Determinants of Residential Mobility: An Adaptive Retrospective Survey Method

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Abstract

This study introduces a survey instrument to collect retrospective life-course events, focusing on residential relocation, then it utilises the survey to evaluate determinants of residential mobility. The survey consists of seven modules collecting information about the household structure and household demographics, latest residential relocation, current and previous home, employment, education, vehicle ownership, and travel behaviour. The time window of the life-course calendar in the survey is customised according to the latest residential relocation as an anchor point to assist with memory recollection and balance the required input from participants. The survey is used to collect data from a sample of 514 respondents in Sydney, Australia and another sample of 404 respondents in Chicago, Illinois, in the US. The Cox proportional hazard model is used to analyse residential mobility. The results show primary school commencement is a salient determinant of residential relocation, but its impact is significantly higher in Chicago compared to Sydney.

Keywords: Retrospective survey, Life-course calendar, Residential mobility, School commencement,

1. Introduction

Urbanisation is a global trend (DESA, 2018) exacerbating housing affordability, accessibility, energy consumption and transport challenges in rapidly growing communities. To plan for intensive urban growth, quantitative and behavioural methods supported by empirical evidence are essential. Although the need for an integrated approach towards land use and transport planning is acknowledged (Waddell et al., 2001, Eluru et al., 2009), targeted longitudinal data on households' long-term decisions and individuals' travel behaviour are rare. Home and work location are two long-term decisions significantly affected by and affecting urban forms. Thus urban design and transport sectors must incorporate individuals' needs and preferences on their place of residence and access to services, including jobs, schools, and daily activities.

Residential mobility (Yu et al., 2017, Short, 1978) and job mobility (Rosenfeld, 1992) directly impact individuals' living conditions and the broader economy. In the transport discipline, researchers have identified significant relationships between home location and travel decisions, including trip generation, mode choice, vehicle ownership, and car use (Scheiner and Holz-Rau, 2013b, Fujii and Gärling, 2003, Hjorthol et al., 2010, Aditjandra et al., 2016, Prillwitz et al., 2006, Oakil et al., 2011, Woods and Ferguson, 2014). In the state of practice, modelling the transport demand is closely related to the spatial distribution of activities, as most urban movements occur between home and work locations[1]. On the other hand, it is shown that home location (Zhou and Kockelman, 2008) and vehicle ownership (Schimek, 1996, Ghasri et al., 2018) have direct impacts on travel behaviours (Müggenburg et al., 2015, Demoraes et al., 2019).

[1] In Sydney Australia more than 50% of daily trips are mandatory trips with fixed destination NSW 2010. Transport Data Centre (2010) 2008/09 Household Travel Survey Summary Report 2010 Release. REPORT.

The interactions between household members and their contribution to the final decision of the household is another source of complexity in housing-related decisions (Rashidi et al., 2011).This complexity varies depending on the household structure, income level, socio-demographic attributes, and vehicle ownership. Capturing these interdependencies requires reliable and representative data on residential, job and education background of household members , along with their household dynamics and travel behaviour attributes.

Studying households long-term decisions, including residential mobility, requires longitudinal data, which is costly to collect (Rashidi et al., 2011, Murakami and Watterson, 1992). Surveys on household long-term decisions are rare. Almost all the previous life-course calendar studies report memory recollection (Schoenduwe et al., 2015, Belli et al., 2001) and participation rate (Calastri et al., 2020) as critical barriers.

The main contributions from this study are twofold. As the first contribution, we present an innovative approach to collect life-course calendar history on home, job, and education-related events. The survey instrument in this study is different from its counterparts in three directions. First, unlike previous surveys, which collect information from respondents for a predetermined period, this survey uses an adaptive timeline to balance the amount of collected data from respondents according to their life events. Second, this survey uses visual aids to assist respondents with memory recollection. Third, this survey collects data on households' dynamics and members interactions to develop a version that can provide insights intothe interrelationships between household dynamics and mobility patterns. The second contribution of this study is a showcase of how the collected data using this survey instrument can provide new insights on residential mobility (Yu et al., 2017, Ghasri and Rashidi, 2018) with a focus on school commencement. Previous studies suggest that life-course events can affect residential mobility. Still, the focus is primarily on employment (e.g. Böheim and Taylor, 2002,

Clark and Davies Withers, 1999) and family structure (e.g. Clark, 2013, Clark and Onaka, 1983). This paper contributes to this stream of research by investigating potential impacts from school commencement on residential mobility.

The rest of the paper is organised as follows. Section 2 includes a brief review ofconsists of a short review of the literature of longitudinal surveys on life course events and the literature of residential mobility in section 2. Section 3 explains the structure and details of the survey instrument in this study. Section 4 presents the results from the implementation of the survey to collect data in Sydney, Australia and Chicago, USA, along with a descriptive and comparative analysis of the collected data for the two cities. , in section 5, the methodology of residential mobility modelling is presented, and in section 6, the modelling results are discussed. The highlights of the study are summarised in the conclusion section.

2. Literature Review

2.1. Life-Course Calendar Survey

From a methodological perspective, survey instruments on life-course events can be divided into longitudinal studies and retrospective surveys. In the longitudinal studies, a sample panel representative of the population is surveyed multiple times (usually every year) over a relatively long period (generally more than ten years). These surveys are often conducted at the national level and are supported by government bodies to provide a holistic understanding of society, life changesthe national level, and are supported by government bodies to provide a holistic understanding of society, life changes, and stability. Examples of longitudinal surveys include the longitudinal survey of Household, Income and Labour Dynamics in Australia (HILDA) (Wooden and Watson, 2007) or the UK Household Longitudinal Study (HLS) (McFall et al., 2010). These surveys are overarching in their data collection to encompass several domains (e.g. background, education, health, finance, income, relationship, wealth,

etc.) and enable research in diverse and multidisciplinary directions. However, the collected discipline-specific information is not always detailed and comprehensive. For instance, HILDA includes information about residential, employment and education history of individuals, as well as their household dynamics; however, it does not provide much insight on individuals' travel behaviour and trip patterns; and consequently, it is not suitable to study travel decisions in the context of broader life.

Unlike longitudinal surveys, the retrospective surveys (Hollingworth and Miller, 1996) are more moderate in the diversity of the collected data. In these studies, the history of employment, residential, education, and car ownership is commonly collected. Depending on the scope of the investigation, other aspects may be added. For instance, the life-course history component of the study by Calastri et al. (2020) included social network history to investigate the influence of social networks on travel decisions. Nakanishi and Black (2016) explored habit formation during life stages to investigate the low propensity of snonmotorised travel modes among residents in Canberra, Australia, and Delbosc and Nakanishi (2017) studied attitudes toward driving habits in young Australian.

Retrospective surveys are not uncommon in the literature of transport studies, as cross-sectional data is not sufficient to detect trends in individuals travel behaviour (Schoenduwe et al., 2015). Behrens and Mistro (2010) conducted a retrospective survey for a group of individuals belonging to a panel study. By comparing the retrospective survey results with the data available in the panel they concluded promising accuracy in retrospective surveys in studying travel behaviour. Beige and Axhausen (2012) designed a calendar table to retrospectively collect life events and mobility patterns over 20 years from 1985 to 2004. They reported a response rate of 23.1 percent. Milakis et al. (2017) designed a quasi-longitudinal survey to study the impact of build environment on travel attitudes and travel behaviour after migration.

