Denne artikel er publiceret i det elektroniske tidsskrift
Artikler fra Trafikdage på Aalborg Universitet
(Proceedings from the Annual Transport Conference
at Aalborg University)
ISSN 1603-9696
www.trafikdage.dk/artikelarkiv

Ny metode til at indsamle interviewdata om rejser med overnatning / Considerations on a method to analyse long distance travel when collecting only data about the two latest journeys

Linda Christensen, LCH@Transport.DTU.dk
DTU Management

Abstract

The purpose of the paper is to present alternative methods to reduce the cost of long distance travel surveys in the hope that it should be more economically feasible to conduct such surveys regularly. A new Danish survey about journeys abroad with overnight stay(s) is used to investigate if it is possible to collect long distance travel data by only asking for information about the two latest journeys. It is shown that the time gap between the latest journey and the journey before this can be used to estimate a survival function for the probability to travel after a certain date. From this the annual number of journeys is calculated and a weight is extracted dependent on the time gap between two journeys. It is shown how these weights can be used as multipliers for calculating among others the annual travel distance, travel purpose and mode. The results are compared with a survey from 2010-11

Different kind of strengths and weaknesses compared to a traditional retrospective long distance travel survey are discussed, especially the memory effect. It is shown that the alternative methodology more than doubles the number of reported journeys compared to a retrospective survey reporting journeys during 3 months. Finally, the paper includes some recommendations on the questionnaire and the data collection process.

Background

During the last 25 years, only relatively few nationwide long distance travel surveys (LDTS) have been conducted in Europe. Two main EU research projects have developed a methodology to collect data. The first project, MEST (Methods for European Surveys and Travel Behaviour) from 1996-99 (Axhausen, Madre, Polak, & Toint, 2003) resulted in the development of the Cross European data collection, Dateline, which was conducted in 2001 by the European National Statistics under the direction of Eurostat. The second project, Kite (a Knowledge Base for Intermodal Passenger Travel in Europe) from 2007-09 had three main purposes, 1) to analyze the results from Dateline (Gomes & Santos, 2004; Kuhnimhof & Armoogum, 2007), 2) to develop new guidelines for an LDTS (Kuhnimhof, Collet, Armoogum, & Madre, 2009) and 3) to test the method on three surveys from the Czech Republic, Portugal and Switzerland (Frei, Kuhnimhof, & Axhausen, 2010).

Several National Travel Surveys (NTS) include a LDTS. However, most outcomes are only reported in national reports, if at all, see e.g. for Norway (Vågane, Brechan, & Hjorthol, 2011). The most recognized European long distance travel (LDT) project is the British in which domestic LDT behavior was analyzed, and a forecast developed (Dargay & Clark, 2012). In Denmark, a LDTS was included the NTS, too, but data were never analyzed and for economic reasons the survey was stopped in 2001. During 2010-11, a new Danish one-year LDTS (only including journeys with overnight stay(s)) was conducted independently of the NTS (Christensen, 2013, 2015; Knudsen, 2015). The reason for separating the surveys was that a very long interview time by telephone was assessed to lead to too many dropouts in case of including a LDTS. After this survey, only very little interest has been paid to LDT, and it has not been possible to raise money for a new Danish LDTS.

Based on the experience with collecting LDTS during the last 30 years, the author of this paper has reached the conclusion that it would be attractive to develop cheaper surveys. Consequently, it was decided by DTU Management Engineering to develop and test a new cheaper methodology and compare the results with the traditional method used in the Danish LDTS from 2010-11. The aim of the present study is to present the methodology and discuss quality of the different methodologies.

Traditional Long Distance Travel Surveys and alternatives

The two most common ways to set up a LDTS today are a retrospective survey and a longitudinal survey, respectively. In the retrospective survey, the respondents are asked to report all trips they have performed during the latest period, which typically covers between 8 weeks and one year (the so-called travel period). The longitudinal survey follows the respondents who have to report when they are active or at certain intervals, which makes intermediate follow-ups by the organizers possible. According to (Richardson & Seethaler, 1999), the two main problems with the retrospective method are:

- A long response period covered by a survey results in a substantial memory effect
- A short response period results in a high share of respondents who have not made a journey. Therefore, the sample has to be rather big to get enough journeys to analyze

The problems with memory effect depend on the frequency of the activity, the length of the trip and whether it is private or business (Armoogum & Madre, 2002). (Denstadli & Lian, 1998) reported a memory effect of 32% for journeys over 100 km whereas longer journeys had a lower memory effect. (Christensen & Knudsen, 2017) only finds an effect of 16% for journeys with overnight stays. For both, the level is measured as the number of journeys made two and three months back in time compared with the number of journeys during the latest month.

A longitudinal survey, which has to run for a year to take into account the seasonality of LDT, solves the problems of the memory effect (Aultman-Hall, Harvey, LaMondia, & Ritter, 2015). On the other hand, a longitudinal survey suffers from problems of dropouts during the survey period and might also suffer from some underreporting from those who do not drop out. If each participant is only participating for a short period and is replaced by a new respondent after 2-3 months, the longitudinal study also suffers from the problem of recruiting many participants with only few journeys each.

The interest of the present paper has been focused on a survey based on an idea put forward by (Richardson & Seethaler, 1999) who suggested to only ask the respondents to report their latest journey. The results from this should be used to estimate the annual travel frequency and the distribution of trips over the population and types of journeys. By using the latest journey methodology, (Richardson & Seethaler, 1999) emphasizes that the respondents only have to report one journey each. They expect this to increase the number of reported trips to - in principle - one trip per respondent. Furthermore, they consider the memory effect to be smaller than in a traditional LDTS and close to zero. Respondents with a low travel frequency are expected to be able to remember their only journey during a long period of time, and respondents with a high trip frequency will only need to remember a journey that took place a short time ago. In a retrospective survey, high frequent travelers are expected to have low recall of trips during the recall period.

