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Considerations on how to conduct a survey about long-distance travel with reduced memory effect

Linda Christensen

DTU Management, Transport Division, Technical University of Denmark, Bygningstorvet 116V, 2800 Lyngby, Denmark

Abstract

The paper presents a survey about international trips with overnight stays. Contrary to traditional retrospective long-distance travel surveys, respondents are asked for their 3-4 most recent trips. Due to this, the traditional huge memory effect is eliminated. The main part of the paper is dedicated to considerations on how to estimate the annual number of trips with this concept. Estimations based on the cumulated hazard function, which is a normal mathematical solution, are rejected because a new journey cannot start until the former was finished. Instead, extra trips should be simulated until all trips during a year are included.

Keywords: Better quality of long-distance travel surveys; Survey asking for latest long-distance trips; Simulation of long-distance trips for rest of a year.

1. Background and purpose

Long-distance travel (LDT) represents a high share of the climate burden from passenger transport. In 2010 the CO_2 emission from Dane's LDT is estimated to represent 31% of the climate burden from passenger transport (Christensen, 2016). On top of this comes the net effect from NO_x emission and the contrail / cirrus formation (Lee et al., 2021). Furthermore, LDT increases kilometres by road and air resulting in congestion and air pollution to and in the main tourist areas.

In order to develop policy to reduce the climate burden by reducing travel activity, knowledge about who are travelling, by which modes, to which destinations / distances, and how frequent is important. Which are their attitudes, and are people willing to change frequency, destination, and mode for some of their trips? Is such a policy acceptable? The only way to get this information is by surveys about LDT activities which include attitudes.

However, Europe has a limited tradition for conducting long-distance travel surveys (LDTS). For many countries the National Travel Survey (NTS) includes too few trips with overnight stay or trips longer than 200-300 km to offer an acceptable data precision. Some countries are not including trips abroad, and in case they are, they are seldom

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reported separately. Only few LDTS are used for research, the most recognized is the British in which domestic LDT was analysed, and a forecast model developed (Dargay & Clark, 2012). In Denmark, an LDTS was included in the NTS from 1992 to 2001, but never analysed. From 2010 to 2011, a dedicated Danish LDTS was conducted with a one-year travel period (Christensen, 2013, 2015; Knudsen, 2015).

Two EU projects tried to overcome the lack of LDT data, MEST from 1996 to 1999 (Axhausen et al., 2003) in which the Cross European data collection Dateline was developed, and Kite from 2007 to 2009 in which Dateline data was analysed (Gomes & Santos, 2004; Kuhnimhof & Armoogum, 2007). In KITE new guidelines for an LDTS was developed (Kuhnimhof et al., 2009) and tested on three surveys (Frei et al., 2010).

The reason for this lack of interest in LDTS is probably that each country according to EU regulation is only responsible for domestic CO_2 emission, which only represents 2% of the overall CO_2 emission from Dane's LDT (Christensen, 2016). The citizens' climate footprint elsewhere, others are responsible for. Therefore, transport authorities will not finance surveys about travelling abroad. Contrary, most countries are interested in attracting tourists, which is between others supported by Eurostat's industry section, which organises a mandatory survey in all member states of EU. However, the survey is not including information about travel distances, and destinations are only reported by country name. Furthermore, only macro data is available for research (Christensen & Nielsen, 2018). These surveys could be used for gathering knowledge about LDT from a transport perspective. Due to the lack of information and micro data, they are unfortunately not useful as a LDTS.

Another reason why LDTS might be less popular is a high price per interview compared to the NTS, and a lower data quality.

1.1. Methodologies to conduct LDTS

The two most common ways to set up an LDTS today are a longitudinal survey and a retrospective survey. The longitudinal survey follows the respondents who must report when they are active or, alternatively, at certain intervals, which enables intermediate follow-ups. Examples of these are the Swiss Mobidrive, which collected data during a 6-week period in 1999 and a Danish 2-weeks overnight survey in 2010 (Knudsen, 2015). The American study (Aultman-Hall et al., 2015) includes a full year period in which each participant had to report their trips during a three-month period.