Lanzendorf (2010) interviewed a sample of 20 parents to investigate the role of childbirth on travel behaviour. Oakil et al. (2014) conducted a retrospective survey over 20 years from 1990 to 2010 to study the relationship between life events and household car ownership. The response rate in their study was about 40 percent. Scheiner and Holz-Rau (2013a) conducted a face-to-face interview to study changes in travel behaviour after residential relocation. The response rate is reported as 27 percent and the average interview duration is reported 58 minutes. Van der Waerden (2003) examined the role of life events on mode choice switching behaviour. They used pen and pencil survey questionnaires to collect data and they reported a response rate of 39 percent.

The two commonly reported issues with retrospective surveys are low participation rate due to the survey duration (Calastri et al., 2020) and data accuracy due to memory recollection issues (Schoenduwe et al., 2015, Belli et al., 2001). Nonetheless, the scope of some of the previous studies only requires data from a particular cohort, such as young adults (Delbosc and Nakanishi, 2017) or older adults (Nakanishi and Black, 2016). The survey instrument in retrospective surveys includes a life-course calendar. The calendar is a table where the columns represent time, and the rows represent domains such as job, home, school, and vehicle ownership. Respondents are asked to complete the table according to their life-course events. The tabular format facilitates carrying out the survey; however, recalling all the past events in all domains and reporting them is time-consuming; however, recalling all the past events in all domains and reporting them is time-consuming. Providing appropriate financial incentives is recommended to increase the participation rate (Calastri et al., 2020), but even with financial incentives.

Memory recollection is another potential issue with retrospective studies. Schoenduwe et al. (2015) mentioned three elements of intellectual competency of the respondent, the elapsed time

from an event, and the affective connotation with an event, in recalling and accurately reporting the event. They argue when memory biases are systematically handled, the memory recollection issue is unfounded (Schoenduwe et al., 2015). As a supporting example, Yu et al. (2017) explicitly asked respondents about their level of confidence regarding the provided information in a life-course calendar survey and they reported the average level of confidence between 7 and 9 (out of 10) across different cohorts.

The proposed survey instrument to reduce memory recollection issues and aims to reduce memory recollection issues to enhance the participation rate by introducing the concept of adaptive time window. The invariant time window of the life-course calendar exacerbates the survey duration and memory recollection issues, especially for those with more frequent life events. While some participants may have experienced several life-course events during the determined time window, some may have only experienced a few. It is plausible to argue that the imbalanced required information may discourage completing the survey for those with a higher number of life-course events. Furthermore, it is conceivable that as the number of life-course events increases, the affective connotation with the events drops and the memory recollection becomes more concerning. We propose an adoptive time-window in the life-course calendar to tackle these issues. The life-course component of our survey starts by asking about the latest residential relocation, and the life-course calendar will be formed around the last residential relocation. All the subsequent questions about employment, education, vehicle ownership and household dynamics will be framed around the latest residential relocation.

Belli et al. (2001) introduced three mechanisms of “top-down”, “sequential” and “parallel” cuing to enhance the quality of retrospective surveys. Sequential cuing refers to the chronological arrangement of events from the same domain to assist respondents with remembering earlier and later events. One example of sequential cuing is asking respondents

to report earlier or later residential relocations relative to a particular relocation. Parallel cuing refers to the link between events from different domains. One example of parallel cuing is asking respondents about their employment details at the time of a particular residential relocation.

In this study, the last residential relocation serves as an anchor point to recall other life-course events, as sequential and parallel cues (Belli et al., 2001). Instead of presenting an empty calendar table to respondents and asking them to complete the table, we first ask respondents about their last residential relocation. Then we used this event as an anchor point, and we asked respondents to report their home details and household structure before and after the relocation (parallel cuing). Then we asked respondents about employment, education, and vehicle ownership history regarding their last residential relocation (parallel cuing). When asking about work, education, and vehicle ownership history, we used sequential cuing to assist with memory recollection. For example, when respondents reported their job status at the time of relocation, we used that as another anchor point and asked about their employment details before and after that job. The same method is used for education and vehicle ownership as well. Besides, a fully interactive timeline is generated in the survey instrument which allows participants to cross-check their details and make adjustments if needed.

2.2. Residential mobility

Residential mobility, and other housing-related decisions, are essential elements in urban planning theoretical frameworks (e.g. Waddell et al., 2007) and they have various implications for the social stability of urban areas (Van der Vlist et al., 2002). Previous studies have investigated reasons for relocation (Coulter and Scott, 2015, Rashidi and Ghasri, 2019, Eluru et al., 2009), its ties with employment (Böheim and Taylor, 2002) and housing markets (Van der Vlist et al., 2002), and its impact on household members (Jelleyman and Spencer, 2008,

Tucker et al., 1998). The decision of residential relocation is jointly modelled with location choice (Lee and Waddell, 2010), vehicle ownership (Eluru et al., 2010), and job mobility (Clark and Davies Withers, 1999, Van Ommeren et al., 1999).

Empirical evidence is reported from investigating longitudinal datasets in different regions across the globe, including the United States (Clark and Withers, 2007, Gabriel, 2018), Netherlands (Kronenberg and Carree, 2012, Van der Vlist et al., 2002), Britain (Böheim and Taylor, 2002), Australia (Ghasri and Rashidi, 2018, Rashidi and Ghasri, 2019, Saghapour and Moridpour, 2019), China (Li, 2004), and many other countries. Accordingly, several parameters are reported as salient determinants of residential mobility, such as socio-demographic attributes of household members and household decomposition, dwelling attributes, tenure status, job and housing market, life-course events and accessibility (Clark and Withers, 2007, Gabriel, 2018, Saghapour and Moridpour, 2019, Eluru et al., 2010, Eluru et al., 2009). However, household-level life-course events, especially school commencement, is not sufficiently studied. We know individuals prefer residential locations with higher quality schools (Lawton et al., 2013), households with pre-school-age children are more mobile (Böheim and Taylor, 2002), and children's education is a significant driving force for intention to relocation (Yang et al., 2019). However, there is no empirical evidence to quantify the effect of school commencement on residential mobility. As a showcase for potential use cases of the survey instrument (discussed in section 3) and data collected using this survey instrument (discussed in section 4), the effect of household-level employment and education related life-events on residential mobility is investigated (discussed in section 6).

3. Survey Instrument

The survey aims at collecting information about residential relocation, employment, education and vehicle ownership history of individuals. As the family decomposition may vary over the

study period, respondents are asked to provide details about family structure and household members on their behalf. The survey architecture includes seven modules designed to collect a comprehensive picture of the household situation before and after their last residential relocation. Figure 1 shows the structure of the survey. The list of questions in each module are presented in appendix A.

