Synchronization of home departure and arrival times in dual earner households with children: Panel regression model of time gaps

Bilin Han*, Harry Timmermans
Urban Planning Group, Eindhoven University of Technology, Eindhoven, the Netherlands

HIGHLIGHTS
- Time gaps departure and arrival time of parents and children vary as a function of gender, age and gender of youngest child.
- Time gaps are smaller for departures compared to arrivals.
- Considering children’s agendas is critical in developing models of work schedule arrangements.

ABSTRACT
Organizing schedules and allocating time to different activities is always a challenge in dual-earner households, especially when they have children. Parents may need to link their schedule to those of their children to allow them escorting their children to school or to take care or be with their children at home. This paper reports the results of an analysis of the degree of synchronization of home departure and arrival times in dual earner households with children, where the degree of synchronization is defined as the gap between departure and arrival times of a parent and child. Using activity-travel diary data of different household members, a random parameters regression model is estimated to examine differences in time gaps in home departure and arrival times between parents and children as a function of gender, day of the week, age of the youngest child, and other socio-demographic characteristics. The results of the analysis provide insight into factors influencing the degree of synchronization and coordination of double activity-travel scheduling decisions in households with children. Findings indicate that gender, number of children in the household, age of the youngest child, travel within or outside peak hours, day of the week, transport mode used for the work commute and household income level significantly affect time gaps, especially arrival time gaps.

© 2019 Periodical Offices of Changan University. Publishing services by Elsevier B.V. on behalf of Owner. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
1. Introduction

Despite many attempts to curtail traffic jams, congestion levels are still on the rise in many countries and cities. Although the idea of zero congestion is likely an idle dream, this does not mean that a multitude of contributions from different disciplines is needed to at least keep congestion to a minimum and reduce the negative externalities that come with it. The challenge of urban planners is to develop strategies of urban growth that involve a balanced spatial distribution of jobs, activity locations and residential areas and stimulate the use of public transportation and slow modes (Martens, 2007; Nelson, 2017; Vos and Witlox, 2015; Yang and Pojani, 2017; Zhang et al., 2017; Zhou et al., 2017). Transportation management schemes, including intelligent transportation systems, should allow better control and optimal use of existing networks (Hashemi and Abdelghany, 2015; Hashemi et al., 2017; Wang, 2010). Congesting pricing and bonus policies may induce people to avoid traveling on particular roads at particular times (Ben-Elia and Ettema, 2009; Hess and Børjesson, 2019; Verhoef et al., 1996). Propagating teleworking (Giovanis, 2017; Lachapelle et al., 2017; Lari, 2012; Moeckel, 2017), and different start times of schools and jobs (Deka, 2017; Owens et al., 2014) may spread travel demand across time and space realizing that the spatial and temporal distribution of observed traffic flows reflects the accumulated results of a multitude of scheduling decisions of individuals and households.

However, when developing these policies and assessing their potential contribution, it should be realized that people face constraints and often can change their behavior only within certain limits, if at all. The scheduling of activities that gives rise to the aggregate traffic flows are subject to temporal and institutional constraints (Rasouli and Timmermans, 2014a). Scheduling processes in dual-earner households with children are even more complicated. Household members do not only have to consider the effects of alternate schedules in terms of their personal preferences, but tasks and resources also need to be allocated and coordinated, while in addition the presence of children implies that schedules need to be synchronized with those of the children (Deka, 2013; Ehteshamrad et al., 2017a, b; Fox et al., 2015; Hsu and Saphores, 2014; McDonald and Aalborg, 2009; Mehdizadeh et al., 2016).

Considering the rapid increasing number of dual-earner households (with children) all over the world (e.g., the proportion dual-earner households in the United States has doubled, from 25% (1960) to 60% (2012), (Pew Research Center), in Netherlands from 51% (2005) to 57% (2009), (CBS). In Canada, the number of dual-earner households with children increased from 36% (1976) to 69% (2015), (Statistics Canada), the topic is highly relevant. Different agendas and different degrees of commitments, jointly with possible lack of flexibility, may imply that children need to spend home alone for some time. In this paper, we use the time gap to reflect the degree of departure and arrival synchronization between parents and children. How big is the time gap between their departure/arrival time from/to home and the departure/arrival time of their children? Does the spouse working on the same day affect respondents’ departure time and/or arrival time decisions? Does symmetry exist between departure and arrival time gaps? Is there evidence of gender differences in the synchronization of schedules? What is the influence of children’s characteristics? These questions will be addressed in the present study.