In the retrospective survey, the respondents are asked to report all trips during a travel period of typically 8 weeks to 3 months, sometimes even one year. Retrospective surveys covering a long travel period result in a substantial memory effect (Armoogum & Madre, 2002; Christensen & Knudsen, 2017; Denstadli & Lian, 1998). Respondents, especially high frequent travellers tend to forget trips that happened some time before the survey. Additionally, the vehicle miles travelled are usually heavily underestimated (Wolf et al., 2003). A shorter travel period results in less memory effect. However, the share of respondents without a trip is higher, resulting in a need for a bigger sample. Furthermore, due to the high response burden that is usually associated with an LDTS, a share of the respondents claim not to have more journeys even though this is not the case (Knudsen, 2015, Janzen et al., 2018). A longitudinal survey suffers from similar problems, and additionally from dropouts during the reporting period (Aultman-Hall et al., 2015).

1.2. Purpose of the project

The purpose of our project is to develop a survey methodology with higher quality and lesser cost in order to recommend an alternative survey layout so that more authorities are willing to conduct an LDTS.

The higher quality should first of all be obtained through less memory effect. The lower cost should be obtained by a more effective data collection methodology in which a higher share of the respondents contributes to information about travel activities. A partly new methodology is developed based on some ideas in the literature. The idea is to ask about the respondents' two or three most recent trips, whenever they took place. This way all respondents contribute with trips, and they only need to remember a few trips.

The tradition in analyses of LDT behaviour in literature, is to analyse and compare the annual number of trips, weighted up to population level. An important task in the paper at hand is therefore to state the annual number of trips per respondent.

1.3. The 'most recent trip methodology' in the literature

Richardson & Seethaler (1999) were the first to suggest such a 'most recent trip methodology' by asking the respondents only to report their latest journey. They suggested a probabilistic model and simulated an average trip rate multiplier as a function of the number of days since the trip was made. However, the results were only correct under ideal conditions and the model was never tested on real data.

Frei et al. (2010) used an alternative version of the most recent trip method for the three KITE LDTS for trips longer than 100 km. Their survey is a retrospective LDTS covering a travel period of 8 weeks. The respondents were asked to report the starting date of up to their 9 most recent trips. In case of no trips during the 8-week travel period, respondents were asked about the date of the latest journey before the 8 weeks. In case no trip existed, they were asked for the date of the most recent trip after the 8 weeks. The time gap to the later / earlier trip was treated as censored. They modelled the time gap between the known journeys by a hazard model using a non-parametric survival distribution, see section 3. In case of proportional hazards (see section 3.1, not clear if it was tested) the estimated hazard ratio h is the mean gap time between the trips and $365/h$ is the annual number of trips.

In the following the most recent trips methodology is developed and the statistical model is described in detail.

2. The conducted web survey

The survey, financed by funding from Eurostat, consists of a web-based survey and a telephone survey. A representative sample of inhabitants over 15 year is drawn from the Danish person register. A representative share of this sample was dedicated to a telephone survey with people who did not answer to the web survey after 2½ weeks and one reminder. The sample was evenly distributed over all dates of a year. This date, called the reference date, is the latest possible date for returning home from a reported LDT in the survey. Data used for the analyses are not weighted.

Exactly one year's web-data, from March 12th 2019 to March 11th 2020, when Denmark locked down due to Covid-19 is included in the paper at hand. The response rate was 13%. 4,563 respondents are included. Due to the lock down, it was not managed to collect a full year's sample of telephone interviews.

LDT is in accordance with the tradition in tourism research defined as journeys with overnight stay(s). In transport research, LDT is most often defined as trips longer than 100 km. As domestic trips are quite well covered in the continuous Danish NTS, only trips with a destination abroad are addressed in the survey.

In 2017, our institute financed a three-month test survey in which the respondents were asked to report their latest trip whenever it took place and their two latest *private* trips prior to this. As it is probably difficult for respondents to remember details far back in time, respondents were only asked about their two earlier private trips if they took place up to 1½ years prior to the interview. This method, however, resulted in a need for censoring data and normalising the model, resulting in less valid results (Christensen, 2018). It was, therefore, recommended always to ask respondents to report the three most recent trips without any time restrictions.

In the new web-survey, respondents were asked to report details including the date of returning home about their three latest journeys (only 2 trips in the telephone interviews). If the trips took place more than two years before their reference date, respondents were asked about the month instead of the date. For trips older than seven years, questions were reduced to year, purpose, destination, and mode.

Because we wanted to be able to model private trips separately, the respondents were asked to include their two latest private trips if only one or none of these were included at first. 1.2% of the respondents had no trips after the beginning of the year they turned 16. 78% of the respondents with trip(s) only had private trips. The rest include business/education trips in their travel patterns in different sequences (see Table 1).