3.1. Survey structure

The survey starts with the *respondent module,* where basic information about respondents is collected. This module includes questions on date of birth and gender. This is followed by the *home module,* which covers move-in/move out dates, property attributes, tenure type, household decomposition, and the amount of rent/mortgage if applicable. The home module is repeated twice for the current and previous properties. In the home module, respondents are asked to specify the number of household members. The next module *is HH member module* which collects the date of birth, gender, and the relationship of household members with respondents. This module will be repeated for all household members. Since the household composition may differ before and after the relocation, respondents are asked to match the reported household members with current and previous properties. The *relocation reason module* collects details about the reason for residential relocation and the decision-making process in the household. To facilitate studying household members' interactions, the survey asks about household members' contribution to household-related decisions such as investment or large purchases.

Residential mobility is closely related to the dynamics of education and employment status (e.g. Böheim and Taylor, 2002, Ghasri and Rashidi, 2015, Ghasri and Rashidi, 2019). Therefore, all household members' employment and education history around the latest residential relocation is also collected. The structure of the survey starts with collecting the

historical employment and education information of the respondent. Then it repeats the same questions for all household members. Along with employment and education, the history of vehicle ownership is also collected.

The last module in the survey is designed to collect respondents' information about their *travel behaviour*. Questions in this module include typical mode of travel for various trip purposes, frequency of using public transport, and any membership subscription with car-sharing, ridesharing, and bike-sharing services.

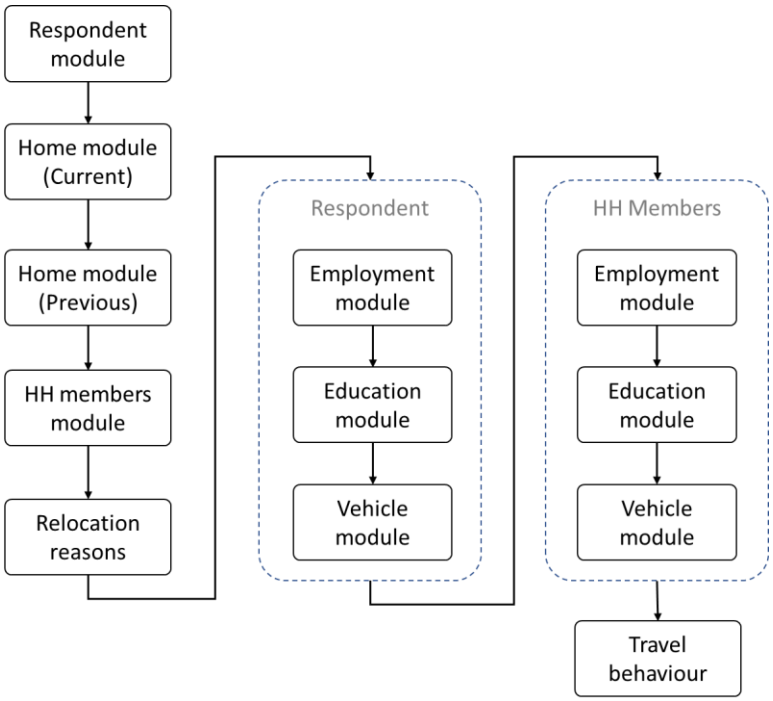

Figure 1 –Architecture of the survey

3.2. Challenges

The main challenges of the adopted retrospective method of this survey are memory recollection and the definition of the study period. Memory recollection affects the accuracy of responses to questions about the past. Decisions such as housing relocation and job relocation

cause major changes in people's lives, making them easier to remember. However, when people experience several events, it becomes more difficult to remember the details of all individual circumstances. To assist respondents with recalling the dates and complete the survey accurately, an interactive timeline is designed to visualise the history of events for the respondents. This timeline is individual specific and is presented to respondents when they completed the education, employment, and vehicle ownership modules. The timeline serves as sequential and parallel cues (Belli et al., 2001) to help with memory recollection (Schoenduwe et al., 2015). As recommended by (Calastri et al., 2020) we allowed respondents to navigate between the sections to add, revise, or remove records from any sections. Figure 2 shows an example of how the data is visualised to respondents in the body of the web-based survey instrument. The dates and words in bold faces in this figure are populated according to input from respondents.

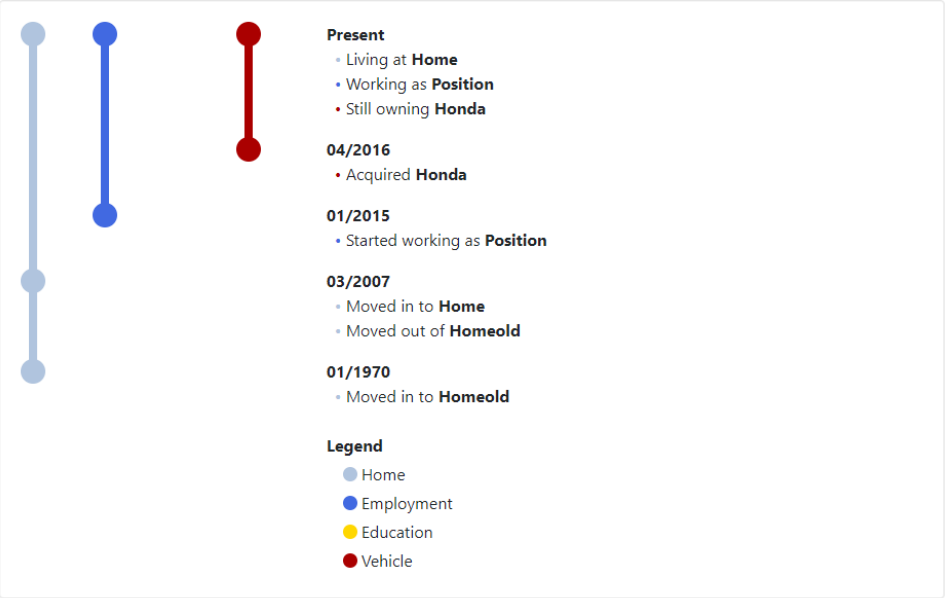

Figure 2 - Schematic view of how decisions are presented to respondents for different household members.

Regarding the study period, the duration of living in a home or working in a job varies across different individuals. When the study period is predetermined for all respondents, some individuals might not have experienced any major events during the predetermined period, and some might have experienced many, which makes the survey difficult for them to complete. To overcome this challenge, we use an adaptive study period in our survey. Figure 3 shows a schematic presentation of the data structure in the survey for a hypothetical participant. The survey is focused on the latest residential relocation (as the anchor point), denoted by T^*, and the analysis period in this survey is defined from the date of occupying previous home (T_1) until now (T_2). These dates will be determined according to the responses in current and previous home modules. All other questions in the survey will be updated accordingly. For example, the employment, education, and vehicle ownership history will be collected from T_1 to T_2, which may vary from respondent to respondent depending on the move-in date into their previous residence.

