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Rush hour commuting in the Netherlands: Gender-specific household activities and personal attitudes towards responsibility sharing

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ABSTRACT

Apart from work-hour commitments, rush hour commuting is dependent on household activities and responsibilities. It can also be gender specific when gender differences in performing household activities prevail. To that end, this study investigates gender differences in rush hour commuting in relation to daily household activities using data from TBO 2006 (Dutch Time Use Survey) and MON 2006 (National Travel Survey of the Netherlands). Two separate analyses were carried out, one for the morning rush hour and one for the afternoon rush hour. The analyses considered household activities such as childcare, child chauffeuring, household maintenance and shopping, and working from home. Additionally, we included personal attitudes towards sharing these activities between partners. We found that females in the Netherlands were more likely to commute during morning rush hours but less likely during afternoon rush hours. In terms of household activities, childcare and child chauffeuring before/after a commute led to a higher probability of commuting during morning rush hours. In the afternoon, only childcare activity was significant. As expected, working from home had a negative effect on rush hour commuting for both analyses. Furthermore, we found that personal attitudes regarding the sharing of household activities and responsibilities were of limited additional value.

1. Introduction

Due to the possibly unequal sharing of household activities and responsibilities, women and men may have different transportation needs and levels of accessibility. Therefore, they may execute different behavioral patterns, which affect their professional and personal wellbeing. Transportation policies, specifically policies concerning rush hour traffic, can be misleading and mismatched given the overrepresentation of male participation in the work force. Although the participation of women in the labor market in the Netherlands has increased significantly, it remained lower at 79% compared with 90% for men in 2009 (van der Waard et al., 2013). Moreover, women are more likely to work part-time than men (Roeters and Craig, 2014). To be more equitable and inclusive, transportation policies should focus especially on the needs of women. It is expected that their behavior will have greater effect than before on the transportation system in general and on rush hour commuting specifically. This study does not analyze people's motivations for rush hour commuting but rather is focused on understanding the impact of the determinants of these commutes. To avoid rush hour commuting, it is necessary to understand that a commute is not only dependent on commuting conditions and resources, and work related attributes but is also related to household tasks and responsibilities. These tasks and responsibilities are often constrained in space and time (Hägerstrand, 1970), thereby affecting the schedule of the journey to and from work. Such constraints are very much gender specific (Kwan, 2000; Gustafson, 2006) because women are more involved in household tasks than men are (Sanchez and Thomson, 1997). Moreover, commuting patterns such as work-trip length also differ between men and women (Hanson and Johnston, 1985; Turner and Niemeier, 1997). This paper aims to account for these often-ignored household issues and gender differences in rush hour commuting.

Work-related issues have received much more attention due to their direct relationship with commuting, particularly in the case of rush hour commuting (Small, 1982; Noland and Small, 1995; Caplice and Mahmassani, 1992). These studies focused on the

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relationship between commute start time and its relationship to arrival time at work. Whereas these issues are important, telecommuting and the possibility of working from home provide structural solutions for avoiding rush hour commuting (Alexander et al., 2010). People have become more flexible in choosing work activities (Handy and Mokhtarian, 1996; Couclelis, 2004), thereby creating options to avoid rush hour traffic. Several studies have indicated that telecommuting could reduce work-related travel (Pendyala et al., 1991; Koenig et al., 1996; Lund and Mokhtarian, 1994). However, progress is slow, and urban roads are still congested, especially during rush hour. Regarding personal attitudes, Mokhtarian and Salomon (1997) found that people may not use work flexibility or homeworking depending on their attitudes toward it even if they have the option to do so. Similarly, the desire to work from home could be affected by household facilities and beliefs about personal life and the home environment (Haddad et al., 2009). Nonetheless, the potential for telecommuting or homeworking to affect rush hour commuting is understandable. In a detailed qualitative investigation, Lyons and Haddad (Lyons and Haddad, 2008) noted commute displacement as a possible outcome of a part-day homeworking. Therefore, work flexibility should be considered in the analysis of rush hour commuting. However, slow improvements in the reduction of congestion call for an investigation beyond working conditions or commuting itself.