In (Frei et al., 2010) is used a modified version of the latest journey method. The survey is a LDTS covering 8 weeks. However, if the respondents made no journeys during the 8 weeks they are asked about the date of a possible journey after the beginning of the 8 weeks or the date of the latest journey before the first journey in the 8-week period. The added journeys are included as censored journeys with no other information than the date.

The two surveys

Both the new survey and the survey from 2010-11 define LDT as journeys with overnight stay(s). In the new survey, only international journeys are included, because domestic journeys are assessed to be properly covered by the continuous Danish NTS (DTU Transport's Data and Model Center, n.d.) with at least 10,000 annual interviews. In the 2010-11 survey, domestic journeys with two or more overnight stays were included too.

The 2010-11 LDTS was a traditional retrospective survey conducted during one year. The survey covered travel behavior during 3 months supplemented with questions about journeys with more than 5 nights' stay during the latest year. For the 2010-11 survey, the respondents received a letter by the turn of a month asking them to answer the questionnaire by the internet (CAWI). Those who had not answered after a week were contacted for a telephone interview (CATI). They were asked about the number of international and domestic journeys month by month and for details for up to six journeys.

For both surveys, respondents are sampled representatively in the Danish central register of persons among adults aged 16 and over.

The new survey is only conducted during a period of 3 months and is mainly a web survey (CAWI). The goal was to collect 3,000 useful interviews, a goal which was reached. The respondents were contacted by an e-mail sent to their electronic mailbox (a so-called e-box). It is mandatory for the Danish population to have an e-box to which public authorities can send e-mails with personal information. However, people without internet access are granted an exemption. 7.4% of the sample has no e-box, the share increasing by age. A small sample of 600 telephone interviews is collected from non-respondents (one third from the group without an e-box) to uncover the size of a possible bias due to use of CAWI and an e-box.

The sample is evenly distributed over each day during a 12 weeks' period starting on June 23rd 2017. 239 persons were allocated to each day. The letters were sent in batches once a week. After two weeks, a reminder was sent to those who had not participated yet. An important problem using the e-box solution is that many people only open their e-box if or when they get a letter they consider relevant for them. 5 weeks after the first e-mail the response rate was too low to reach the intended 3,000 interviews. A reminder was therefore sent by SMS to people with a known cell phone number. The final response rate by CAWI is a bit over 15%. In 2010-11, the response rate by CAWI was 16%.

The main part of the new questionnaire is allocated to the latest journey. The respondents are asked in which year the journey took place. In case it took place in the period 2015-17 they were asked to report many details, including the exact date of returning home (if not available, the week or month). In the CAWI interview, the respondents were furthermore asked to report two more journeys with a private purpose in the period 2016-17. For these, only the main information about the journeys was collected on top of the exact date.

Methodology to analyze the new LDTS data

A main purpose of the new survey is to develop a methodology to determine the travel frequency of the respondents measured as number of trips per year. In the traditional LDTS from 2010-11, the number of annual journeys is derived by multiplying the number of journeys during the 3 months by 4, while ignoring the memory effect. A survey including only the latest journey is missing journeys performed by respondents who have more than one journey during the one-year period. It is therefore necessary to use knowledge about the reported journeys to infer the missing journeys. Furthermore, the results are biased if travel behavior and distances are analyzed based on the pool of all journeys in the survey. Journeys taking place a year or more ago are probably not representative for the journeys taking place shortly before the survey. It is needed to develop a trip rate multiplier as a function of the number of days since the journey was made, which can be used as a weight for analyzing the distribution of mode choice, travel purpose etc. It is especially necessary to upweight travel distances for the journeys to calculate the correct annual travel distance per inhabitant or per mode.

Based on simulations, a probabilistic model is developed in (Richardson & Seethaler, 1999) for an average trip rate multiplier under ideal conditions as a function of the number of days since the journey was made. The ideal conditions are e.g. no seasonality and a linear distribution of the population's travel frequency.

When collecting real data, a model developed under ideal conditions is not feasible. First of all the assumption about the distribution of number of journeys over the population is unknown, because it cannot be revealed from a three-month survey. In the Danish survey from 2010-11, nearly half of the respondents were not travelling and the distribution of journeys is unknown. 10% of the respondents represent 50% of the journeys, which indicates that the distribution is not linear.

Survival modelling

Instead we turn to the method suggested by (Frei et al., 2010) for which a censored journey is added before or after the analyzed travel period in case the respondent has made no journeys during the survey period. The time gap between the censored journeys before or after the survey period and the time gap between the known journeys are modelled by hazard modelling using a non-parametric survival distribution. From this the hazard ratio is estimated, and is used to upweight the annual number of journeys for the surveyed respondents. The method is, however, not clearly described in the paper and therefore not easy to use. An alternative method, which is statistically consistent, is therefore developed and described in this paper.

Survival and hazard modelling is developed to estimate e.g. survival time of a population or a group of people suffering from a disease, to test the effect of medical treatment in epidemiology and pharmacy or to analyze breakdown of technical products. In transport research, survival modelling has been used for analyzing duration of transport activities, e.g. (Bhat, 1996).

Gap times and censored gap times

In epidemiology, the time to an event is normally censored meaning that it is not the whole sample that has experienced the incident (yet). Some of the test persons might have died from other reasons and have therefore been left out of the investigation. Others have not experienced the analyzed incident (yet) when the experiment / investigation ends. The same is the case with our travel data, among other things because many respondents have not taken part in two private journeys after January 1st 2016, the date for which a limit for travelling was set up. In (Lu & Shen, 2014) it is emphasized that special methods are needed when handling censored data, because ignoring the censored observations and using traditional multivariate regression methods will result in serious mistakes when the censored observations reach a certain amount, which is the case of our data.