3.3% of the respondents (see sequence types 31 and 41 in Table 1) only include one private trip in the reported three most recent trips, so, they were asked about their immediately prior private trip. 4.6% of the respondents reported two business trips as their latest trips (trip sequence 5) and were asked for their two latest private trips before these. It is unknown if these respondents had more business trips before the reported private trip(s); a censored 'trip' with the shortest possible length is therefore needed before the reported business trip(s). The length of the censored trip is the number of nights of the following later trip. This new gap time is interval censored, which is less developed in statistical programme packages.

Table 1 Sequences of private (P) and business (B) trips in the CAWI survey and the gap times used for the model.

Sequence number +share	Sequence type	Reference date	Gap time 1	Arrival time 1[2]	Gap time 2	Arrival time 2	Gap time 3	Arrival time 3	Gap time 4	Arrival time 4
1: 78%	PPP, PP, P	T0[1]	T0-T1	T1	T1-T2	T2	T2-T3	T3		
2: 4.0%	PPB	T0	T0-T1	T1	T1-T2	T2	T2-T3	T3		
3: 3.9%	PBP, PB	T0	T0-T1	T1	T1-T2	T2	T2-T3	T3		
31: 1.8%	PBBP, PBB	T0	T0-T1	T1	T1-T2	T2	T2-T3	T3	Possible Cen. trip Gap trip 3s nights	T4
4: 4.2%	BPP, BP, B	T0	T0-T1	T1	T1-T2	T2	T2-T3	T3		
41: 1.5%	BPBP, BPB	T0	T0-T1	T1	T1-T2	T2	T2-T3	T3	Possible Cen. trip Gap: trip 2s nights	T4
5: 4.6%	BBPP, BBP, BB	T0	T0-T1	T1	T1-T2	T2	Possible Cen[3].trip Gap: trip 2s nights	T3	Possible Cen. trip Gap: trip 3s nights	T4

[1] T0 is the reference date, [2] T1 is the date for arriving home from the latest trip etc. [3] Cen. indicates a censored time, and nights refers to the number of nights of the trip.

3. Survival modelling

The method to analyse data is survival and hazard modelling see e.g. (Cox & Oakes, 1984; Kalbfleisch & Prentice, 2002). Survival modelling is specially developed to estimate the survival time of a population or a group of people suffering from a disease to test the effect of medical treatment or to analyse the breakdown of technical products. In transport research, (Bhat, 1996) is an example of using survival modelling, in this case to analyse the duration of transport activities.

In survival modelling, the cumulative distribution function F(t) describes the probability that the random time T to an event will be less or equal to a chosen date:

$$F(t)=P[T < t],\ t > 0 \qquad (1)$$

The derivative of $F(t)$ is called the probability density function $f(t)$. The survival function $S(t)$, which is the probability that an event takes place later than a specified date, is defined as:

$$S(t) = P[T > t] = 1 - F(t) = 1 - \int_{x=0}^{x=t} f(x)dx \qquad (2)$$

$S(t)$ is a non-increasing function with values between 1 and 0. When t approaches ∞, $S(t)$ approaches 0. The survival curves for the gap times (the time between two events/trips) can be interpreted as the probability that there is more than the shown number of days between two trips. Survival curves can be compared, and differences can be tested by a log-rank test (called a test of homogeneity). Differences between survival curves are relevant for understanding LDT behaviour including its dependency on the covariates.

From a theoretical point of view, the cumulative hazard function at t=365 should be used for estimation of the annual number of trips:

$$H(t) = \int_0^t h(u)du = -log\,\{S(t)\} \qquad (3)$$

3.1. The use of survival modelling in the paper

Our survey data is organised as recurrent event data, which means that each respondent normally has one or more events for which the time gaps between the events are modelled. The gap times in recurrent event data can either be dependent on each other or be independent. Recurrent event data can be modelled by an Andersen-Gill (AG) model for which the failures/events are mutually dependent or by the conditional Prentice-Williams-Peterson (PWP) models for which the gap times are independent. Because a traveller's trip must be finalised before the following can start, all trips are in principle dependent on the former. For the main part of travellers, who travel a few times per year, we assess their trips to be independent. However, for high frequent travellers, the occurrence of a new trip might depend on the former. We will come back to this problem below.