To that end, we argue that family issues are given scant attention compared with work-related issues in the investigation of commuting choices. The activity travel patterns of individuals in a household are dependent on household tasks and responsibilities such as maintenance, shopping and caregiving activities. The travel behavior implications of these activities have been analyzed in terms of the interdependence between partners (Golob and McNally, 1997; Hanson and Hanson, 1981) and activity participation of partners in households (Zhang et al., 2005; Srinivasan and Bhat, 2005; Turner and Niemeier, 1997). Nevertheless, a reference to rush hour commuting is absent. Moreover, household activity sharing and participation could also be gender specific. Looking into the effect of the built environment on household activity sharing, Schwanen et al. (2007) found that the distribution of household tasks between partners is more equal in higher density and more diverse neighborhoods. They indicated that women perform the bulk of out-of-home household activities and that the impact of working hours and the presence of young children is gender specific. Similarly, Kwan (1999) established that child chauffeuring is more of an obligatory task for women than for men. Therefore, women respond to childbirth differently than men (Oakil, forthcoming). Whereas these studies indicated gender differences in household activities and travel, Presser (1994) found that there is a substantial lack of overlap in the employment hours of husbands and wives and that in over one-fourth of couples, at least one spouse could work a non-daytime shift. Also relevant is the finding that mothers prefer work flexibility to cope with their childcare and domestic responsibilities (Golden, 2001; Presser, 2003; Spitze, 1988). Therefore, different time schedules or flexible time choices for women may mean different commuting times; if one partner travels during rush hours, the other may travel outside peak traffic periods. However, it can also be argued that these responsibilities may require women to be traveling at a certain time as when, for example, picking up or dropping off the children at school, for which business hours can limit the choice of departure time for commuting. In the Netherlands, it has been reported that rewarding schemes to avoid rush hours are less effective for women than for men (MuConsult, 2013).

In this regard, this paper contributes to the understanding of rush hour commuting in different ways. First, this paper provides direct empirical evidence regarding the impact of work flexibility on rush hour commuting. Previously, this was performed indirectly, for example, by investigating the choice of working from home. Most of those studies addressed factors that facilitate homeworking or telecommuting, for instance, Information and Communication Technology (ICT) ownership (Alexander et al., 2010) or household facilities (Haddad et al., 2009). Second, one of the gaps addressed in this paper is the lack of attention paid to the relationship between rush hour commuting and activity scheduling and sharing within households. Whereas work-related issues have received much more attention than family issues (Swanberg et al., 2005), we intend to incorporate family issues by considering daily activities regarding caregiving, maintenance, and shopping, along with partner work activities. In this way, we can explore gender differences by taking into account those household responsibilities that are assumed to cause behavioral differences between men and women rather than looking into gender differences in isolation from these responsibilities.

Analytically, we differentiated between morning and afternoon rush hour. This is an important consideration given the different time windows for performing certain activities that are bounded by institutional constraints such as the business hours of shops and schools. Furthermore, the paper focuses on rush hour commuting by car because cars have the largest share on the road during rush hours. Therefore, car commuting during rush hours has the biggest negative impact on traffic flows on roads and can in these situations be accompanied by great economic loss. In the next section, we will explain our analytical procedure in detail. Following that, we will elaborate on the sample and variables accounted for in Section 3. Section 4 will present the results of our empirical analyses of rush hour commuting. Section 5 will discuss results, and Section 6 will conclude the paper with some policy implications of our results.

2. Methods and data

A binary logit analysis was performed to identify the factors that influence rush hour commuting. We defined the morning rush hour from 7 am to 9 am and the afternoon rush hour from 4 pm to 6 pm. This definition was based on the classification used by Statistics Netherlands (CBS). It is also similar to the distribution found in the dataset we used. The distribution of commuting trips is shown in Fig. 1, in which rush hour traffic is marked with dark-colored columns. In two separate models, the morning rush hour commute and the afternoon rush hour commute were investigated. Rush hour commuting was defined by the mid-point of commuting time rather than the start or end time of the journey to and from work. This was performed to capture those individuals who may start just before or arrive just after rush hours but would still be contributing to rush hour traffic. The CBS definition was based on traffic volume at a particular time of the day on the road. Therefore, we considered the mid-point as the most appropriate definition of traveling during rush hours.

The data used in this paper came from TBO 2006 (Dutch Time Use Survey) (Sociaal en Cultureel Planbureau, 2006) and MON 2006 (National Travel Survey of the Netherlands) (Ministerie van Verkeer en Waterstaat et al., 2006). TBO consisted of three parts as follows: basic information about time use, a detailed time use survey and a travel diary. Approximately 1900 individuals participated in the TBO 2006 survey and completed an activity diary for one week. In addition, MON data were used to supplement the TBO data with the necessary socio-demographic variables. This was possible because the TBO 2006 respondents were a selection of the MON 2006 respondents. Because TBO consisted of travel diary data of one week, each individual had multiple observations based on the days s/he traveled to and from work. Therefore, a

