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De Haas, Mathijs; Ecke, Lisa; Chlond, Bastian; Hoogendoorn-Lanser, Sascha; Vortisch, Peter

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State-of-the-art of Longitudinal Travel Surveys – A Comparison of
the MOP and MPNMathijs de Haas^{a*}, Lisa Ecke^b, Bastian Chlond^b, Sascha Hoogendoorn-Lanser^c, Peter
Vortisch^b^aKiM Netherlands Institute for Transport Policy Analysis, Bezuidenhoutseweg 20, 2594AV The Hague, The Netherlands^bInstitute for Transport Studies, Karlsruhe Institute of Technology (KIT), Otto Ammann-Platz 9, D-76131 Karlsruhe, Germany^cDelft University of Technology, Valorisation Centre, Van der Burghweg 1, 2628CS Delft, The Netherlands

Abstract

Longitudinal travel surveys are needed to capture individual travel behaviour changes. Only two longitudinal travel surveys of national relevance are currently in operation, the German Mobility Panel (MOP) since 1994 and the Netherlands Mobility Panel (MPN) since 2013. This paper provides an overview of both panels' differences and similarities in design and data collection. Furthermore, representativeness, diary fatigue and non-random attrition are assessed in both panels to show the challenges panel surveys have to deal with. Overall, this paper shows important aspects of a panel survey that should be considered when designing a new longitudinal travel survey.

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1. Introduction

Travel behaviour is known to be relatively stable over time on an aggregated level (Thøgersen, 2006). Earlier research has shown that also on an individual level travelers are behaviourally inert; they do not change their travel behaviour often (Chorus & Dellaert, 2012; Gärling & Axhausen, 2003). However, changes in an individual's travel behaviour occur from time to time. It is essential to understand the underlying mechanisms of these changes from a

* Corresponding author. Tel.: +31-6-112-999-20;

E-mail address: Mathijs.de.Haas@minienw.nl

research and policy point of view. To do so, individuals should be observed over time (longitudinally) to capture these changes and thus to be able to link these changes to trigger events in the individual's life (Chlond & Eisenmann, 2018). Longitudinal travel surveys are therefore needed to study these underlying mechanisms of travel behaviour change and ideally – in order not to blur the results by methodological artefacts – without any design changes. The benefits of panel surveys with regard to cross-sectional surveys are well described by Zumkeller et al. (2006).

In addition to a variation over extended periods (years, decades), understanding individuals' situational behaviour is of great interest. To this end, a longitudinal capturing of travel behaviour enables measuring and understanding intra-individual variability. The temporal dimension can range from several days to weeks, during which travel behaviour is captured continuously. Schlich and Axhausen (2003) show that the survey period should not be less than two weeks if a survey aims to measure variability in daily travel. However, with every increase in the survey period, costs and response burden rise. Furthermore, Armoogum et al. (2022) state that the variability between workdays is less than between weekdays, Saturdays and Sundays, so that one week with two weekends could be a sensible compromise between capturing variability and keeping respondent burden low.

While longitudinal national household travel surveys are supposed to be representative, it is known from the literature that they often suffer from selective participation (Chung & Goulias, 1995; Kuhnimhof et al., 2006). The recruitment for a survey with a higher response burden likely creates selectivity related to the characteristics of participating households and their members (Armoogum et al., 2018). Moreover, as a longitudinal survey wants to maintain representativeness throughout multiple waves, the survey needs a refreshment with new participants to account for (non-random) attrition. Furthermore, the response burden is generally higher in longitudinal surveys than in cross-sectional surveys. Participants have more opportunities to drop out of the survey. Hence it takes some effort to maintain a representative sample.

In longitudinal surveys, the willingness to report may decline over time among some respondents. The reasons for this decline vary, e.g., decreased motivation for the content or lack of motivation to complete the survey documents. This decline has several dimensions. A distinction has to be made between attrition between waves (people do not want to participate again) and attrition within waves (people start to report but decline in accuracy over the survey period). Previous studies have analyzed both types of attrition (Axhausen et al., 2007; Chlond et al., 2013; Golob & Meurs, 1986; Kitamura & Bovy, 1987).

Only a limited number of large-scale longitudinal travel surveys have been conducted worldwide. Examples are the American Puget Sound Transportation Panel (PSTP) (Murakami & Watterson, 1992), the Dutch National Mobility Panel (LVO) (Van Wissen & Meurs, 1989), the Chilean Santiago Panel (Yáñez et al., 2010), the German Mobility Panel (MOP) (Ecke et al., 2019; Zumkeller et al., 1997) and the Netherlands Mobility Panel (MPN) (Hoogendoorn-Lanser et al., 2015). Of these panels, only the latter two are still in operation with unchanged designs. Both panels are based on experiences gained from earlier research, especially the Dutch Mobility Panel of the eighties (LVO) (Van Wissen & Meurs, 1989). An overview of relevant aspects such as definitions, analytical and practical advantages, and empirical challenges of longitudinal surveys is given in (Golob et al., 1997; Zumkeller et al., 2006).