The events can be ordered so that the next event cannot take place without the former having taken place, or they can happen more randomly. Survey data of trips is ordered for each respondent, whereas trips observed as arrivals in an airport/train station are random.

The survival function can be semi-parametric, i.e., the survival time can be non-parametric, while the distribution of the covariates needs to be parametric. An important prerequisite for comparing effects in data by the hazard ratio is that the hazards are proportional, which as an outset can be tested visually by comparing the curves in a plot of the log of the negative log of the estimated survival functions against the log of the gap time.

The PWP model is a stratified Cox-type model that allows the shape of the hazard function to depend on the number of preceding hazards and possibly other characteristics (Cox and Oakes, 1984). The PWP model exists in two versions, a gap time model, and a total time model. The first is used for this paper.

A censored observation needs to be included when a respondent is not reporting all trips, he/she is asked to report. When only one or two trips are reported, a censored trip is added. In case the respondent declares not to have had any trips, no censored trip is added. The censored gap time must be as long as minimum possible, that is the number of nights of the earliest reported trip. Data including this kind of censors is right censored. Standard program packages such as SAS, Strata and R include rich developed program packages to handle the right censored data. For basic descriptions, see (Amorim & Cai, 2015; Kleinbaum & Klein, 2012; Lu & Shen, 2014).

Be aware that the time scale goes backward in time; in pharmacy, it points into the future. The first gap time is the number of days from the respondent's reference date to the date of returning home from the latest trip. The second and third gap time is the number of days from the end of the later trip to the date of returning home from the trip immediately before this trip.

3.2. Estimation of the survival models

The survival functions are estimated as a product-limit estimate of the distribution, also called a Kaplan Meyer (KM) estimate. It is fitted by a non-parametric survival distribution, for which no assumption is made about the distribution *S(t)*, i.e., the estimation can get 'closer' to the real distribution of the observed gap times (see Fig. 1). A gap number keeps track of the gaps so that trip number two does not take place until the latest trip has occurred, etc.

4. Results

4.1. Survival function

In Fig. 1, the survival functions for the three gap times between the trips are shown. The SAS procedure Proc ICLifetime, which is specially prepared for interval censored data (Lu & Shen, 2014) is used for estimation. The first gap time is clearly different from the following, because the time from the random reference date to the most recent trip is shorter than the time between two trips. The difference disappears for respondents who have only travelled a little more than a year before the reference date.

The second and third gap times follow survival functions that are more similar. Theoretically, it is expected that the time gap between a random trip and the immediately earlier trip should be the same independent of the gap number – at least for trips during the latest years and before Covid-19. The statistical test for equality over strata shows that the two distributions coincide with a p-value for the Dunnett-Hsu test at 0.58. Equality is confirmed for all included socioeconomic variables (age, gender, position, education, car ownership, ownership of a second home abroad, or in Denmark, and if the respondent had a business trip versus only private trips).

The curves for the second and third trips have 'a bump' immediately before 365 days. This shows that a high share of the respondents/Danes travel abroad at least once a year (81% have made their latest trip less than a year ago). A similar but weaker bump is observed again after two years. The probability that the respondents have had their first trip after a year is more or less the same as having a trip during the year, given that they had a trip during the year before. The curves can also be interpreted so that the main part travel at least once a year, sometimes a little earlier and sometimes a little later.

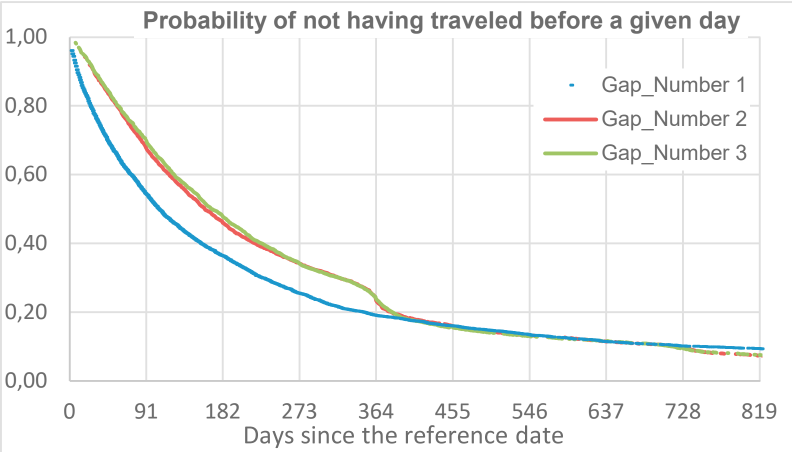

Fig. 1 Survival curves for the gap time in days between the reference date and the first trip, between trip one and two and between trip two and three back in time.