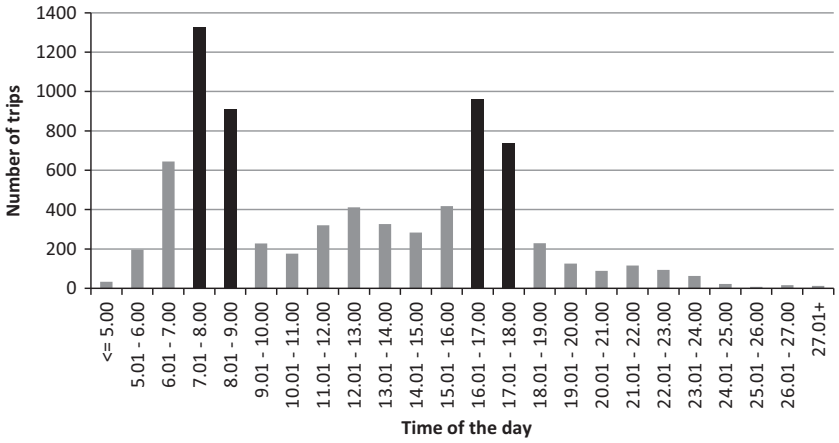

Fig. 1. Distribution of commuting trips throughout the day in the sample of TBO 2006. Source: Sociaal en Cultureel Planbureau (2006).

mixed logit formulation was applied to capture the random effect between individuals. For two alternatives (rush hour commuting or not), we defined utility functions as shown in Eq. (1).

$$u_{1it} = \sum_{k=1}^{n} \beta_{1itk} x_{1itk} + \lambda_{1i} + \varepsilon_{1it}$$
$$u_{0it} = \alpha_{0it} + \varepsilon_{0it} \quad (1)$$

where u_{1it} = the utility of choice 1 – commuting during rush-hour at day t, u_{0it} = the utility of choice 0 – commuting outside rush-hour at day t, i = an index for individual i, t = an index of working weekday, k = an index of explanatory variables, x_{1itk} = the value of explanatory variable k for choice 1 at day t, α_{0it} = the intercept value explaining choice 0, ε_{0it} = the random effect within individual choice 0, ε_{lit} = the random effect within individual choice 1, λ_{il} = the random effect between individuals.

To disentangle the relationship between gender and rush hour commuting, we sequentially added household activity variables and attitudes toward responsibility sharing. To this end, we estimated three models for both the morning and the afternoon rush hours. Model 1 included socio-demographics, working status, commuting condition and work flexibility. In Model 2, we considered household activities such as child caregiving, child chauffeuring, household maintenance and shopping in addition to the variables in Model 1. Attitudes towards household responsibility sharing between partners were finally accounted for in Model 3 by adding them to Model 2. In the following section, we will explain the variables used in our analyses and the sample.

3. Variables and sample description

In this analysis, we concentrated on car commuting during rush hours because bicycle and public transport hardly contribute to congestion and delays on roads. Moreover, approximately 60% of commuting trips were made by car according to the sample of TBO 2006. Bicycle commuting accounted for more than 20% of the commuting trips. This modal split is representative of the travel behavior of the whole Dutch population. We selected individuals who commuted during the day. As a result, the days on which respondents worked from home were excluded. We also removed weekend commutes because these will always be off-peak and belong to special or atypical working groups. Based on these considerations and after accounting for missing values, the sample sizes were 1092 observation-days (or 475 respondents) for the morning rush hour and 907 observation-days (or 450 respondents) for the afternoon journey from work. Table 1 lists the variables used and their related statistics. Although the respondents came from the same sample, the difference in the sample sizes between the morning and the afternoon rush hour analyses was due to missing values, and there were minor differences between the compositions of the samples.

The variables were grouped into three sets according to the method of analysis. In the first set, socio-demographics, working status, commuting condition and work flexibility were included. The socio-demographic variables consisted of the age, education and gender of the respondent. The working status included two dummy variables, namely part-time work and a professional job. Approximately 2% of the values were missing in the reference category for these variables (i.e., in no part-time work and no professional job). The dummy variables were included to avoid further reduction of the sample size, and the percentage was considered too low to have a significant effect on the estimations. Managerial/professional work was used as an indicator variable because the literature (Vana et al., 2007) has suggested that employees in managerial, technical/professional, and clerical occupations were more likely to take up conventional work-hour arrangements. The commuting condition comprised the commute duration and experience of congestion during commuting. In the questionnaire, the experience of congestion was defined by a 5-point scale (very annoying, annoying, annoying nor pleasant, pleasant and very pleasant). However, a dummy variable was used to explain whether the experience of congestion is very annoying to the respondent due to the presence of a small number of missing cases. With respect to working facilities and flexibility, we considered the presence of a company car, flexibility in the choice of work time and provision of homeworking. These facilities are important factors in the choice of commuting time, specifically with respect to mode choice and the possibility of avoiding rush hours.