The analyzed time is referred to by the term 'gap time'. The first gap time starts on the date allocated to the respondent. The latest journey has to be finished at the latest at this date, mentioned as '*the latest date*'. The second and third gap times are the time gaps between the latest journey and the latest private journey and between the two private journeys, respectively. These gap times start when the respondent returns home from one journey and ends when he/she is back from the former journey. The first gap time can be zero. However, to be able to use the logged value (which is used in the estimation) it is offset with one in case of the value zero.

The CAWI data can include up to three journeys and gap times. The CATI survey only includes one journey, and therefore only one gap time. The latest journey in both surveys is reported at any date back in time, whereas the two private journeys in the CAWI survey are only reported if they took place in 2016 or 2017. Therefore, in many cases only one earlier private journey is included and sometimes none at all. When only one or two journeys are reported, it is needed to add an extra earlier 'journey' as a censored 'journey' to indicate that the respondent had no more journeys in the survey period. The added censored journey is allocated to the latest date it could have taken place as the only information. When it is known that the respondent has no earlier journeys than the reported one(s), no censored journey is included. In case the respondent has no journeys at all, no observation is included in the dataset for estimation of the survival model. However, these respondents (59 of 2987=2.0%) are still needed for calculation of the annual number of journeys and travel distance per capita.

In most cases, the earliest date a third (or second) journey could take place is January 1st 2016. In case the latest journey is a business journey or, by mistake, ends after the stated *latest date*, the number of included journeys is reduced and we do not know if an earlier journey has taken place before or after January 1st 2016. The censored 'journey' is then dated to the day before the respondent left for the earliest known journey. If the length of the later journey is unknown, the travel length is chosen as the median number of nights, which is seven. The latest journey can end before January 1st 2016 and the respondent is not asked for earlier journeys. In this case, a censored 'journey' is added too with a return date as the one described above.

The survey only includes persons aged 16 or above. Consequently, it should not be possible to include journeys that have taken place before the beginning of the year when the respondent turned 16. All journeys and censored 'journeys' dating from before the respondent turned 16 are therefore removed.

Survival modelling

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 (Kalbfleisch & Prentice, 2002; Lu & Shen, 2014):

$$F(t)=P[T \leq t\,],\ t \geq 0. \tag{1}$$

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:

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

S(t) is a non-increasing function with its values between 1 and 0. When *t* approaches ∞, *S(t)* approaches 0. In our case, each of the survival functions has a maximum value (MAX) of t. The survival function therefore has to be corrected by normalization of the density function. The normalized density function is

$$\tilde{f}(t) = [S(t) - S(t+1)] \mid t < MAX = \frac{f(t)}{\int_{x=0}^{x=MAX} f(x)} \tag{3}$$

The normalized survival time, which is 0 by the maximum gap time, is therefore:

$$\tilde{S}(t) = 1 - \int_{x=0}^{x=t} \frac{f(x)}{\int_{y=0}^{y=MAX} f(y)} \tag{4}$$

The survival function is estimated as a Kaplan Meyer estimate and fitted by a non-parametric survival distribution (Kalbfleisch & Prentice, 2002). For the estimations is used the SAS procedure Proc Lifetime (Lu & Shen, 2014). When using a non-parametric form no assumption is made about the distribution of the gap times which means that the estimation can get 'closer' to the real distribution of the observed gap times.

The estimated gap time at time t *μ(t)* is the mean value of the survival function. The mean gap time is used to calculate the annual number of journeys per capita (persons over 15 years) as 365/μ(365). The estimated figure *x/μ(x)* can furthermore be used as a weight for day *x*, when analyzing the annual travel distance per capita over 15 years and the distribution of mode choice, travel purpose etc. The probability of travelling is much higher for people who only had a few days between their reported journeys than those who have reported a long interval in between. This is reflected in a high weight for the respondents who have a very short gap time between two journeys.

Figure 1 shows the estimated normalized survival curves for the three gap times. The survival curve for the first gap time lies below the curves for especially the second gap time. This means that the probability of travelling three months before the *latest date* is higher than traveled 3 months earlier than the latest journey. This is, however, what could be expected. In theory, the time from the date of the survey until the most recent journey is only half of the time between two random journeys when the survey date is chosen independently of the travel dates. Using the gap time to the latest journey is therefore not the correct choice for an alternative method to the traditional survey method. The analyses have to be based on a gap time between two journeys. The survival curves for the gap time between journey one and journey two and between journey two and journey three should on the other hand be the same when there is no memory effect and no seasonality.