4.2. Annual number of trips stated in the interviews

The main interest is to unveil the annual number of trips. As a reference point is used a question to the respondents in the interview about how many private and business trips, they have had during the last year prior to the reference date. The mean number for all respondents is 1.85 private trips (standard dev 2.06) and 0.69 business trips (standard dev 3.20). Overall, the respondents stated that they had 2.5 trips on average. 17.8% of the respondents reported having more than three trips during the latest year. These figures are not taking the memory effect into account.

4.3. Annual number of trips by hazard modelling

The annual number of trips per respondent (t < 365 days) is, based only on one trip, the hazard function of the gap time between two trips, 1.47 [1.42:1.53] for gap number two, and 1.45 [1.39:1.50] for number 3, see Fig. 2. For the first gap time, the annual number of trips is estimated to be 1.67, emphasising that estimation should not be based on only the first trip as suggested by Richardson & Seethaler (1999).

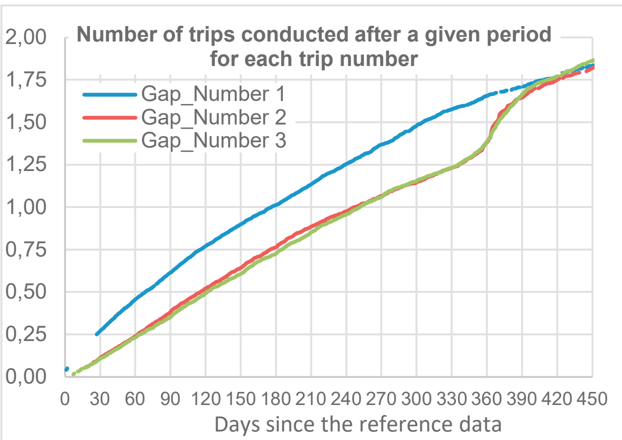

Fig. 2 The hazard function for the gap time in days between the reference date and the first trip, between trips one and two and between trips two and three back in time.

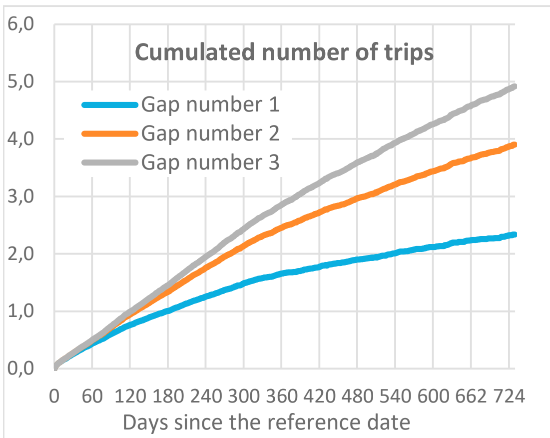

Fig. 3 The annual number of trips estimated by the PWP total time model for travel sequence 1.

The overall annual number of trips cannot be calculated by summing the annual number of each trip separately because the former trip is ending before the following starts. The number is therefore estimated as the cumulated hazard by the PWP total time model. Table 2 shows the results for travel sequences 1–4. For the private trips, the results are much higher than stated in the interviews, while it is lower for business trips for two of the three sequences with business trips. Fig. 3 shows an estimation of the cumulated hazard for travel sequence one. However, for respondents with more than three annual trips, these further trips should also be included. Table 2 shows that some respondents have stated to have up to 45 private trips or even 100 business trips. The result is therefore underestimated.

Table 2 Number of annual trips stated by the respondents and as a result of the analyses of the cumulated hazard.

Travel sequence		Number stated in the interview			Stated maximum		Travel diary, Cumulated Hazard		
		All Trips	Private	Business	Private	Business	All Trips	Private	Business
1	P-P-P	2.26	2.04	0.22	45	40	2.89	2.89	0
2	P-P-B	3.19	2.11	1.09	25	20	3.11	2.57	0.54
3	P-B-P	3.09	1.81	1.28	11	16	3.95	2.87	1.08
4	B-P-P	3.21	1.61	1.60	10	50	3.46	1.68	1.78
All respondents		2.50	1.85	0.69	45	100			

4.4. Simulation of extra trips to estimate the annual number of trips

Instead, we turn to simulation of the extra trips for up to one year. The following analyses are based on an ideal situation, in which all respondents who have stopped reporting before 3 trips were fulfilled, are excluded. In all estimations the censor is therefore null.