By contrast, the literature has suggested that females may face different constraints in avoiding rush hours and indicated that activity scheduling may have different implications for women. To account for these issues, TBO travel diary data were used to consider activities that were scheduled around commuting time. This represented the second set of variables. These variables explained whether childcare, child chauffeuring and household maintenance activities were performed before or after a commute. A variable also indicated whether the partner had worked on the same day or not. Apart from basic work flexibility, we explicitly examined the effect of performing work at home before the morning commute or after the afternoon commute.

In addition to involvement in the household and child-related activities, personal attitudes regarding such activities may affect

Table 1
Description and composition of the samples.

	Morning commute		Afternoon commute	
	Frequency	%	Frequency	%
Total observation days	1092	100.0	907	100.0
Total number of respondents	475	100.0	450	100.0
Rush-hour commuting[*]	752	68.9	416	45.9
Socio-demographics				
Age of the respondent > 50 years (Y/N)	127	26.8	127	28.2
Respondent is a female (Y/N)	215	45.3	189	42.0
Respondent's highest education achievement				
Higher education	184	38.7	170	37.8
Lower education	86	18.1	80	17.8
Other	205	43.2	200	44.4
Working status				
Respondent has a part-time job	164	34.5	144	32.0
Respondent has professional/managerial work	173	36.4	157	34.9
Commuting condition				
Respondent's commute duration > 30 min	143	30.1	151	33.6
Respondent is very annoyed with congestion	45	9.5	40	8.9
Working flexibility/facilities				
Respondent receives company car	46	9.7	45	10.0
Respondent can choose own work time	79	16.6	76	16.9
Respondent is allowed to work 8 h/week from home	46	9.7	33	7.3
Daily activity schedule[*]				
Respondent performs childcare before/after commute	48	4.4	32	3.5
Respondent performs child related travel before/after commute	72	6.6	11	1.2
Respondent performs HH work (maintenance, shopping, repair, related travel) before/after commute	260	23.8	218	24.0
Respondent works at home before/after commute	30	2.7	38	4.2
Partner works on the day	547	50.1	432	47.6
Responsibility sharing attitudes				
Women are suitable for the up-bringing of babies	170	35.8	172	38.2
HH duties are the responsibility of both men and women	262	55.2	251	55.8
For women, childcare is an attractive alternative to a not-so-nice job	174	36.6	176	39.1
Men and women should work equally	140	29.5	139	30.9
Men should work less after childbirth	272	57.3	259	57.6

[*] Indicates that the frequencies and percentages are based on total observation days. For other variables, the frequencies and percentages are based on the total number of respondents.

commuting during rush hours. Therefore, the third analysis considered attitudes towards responsibility sharing regarding household and child-related activities and work-related attitudes. In the questionnaire, attitudes were defined by a 4-point scale (completely agree, agree, disagree and completely disagree). To solve the missing value problem, a dummy variable rather than an ordered variable was included. The variable defined whether a respondent at least agreed (i.e., a combination of completely agree and agree) with the statements related to responsibility sharing. Missing values were considered disagreement with the statement in question. We understand the implication of using the missing cases. Therefore, we will only report the variables that are statistically very significant. The statements are listed in Table 1. Although attitudes may be related to activities directly, these are not identical. Households may share responsibilities based on different activities rather than sharing the same activity. For instance, one partner may pick up the children, whereas the other partner may buy groceries. Therefore, we used these parameters simultaneously during the model estimations.

4. Findings

As mentioned in Section 2, there are two separate model estimates for both morning and afternoon rush-hour commuting. Table 2 represents the final results of the morning rush hours and the afternoon rush hours. The table comprises only variables that are statistically significant. We started with analyzing the effects from the three different sets of variables as mentioned in the method section. The model estimates are shown in the Appendices. In the Appendix A, Tables 3 and 4 illustrate the findings of the model estimates for morning and afternoon commuting, respectively. We obtained the final model by applying backward elimination until the highest adjusted Rho-square was achieved and the variables were statistically significant. Finally, we tested whether there was any significant interaction effect between gender and the significant variables.

Table 2 shows many expected results and provides an important understanding about rush-hour commuting. The table shows that the constant is negative and statistically significant for the morning commute. We defined the constant as affecting non-rush-hour commuting. Hence, a negative value means that people are less likely to avoid the morning rush hours; in other words, they are more likely to commute during morning rush hours.

Importantly, we found that females were more likely to use morning rush hours and less likely to use afternoon rush hours. A recent report (MuConsult, 2013) on rush-hour avoidance in the Netherlands advocated that women were less likely to avoid rush hours. However, we found that women were more likely to avoid the afternoon peak period. The separation of the morning and the afternoon rush-hours depicted this difference in outcome. One can assume that women are more likely to work part-time and therefore may work less in the afternoon, affecting their commuting behavior in the afternoon. However, this does not seem to be the case with regard to our result because the consideration of part-time work did not show a significant effect in the case of the

Table 2
Estimation results of the morning and the afternoon rush hour commuting.