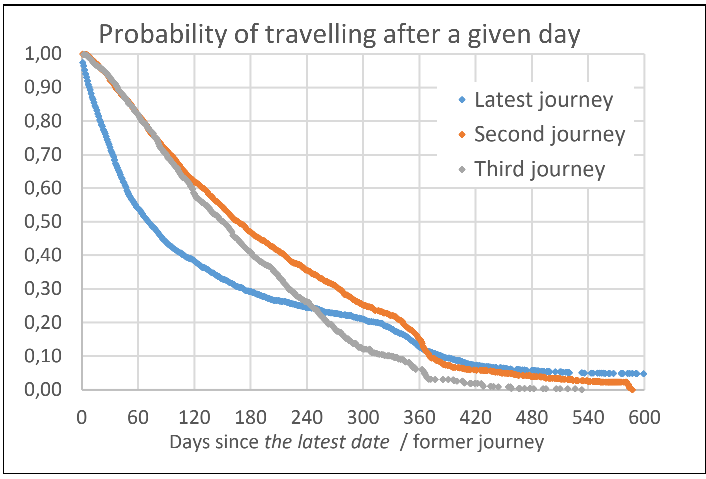

Figure 1 The estimated normalized survival curves

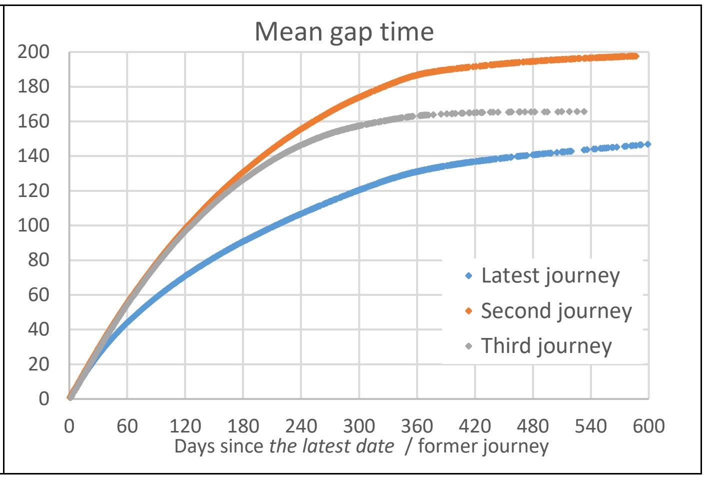

Figure 2 The estimated mean gap times

Estimation results for the new survey

Due to seasonality, the journeys are not randomly distributed in our test survey. A high share of the latest journeys took place during the summer holiday (the Danish school holiday is in July) shortly before *the latest date* (see Figure 3). More than 10% arrived home during the last 10 days before *the latest date*. A top in the summer one year earlier is clear too. The gap time between the latest journey and the former journey is a little more evenly distributed. However, the summer one year earlier is very clear and a smaller peak can be observed after 140-160 days, which represents the winter and spring holidays. This underpins the need to conduct a full year LDTS. The distribution of the gap times between journeys 2 and 3 (not shown) is more evenly distributed during the first 3 months. On the other hand, it is heavily influenced by the limit imposed for private journeys at the start of 2016, which properly explains the big difference between the survival curves of gap times 2 and 3.

Figure 2 shows the mean gap time between two journeys. Based on the gap times for the time between the latest journey and the former journey, the annual number of journeys can be calculated at 1.94. When also taking the 59 respondents who have no private journeys into account, the annual number is reduced to 1.90. Using the gap time to the latest journey results in 2.71 journeys. Consequently, it is very important not to rely on the latest journey. The survey in 2010-11 resulted in 1.45 annual private journeys per respondent, or an increase (or difference) at 31%.

The interview includes a question about the travel destination (the place furthest away or, if this is unclear, the destination with the longest stay). The respondents were asked to show the destination at Google map from which the coordinates are extracted. After post-processing destinations only described in words, the craw fly distances from home to all destinations are calculated (one-way distance). The mean distance for all included second journeys is 2,565 km[1] (Std Dev=2,943). However, the weighted mean is only 2,275 km (Std Dev=4,788). With 1.90 annual journeys, it makes 8,645 annual kilometers two-way per Dane over the age of 15 for private travel purposes. This can be compared with the results from the LDTS from 2010-11 which resulted in 6,818 km, showing an increase (or difference) at 27%.

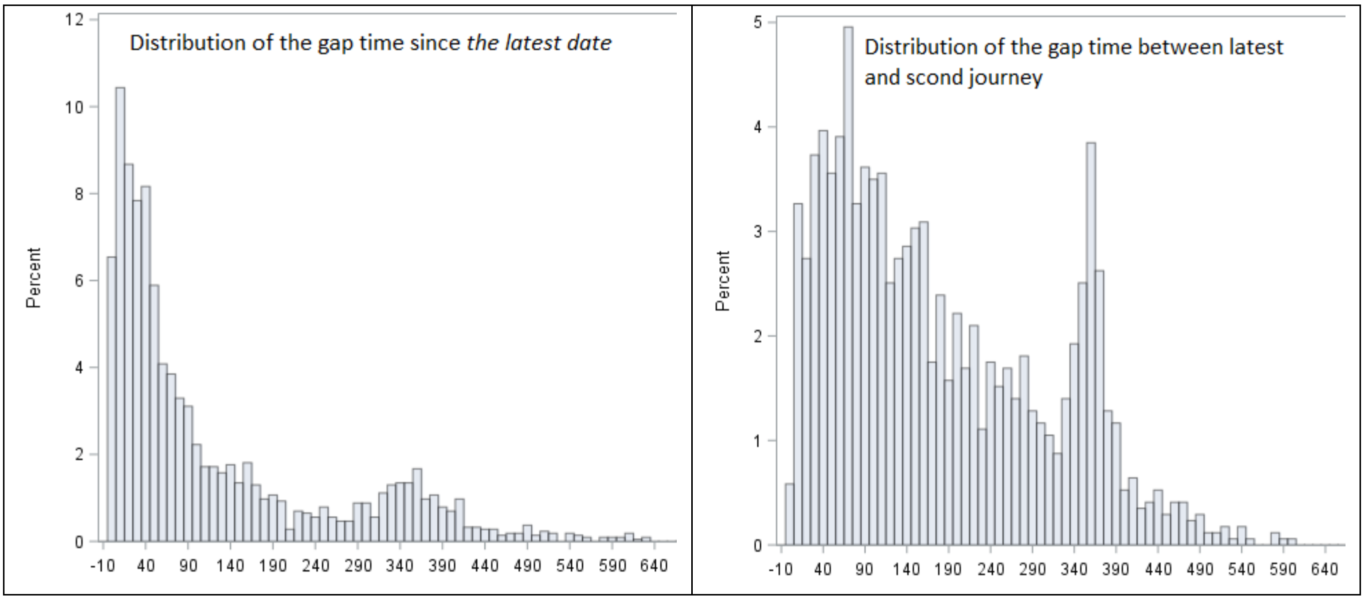

Figure 3 Distribution of the gap times between *the latest date* and latest journey and between the two latest journeys

The results indicate that taking the high frequent travelers into special account reduces the travel distances per journey (but not the high frequent travelers' overall annual travel distance). Respondents with very short gap times and high weights are few, 1% of the respondents have a weight over 20 and 10% have a weight over 5.9 (travelling at least every 33 days - once a month). The unweighted mean distance is 2,095 km for the latter 10%. A simple (weighted) regression analysis with gap time in first and second power as independent variable confirms that those who travel often travel shorter per journey than the majority (travel distance=1,939 km + 5.70*gap time - 0.0084*gap time^2 - (the second power is not significant)). Taking the variation in travel frequency into account is therefore important. When business journeys are included, it is probably even more important.