Two kinds of simulations are relevant, 1) simulation of extra trips earlier than the reported trips until the first trip ends more than a year before the reference date. 2) Simulation of extra business trips in the gap between the last reported business trip and the first and/or second reported private trip for travel sequences 5, 31 and 41.

The predictive model for the simulations is based on the estimated aggregated survival function for gaps 2 and 3, subdivided into travel sequences and short periods in order to avoid that respondents with many trips per year are assigned trips with longer gap times than their travel pattern represents; and vice versa for those with few trips. Quarters of a year are chosen. However, to get enough observations in each group, some sequences/quarters are aggregated mutually (at least 10 trips are needed, not to get an unstable function (Kleinbaum and Klein, 2012)). It is for each type of simulation tested that the groups of sequences/quarters can be accepted to have similar gaps and the groups are accepted to be mutually different.

The estimation of the travel times is based on an assumption that the trips for each person are independent. In order to secure this, returning home from an additional simulated trip can at the latest be the day before the more recent trip starts. The date furthermore must be a year before the reference date of the respondent at the earliest. These requirements are handled in programming in SAS.

For each respondent, 100 random figures between zero and one are generated. These random figures should correspond to the survival probability of the predictive model. Because the random figures fall between two observations of the number of days since the reference date, a linear interpolation is made between the numbers of days in the predictive survival functions.

4.5. Simulation of extra private trips

Extra private trips are simulated before the earliest private trip until all private trips up to a year before the reference date are included. For the first quarter, all travel sequences are estimated together, see Fig. 4. For the following 3 quarters, travel sequence 1 is simulated separately. Sequences 2 and 4 are aggregated, because for these the two private trips are following each other. Sequences 3, 5, 31 and 41 are aggregated, too. They all have one or more business trips between the private trips resulting in longer gaps between the private trips.

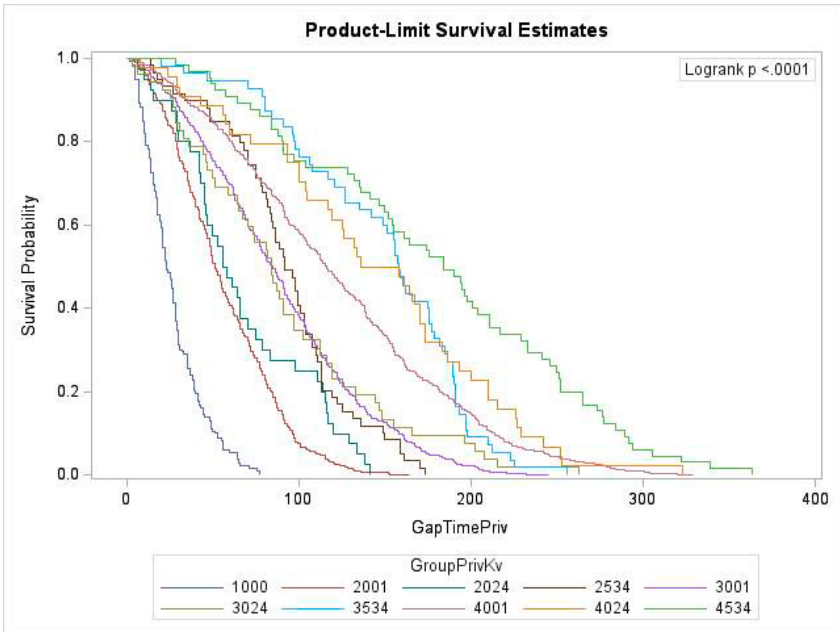

Fig. 4 Survival functions for each of the estimated groups of quarter and sequences. The first digit represents the quarter, and the 3 following digits indicate the groups of sequences, for instance, 24 are the sequences 2 and 4, and 534 are the sequences 3, 5, 31 and 41.

The result is 2.08 annual private trips per respondent, 1.50 from the diary and 0.58 simulated private trips, which means that 28% of the private trips are simulated. On average, the respondents assess that they have had 11% fewer private trips than the simulation indicates, see Table 3.