	Morning commute			Afternoon commute		
	β	t-test		β	t-test	
Constant (Choice 0 – commuting outside rush-hour at day t)	−2.18	4.13	***	−0.08	−0.27	
Random effect across individuals	4.02	8.23	***	2.44	8.20	***
Mean (fixed)	0.00			0.00		
Respondent is a female (Y/N)	2.37	3.58	***	−0.91	−2.70	***
Respondent's highest education achieved						
Higher education (HBO/University)	–	–	–	0.75	2.26	**
Lower education (BO/LO/MULO)	−1.27	−1.99	**	–	–	–
Working status						
Respondent has a part-time job	−1.25	−1.87	*	–	–	–
Commuting condition						
Respondent's commute duration > 30 min	–	–	–	0.47	1.71	*
Working flexibility/facilities						
Respondent receives company car	2.69	2.81	***	–	–	–
Daily activity schedule						
Respondent performs childcare before/after commute	1.70	1.94	**	1.55	2.21	**
Respondent performs child-related travel before/after commute	1.79	2.41	**	–	–	–
Respondent performs HH work before/after commute	−0.74	−1.98	**			
Respondent works at home before/after commute	−2.07	−2.15	**	−2.29	−3.17	***
Responsibility sharing attitudes						
HH works are the responsibility of both men and women	−1.11	−2.18	**	–	–	–
Men should work less after childbirth	–	–	–	−0.69	−2.10	**
Adjusted Rho-square	0.316			0.124		

– Insignificant variables that are not included in the final analysis.
* p-Value 0.05–0.10.
** p-Value 0.01–0.05.
*** p-Value 0.00–0.01.

afternoon rush hours. A reasonable explanation for the avoidance of afternoon rush hours can be the time flexibility of performing different activities. For instance, child chauffeuring to school and business operating hours are more flexible in the afternoon than in the morning. This was also supported by the effects of activity scheduling found in the results. Whereas child-related travel positively affected the rush-hour commute during the morning, it showed no significant effect regarding afternoon rush hours. The negative effect of household maintenance activities for the morning can also be explained in terms of time flexibility because household maintenance activities are not as restricted as taking a child to school. However, we observed that child care activities had positive effects on both commuting peaks. It can be argued that these activities are not very time restricted; however, at least one of the parents must be involved in these activities, which indicates the significance of sharing and negotiation between partners. In this reasoning, our result indicated that women in the family may opt for afternoon rush-hour avoidance, and men may choose to avoid the morning peak period. Whether providing more time flexibility in performing different activities would improve the travel condition cannot be ascertained. However, ignoring these facts would certainly mislead policy formulation, and many relevant issues would have remained unknown.

Another relevant outcome was the significant influence of work facilities on commuting during rush hours. Among other activities, part-day homeworking showed the highest negative effect on rush hour commuting in both cases. If an individual works from home before the morning commute and after the afternoon commute, the probability that s/he will be commuting during rush hours is very low. Thus, work-related aspects continue to be the most important aspect in the analysis of rush hour commuting. However, the provision of flexibility in work-time choice and the possibility of working from home were not significant. These findings are consistent with the finding of Mokhtarian and Salomon (1997). When work schedule flexibility is allowed, it does not ensure rush hour avoidance as other factors may affect behavior as well. Therefore, the consideration of daily activity participation improves our understanding of commuting during rush hours. Similarly, part-time work affects morning rush hour commuting negatively although it is not significant for afternoon rush hours. The provision of a company car was also considered in the analyses as an indicator of commuting allowance because company car drivers are 'forced' to commute by car. The result shows that it has a positive and high impact on the morning rush-hour commute. This is an interesting outcome because Nijland and Dijst (2015) found that employees with a company car have more opportunities to work from home, and work schedule flexibility is more often part of their work agreement. This implies that company car drivers should, in theory, be more able to avoid peak traffic periods. Nevertheless, our analysis shows that, with respect to the avoidance of the morning peak, this is clearly not the case. This suggests that an employee may become insensitive to congestion-related costs because the employer bears the cost of commuting. Thus, policies targeting employers to reduce car use and the provision of company cars in particular can effectively reduce congestion during rush hours.