In these analyses, we have used travel distances for the reported second journeys. However, these might very well be influenced more from memory effect than the latest journey. If the presented alternative method for a LDTS is applied, it might be attractive to use the latest journey for the analyses - or both to increase the included number of journeys. We have therefore also calculated the travel distance for the latest journey, but still used the weight estimated from the gap between the latest and the second journey. The weighted mean travel distance of the latest journey is 2,045 km, which is 10% less than for the second journey. Similar with the unweighted distance (2,376 km - 7% less). Finally, the unweighted mean distance is calculated for all latest journeys at 2,430 km. This figure includes journeys by those who have only reported one private journey during 2016-17. It is only 5% lower than all included second journeys.

Table 1– Distribution of the second journey on private travel purpose, 2017 and 2010-11

	2017		2010-11	
Purpose	Annual number	Distance	Annual number	Distance
Holiday	77%	80%	78%	85%
Other	8%	6%		
Visiting	13%	13%	9%	2%
Second homes	1%	1%	10%	11%
No information			4%	2%

[1] 1 kilometer=0.612 miles

In Table 1 and Table 2 is shown the distribution on travel purpose and mode choice for the second journey. A surprising high share is mentioned as 'other purpose', however, with a low share of the travel distance. When comparing with, the share of the journeys for visits to friends and relatives and to second homes has increased substantially. This is probably again due to seasonality with a predominance of visits in spring and holidays in the summer.

Table 2 Distribution of the second journey on modes, 2017 and 2010-11

	2017		2010-11	
Mode	Annual number	Distance	Annual number	Distance
Plane	67%	89%	54%	78%
Car	28%	9%	30%	13%
Train	1%	0%	4%	6%
Coach	2%	1%	5%	
Bus	0%	0%	2%	
Ferry	1%	0%	1%	
Other	0%	0%	1%	
Cruise	0%	1%	n.a.	
No information			3%	2%

According to modes, a shift is observed to plane from all other modes. Especially coach and public transport has nearly disappeared as mode for LDT. Car has been concentrated on shorter distances.

Comparing quality with the LDTS from 2010-11

An evaluation of the two survey methodologies has to include both quality and economy, which is discussed below.

Memory effect

An important question is the quality of the responses when collecting information about journeys far back in time. Most important is the memory effect. In the LDTS from 2010-11 is asked for the number of journeys month by month during the three latest months. The number of journeys was divided into domestic and international journeys and into journeys with 5+ nights' stay and less. When the latest month is taken as baseline, the overall number of reported journeys is 22% lower one month earlier and 19% lower two months earlier. When only looking at international journeys, the same figures are 18% and 16%, respectively. This indicates a substantial memory effect, however, surprisingly only for the second month. Furthermore, the respondents are asked how many journeys they have had with 5+ nights during the previous nine months (up to one year overall). With the same methodology, the result is 43% lower for international journeys and 39% lower for domestic journeys than in the latest month, indicating an increasing effect over time.

A distribution of the journeys over the year gives a hint about the mysterious memory effect 3 months back in time, see Figure 4. The distribution of the journeys for the baseline month shows clear peaks in April (Easter), May (several short holidays) and July (summer holiday). The peaks for the distribution of the journeys in month two is less distinct and in the third month, the peaks have nearly disappeared. Only a small peak is seen for the summer. This indicates not only a memory effect due to which journeys are forgotten but probably also a memory effect due to which earlier journeys are reported as conducted within the 3-month period. This can explain the 'missing' decrease in number of journeys in month three back in time. It confirms that a retrospective survey suffers seriously from memory effect probably from both high frequent travelers who give up remembering their journeys, and from low frequent travelers who want to tell about a journey even though it is not quite recent. These effects are not needed with the alternative method in which everybody have to report two journeys.

In (Richardson & Seethaler, 1999) it is suggested that the respondents might better remember the latest journey, even if it is a little back in time. If our alternative method should be used, the respondent must remember the two latest journeys. When the second journey is 5-10% longer than the latest, it indicates that some of the respondents have forgotten a short international journey conducted between the latest and the reported former journey. They are probably reporting the more outstanding journeys. The difference is probably not due to a mistake in the distance as such because it is based on the chosen destination, which is probably the easiest to remember.