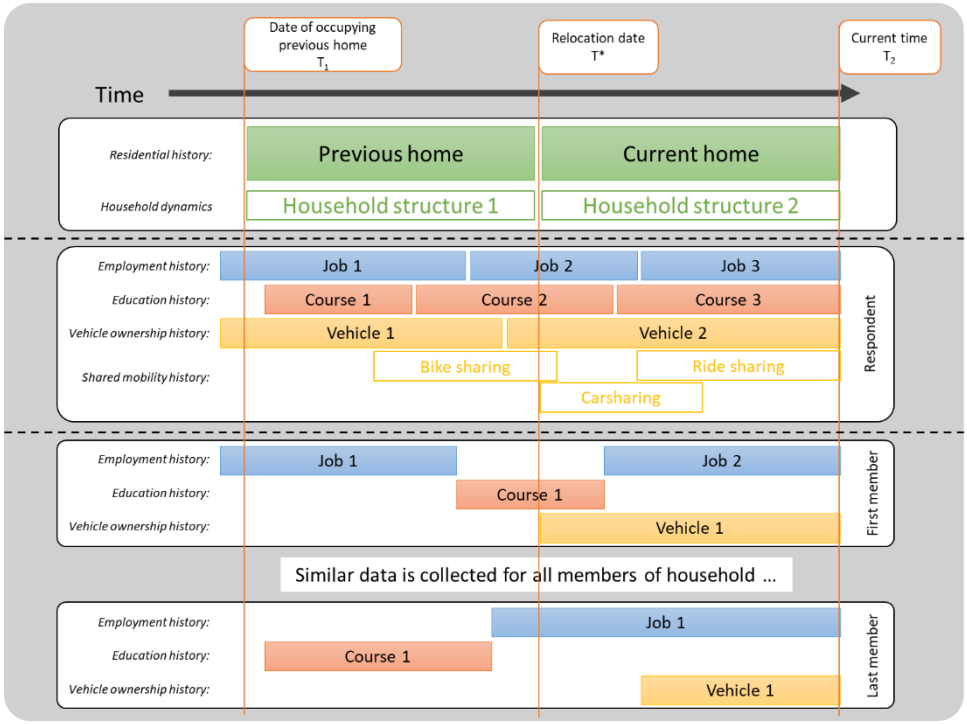

Figure 3 - Visualisation of the information collected from a hypothetical respondent

4. Data

The survey instrument described in section 3 was used to collect data from residents in Sydney, Australia and Chicago in the United States in January 2019. The survey was programmed online using Express.js and the survey link was shared with the market research company to share with participants.

As highlighted by Calastri et al. (2020), the adequate financial incentive is essential for lengthy life-course surveys; therefore, assistance from a market research company was used to invite participants and obtain a representative sample. In Sydney, out of 1062 invited individuals, 512 respondents completed the survey, and in Chicago, out of 838 invited individuals, 404 respondents completed the survey. The response rate in both cities was 48.2 percent and the average duration to complete the survey in both cities was approximately 40 minutes.

4.1. Sample Attributes

Marginal distributions of age, gender and geographical location of the collected data are compared with their corresponding distributions from the population. The population distributions are obtained from the latest available Census in Australia (ABS, 2016) and the United States (U.S.CensusBureau, 2011).

Table 1 shows the marginal distributions for gender and age in Sydney and Chicago. The distributions for the collected data are separated into respondents and household members. As shown in this table, the gender distributions for respondents and household members closely match their corresponding distributions of the population. Similar distributions across respondents are not unexpected as the market research company controlled them; however, a close match between the household members' gender distributions shows negligible misreporting of the household members gender.

Table 1 – Marginal distributions of age and gender for the collected samples in Sydney and Chicago, and their corresponding values from the population (percent)

Variable	Population	Sample	
		Respondents	HH members
Sydney			
Gender			
Male	52.18	51.95	49.53
Female	47.82	48.05	50.47
Age			
Children	22.15	0.00	24.15
College	5.19	7.42	7.67
Younger adults	27.79	37.70	26.99
Older adults	30.93	41.60	31.11
Senior	13.94	13.28	10.09
Chicago			
Gender			
Male	48.60	47.28	51.79
Female	51.40	52.72	48.21
Age			
Children	21.92	0.00	24.69
College	5.56	3.22	5.27
Younger adults	31.90	40.10	33.16
Older adults	29.39	48.02	27.69
Senior	11.23	8.66	9.19

Age is divided into five categories of children (less than 18 years old), college (from 18 to 21 years old), younger adult (from 22 to 39 years old), older adult (from 40 to 64 years old), and senior (65 years old and more). Similar to gender, the distributions are separated for the respondents and their household members. For respondents, there is no individual younger than 18 as they were not eligible to participate in the survey; however other brackets will closely match the corrected population distribution (figures presented in brackets). Both samples closely match their corresponding population distributions. For the Sydney sample, the highest difference pertains to seniors and for the Chicago sample the highest difference is for older adults. For both samples, the distribution for household members shows a closer match to the population. This suggests negligible misreporting regarding household member age distribution.

Table 3 shows the marginal distributions for personal income, household structure and dwelling type in Sydney and Chicago. Although the survey collects historical information about previous

homes and family structures, the distributions in Table 3 are obtained using the attributes of current employment, current residence and current family structure. This is to make the distributions comparable with the census information. As shown in this table, the distributions of income, dwelling type, and tenure status closely match Sydney and Chicago's population distributions. However, the distribution of household structure is skewed towards singles in the collected sample in Sydney. One plausible reason for this observation is the shorter completion time for singles, as they only report their employment and education history. In contrast, if the respondent comes from a couple household, or in general larger households, the completion time will be higher, which may be a discouraging factor in completing the survey. It is noteworthy to mention that the data for the modelling practice is obtained from an exogenous sampling method (Ben-Akiva and Lerman, 2018). Therefore all the parameter estimates are unbiased despite the differences between the marginal distributions of the sample and the population.

Table 2 – Marginal distributions for households' demographic attributes in Sydney and Chicago

Variable	Population	Sample
Sydney		
Personal weekly Income ($)		
1-299	17.0%	14.7%
300-999	42.0%	42.5%
1000-2000	28.1%	32.1%
2000 +	12.8%	10.8%
Household Structure		
Couple with kids	50.6%	33.4%
Couple without kids	32.7%	28.3%
Single parent	14.8%	5.3%
Other	1.9%	33.0%
Dwelling type		
House	69.3%	64.3%
Apartment	29.8%	24.8%
Other	0.9%	10.9%
Tenure type		
Owner occupied	63.8%	60.7%
Other	36.2%	39.3%
Chicago		
Personal weekly Income ($)		
1-299	11.6%	12.5%
300-999	45.2%	44.6%
1000-2000	29.8%	30.2%
2000 +	13.4%	12.6%
Household Structure		
Couple	32.7%	57.2%
Single parent	21.6%	4.7%

Other	45.7%	38.1%
Dwelling type		
House	45.8%	58.7%
Other	54.2%	41.3%
Tenure type		
Owner occupied	74.0%	45.0%
Other	26%	55.0%

Table 3 shows the spatial distribution of current residents in the collected sample and the spatial distribution of the population (obtained from Census) in the region. For Sydney, the zoning system of Statistical Area 2 is used to control for spatial distribution. For Chicago, Cook County and major neighbouring counties are considered for this purpose. The results show an acceptable coverage of the collected sample over the study region. Overall, the characteristics of respondents and their household members show a close match to the characteristics of the population regarding age, gender, and spatial distributions.