An examination of the literature reveals that topic has hardly been directly addressed in prior research. Klaveren and Van den Brink (2009) found that couples tend to synchronize their work schedules to have more joint leisure time. The synchronization of work schedules, however, decreases if they have young children because of the need to take care of them. Gupta and Vovsha (2013) formulated a hybrid discrete choice-duration choice model. Its results suggested a strong synchronization of work schedules in multiple-worker households.

The degree of synchronization of different agendas is related to time and task allocation decisions in the household. The parent who spends less time on mandatory activities may have more flexibility and may therefore be better able to synchronize his/her activities and those of other household members. Task allocation in traditional households tends to be based on classic gender roles. Fathers tend to be mostly responsible for bringing in household income whilst mothers tend to take charge of household and children-related activities. Several studies revealed that mothers tend to take a larger share of escorting children than fathers (Barker, 2011; Ekert-Jaffé, 2011; Fyhri and Hjorthol, 2009; Hjorthol and Vagane, 2014; Scheiner and Holz-Rau, 2012; Scheiner, 2016a, b). Consequently, the importance of synchronizing their schedules with the children’s schedule is higher than for fathers. In dual-earner households, however, mothers also participate in the workforce, which may lead to less flexibility and more constraints in time and space. Consequently, fathers may also need to synchronize their schedules with those of the children and their spouse.

To add to the scarce literature on schedule synchronization, the present paper reports the results of an analysis that examines differences in departure and arrival times between parents and children. A random effects regression model is estimated to examine the size of the differences and the effects of a set of covariates.

The remainder of this paper will provide details of the design of our study and the answers to the formulated questions. We set out with a discussion of the data collection. Next, we will explain the analysis that was conducted and discuss the results of the analysis. A summary and discussion of main findings and future work completes the paper.

2. Data

2.1. Sample selection

Synchronization of schedules, or the lack of it, can be captured in terms of time gaps between home departure, respectively arrival times of different members of a household. In order to analyze the effect of co-variates on such gaps, data are needed from a sample of dual-earner households with children about
departure and arrival times of all household members, together with contextual information.

To that end, a web-based survey was designed and administered to a sample of a national buy-in panel. This panel is representative of the Dutch population. The survey collected data about personal and household characteristics, parents’ work schedules, children-related agendas, household task allocation, and attitudes towards the trade-off between work and children-related activities under social influence. This paper is based on part of the collected data, particularly the part concerned with socio-demographic characteristics, the work schedules of the parents, and the children-related agendas. Information about work schedules included the departure time from home and the arrival time at home for the spouses, total number and timing of working hours, travel time, and transport mode. Data about children-related agendas included activity type, including school and day care, departure time from home, duration of the escorting episodes, travel times, arrival time at home, and who is escorting the children.

The web-based questionnaire was administered to the opt-in panel. Our target sample was 1000 respondents. This number was based on experiences with similar research. Note that the minimum sample size for binary variable with a 5% error and a 95% confidence level is 385 respondents. Technically, the respondents received a link to our local server, and hence their privacy was protected. The questionnaire was distributed to potential panelists in the sense that respondents had to work, belong to a dual earner household and have at least one child younger than 12. Once the target number of questionnaires was reached, which in this case was 1000, the data collection ended. In the present case, the data collection took just 3 days.

The questionnaire was designed using internally developed software. It has the same functionality as commercial survey software, but has some templates for data collection.