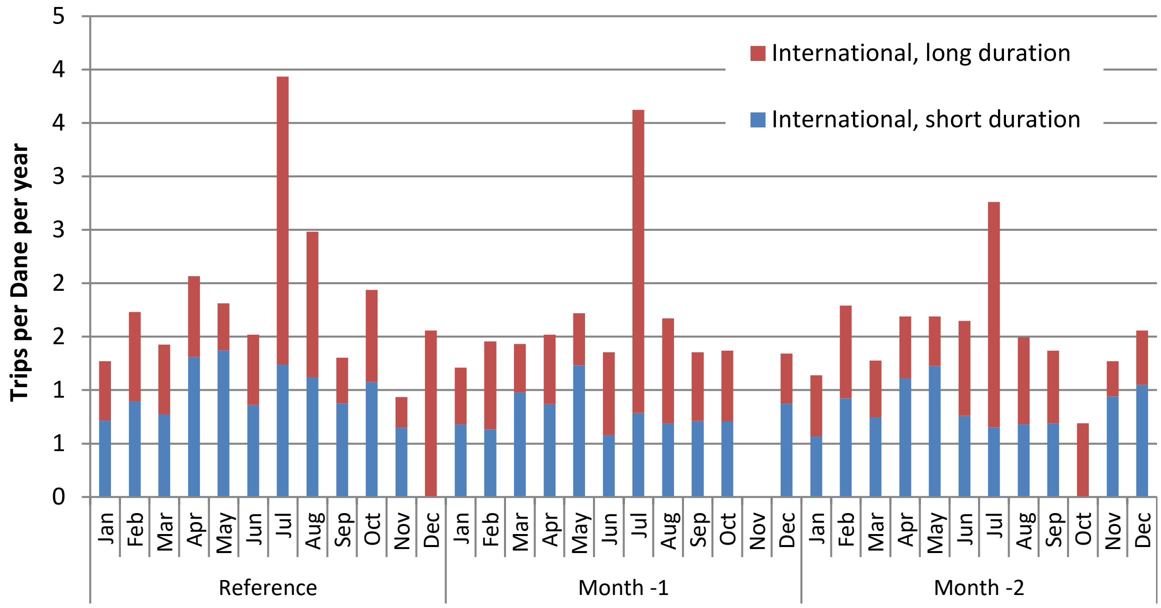

Figure 4 Distribution of journeys over the year from the LDTS in 2010-11.

However, the difference might partly be explained by the seasonality, where the latest journey is the summer holiday travel, whereas the second journey for the high frequent travelers is a spring journey. The result is also influenced by the fact that only respondents who have at least two journeys in 2016-17 are included, which means that the more frequent travelers are dominating the results. Conclusions about the memory effect need to wait a full year survey with an improved questionnaire.

An alternative indication of the memory effect could be to assess how exact the respondents remember or report the date of returning home. In the web interview, 71% of the respondents report an exact date for the latest journey. This share has decreased to 63% and 66%, respectively, for the second and third journeys taking place during the latest 18 months. The share reporting only the month is similar for the 3 journeys (13%, 15% and 13%, respectively). A small change from reporting the exact date to reporting only the week can be observed (16%, 22%, and 21%, respectively). Of course, we do not know if the date is correct. However, with the available information, the web respondents seem to remember / recall their journeys quite well.

Included respondents

In the 3-month retrospective survey from 2010-11, only 29% of the respondents were travelling internationally. By upweighting their journeys to one year it is shown that the population over 15 years made 1.45 international private journeys and 0.35 business journeys per year. When taking the known memory effect into account and adding a 2% annual increase in number of journeys per traveler the result is 1.79 journeys per year. Considering the season effect in the new survey, the number of journeys per inhabitant is in acceptable accordance. In the new survey, 43% of the respondents have travelled during the last 3 months prior to *the latest date*. This is a higher share than 29% in 2010-11. Again, some of the difference is due to the season effect. Furthermore, there seems to be a minor increase in the share of the population who travels internationally; in fact 7% of those who have travelled during the latest 18 months report that they have never travelled internationally earlier whereas only 2% has never been traveling (some might, however, have stated this to stop the interview (soft refusal)).

Using these figures, it can be assessed that around 40% will report at least one international journey during a three-month retrospective period. They will have 1.8 private journeys per year or 0.45 per three months.

However, they will only report 0.40 journeys due to memory effect. All in all, a traditional LDTS will deliver 4,000 international journeys per 10,000 interviews.

Using the alternative method, 94% of the respondents have been travelling during the latest two years. 7% has probably not been travelling earlier resulting in 87% reporting two journeys useful for modelling. Some of these journeys might be far back in time, but only reporting the travel month or even the year is in this case needed to estimate a satisfying survival model. If the latest journey performed during the previous two years is accepted in the analyses, this results in 8,700 useful journeys per 10,000 respondents or more than twice as many as in the traditional survey. Due to the few reported second journeys in the actual survey, only 1,646 journeys are included, equivalent to 5,750 journeys per 10,000 interviews.

Web interviews as an alternative to telephone interviews

The survey is based on CAWI, however a little more than 600 telephone interviews about the latest journey were conducted. The normalized survival function is estimated for the latest journey surveyed by CAWI and for CATI respondents with and without an e-box to receive the invitation, see Figure 5. The annual travel frequency for the respondents interviewed by web is calculated at 2.99. This is a little more than the frequency for the latest journey found above, because the actual analysis includes business journeys. For respondents without an e-box, the annual frequency is 1.92. The low level is first of all due to a high share of respondents over 70 who have not travelled abroad for several years. The CATI interviews with respondents with an e-box results in 3.43 annual journeys, which indicates a higher travel activity than for the respondents using CAWI.