Table 3 – Spatial distributions of households for the collected samples in Sydney and Chicago, and their corresponding values from the population (percent)

	Population	Sample
SA4 in Sydney		
Central Coast	6.79	6.25
Baulkham Hills and Hawkesbury	4.72	3.13
Blacktown	7.04	6.05
City and Inner South	6.54	11.52
Eastern Suburbs	5.54	2.54
Inner South West	11.85	7.81
Inner West	6.08	7.62
North Sydney and Hornsby	8.40	8.59
Northern Beaches	5.24	3.71
Outer South West	5.43	3.52
Outer West and Blue Mountains	6.36	5.47
Parramatta	9.30	12.30
Ryde	3.78	9.57
South West	8.42	6.05
Sutherland	4.52	5.86
County in Chicago		
Cook	61.59	64.36
DeKalb	1.25	0.25
DuPage	10.87	12.13
Kane	6.11	3.71
Lake	8.34	9.41
McHenry	3.65	2.97
Will	8.19	7.18

4.2. Descriptive Statistics

Home type, tenure status, household structure, and the change in the household structure are important determinants in residential mobility (Michielin and Mulder, 2008, Eluru et al., 2009, Böheim and Taylor, 2002, Clark and Davies Withers, 1999, Kronenberg and Carree, 2012). Figure 4 shows the frequency of these attributes in the collected sample. As seen in plot (a) the most observed home type in both cities is "house". In Sydney, 64.3 percent of respondents live in a house and this portion is 58.7 percent for respondents in Chicago. According to plot (b), most of the respondents are owners, however, the difference between owner and renter is lower in Sydney. In Chicago, the shares of owners and renters are 74.0 percent and 23.5 percent, respectively, whereas in Sydney, the percentages for owners and renters are 60.7 and 30.9 percent, respectively. The distribution of household structure shows distinct patterns between the two cities (plot (c)). In both cities, the portion of single and couple households is considerably higher than other household structures. Plot (d) shows the change in the household structure when moving into the current property. According to this plot, most of the relocations do not involve household structure change. In both cities, moving in with a partner and leaving parental home is the greatest observed change in the household structure.

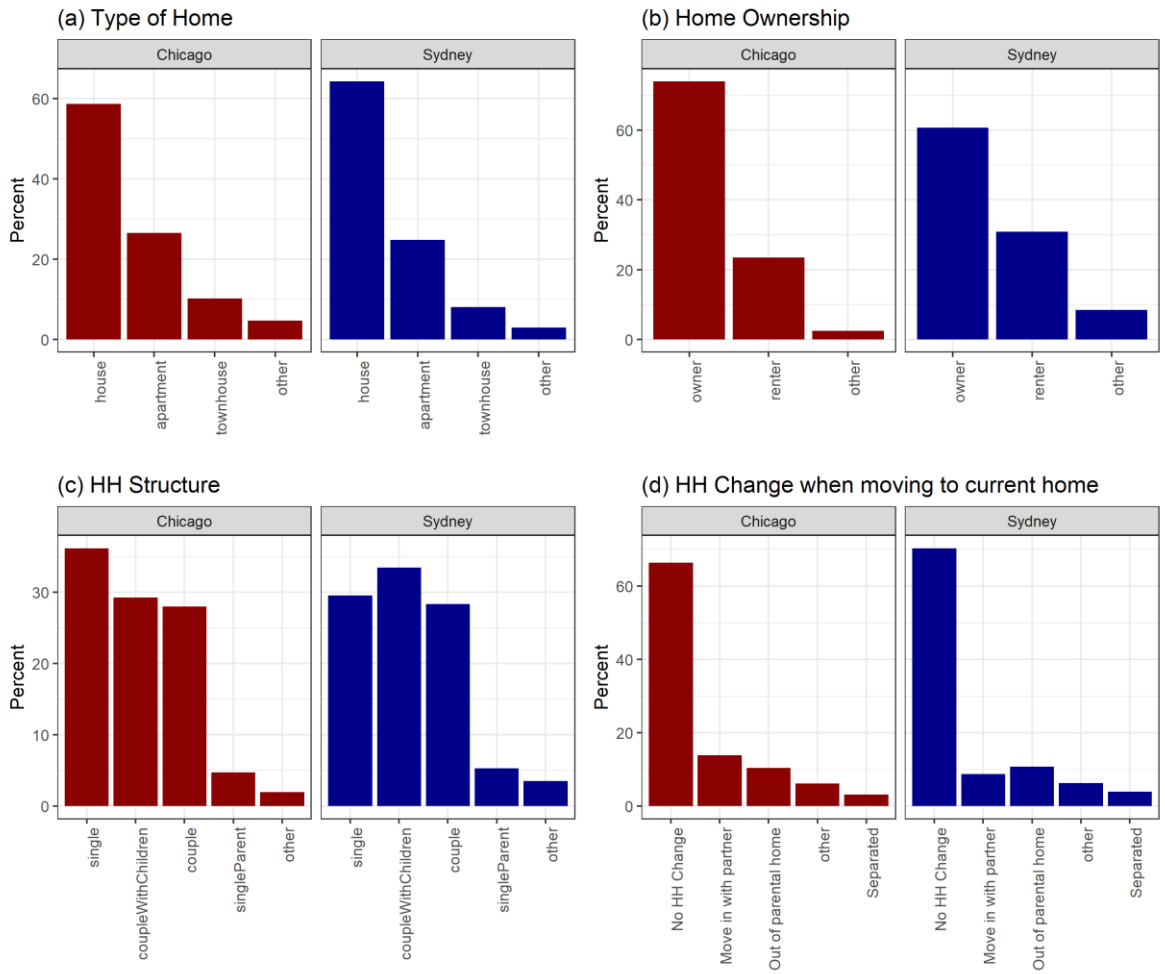

Figure 4 - Attributes of current home

By mapping the attributes of the current home to the previous home, the changes in home attributes through relocation are revealed. Figure 5 compares home type (plot (a)) and tenure (plot (b)) before and after the relocation. To simplify the discussion, the "other" option is removed from these plots. As seen in plot (a), if the previous home is a house, the current home is likely to be a house too. In Chicago, 77.4 percent of those who lived in a house before relocation have moved into a house. In Sydney, this portion is 81.1 percent. For tenants of apartments, nearly half have moved into an apartment (51.7 percent in Sydney and 49.4 in

Chicago). The next popular choice for this cohort is moving to a house (39.7 percent in Sydney and 40.4 percent in Chicago).