Both the MOP and MPN offer many possibilities for studies that are not possible without having panel data. As respondents are followed for a longer period, one does not have to rely on, for instance, stated (travel behaviour) changes from the respondents but can observe changes. This allows, for example, for studies on the effect that life events (e.g. birth of a child, moving house) have on travel behaviour as well as determining substitution effects between different travel modes. Another advantage of a travel behaviour panel is the possibility for additional questionnaires. Besides the standard fieldwork, panels can be used to efficiently study topics through an additional questionnaire. As respondents already participated earlier, additional questionnaires do not have to include already known information (e.g., socio-demographics and travel behaviour). They can be relatively short and fully focused on the topic. This, for instance, allows studying the potential impact of new mobility concepts (such as MaaS) while differentiating between people with different travel patterns. A repetition of the standard fieldwork can also be added between waves, to, for instance, study the effect of measures related to the COVID-19 pandemic on (travel) behaviour. In cases such as the pandemic, it is essential to study its effects in a timely manner. Therefore, waiting for the yearly wave of a panel may take too long. Without a panel, correctly studying the effects of events such as the pandemic would not be possible, as no information would be available about prior (travel) behaviour.

This paper aims to overview the differences and similarities between the large-scale longitudinal travel surveys, MOP and MPN. Different aspects of a longitudinal travel survey and insights from both panels concerning these

aspects are discussed. As the set-up of both panels is somewhat different, experiences with both panels may help other researchers when designing a new longitudinal travel survey. Besides discussing the designs of both panels, this paper examines the representativeness of longitudinal travel surveys, as well as issues around diary fatigue and non-random attrition. It should be noted that, as two panels from different countries with different set-ups are compared, the impact of differences in the design of the panels cannot be separated from other factors.

The paper is structured as follows: In section 2, the process of data collection of the MOP and MPN is discussed, as this has implications for comparing the panels. After that, both panels are compared: The representativeness of both panels is discussed in section 3 in order to identify hard-to-reach groups. As every panel has to deal with attrition between waves, section 4 compares groups that consistently drop out at a higher rate from both panels. Finally, diary fatigue effects in terms of reported trips per day are discussed in section 5 to assess whether these effects become larger throughout a trip diary. The last section summarises and concludes the results.

2. Two large-scale travel behaviour panels

The following section presents insights from the German Mobility Panel (MOP) and the Netherlands Mobility Panel (MPN). The MOP is one of the longest-lasting studies on travel behaviour research worldwide. It has been in operation since 1994 and is undoubtedly the one with the most prolonged use of an unchanged design. The MPN is a relatively new large-scale mobility panel, with its first wave in 2013. While both panels aim to gather longitudinal data on travel behaviour of households and individuals, there are some essential differences in the setup and process of data collection.

Table 1 shows several similarities and differences of the MPN and MOP. One of the most important differences between the panels is that the MOP started almost twenty years before the MPN. Not only was the state-of-the-art of panels/surveys much different in 1994 (the MOP primarily relied on experiences from the Dutch Mobility Panel while the MPN also learned from almost 20 years of MOP experience), but possibilities were also more limited compared to 2013. This directly explains several differences in design. Most importantly, a web survey was not yet an option when the MOP was designed. The lack of an in-home internet connection also limited the possibilities of recruiting respondents.

The lack of digital tools also had implications for the questionnaire and diary design. For instance, a paper diary does not allow to automatically check consistency or auto-complete certain information. In 2013, when the MPN was started, almost 93% of Dutch citizens had access to the internet, making it logical to design an online survey. Therefore, differences in design between the panels are not always caused by deliberate decisions but mostly by possibilities and experiences at the time of starting the panel.

Both panels conduct their fieldwork each year between September and November and all household members (in the MOP, those aged 10 years and older and the MPN aged 12 years and older) are included in the panels. The goals of the panels are somewhat different. One of the goals of the MOP is to produce a yearly indicator of everyday travel in Germany. In contrast, the MPN is not used to generate national statistics, as the Netherlands has a yearly national travel survey since 1978 (OVG/MON/OViN/ODiN), which is used to monitor mobility trends on a national level. Finally, there are differences between the panels, which may influence aspects such as the involvement and loyalty of respondents and response burden. The differences are briefly described in the following.