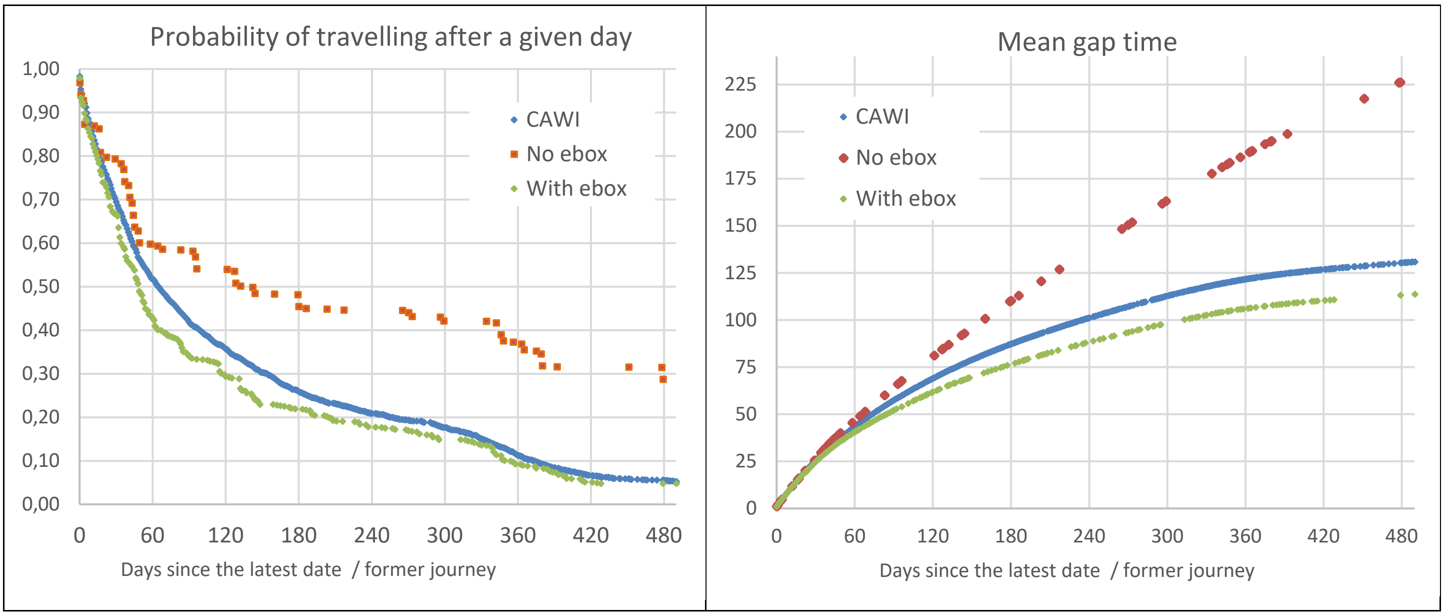

Figure 5 The estimated normalized survival curves and mean gap time for the three surveys, CAWI and CATI with respondents with and without e-box

A linear regression model has been used to analyze if the difference between the estimated survival functions can be explained by age, education and participation in the labor market. The analysis shows that this is not the case. A more detailed analysis for the CATI respondents with e-box is, however, needed to obtain an understanding of the high level of the travel activity. Only with this, it is possible to state if it differs so much from the CAWI that it is needed to include a CATI in future LDTS.

Conclusion and recommendations

The aim of this study is to develop a survey methodology for collecting travel data for LDT that can increase the amount of reliable data about the journeys at a reduced cost.

Only 29% of the respondents in a Danish retrospective survey in 2010-11 had been travelling internationally during the last three months. Some of these had never travelled; others might have travelled 4 months ago. This makes a substantial difference. On the other hand, 10% of the respondents had been travelling at least

10 times during the 3–month survey period (both domestic and international journeys). They represent 50% of the journeys. Together, this might bias the understanding of the resulting travel pattern and especially of the travelers' behavior. Furthermore, the high frequent travelers easily forget a journey or two, which is documented by a bias in the number of journeys one, two and three months back in time. Due to the high share of respondents without any journeys, a high number of interviews needs to be collected to get a reliable number of journeys to analyze.

Instead, as an outset we proposed to ask for the latest journey only. However, as the analysis shows, it is not a correct solution to ask for the most recent journey only, it is necessary to ask about the date of the latest journey before that too. With this information, it is possible to use a non-parametric survival modelling procedure to estimate a survival function for the gap time between the most recent journey and the latest journey before that. This survival function is normalized due to the cut off at the highest observed gap time. Based on the survival function for the second journey, the mean gap time and the annual number of journeys can be estimated.

It has been shown that using the two latest journey methodology will produce information about more than twice as many journeys as a retrospective survey reporting journeys within a 3–month period. In the Danish case, 87% will deliver information about their international journey with the new survey whereas around 40% deliver data in the traditional way. This means that the number of interviews can be more than halved and still provide the same precision. The average interview time will increase but less than the time saved by reducing the number of interviews.

What we do not know is to what extent the new survey is suffering from memory recall regarding details about the two most recent journeys. Especially, mistakes in the travel dates will bias the results. This can only be analyzed when a survey covering one full year is available, and even then only with difficulty. Another weakness is that it is not possible to point out the high frequent travelers and analyze their travel behavior separately. Of course, travelers with 2 or 3 journeys during a short period are more frequent travelers than those who have not been travelling during one year. However, the 2-3 journeys can be accidental and the gap to a former journey can be large. Asking about the behavior throughout a 3-month period provides more information about the high frequent travelers but less about the low frequent travelers.

It should be mentioned that the two methodologies can be combined similarly to what was done by (Frei et al., 2010). You can ask for the two latest journeys and supplement with a number of journeys performed during the last 8 weeks or three months. In our survey, we asked about the number of business journeys during the recent year. This can also be used to identify the high frequent business travelers, even though the exact number of journeys is uncertain. The same can be done for holiday journeys and visits to family and friends.

The survey has also been used to investigate if it is possible to get reliable information about the travelers by only using CAWI. It seems as if some of the most travel active persons are lost this way so that the resulting travel activity is under estimated. It is needed to look more into the results before a final conclusion can be drawn.

Recommendations for details in a new survey

It should be mentioned that the method used in the present survey to ask about journeys undertaken in a limited period should not be repeated because it reduces the mean gap time for the journeys taking place close to the beginning of the period. Instead, the date should be open-ended. In case of fear of a memory recall effect or dropouts due to respondents' problems with answering the question precisely, it is better to accept an imprecise answer, for instance only the month for journeys made more than two years back in time, because the effect on the mean gap time is limited. An imprecise answer is probably better than a censored gap time when estimating the survival model. The need to normalize the survival function also increases the uncertainty of the results. The closer the survival function gets to zero by observed journeys the more correctly the mean gap time can be estimated (the area under the survival curve)

On the other hand, it is important to get the precise date for the journeys finished shortly before the former journey. Mistakes in these journeys lead to a change in the model and in the annual number of journeys. This is an important weakness of the proposed method. As a control during the interview, you should ask for the duration of the latest journey and if the respondent can remember how many days they stayed at home before the next journey started. This is especially important if the respondent reports two journeys in the same month or week without specifying the exact dates.