With respect to personal attitudes, the results showed limited effects. Childcare and household activity sharing attitudes were not statistically significant. This is understandable because the models included variables that directly measured participation in these activities. Additionally, the impacts of these direct measurements were very significant. However, work-related attitudes were found to be important. The statements, "Household works are the responsibility of both men and women" and "Men should work less after childbirth" had negative effects on the morning and the afternoon rush hours, respectively. This is an expected result because equal sharing of household activities means more flexibility for both of the partners and thus more flexibility in choosing the time

of commuting. However, one can assume that if a partner works on a particular day, this may be more important than men working less after childbirth. However, allowing men to work less after childbirth does not imply working less on the same day. Thus, the variables of work-related attitude and a partner working on a particular day are not substitutable.

The analyses also considered age and education level as socio-demographic variables. In addition, commuting duration and experience about congestion were indicators for commuting conditions. Only education level showed a significant impact. Respondents with a lower education level were less likely to commute during morning rush hours, and respondents with a higher education level were more likely to commute during afternoon rush hours. This is related to the fact that higher-educated persons generally have longer commuting distances than others. Similarly, the results showed a positive influence of longer commuting time on rush hour commuting in the afternoon (i.e., an employee with a commuting duration of more than 30 min is more likely to travel during the afternoon peak traffic period). This is understandable given that a longer commuting distance means fewer possibilities to avoid rush hours compared with shorter commuting distances. However, commuting duration largely depends on the residential and work locations of the respondents. In general, women have shorter commuting distance than men do. Therefore, women may have options to avoid car commuting more often than men do, especially in the Netherlands where cycling is a suitable alternative. We could not reflect on this issue because our sample looked solely into commuting by car. With respect to lower-educated respondents, this would mean shorter commuting distances, and therefore, the probability of avoiding rush hours is higher. However, this may also be related to work arrangements. For instance, lower-educated job sectors, such as construction works, often follow nontraditional work schedules. Although part-time work, working as a professional or manager and personal attitudes were controlled for, the additional influence of education level could either mean a combined effect of the job and attitudes, which were not significant separately, or represent unobserved working preferences and different personal attitudes such as a preference to work early in the morning or working late in the afternoon to have a day off later.

Finally, we found that none of the interaction effects between gender and other significant variables were significant. Therefore, the interaction variables are not included in Table 2. The insignificance in the interaction effects meant that the effects of different work situations, activity scheduling and personal attitudes were not gender specific. A reasonable explanation can be that our sample may be selectively looking into a special group of women who were more similar to men, for instance, working women and those commuting by car.

5. Discussion

This paper has emphasized the influence of daily activity scheduling and household responsibilities on rush-hour commuting. We found that household and child-related activities were important daily activities that were mostly associated with commuting during rush hours. These maintenance activities were even more important than the commuting duration and congestion experiences. Our result suggested that an individual may be very annoyed with regular congestion, yet s/he would continue to commute during rush hours due to other household responsibilities. Furthermore, our results suggested that consideration of personal attitudes was not sufficient to represent rush hour commuting. The Appendix A shows that the addition of personal attitudes did not improve the model performance because the adjusted Rho-squares remained unaffected. Therefore, an assessment or prediction of the policy impact on rush hour commuting should account for household activities and responsibilities, which can affect the rush hour avoidance significantly. Assessments based on only congestion cost or time saving may lead to erroneous results.

The paper also found that women were commuting during rush hours in the morning but avoiding rush hours in the afternoon. In other words, they may follow regular commuting in the morning to keep their afternoon open and flexible for different activities. However, it could not be ascertained whether this was due to childcare or household activities. These activities did not affect the significance and the contribution of gender to rush hour commuting when they were included in the models. Rather, the effect of being female increased in the morning rush hour analysis. Statistically, this can be explained by the presence of unobserved issues related to gender that encouraged commuting during morning rush hours. However, this can also be interpreted as men being responsible for the morning childcare and other activities because the coefficient value for males decreases (i.e., an increase in the coefficient value for females) with the addition of these activity variables. In other words, men are more likely to avoid rush hours when childcare and similar activities were accounted for. Therefore, it is important to know how these activities are shared between partners, and this requires further investigation considering intra-household interactions.

Although this paper contributes to a better understanding of rush hour commuting by considering important and often-ignored activities, it is worth noting that several issues remained unobserved due to data limitations. This paper could not account for cultural and geographical issues, whereas accessibility to services, schools and other travel modes are expected to affect the outcomes. Furthermore, a consideration of daily activities only around the time of commuting can provide only a limited explanation for rush hour commuting. The activity schedules of the rest of the day or other responsibilities such as social and recreational activities may also have important influences. This may be one of the explanations why women choose to avoid the afternoon rush hours instead of the morning rush hours. Women may do a bundle of household activities, including child care, household maintenance and other activities, because women are usually more involved in these activities than men (Sanchez and Thomson, 1997). Furthermore, the afternoon may provide more flexibility not only in terms of business operating hours but also in terms of a longer time span to take care of children and other household tasks. Therefore, overall activities may play an important role in choosing the morning rush hours instead of the afternoon rush hours. On the other hand, a household situation may depend largely on the negotiation process between the partners and the decision of where to live and work. Households may choose to live close to the work place of the wife, thereby increasing the opportunity to travel by other modes, which was not included in our analyses. Therefore, we found that the men and women in our sample were more similar in terms of the effects of different influential factors. This may have implications for our results.