Table 3 Results from simulating extra private trips up to one year. The resulting private trips are divided into the number from the diary and the number from the simulation.

Travel sequence		Stated in the interview			Diary + Simulated	Memory effect
		All Trips	Private	Business	Private trips	
1	P-P-P	2.26	2.04	0.22	1.64 + 0.61 = 2.24	9%
2	P-P-B	3.19	2.11	1.09	1.41 + 0.50 = 1.90	-11%
3	P-B-P	3.09	1.81	1.28	1.29 + 0.67 = 1.95	7%
4	B-P-P	3.21	1.61	1.60	1.05 + 0.97 = 2.02	20%
5	B-B-xb-P-xb-P	7.18	1.11	6.06	0.77 + 0.23 = 1.01	-10%
31	P-B-B-xb-P	4.35	1.52	2.83	1.11 + 0.53 = 1.64	7%
41	B-P-B-xb-P	4.86	1.66	3.21	1.16 + 0.42 = 1.58	-5%
All		2.50	1.85	0.69	1.50 + 0.58 = 2.08	11%

4.6. Simulation of extra business trips

Extra business trips are simulated for the three travel sequences with a gap between the second business trip and the first/second private trip. Due to fewer observations, more aggregation for each sequence/quarter is needed to get more than 10 observations in each group for estimation of the survival function, see Fig. 5. Table 4 shows the number of annual trips per respondent and the added simulated business trips. Overall, 42% of the resulting annual trips are simulated for the three trip sequences.

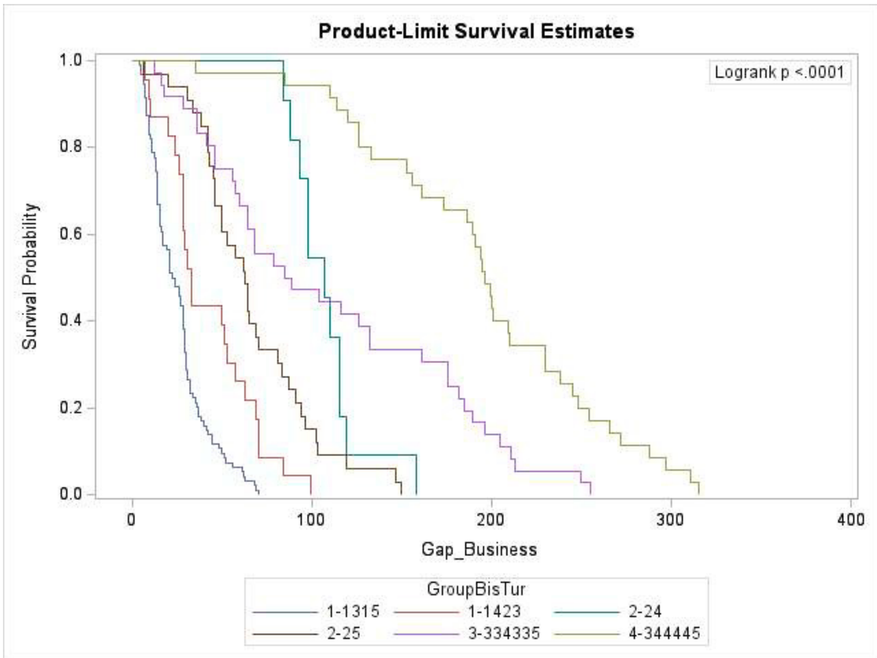

Fig. 5 Survival functions for each of the estimated 6 groups of quarter/sequences. The first digit represents the main quarters and the 2–6 following digits are the real quarters (1–4) followed by the sequence numbers (31, 41, 5)

Table 4 Number of annual trips from diary plus simulated business trips before the private trips.

Travel sequence	Stated in the interview			Interview maximum		Diary	Diary + simulated
	All Trips	Private	Business	Private	Business	Private	Business trips
5 B-B-xb-P-xb	7.18	1.11	6.06	8	100	0.77	1.43+2.34=3.77
31 P-B-B-xb-P	4.35	1.52	2.83	9	30	1.11	1.14+0.93=2.07
41 B-P-B-xb-P	4.86	1.66	3.21	8	28	1.16	1.52+1.16=2.68

5. Discussion

Two questions can be raised from the results of the analyses, 1) Is the latest trip methodology removing the memory effect? and 2) Are the methods to calculate the annual number of trips useful and will they give a correct result?