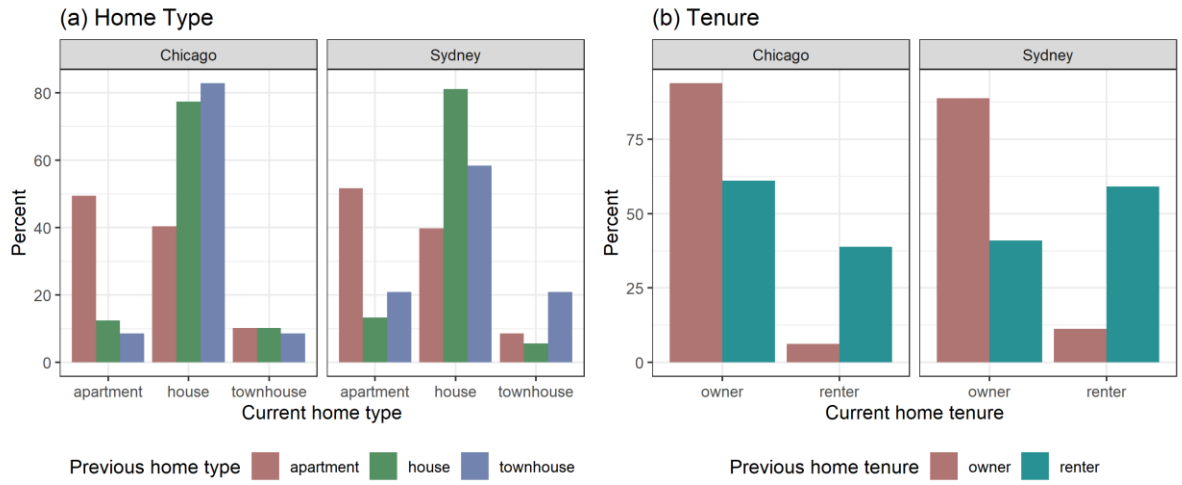

Figure 5 - Changes in home type and tenure choice during residential relocation

Plot (b) in Figure 5 shows the transition between the tenure status of owner and renter. As expected, most owners tend to maintain their tenure after relocation. Accordingly, in Chicago 93.9 percent, and in Sydney 88.8 percent of previous owners remain owners after relocation. The transition pattern for renters is different between Sydney and Chicago. In Chicago, 61.8 percent of previous renters have become owners after relocation, but this rate is 41.0 percent in Sydney. This observation reflects the high portion of long-term renters in the Australian housing market (Wulff and Maher, 1998, Pawson et al., 2017).

Figure 6 shows the distribution of home tenancy separated for owners and renters. The data from the previous home is used for this figure as the duration for the current home is right censored (the moving-out date for the existing home is not observed). The results confirm the previous findings in the literature that owners have lower residential mobility compared to renters (Böheim and Taylor, 2002, Kronenberg and Carree, 2012, Ghasri and Rashidi, 2015).

In Sydney, the average duration of residency for owners and renters are 9.92 and 4.11 years, respectively. According to the longitudinal survey of Household Income and Labour Dynamics (HILDA), which contains information from nearly 20,000 individuals in Australia over 18 years (Wilkins et al., 2020), the average time spent at the current address is around ten years. This duration varies depending on households' demographics and other socioeconomic conditions and tenure status. For example, in 2003 the average durations of living in current address for homeowners and renters were 13 and 3.6 years, respectively (Smatsgroup, 2006). In Chicago, the average durations of residency for owners and renters are 8.56 and 4.22 years, respectively. In 2018, the median duration of homeownership in The United States was 13.3 years (Moon, 2018).

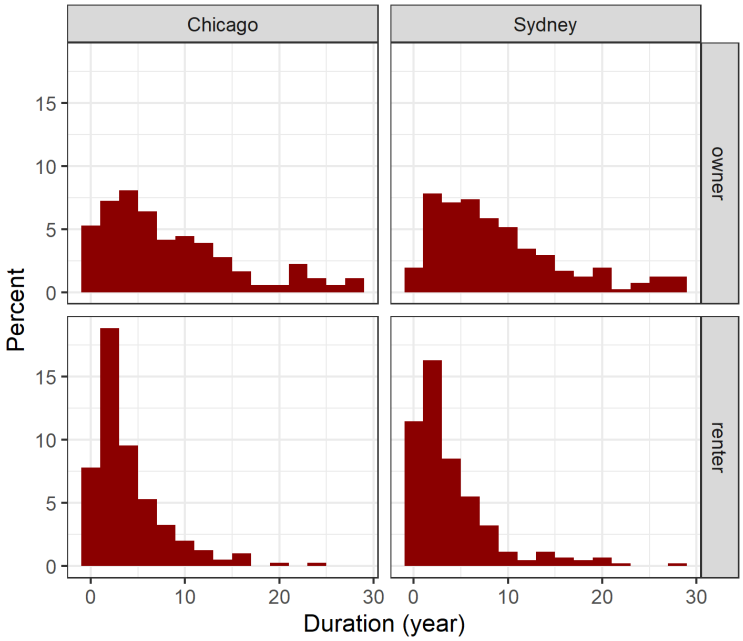

Figure 6 - Residential mobility

The histograms of time-lag between residential relocation and two other major life-course events are presented in Figure 7. The histograms of this figure are generated based on the time difference between residential relocation and its closest major event for any of the household

members. The major events analysed in this figure are employment and education commencement. Negative time lag values indicate employment or education-related life events occur before residential relocation, and positive time lag values indicate employment or education-related life events occur after residential relocation. The results show a spike for the time lags less than one year, which suggests a relationship between residential relocation and education or employment commencement. If a time lag below two years between residential relocation and the major events are considered as concurrent, then

21.7 percent of residential relocations in Sydney and 23.5 percent of residential relocations in Chicago are observed to be associated with a job relocation with a time lag below two years (plot (a)), and 18.4 percent of residential relocation in Sydney and 15.8 percent of residential relocations in Chicago are observed to be associated with an education related event with a time lag below two years (plot (b)).

Therefore, a considerable portion of residential relocations seems to be conjugated with employment and education life events. The following sections show how the survey instrument in this study is used to explore the interdependencies among these life events.

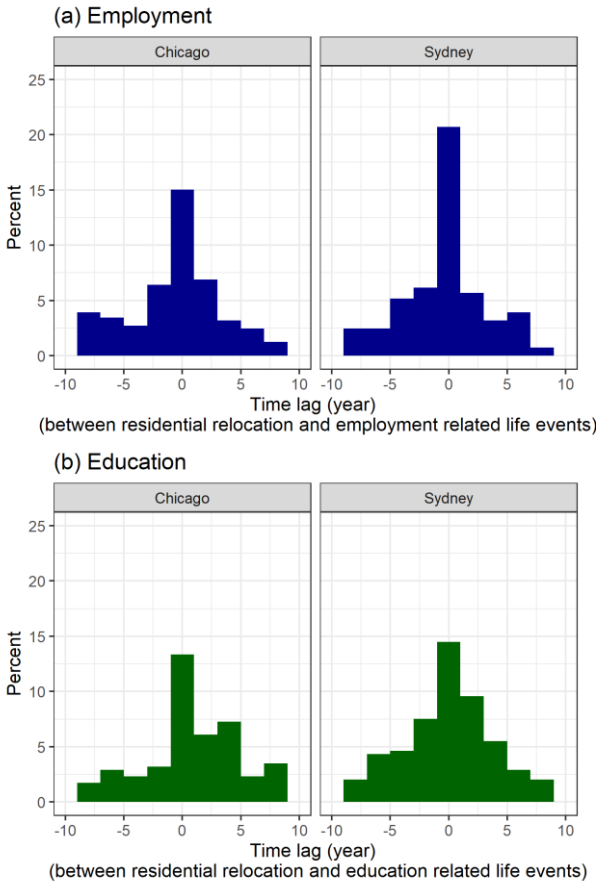

Figure 7 - Histograms of time-lag between residential relocation with job relocation and educational activities

5. Methodology

This study uses survival analysis to model residential mobility. Survival analysis is commonly used to model the time of an event (Stevenson and EpiCentre, 2009, Jenkins, 2005). The event is interpreted as a transition from a base state to an alternative state, and the instantaneous intensity of the transition is known as hazard rate (Jenkins, 2005). The event of interest in this study is residential relocation, where the transition is the relocation from a previous home to the current home. The dependent variable of the analysis is the duration of the residency. As discussed in section 3.1, the duration of residency can be calculated for the previous home as the move-in and move-out dates are observed. However, for the current residence, only the

move-in date is observed. When the start time of the duration is known but the end time is unknown, this case is referred to as *right censored*. As censored data can be incorporated in the survival analysis, we use the collected data from previous and current homes to develop the models.