![Fig. 1 – Distribution of sample characteristics. (a) Gender. (b) Age. (c) Education. (d) Household income. (e) Number of children in household. (f) Age of the youngest child. (g) Gender of the youngest child.](image)
2.2. Sample characteristics

For the present analysis, only the 685 dual-earner households with children were selected from the sample. The frequency distributions of the selected socio-demographic characteristics are shown in Fig. 1. The frequency distribution of male and female respondents is 44.23% and 55.77% respectively. The percentages of three age categories are 4.67%, 84.67% and 10.66% respectively, indicating that the majority of the respondents is between 26 and 45 years old. In Fig. 1, the percentage of respondents with a low and a high level of education is 3.36% and 51.53% respectively, while 45.11% of the respondents has medium level education. The majority of the respondents has a household income larger than 2801 Euro/month, while the percentage respondents with a lower household income level, less than 1400 Euro/month and between 1401 and 2800 Euro/month is only 3.65% and 9.20% respectively. Fig. 1 also indicates that only 6.90% of the respondents has more than two children, which means that more than 90% of the respondents only has one or two children. Fig. 1 also shows that more than 50% of the respondents’ youngest child is younger than five years old, while the percentage youngest child between 5–8 years and 9–12 years old is 20.00 and 21.46% respectively.

Fig. 2 shows the distribution of the work schedules of respondents and their spouses, classified into flexible and non-flexible schedules, and the distribution of their working hours across weekdays. It indicates that most respondents and their spouses have a fixed weekly work schedule; only a small portion has a flexible work schedule. As shown in Fig. 2, the total number of respondents working out of home on Monday, Tuesday, Wednesday, Thursday and Friday is respectively 68.2%, 69.1%, 59.6%, 66.7%, and 58.0%, and 66.4%, 67.9%, 58.83%, 65.3%, and 59.4% for spouses, suggesting that less people work on Wednesday and Friday. To understand these statistics, it is important to realize that elementary schools tend to be closed on Wednesday afternoon. People working part-time may not work on that day to take care of their children. Friday is another popular non-working day for people working part-time because it will extend their weekend.

Fig. 3 depicts the home departure and arrival time distribution of respondents and their children from Monday to Friday. As shown in Fig. 3, the departure peak of both parents and their children tends to be between 7 a.m. and 9 a.m. on weekdays, with the intuitive observation that on average the children’s departure time is later than those of the respondents. This finding is consistent with the morning peak (7 a.m.—9 a.m.) in Netherlands (CBS). By contrast, the arrival peak of the respondents and the children shows a more dispersed tendency compared with the departure peak. As for respondents, the main arrival peak tend to occur between 16 p.m. and 19 p.m. However, the graphs also indicate that home arrivals are scattered during the whole afternoon. In addition to flexible working hours and flexible work schedules, it can be explained by the fact that a relatively large percentage of women only work part-time with flexible number of working hours. For children, the arrival times differ significantly by days of the week. For instance, the main arrival peaks of children on Mondays, Tuesdays and Thursdays, tend to concentrate around 15 p.m. This is mainly due to school closing hours. The arrival peaks of children on Wednesdays and Fridays tend to concentrate around 12 p.m., 15 p.m. and 18 p.m. respectively. The reason of this dispersed tendency of children arrival times is that elementary schools tend to be closed on Wednesday afternoon. On Friday, there is a relatively large share of parents not-working or only working half a day. Consequently, the can limit the number of hours children go to day care. Fig. 3 also indicates that, on average, the arrival time of parents is later than those of children.

3. Analysis and results

The collected data allow the construction of different gaps between home departure respectively home arrival times of parents and children and between parents, providing different perspectives on the synchronization and coordinating of schedules. In particular, differentiating between home departure and home arrival gaps, the following gaps were calculated from the data on work schedules and children-related agendas.

\[ \text{DG}_{\text{dep}} = t_{\text{dep}} - t_{\text{dep}} \quad \text{(1)} \]

\[ \text{AG}_{\text{arr}} = t_{\text{arr}} - t_{\text{arr}} \quad \text{(2)} \]
Fig. 3 – Distribution of home departure and arrival times. (a) Departure time on Monday. (b) Arrival time on Monday. (c) Departure time on Tuesday. (d) Arrival time on Tuesday. (e) Departure time on Wednesday. (f) Arrival time on Wednesday. (g) Departure time on Thursday. (h) Arrival time on Thursday. (i) Departure time on Friday. (j) Arrival time on Friday.
The time gaps between the respondent and child can reveal time use and task allocation in a household. Take the home departure gap as an example (Fig. 4). A negative departure gap means that the respondent departs earlier than the child, which indicates that the respondent did not drop off the child. If the spouse also departs earlier than the child, the departure gap indicates that the child was home alone, or was accompanied by someone else than one of the parents.