Nonetheless, the results of our analyses are generally consistent. For instance, a longer commuting time increases and working from home decreases the probability of rush hour commuting. Importantly, this study shows gender differences in rush hour commuting behavior. Simultaneously, it notes the distinction between the morning and the afternoon rush hours.

6. Policy implications

Rather than providing direct recommendations, this paper intends to provide important insight about rush hour commuting that would work as a precursor to better policy formulation and

implementation. In this regard, this study provided two important results as follows: first, it showed not only gender difference in rush hour commuting but also gender differences in the choice of the time of day; second, household responsibilities are important factors in rush hour commuting irrespective of the time of day.

These findings are helpful to identify the most likely time of congestion given the increasing share of the labor market participation of women. Although it cannot be ascertained, the analyses indicated that the morning rush would be more likely if we had observed increased female participation in the work force. Thus, the analyses provided a better ground to predict time variability in traffic volume and demand during rush hours and to formulate policy accordingly. Most importantly, our recommendation is that policies should take into account behavioral differences between men and women and avoid generalizing policies. A direct example is the rewarding scheme for avoiding rush hours as a congestion policy, which was tested in different locations in the Netherlands. Few of these policies have been successful in terms of the social costs and benefits (MuConsult, 2013). A common finding of these policy initiatives was that women were less motivated by rewards. Note that most of the rewards were based on the morning rush hours. Knowing that women are more likely to avoid the afternoon rush hours is important feedback to such policy initiatives. This information will eventually affect travel demand analyses and policy evaluation, which are currently based on an aggregation of the outcomes from the morning and the afternoon rush hours. The contribution of this paper in this regard lies in the area of rush hour avoidance.

Moreover, our results showed that morning was generally the most likely time to commute during rush hours. Even after consideration of different factors, morning rush hour avoidance was negatively affected by the constant. However, the constant was not significant for the afternoon rush hours. This means that the afternoon rush hours were mostly affected by the factors considered in this study. Work-related policies targeting a change in behavior during the morning peak traffic period may not be effective, most likely due to the space and time constraints of performing different household activities in the morning.

Similarly, knowing that neither the commuting situation or work situation leads women to commute during the morning rush hours is very useful information for future policy formulation. For instance, women with part-time jobs and work flexibility may still be traveling during morning rush hours due to other household responsibilities. In this case, childcare activities and child chauffeuring can significantly increase the likelihood of morning rush hour commuting. Finding the right target is of the upmost importance for effective policy formulation, either the right population segment or the right factors. However, the factors in these analyses are the choices of individuals and households. Therefore, to recommend policy regarding household and childcare activities, more information about accessibility and the interactions between partners is needed.

Nonetheless, the most important factors are related to work flexibility. If people are allowed to work from home more often, a higher level of rush hour avoidance can be observed. This may not lead to a reduction in gender differences, but it serves the higher goal of encouraging commuting outside rush hours. In addition to already-known work-related issues, our results suggested that people may not avoid rush hours due to household activities and responsibilities. We may not realize our expected outcome in terms of rush-hour avoidance by providing higher work flexibility or rewards. We now know to what extent and when this outcome may be affected by household responsibilities and how it may differ between men and women.

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Appendix A

See Tables 3 and 4.

Table 3
Results for the morning rush-hours commuting.

	Model 1			Model 2			Model 3		
	β	t-test		β	t-test		β	t-test	
Constant (Choice 0 – commuting outside rush-hour at day t)	−1.13	−2.18	**	−1.69	−2.81	***	−1.82	−2.36	**
Random effect between individuals	3.95	8.27	***	4.11	8.08	***	4.06	8.08	***
Mean (fixed)	0.00			0.00			0.00		
Age of the respondent > 50 years	0.13	0.23		0.23	0.38		0.50	0.82	
Respondent is a female	2.16	3.21	***	2.39	3.39	***	2.60	3.60	***
Respondent's highest education achieved									
Higher education (HBO/UNI)	0.89	1.52		0.84	1.36		0.77	1.26	
Lower education (BO/LO/MULO)	−0.98	−1.43		−1.03	−1.46		−1.19	−1.68	*
Other (ref.)									
Working status									
Respondent has a part-time job	−0.85	−1.29		−0.97	−1.42		−1.16	−1.69	*
Respondent has professional/managerial work	0.30	0.53		0.17	0.28		0.23	0.40	
Commuting condition									
Respondent's commute duration > 30 min	−0.27	−0.69		−0.41	−0.99		−0.37	−0.88	
Respondent is very annoyed with congestion	−0.51	−0.62		−0.57	−0.66		−0.56	−0.65	
Working flexibility									
Respondent receives company car	2.79	2.87	***	2.84	2.80	***	2.73	2.73	***
Respondent can choose own work time	−1.10	−1.65	*	−1.26	−1.77	*	−1.31	−1.85	*
Respondent is allowed to work 8 h/week from home	0.23	0.27		0.52	0.57		0.37	0.41	