It is furthermore important to refer to the date of returning home and not to the start of the journeys, to be sure to include all journeys finished at the allocated date. Using the date of start of the journeys would result in long-stay journeys being left out. Another important issue is that the latest date of finalizing the latest journey has to be fixed and evenly distributed over the year. The date should not be up to negotiation and journeys that are finalized too late have to be removed. A warning to the respondent should be included already during the interview.

In our survey we ask for many details about the most recent journey, whereas only the main questions are asked for about the earlier journeys. It might be more correct to ask for details about the journey before the most recent one, because it is more random. On the other hand, asking about an earlier journey instead of the most recent one will result in more memory effect. Analyses on the actual data seems to show a minor memory effect with loss of some shorter journeys. This is influencing both the weights, the number of annual journeys and the distribution of the journeys on distance. Furthermore, the further back in time the journey took place, the higher is the probability for a change in income, family situation and location of the residence. In a year long survey the memory effect can be investigated more in details.

Acknowledgement

The author wants to thank Professor Jeppe Rich and associate professor Anders Stockmarr for their support with developing the methodology for analyzing the collected data.

Armoogum, J., & Madre, J.-L. (2002). Weighting and correcting long-distance travel surveys. In K. W. Axhausen, J.-L. Madre, J. W. Polak, & P. L. Toint (Eds.), *Capturing Long-Distance Travel* (pp. 151–169). Research Studies Press, Baldock.

Aultman-Hall, L., Harvey, C., LaMondia, J. J., & Ritter, C. (2015). Design and response quality in a one-year longitudinal survey of overnight and long-distance travel. *Transportation Research Procedia*, *11*, 136–153. https://doi.org/10.1016/j.trpro.2015.12.012

Axhausen, K. W., Madre, J.-L., Polak, J. W., & Toint, P. L. (Eds.). (2003). *Capturing Long-Distance Travel*. Baldock: Research Studies Press LTD.

Bhat, C. R. (1996). A hazard-based duration model of shopping activity with nonparametric baseline specification and nonparametric control for unobserved heterogeneity. *Transportation Research Part B: Methodological*, *30*(3 PART B), 189–207. https://doi.org/10.1016/0191-2615(95)00029-1

Christensen, L. (2013). Development in Danish international air traffic. In *Proceedings from the Annual Transport Conference at Aalborg University* (pp. 1–21). Trafikdage i Aalborg / Annual Transport Conference at Aalborg University. Retrieved from www.trafikdage.dk/artikelarkiv

Christensen, L. (2015). Demand for long distance travel - A fast increasing but scarcely documented travel activity. Illustrated by Danish travel behaviour and compared with the other European analyses. In *AET Papers Repository* (pp. 1–21). European Transport Conference. Retrieved from https://abstracts.aetransport.org/paper/index/id/4626/confid/20

Christensen, L., & Knudsen, M. A. (2017). *Long Distance Travel - A study of Dane's journeys during 15 years*. Lyngby: DTU Transport Report 10.

Dargay, J. M., & Clark, S. (2012). The determinants of long distance travel in Great Britain. *Transportation Research Part A: Policy and Practice*, *46*(3), 576–587. https://doi.org/10.1016/j.tra.2011.11.016

Denstadli, J. M., & Lian, J. I. (1998). *Memory effects in long distance travel surveys*.

DTU Transport's Data and Model Center. (n.d.). The Danish National Travel Survey, TU. Retrieved November 6, 2017, from http://www.modelcenter.transport.dtu.dk/english/TU

Frei, A., Kuhnimhof, T., & Axhausen, K. W. (2010). Long-Distance Travel in Europe Today: Experiences with a New Survey. In *Transportation Research Board* (p. 16). ETH, Eidgenössische Technische Hochschule Zürich, IVT, Institut für Verkehrsplanung und Transportsysteme. https://doi.org/http://dx.doi.org/10.3929/ethz-a-005976787

Gomes, F., & Santos, F. (2004). Design and Application of a Travel Survey for Long-distance Trips Based on an International Network of Expertise. In *European Transport Conference* (p. 11). Association for European Transport.

Kalbfleisch, J., & Prentice, R. (2002). *The statistical analysis of failure time data*. Wiley-Interscience. John Wiley & Sons Inc, Hoboken. https://doi.org/10.1002/9781118032985

Knudsen, M. A. (2015). *Danish Long Distance Travel - A study of Danish travel behaviour and the role of infrequent travel activities*. Technical University of Denmark.

Kuhnimhof, T., & Armoogum, J. (2007). Existence and Comparability of Data Sources. Retrieved from http://kite-project.eu/kite/cms/images/stories/kite/WP2/D3 - Existence and Comparability of Data Sources.pdf

Kuhnimhof, T., Collet, R., Armoogum, J., & Madre, J.-L. (2009). Generating Internationally Comparable Figures on Long-Distance Travel for Europe. *Transportation Research Record: Journal of the Transportation Research Board*, *2105*, 18–27. https://doi.org/10.3141/2105-03

Lu, J., & Shen, D. (2014). Survival Analysis Approaches and New Developments using SAS. In *PharmaSUG* (p. 13). Retrieved from https://www.pharmasug.org/proceedings/2014/PO/PharmaSUG-2014-PO02.pdf

Richardson, A. J., & Seethaler, R. K. (1999). Estimating Long-Distance Travel Behavior from the Most Recent Trip. In TRB Committee on Travel Survey Methods (A1D10) and TRB Committee on National Transportation Data Requirements and Programs (A5016) (Ed.), *Personal Travel:The Long and Short of It* (p. 18). TRB Transportation Research Circular E-C026. Retrieved from http://ntl.bts.gov/lib/9000/9200/9200/09_richardson.pdf

Vågane, L., Brechan, I., & Hjorthol, R. J. (2011). *Den nasjonale reisevaneundersøkelsen 2009 - Nøkelrapport* (TØI rappor). Oslo: Transportøkonomisk Insttut. Retrieved from https://www.toi.no/getfile.php/Publikasjoner/TØI rapporter/2011/1130-2011/1130-2011-el.pdf