When the household consists of more than one child, departure and arrival times may differ across children. Therefore, in multi-children households, two different gaps were defined: the departure gap between respondent i and the last child c leaving home (DGap), and the arrival time gap between the respondent and the first child arriving home (AGap).

\[
\text{DGap} = t_{\text{i-dep}}^{\text{c}} - \max(t_{\text{i-dep}}^{\text{c}})
\]

\[
\text{AGap} = t_{\text{i-arr}}^{\text{c}} - \min(t_{\text{i-arr}}^{\text{c}})
\]

The research questions posed attempt to analyze regularities, if any, in these gaps. The magnitude of the gaps was analyzed as a function of socio-demographic characteristics, work status in the household, transport mode to work, and day of the week, as shown in Eq. (5). Socio-demographic characteristics included gender, age, education level, household income, age of the youngest child, number of children, gender of the youngest child, work status of the parents, transport mode and days of the week. Gender was included as an explanatory variable to examine any gendered-differences in gaps. Based on prior studies, we expect women to spend a larger of their time on child care. Age was selected to reflect the possibility that task allocation differs by age. Education level was chosen as an explanatory variable because it may be a proxy variable for different gender roles in dual-earner households. Household income may reflect similar differences, but will also affect how easy household can pay for day care or hiring help at home. In this study, considering that people may wish to spend more time with their younger children than older children, gaps may also be affected by the age of the youngest child. The age of the youngest child was therefore categorized into younger than 5 years, 5–8 years, and 9–12 years. Number of children relative to household composition is relevant in the sense the presence of older children in the household may give parents more flexibility as older children can take care of younger children. The more children in a household, the more complicated for parents to synchronize their departure/arrival times with those of the children. Gender of the youngest child was included to allow for any gender-match in deciding on escorting activities. Spouses' work status may also affect gaps. If the spouse does not work on the same day as the respondent, the opportunities to organize children-related activities are increasing, while constraints tend to decrease. In contrast, if the spouse also works on the same day, the adults need to allocate the children-related escorting activities, which may affect their departure and/or arrival time decisions. Transport mode was selected as an explanatory variable because it may also affect the time gaps depending on their attributes such as speed and flexibility. Flexible transport modes, including car driver, cycling, walking, etc., will not restrict respondents' departure and arrival time decisions. However, non-flexible transport modes, particularly public transportation are organized on fixed schedules and therefore tend to involve temporal and spatial constraints on respondents' departure and arrival time decisions. Particularly, if the frequency of service is low, gaps more increase for this reason only. Also if access and egress times are substantive, the concerned parent may have to leave earlier to be at work on time. Moreover, uncertainty in travel times also varies by transportation mode and time of day. For instance, travel time may differ between peak-hours and off-peak hours for cars and bus public transport, but maybe less for cycling and train/metro. Prior research has indicated the effects of travel timing variability on activity-travel scheduling (Liao et al., 2014; Rasouli and Timmermans, 2014b, c). Finally, different days of the week may affect time gaps owing to different out-of-home children-related activities across different days, working habits, etc. Because the same respondent provided multiple responses across different days of the week, a random parameter regression model with panel effects was estimated. To allow for heterogeneity in scheduling decisions, random parameters were estimated for gender, peak hour travel, the spouse working on the same day, number of children, age of the youngest child and gender of the youngest child. A normal
distribution was assumed for all random parameters. Fixed
parameters were estimated for the remaining variables. All
categorical variables were effect coded. Thus, the estimated
model can be expressed as