To capture the effect of explanatory variables on the duration of residency, we use the proportional hazard (PH) model. In PH, absolute differences in explanatory variables imply proportionate differences in the hazard ratio (Jenkins, 2005). Equation (1) shows the hazard function of the PH model. In this equation $h_0(t)$ is the baseline hazard function which is invariant across individuals, x_i is a vector of covariates for household i and β' is a vector of coefficients to be estimated.

$$h(x_i, t) = h_0(t) \exp(\beta' x_i) \quad (1)$$

We use Cox PH method to examine the impact of employment and education commencement on residential mobility. The Cox PH model is a semi-parametric model that allows for estimating β' without any assumption on the baseline hazard rate ($h_0(t)$) (Stevenson and EpiCentre, 2009, Jenkins, 2005). Using Cox PH, we can study the effect of employment and education commencement on residential mobility without specifying any assumption on the baseline distribution for the duration of the residency.

To set up the likelihood function, the observations need to be sorted according to the recorded duration of the residency. The partial likelihood ($\mathcal{PL}_i$) is defined as the probability of transition for household i over the cumulative probability of transition for all households that have not experienced the transition (equation (2)). In this equation, Y_i represents the observed duration for household i. The partial likelihood is evaluated for all the uncensored cases and wrapped

over to form the likelihood function. Equation (3) shows the log-likelihood function for the Cox PH model. In this equation C_i is a binary variable indicating whether household i is censored ($C_i = 0$) or not ($C_i = 1$). As seen in equation (3), the log-likelihood function only depends on the covariates and is free of the baseline hazard function.

$$\mathcal{PL}_i = \frac{h(x_i, t)}{\sum_{j:Y_j \geq Y_i} h(x_j, t)} = \frac{\exp(\beta' x_i)}{\sum_{j:Y_j \geq Y_i} \exp(\beta' x_j)} \quad (2)$$

$$\mathcal{LL}(\beta') = \sum_{i:C_i=1} \left(\beta' x_i - \log\left(\sum_{j:Y_j \geq Y_i} exp(\beta' x_j) \right) \right) \quad (3)$$

6. Results

We examine associations between education or employment commencement and residential mobility, and whether those associations were moderated by employment or education type, using Cox PH models. Because the association between education or employment commencement and residential mobility could look different in different places, we fit separate models for Sydney and Chicago. As capturing the dynamics in household structure is beyond the scope of this study, we only consider relocations with no change in household structure when developing the models.

Regarding the dependent variables, the main determinants on residential mobility, including home type, tenure choice household structure, are extracted from the literature, and their associations with residential mobility is investigated. Employment is divided into full-time and part-time. It is included as a binary variable that takes a value of one if any of the household members have experienced employment commencement during the twelve months preceding the residential relocation. Education is divided into primary, secondary, and tertiary, which are

represented as binary variables in the model. The binary variables take a value of one if any of the household members have experienced education commencement during the twelve months after the residential relocation[2].

The time-lag analyses in section 4.2 indicate a correlation between employment or education commencement and residential relocation. Table 4 shows the estimated coefficients (β) and the hazard ratios for the covariates (exp (β)). Hazard ratios show the proportional effect of the covariates on residential relocation. When the hazard ratio is above one, it indicates a positive impact on residential mobility and when it is below one, it indicates a negative impact on residential mobility.

After controlling for other determinants, our findings show that commencing primary school is a significant determinant for residential relocation. In Sydney, with a hazard ratio of 2.46 and in Chicago, with a hazard rate of 3.65, commencing primary school has the highest effect on residential mobility. This observation confirms previous findings on higher residential mobility for households with pre-school-age children. Yang et al. (2019) showed that children's education can have a higher impact on the intention to relocate than parents' employment. Böheim and Taylor (2002) suggested that these families are searching to find a suitable home in a liveable neighbourhood to raise the family. Our findings complete and quantify this argument by the suggestion that finding an appropriate primary school is an essential element in the search for a suitable neighbourhood to reside. This finding indicates

[2] we considered other categories of employment and education as well, but we only report the model with the highest goodness-of-fit and meaningful and interpretable coefficients.

that households with pre-school-age children will plan ahead for their children's primary school and will move at an earlier point in time.

Previous studies suggest that job-related life-course events positively affect residential mobility (Böheim and Taylor, 2002, Clark and Davies Withers, 1999). Our modelling practice confirms this relationship for full-time employment commencement. Starting a full-time job will increase the hazard ratio by 89 percent in Sydney and 80 percent in Chicago ($1 - \exp(\beta)$). Starting a new job is expected to change the commuting distance, and as the travel distance is a source of disutility, it is expected that households make appropriate adjustments to reconcile the change in the commute (Kronenberg and Carree, 2012). However, the coefficient for part-time employment is insignificant in both models, indicating that part-time employment is not a significant determinant in residential mobility. Part-time jobs are less secure and, on average, are lower paid compared to full-time jobs. Therefore they seem not to provide enough incentive to trigger a residential relocation.

Table 4 – Parameter estimates and hazard ratios in the Cox PH models for residential mobility in Sydney and Chicago

	Sydney		Chicago	
Variable	Parameter estimate (se)	Hazard ratio	Parameter estimate (se)	Hazard ratio
Tenure is owner	-0.77 (0.18)	0.46*	-0.78 (0.32)	0.46*
Tenure is renter	0.46 (0.18)	1.58*	0.64 (0.34)	1.89⁺
Home type is house	-0.04 (0.15)	0.96	0.02 (0.2)	1.02
Number of rooms	-0.11 (0.07)	0.9⁺	-0.12 (0.08)	0.89⁺
HH type is couple	0.12 (0.13)	1.12	-0.09 (0.15)	0.91
HH type is single parent	-0.69 (0.4)	0.5⁺	0.25 (0.34)	1.28
Employment Fulltime	0.64 (0.18)	1.89*	0.59 (0.19)	1.8*
Employment Parttime	-0.13 (0.33)	0.88	0.46 (0.39)	1.59
Education Primary	0.90 (0.33)	2.46*	1.30 (0.37)	3.65*

Education Secondary	0.10 (0.63)	1.1	0.96 (0.72)	2.62
Education Tertiary	0.72 (0.3)	2.04*	0.10 (0.52)	1.1

* Significant at 95% confidence level
+ Significant at 85% confidence level

In line with previous studies, our results show homeowners are less mobile (Eluru et al., 2009, Ghasri and Rashidi, 2015, Clark and Withers, 2007) and renters have higher mobility (Böheim and Taylor, 2002, Kronenberg and Carree, 2012). Households will relocate if the utility from relocation is higher than staying (Kronenberg and Carree, 2012). Since relocation costs are lower for renters, they are more likely to obtain higher utilities from relocation, making them more mobile. Also, Kronenberg and Carree (2012) argue that psychological attachment is higher for owners, thus reducing the propensity of relocation. It is noteworthy to mention that the relationship is not entirely causal. It is conceivable to assume that renting is a more flexible tenure, so it is a suitable choice for those with higher propensity of relocation (Böheim and Taylor, 2002). According to Table 4, the decreasing effect of homeownership on residential mobility in Sydney and Chicago are found similar with a reduction of 54 percent in hazard ration; however, the increasing effect of renting is considerably higher in Chicago.