(*continued on next page*)

Table 3 (*continued*)

	Model 1			Model 2			Model 3		
	β	*t*-test		*β*	*t*-test		*β*	*t*-test	
Daily activity schedule									
Respondent performs childcare before/after commute				1.81	2.02	**	1.79	2.02	**
Respondent performs child related travel before/after commute				1.81	2.40	**	1.82	2.41	**
Respondent performs HH work before/after commute				−0.70	−1.87	*	−0.73	−1.94	**
Respondent works at home before commute				−2.10	−2.17	**	−2.14	−2.19	**
Partner works on the day				−0.68	−1.67	*	−0.68	−1.66	*
Responsibility sharing attitudes of the respondent									
Women are suitable for up-bringing babies							0.38	0.71	
HH works are responsibility of both men and women							−1.30	−2.19	**
For women, childcare is an attractive alternative to a not so nice job.							0.09	0.18	
Men and women should work equally							−0.25	−0.40	
Men should work less after childbirth							0.79	1.42	
Adjusted Rho-square	0.297			0.309			0.308		

* *p*-Value 0.05–0.10.
** *p*-Value 0.01–0.05.
*** *p*-Value 0.00–0.01.

Table 4
Results for the afternoon rush-hours commuting.

	Model 1			Model 2			Model 3		
	β	*t*-test		*β*	*t*-test		*β*	*t*-test	
Constant (Choice 0 – commuting outside rush-hour at day *t*)	0.13	0.38		0.05	0.12		−0.34	−0.71	
Random effect between individuals	2.44	8.15	***	2.45	8.11	***	2.42	8.03	***
Mean (fixed)	0.00			0.00					
Age of the respondent > 50 years (Y/N)	−0.33	−0.91		−0.31	−0.84		−0.34	−0.90	
Respondent is a female (Y/N)	−0.73	−1.73	*	−0.73	−1.71	*	−0.81	−1.87	*
Respondent's highest education achieved									
Higher education (HBO/UNI)	0.83	2.22	**	0.88	2.30	**	0.92	2.42	**
Lower education (BO/LO/MULO)	0.18	0.39		0.17	0.37		−0.04	−0.10	
Other (ref.)									
Working status									
Respondent has a part-time job	−0.32	−0.74		−0.27	−0.62		−0.34	−0.76	
Respondent has professional/managerial work	−0.42	−1.14		−0.44	−1.19		−0.34	−0.93	
Commuting condition									
Respondent's commute duration > 30 min	0.54	1.94	**	0.50	1.77	*	0.54	1.92	*
Respondent is very annoyed with congestion	−0.49	−0.89		−0.44	−0.79		−0.39	−0.71	
Working flexibility									
Respondent receives company car	0.33	0.63		0.27	0.51		0.19	0.36	
Respondent can choose own work time	0.28	0.65		0.31	0.71		0.22	0.49	
Respondent is allowed to work 8 h/week from home	−0.99	−1.63		−0.83	−1.36		−0.91	−1.50	
Daily activity schedule									
Respondent performs childcare before/after commute				1.48	2.08	**	1.46	2.06	**
Respondent performs child related travel before/after commute				−0.78	−0.85		−0.69	−0.76	
Respondent performs HH work before/after commute				0.10	0.33		0.13	0.47	
Respondent works at home after commute				−2.25	−3.14	***	−2.26	−3.15	***
Partner works on the day				−0.19	−0.66		−0.13	−0.46	
Responsibilities sharing attitudes of the respondent									
Women are suitable for up-bringing babies							−0.06	−0.19	
HH works are responsibility of both men and women							−0.52	−1.36	
For women, childcare is an attractive alternative to a not so nice job.							0.35	1.05	
Men and women should work equally							0.62	1.59	
Men should work less after childbirth							−0.66	−1.89	*
Adjusted Rho-square	0.104			0.111			0.109		

* *p*-Value 0.05–0.10.
** *p*-Value 0.01–0.05.
*** *p*-Value 0.00–0.01.

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