significant. Thus, the amount of time spend by women on out-of-home leisure activities is not significantly influenced by their work status and that of their spouses. The sign of the estimated parameters, however, suggest that time allocation by women to out-of-home leisure activities is higher if they or their spouses have a part-time or full-time job. In part, this may reflect affordability, but it may also reflect the need to spend more time on job-related social and leisure activities.
The last column of Table 4, which reports the effects of the independent variables on the bring/get activity, demonstrates that women spend more time on this activity if they have young children, and less time if they have older children, again compared to the “no children” situation. The latter effect might indicate that older children may be involved in running errands for the household. None of the other effects is statistically significant.

4.4 Effects on time spent together by spouses

The first choice model predicted the probability that time would be spent together by the spouses. In order to know, however, which activities are involved and the time allocation to these joint activities, another choice model, which predicts the impact of the selected independent variables on the time allocation to joint activities is required.
Table 5 lists the estimated effects for this model. Rho-square for this model is 0.54, which is still very good for conventional standards, but obviously considerably less than the Rho-square obtained for the other choice models.
The first column of Table 5 indicates that spouses tend to spend more time together on sleeping, drinking, eating and personal care if they have young children. Moreover, the time allocation to this activity class is significantly higher if the man works full-time and the woman works part-time. If the women works full-time, the effect is also positive, but non-significant. As far as joint shopping is concerned, households of medium or high socio-economic class spend significantly less time together on shopping and related activities. None of the other effects is significant, but the positive effects for the work status variables of the

women suggest that spouses spend more time together on shopping if the woman in the household has a job, especially if it is a full-time job.

Table 5. Effects of the independent variables on the time spent together

Variable	Care	Work out-of-home	Shopping	Non-leisure in-home	Leisure in-home	Leisure out-of-home	Bring/get
Constant	**-0.71**	---	**-0.75**	-0.24	**0.87**	---	---
Child_1	**0.54**	---	-0.10	**-0.71**	0.11	---	---
Child_2	-0.05	---	0.45	-0.37	0.20	---	---
soc/ec_1	-0.18	---	**-0.74**	**-0.96**	**-0.43**	---	---
soc/ec_2	-0.29	---	**-0.79**	*-0.61*	-0.25	---	---
Cars	-0.20	---	-0.11	0.31	-0.21	---	---
Age	0.41	---	-0.17	-0.49	*0.36*	---	---
Work man_1	---	---	---	---	---	---	---
Work man_2	**0.57**	---	0.49	-0.20	**0.61**	---	---
Work fem_1	**0.57**	---	0.12	**0.86**	0.06	---	---
Work fem_2	0.33	---	0.22	0.46	-0.30	---	---

significance: bold 95%; italics 90%

Table 5 also demonstrates that time spent together on in-house work activities is less if there are children in the households, but only the effect for the presence of young children is significant. Time allocation to in-home work activities is also lower for households of a medium (significant) and high socio-economic status (non-significant). If the woman in the household works part-time, spouse spend significantly more time together on in-house work activities. Time spent together on in-home leisure activities is significantly higher if the male spouse has a full-time job, and less but not significant if the female spouse has a full-time job. None of the other effects is statistically significant at conventional probability levels, except for age which is positive and significant at the 90% probability level, suggesting that households in which the oldest person is over 50 years of age, spend more time together on in-home leisure activities.

5. Conclusion and discussion

The present paper has reported the results of a series of estimations of conditional choice models, developed to predict time allocation by men and women, either spend alone or together. These conditional models first predict the amount of time spent alone or together, and then predict the amount of time that will be spent on 8 classes of activities as a function of household characteristics and the works status of the spouses.

Overall, the results of the models are satisfactory, even though the sample size is relatively small. The estimated effects are largely consistent with one's expectations. Moreover, the goodness-of-fit of the choice models as indicated by their rho-square is generally high. Future research, involving larger sample sizes should examine whether similar, positive results can be obtained for additional sample.

The model represents one potential avenue for incorporating time allocation in households in an activity-based model. Input to this system is a household activity program that ideally

should be completed during the simulated day. The model developed in this paper can be used to predict who will perform the activities included in the program that can be shared or should be assigned to one of the spouses. One possibility of accomplishing this would be to conduct a (constrained) micro-simulation using Monte Carlo techniques. Activities are then drawn proportionally to the predicted time allocation to the set of activities. The research team hopes to report on their experiences with such micro-simulation in the near future.

References

Arentze, Th., F. Hofman, H. van Mourik and H.J.P. Timmermans (2000). `Albatross`: A multi-agent rule-based model of activity pattern decisions. Paper presented at the 79th Annual Transportation Research Board Meeting, Washington, D.C., January 9-13, 2000.

Axhausen, K. and T. Gärling (1992). Activity-based approaches to travel analysis: Conceptual frameworks, models and research problems. *Transport Reviews*, **12**, 324-341.

BGC (1995b). Taakcombinatie en mobiliteit. Report prepared for AVV, Deventer.

Bhat, C.R. and F.S. Koppelman (1999). A retrospective and prospective survey of time-use research. *Transportation*, **26**, 119-129.

Golob, T.F. and M.G. McNally (1997). A model of activity participation and travel interactions between household heads. *Transportation Research B*, **31**, 177-194.

Gordon, P., A. Kumar and H.W. Richardson (1989). Gender differences in metropolitan travel behavior. *Regional Studies*, **23**, 499-510.

Hanson, S. and P. Hanson (1980). Gender and urban activity patterns in Uppsala, Sweden. *Geographical Review*, **70**, 291-299.

Singell, L.D. and J.H. Lillydahl (1986). An empirical analysis of the commute to work patterns of males and females in two-earner households. *Urban Studies*, **2**, 119-129.

Timmermans, H. (2000). Theories and models of activity patterns. In Arentze, T. and H. Timmermans (Eds.) `Albatross`, A Learning Based Transportation Oriented Simulation System. European Institute of Retailing and Services Studies, Eindhoven, pp 6-70.

Turner, T. and D. Niemeier (1997). Travel to work and household responsibility: New evidence. *Transportation*, **24**, 397-419.