5.1. Evaluation of the methods to estimate the annual number of trips

The number of annual private trips with the simulation method is quite different from the cumulated hazard method. On the one hand, we mention that trips are missing in the cumulated hazard modelling, especially when estimating the extra private trips. On the other hand, the resulting number of trips is very high compared to both the number of simulated trips and the information from the respondents. The only explanation for the contradicting results is that the cumulated hazard model cannot be used for estimating the annual trips. In a hazard model, the risk function generates new risks/trips immediately before the former risk i.e., the day of returning home from a trip. However, the real date for the former trip is much earlier due to the duration of the trip. Therefore, it is not possible to accommodate the estimated high number of trips during one year. The cumulated hazard modelling, therefore, must be rejected as a practicable method for our purpose.

(Frei et al., 2010) used the hazard ratio, based on the mean gap time between the trip starts. Based on this, the annual number of trips is calculated as $365/h$. Due to their definition of LDT as trips over 100 km, only a minor share includes overnight stays, and therefore the result is less overestimated than in the paper at hand.

The results from the simulation indicate more homogeneous results for the simulation of extra private trips in Table 3. Respondents with only private trips have the highest number of annual private trips. The three groups with few business trips in different patterns have a rather similar number of private trips (1.90–2.02) whereas those who mention two business trips and one private trip as the three most recent trips have again close to the same number of annual private trips (1.58–1.64). The intensive business travellers in sequence 5 only have one annual private trip.

5.2. Further development of the simulation

At this stage of work, simulation of both private and business trips prior to the earliest reported trips is not developed. Only earlier private trips are simulated. Following the methodology developed in the section above, extra business trips should be simulated between the simulated private trips for both trip sequence 5-41 and 2-4.

A precondition for using the PWP total gap model is that the trips are independent, which is probably not the case for respondents with many private and business trips. Using the PWP model for the analyses might therefore lead to overestimation. For instance, travellers reporting sequences 5, 31 and 41 might not have so many extra private trips as simulated if they are travelling intensively for business. They might take the opportunity to have a short holiday break together with the business trip, or prefer to stay more at home, tired of travelling.

Instead of starting with simulation extra private trips, simulation could start with simulating extra business trips before the first reported private trip, especially for trip sequence 5-31. This way fewer private trips might be squeezed in between the business trips than what was observed in the result above. In all cases it is needed to test if the private and business trips in the final simulated trip sequences are independent. If this is not the case, the outset should be in an Andersen-Gill model with simulation based on a marginal model and not on a PWP total gap model. This will be developed and analysed in the further work.

5.3. Is the most recent trip methodology removing the memory effect?

As mentioned, the distribution of the survival function for the second and third trips is estimated not to be different. This shows that an important purpose of the alternative data collection method used in this survey has been obtained. Still a smaller memory effect or conscious incorrect reporting can be the case.

When inspecting the two curves in Fig. 1, a weak difference between the curves can be observed from around month four to month eight where the red curve for gap two lies a little under the green curve for gap three. This could be an indication of a small memory effect for trip number three. Even though the difference between the curves is not significant, it seems as if a few respondents forget a trip. Such missing trips could be less important (shorter) weekend trips while the respondents remember the long holiday trips the year before.

An important problem is respondents with many trips. The solution of asking for the most recent trips improves the results compared to the retrospective method. However, the need for a high number of simulated trips might give rise to more uncertain results. An option is to ask for one or two extra trips. This way only the real high frequent travellers will need simulation. However, it will give rise to more response fatigue and respondents who drop out. Frei et al. (2010) ask respondents for the number of similar trips in one group. However, what similar trips are, is unclear. Should both the destination and transport mode be similar? The method seems to be an obvious addition after having asked for the latest trips from respondents with a second home or close family abroad. It could also be a possible solution for respondents who state to have had many business trips. In any case, it introduces a new memory effect.

6. Conclusion

The alternative method of asking for the most recent trips supplemented by the simulation of trips up to one year is promising. However, more work on the methodology and more surveys are needed to draw the final conclusion and recommendations. In any case, it is never possible to get information about all trips during a year from the survey due to response fatigue. A method to get hold of the right number is needed in any case. It is shown that the cumulated hazard cannot be used for estimating the annual number of trips.

Furthermore, it should be remembered that estimating the annual travel distance is essential too. Travel distance cannot be simulated; instead, a traditional regression analysis, which takes care of the relationship between travel frequency and travel distance must be used.

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