\[
\text{DGap}_i = \beta_0^D + \sum_{m} \sum_{l=1}^{L_m} \left( \beta_{ml}^D + \theta_{ml}^D \right) x_{iml} + \sum_{m} \sum_{l=1}^{L_m} \gamma_{ml}^D x_{iml} + \epsilon_i \tag{5}
\]

\[
\text{AGap}_i = \beta_0^A + \sum_{m} \sum_{l=1}^{L_m} \left( \beta_{ml}^A + \theta_{ml}^A \right) x_{iml} + \sum_{m} \sum_{l=1}^{L_m} \gamma_{ml}^A x_{iml} + \epsilon_i \tag{6}
\]

where DGap and AGap are respectively the home departure
gap and arrival gap of individual i, \( \beta_0 \) is the constant, \( x_{iml} \) codes

individual \( i \) on one of the levels \( l \) of variable \( m \), \( \beta_{ml} \) is the effect
of the \( l \)-th category of the \( m \)-th variable \( x_{iml} \), \( \gamma_{ml} \) is the random
effect of the \( l \)-th category of the \( m \)-th variable \( x_{iml} \), which is
assumed IID normal distributed, \( L_m \) is the number of cate-
gories of variable \( m \), \( \epsilon_i \) is an error term.

Note that an individual was invited to provide the data for
every home-based trip. Thus, the two gap measures may have
multiple observations that entered the regression model.
Because the same unobserved personality traits, attitudes and
other omitted variables may affect the gap measurements,
panel effects were estimated.

The estimated results for the departure time gap and the
arrival time gap are summarized in Table 1. The R-squared of
the DGap and AGap models are respectively 0.16, and 0.23 respectively, which suggests that the relationships are weak to modest. The first part of Table 1 lists the estimated coefficients of the variables with random parameters, followed by the second part, which concerns the estimated coefficients of the variables with fixed parameters. The last part of Table 1 presents the scale parameters of the random parameters.

As shown in Table 1, the estimated constant of the DGap is negative, while the constant of the AGap model is positive. This indicates that, on average, the home departure time of the respondents is earlier than the home departure time of their children, while the home arrival time of the respondents is later than the home arrival time of their children. These results are consistent with the distribution of departure and arrival times of respondents and their children depicted in Fig. 3. Gender significantly affects both home departure and arrival time gaps. Male respondents have a bigger time gap for both departing from and arriving at home, implying they leave home earlier and arrive at home later than females. Travel during peak hours also generates significant effects for both the departure gap and the arrival gap. The departure gap becomes smaller if the respondent travels during the morning peak hour, in contrast to the bigger arrival gap when respondents travel during evening peak hours. An explanation may be that the percentage start times of children's school/daycare during the morning peak hours is also higher.

The estimated effects for the variable indicating whether the spouse works on the same day show a very interesting result. The arrival gap between the respondent and the first child is significantly bigger if the spouse does not work on the same day. It might be that on those days respondents do not need to coordinate their schedules, but can choose more freely when to arrive at home. However, these effects are not significant for the departure time gap. It may suggest that individual's departure time to work is less affected by the spouse's work schedule. If only one spouse is working on a specific day, the spouse who is not working tends to take charge of children-related activities such as escorting. The estimation results for the number of children in the household indicate that gaps in both departure and arrival times tend to be bigger with an increasing number of children in the household. Similarly, the estimated coefficients for the age of the youngest child suggest that both the departure and arrival gap increase with increasing age, which indicates that parents tend to spend more time with younger children, as well as if there is only one child in the household. It also indicates that children are easier left home alone more when they get older.

Table 1 also indicates that younger parents (≤25 years) tend to have a bigger departure gap and arrival gap than older parents. As for education level, a low education level is associated with a significant negative home departure time gap, suggesting that people with a low education level have a bigger departure time gap than those of medium and high education levels, while the arrival gap tends to smaller for respondents with a primary education level. Respondents with a lower household income have a smaller departure time gap than those with a higher household income. One reason may be that they work less. The estimated coefficients for transportation mode suggest that both the departure and arrival gap decrease significantly when respondents traveling to work by car. This finding may reflect the higher flexibility in choosing departure times for the care and the higher average speed of this transportation mode.