Household composition turned out to be less important but still partially significant in Sydney, where single parents are less mobile. The coefficients for couples are not found significant. Household size (Eluru et al., 2009) and living in a house (Kronenberg and Carree, 2012) are expected to reduce mobility as they increase financial and psychological attachments. We used a number of bedrooms as a proxy for house size and the results show a decreasing effect of 10 percent on the hazard ratio in both cities. However, living in a house is not found significant in our models. This can be a sample size issue and due to the high correlation between living in a home and number of rooms.

Conclusion

This paper presented a life-course calendar survey instrument, along with a residential mobility analysis as a use case for this instrument. The survey was launched in January 2019 and the data from 514 respondents in Sydney and 404 respondents in Chicago were collected. The results showed a population-representative sample with a close match between the collected sample's age, gender, and home location spatial distributions and their corresponding distributions.

According to the results, 70.3 percent of residential relocations in Sydney and 66.3 percent of residential relocations in Chicago do not involve changes in household structure. For one-third of the relocations, at least one concurrent life-course event related to job or school is observed. For 21.7 percent of residential relocations in Sydney and for 23.5 percent of residential relocations in Chicago, a job-related event is observed within a time-lag of two years. When education-related events are considered, 18.4 percent of relocations in Sydney and 15.8 percent of relocations in Chicago have a major event within a time-lag of two years. The semi-parametric Cox proportional hazard model is used to quantify the effect of covariates on residential mobility. The model results echo previous findings that dwelling size, tenure status, and life-course events are significant determinants of residential mobility. We found primary school commencement to have the highest effect on residential mobility. Starting primary school will increase the hazard ratio to 2.46 and 3.65 in Sydney and Chicago, respectively. Our findings suggest homeownership reduces the hazard ratio by 54 percent. Renters are more mobile, but this impact is nearly two times higher in Chicago. Also, the increasing effect of employment commencement on residential mobility is only found significant for full-time employments.

The collected data in this study can be further explored to reveal similarities and differences in housing-related decisions between Sydney and Chicago. Furthermore, this study can be extended by incorporating more detailed methods for evaluating residential mobility to capture group decision making and intra and inter household interdependencies.

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Appendix

This section presents the question in each module. For brevity reasons, only question prompts are reported. To address the contextual and language differences, appropriate revisions in the articulation are considered when the survey was conducted in Chicago.

Respondent Module

1. What do you prefer us to call you?
2. Date of Birth? (Month and year)
3. Gender?
4. Latest residential relocation?

Home module (current and previous)

1. What do you prefer us to call this home?
2. Date moved in? (Month and year)
3. Suburb
4. Type? (house/apartment/townhouse/others)
5. Ownership? (Owner/renter)
    a. Usual rent payment (your contribution)?
    b. Usual rent payment (overall for the family)?
    c. Usual mortgage payment (your contribution)?
    d. Usual mortgage payment (overall for the family)?
6. Number of bedrooms?
7. Number of parking?
8. Household structure when moved into this home?
9. Change in your household structure along with moving into this home?

HH Members module

1. What do you prefer us to call this member?
2. Date of Birth? (Month and year)
3. Gender?
4. Relationship with you?

Relocation reason module

1. Regarding your last residential relocation, specify which reason(s) were the main reasons for moving? (Select as many as applicable and specify the importance on a Likert scale from 0 to 5)

a. To start a new job with a new employer
b. To be nearer place of work
c. To be close to place of study
d. Work transfer
e. To start own business
f. Decided to relocate own business
g. To look for work
h. To get a larger/better place
i. To get a smaller/less expensive place
j. To get a place of my own/our own
k. To live in a better neighbourhood
l. To be closer to amenities/services/public transport
m. To get married/moved in with partner
n. To be closer to friends and/or family
o. Marital/relationship breakdown
p. To follow a spouse or parent/Whole family moved
q. Seeking change of lifestyle
r. Property no longer available
s. Health reasons
t. Government housing (no choice)

2. When selecting your home, specify the importance of the following features to you

a. Close to family and friends
b. Close to leisure activities
c. Close to public transport
d. Close to shops, groceries
e. Close to work
f. Frequent contact with neighbours
g. Good contact with neighbours
h. Neatness and tidiness
i. Appearance of buildings/architecture
j. Presence of bike paths
k. Presence of green areas
l. Presence of sidewalks
m. Quietness
n. Social safety, low crime
o. Sufficient parking
p. Traffic safety

3. Considering your household in your previous home, who used to make the decisions about the following issues?

a. Managing day-to-day spending and paying bills

    b. Making large household purchases
    c. The number of hours you spend in paid work
    d. Savings, investment and borrowing
    e. Social life and leisure activities

Employment module

1. What do you prefer us to call this job?
2. Date started? (Month and year)
3. Date left? (Month and year)
4. Suburb?
5. Contract Type? (Fulltime / part time)
6. Role? (manager/professional / …)
7. Flexible hours?
8. Work from home?
    a. How often?
9. Starting gross income? (Multiple choice question with various brackets)
10. Final gross income? (Multiple choice question with various brackets)

Education module

1. What do you prefer us to call this education centre?
2. Date started? (Month and year)
3. Date graduated? (Month and year)
4. Suburb?
5. Type? (Primary / secondary / tertiary/ TAFE/ …)
6. Course Type? (Fulltime / part time)

Vehicle ownership module

1. What do you prefer us to call this vehicle?
2. Date owned? (Month / year)
3. Date sold? (Month / year)
4. Model Year?
5. Make?
6. Model?
7. Powertrain/fuel? (Petrol / electricity / …)
8. Purchase price? (Multiple choice question)
9. Purchased brand new or used?

Travel behaviour module

1. What is your typical travel mode for the following trip purposes?
    a. Commute

    b. Shopping
    c. Recreation
    d. Study
2. Do you have a valid driving license?
3. How frequently do you ride each of the following services?
    a. Bus
    b. Light rail
    c. Train
4. Are you a member of any carsharing services (such as GoGet or car next door)?
    a. When did you join this service? (Month and year)
    b. How often do you use this service?
5. Are you a member of any ridesharing services (such as Uber, Lyft or Sidecar)?
6. Are you a member of any bike sharing services?