Table 1 also indicates that the effects of days of the week are not significant for the departure time gap, but strongly influence the arrival time gap. The arrival time gaps are smaller on Monday, Tuesday and Thursday, while they are bigger on Wednesday and Friday. The biggest average arrival time gap is found on Wednesday. Taking into account that most elementary schools are closed on Wednesday afternoon in the Netherlands. Results may suggest that people tend to trade-off between work and taking care of their children, but not simply pursue the synchronization of arrival times.

Because all random parameters are significant, the estimated effects show strong evidence of heterogeneity in the size of the departure and arrival gaps and the effects of the relevant covariates.

4. Conclusions and discussion

The purpose of this study has been to analyze the degree of synchronization in home departure and arrival times between working parents and their children. Synchronization of schedules was measured in terms of time gaps in home departure and arrival times of a working parents and their children. A random parameter regression model with panel effects was estimated to examine the explanatory power of gender differences, contextual effects, children effects and socio-demographic characteristics effects on the extent of the time gaps. Estimation results give rise to some interesting conclusions. First, home arrival time gaps are more influenced by the various attributes than home departure time gaps. To understand this, we need to realize that the time in morning between getting up and departing from home that can be used to organize household activities is limited. The evening period after arriving home and before going to bed is much longer. This may give rise to more variation in arrival times back home, depending on the selected explanatory variables. Second, gender roles significantly affect time gaps. Males depart earlier and arrive later than females on average, suggesting that males contribute more working hours on average, while women contribute a higher share of caring activities. Third, arrival time gaps in single child households/households with young child (≤4 years) are small, indicating that parents tend to synchronize arrival times to avoid the child stays at home alone and spend more time on taking care of young children. Fourth, work status of parents on a day affect time gaps significantly, if the spouse does not work on the same day, people tend to extend their working hours by departing earlier and arriving later because they do not need to coordinate their schedules, considering children-related activities. This phenomenon also reveals the role of time and household activity allocation between parents, as they need to trade-off time allocation between work
and household activities to generate enough income to support daily life as well as have sufficient time to cope with children-related activities. Fifth, people who use the car as their transport mode tend to depart later and arrive earlier than people using other transport modes, indicating that using the car as the transport mode still has advantages in terms of time and flexibility compared with slow transportation modes and/or public transportation.

These findings about time gaps are related to the synchronization and coordination of work schedule arrangements between the working adults and constitute the basis for the allocation of non-work household tasks. A model of this process will improve activity-generation in current activity-based models of travel demand (Rasouli and Timmermans, 2014a, b). To that end, our future work will address the ultimate goal of the larger research project: developing a work schedule arrangement and task allocation model across household members in two adults households with children. We plan to report these further developments in the near future.

This study has contributed to the understanding of the degree of synchronization of home departure and arrival times in dual earner households with children. However, this study can be elaborated in several ways. First, this study takes one of the parent’s (respondent) work schedule in the regression model, and only considers whether their spouse works on that day. Incorporating the details of the schedules of both spouses into account may allow a more detailed analysis. Second, this study focused on temporal synchronization, but ignored spatial coordination. Different degrees of spatial coordination, such as location of school, home and office may interact with temporal synchronization, therefore affecting the time gaps. The current study is concerned with the outcomes of the underlying space-time decisions.

Conflict of interest

The authors do not have any conflict of interest with other entities or researchers.

REFERENCES


Bilin Han is a PhD candidate in urban planning at the Building Environment Department of the TU/e. Her supervisor is Professor Harry Timmermans. Her PhD project is focused on work schedule arrangement in dual-earner households with children.

Harry Timmermans is a professor of urban planning at the TU/e. Research activities of his multidisciplinary group concern the development and application of innovative models and ICT tools for urban planning and transportation. He has been awarded prestigious grants, and won many (best paper) awards with his PhD students. He serves on TRB and WCTR Committees. He has co-authored more than 600 publications in urban planning, transportation, artificial intelligence, marketing, and environmental psychology.