Table 1. Set-up and goal of the MPN and MOP

	MPN	MOP
Start	2013	1994
Funding	Dutch government	German government
Operation/ scientific supervision	Research institute within the Dutch government	Research institute within a university
Fieldwork	Each year between September and November	Each year between September and November
Goal	Underlying mechanisms of individual dynamics in travel behaviour	Mapping travel behaviour and data provision to understand the dynamics of travel demand processes. Yearly indications of volumes of everyday travel

Sample size	Around 2.500 complete household (±5.000 respondents)	Around 1.800 households (±3.000 respondents)
Method	Online only	Mixed mode: online and paper
Reporting period	Three days	Seven days
Refreshment	Yearly partial refreshment	3 year rotation
Recruitment	Online screening questionnaire (online-access panel)	Telephone interview followed by registration sheet (random digit dialling – landline/mobile phone)
Sampling unit	Households (all members aged 12 years and older)	Households (all members aged 10 years and older)
Survey components	Household questionnaire, (extensive) personal questionnaire, trip diary	Household questionnaire, trip diary
Incentives	<i>Complete households:</i> voucher for online retailer and raffle with 40 family excursions <i>Complete individuals (who completed both the personal questionnaire and trip diary):</i> raffle with 1.000 vouchers for online retailer	<i>Households:</i> Lottery ticket for a German national lottery (<i>Aktion Mensch</i>)

Both panels work with the fieldwork agency Kantar (in the Netherlands, the subdivision Kantar Public). An important difference lies in the formal arrangements. The German government tenders the fieldwork for the MOP, resulting in a legal agreement between the government and the fieldwork agency for each cohort. Thereby, the Karlsruhe Institute of Technology (KIT) (who are in charge of the scientific supervision and operation of the panel) are not a direct client of the fieldwork agency. For the MPN, the Netherlands Institute of Transport Policy Analysis (KiM), which are in charge of the operation and scientific supervision, also does the tendering.

The recruitment of new respondents in both panels is the responsibility of the fieldwork agency. However, there is a big difference in how these respondents are recruited. The MOP has a rotation scheme of three years, which means the participants are rotated out after three years to keep the response burden reasonable. To replace these participants, a new cohort is recruited each year. This new cohort must be chosen so that each total yearly sample with old and new cohorts is representative in terms of spatial types, household types and car ownership (on the household level) and on the personal level on age and gender. New households are recruited through random digit dialling (via landline and mobile phone). A short recruitment interview is conducted by telephone in which the gatekeeper of the household can indicate whether the household is interested in participating. After this interview, the households receive a registration sheet in which each member can indicate whether they are willing to fill out a trip diary.

In the MPN, new respondents are recruited from an existing online-access panel operated and maintained by Kantar Public. As the MPN was originally only funded for four years, it was decided not to use a rotating scheme (Hoogendoorn-Lanser et al., 2015). Therefore, respondents remain in the panel until they decide otherwise. To account for attrition, new respondents are added yearly. Representativeness is assessed yearly based on gender, age, education, work status, household composition and level of urbanization. Underrepresented groups are recruited for the following year. The gatekeepers of the sampled households are requested to fill out a so-called screening questionnaire to indicate whether they are willing to participate with the whole household.

In the MOP, the total sample consists of the newly recruited cohort and the remaining respondents of the two previous cohorts (due to the rotation scheme, cohorts drop out after three years by definition). In the MPN, the total sample consists of households already part of the MPN who skipped a maximum of one consecutive wave and the newly recruited households willing to participate. A significant difference is that in the MOP households can suggest that certain household members are not willing to participate. In contrast, in the MPN, all household members are recruited if the gatekeeper decides to participate.

When designing a new panel, privacy regulations should be considered, as they might not allow the fieldwork agency to give out certain information. For instance, because of privacy regulations, there is no information on initial nonresponse (respondents that do not answer the phone or turn down the invitation to participate) in the MOP.

Also, in the fieldwork process, there are some essential differences between the two panels. Each cohort is recruited representatively based on gender, age, household size, city size, and the number of cars in the household. Each wave

consists of three cohorts that participate. One household member fills out a household questionnaire. It includes questions about the household (e.g. composition and availability of transport means) and all its household members (e.g. gender, age and education). Furthermore, each household member who actively affirmed participation in the trip data collection fills out a trip diary by him-/herself. Since 2013, respondents can choose whether to fill out the survey and trip diaries online or on paper (Eisenmann et al., 2018). About 90% of respondents currently use the traditional paper method and 10% participate online. Eisenmann et al. (2018) indicate that this low share of online responses is probably due to the design of the online surface. Trip reporting in the online diary is more complex than in the paper version, indicating the importance of an efficient and user-friendly design when a web survey is used. Each cohort is recruited representatively based on gender, age, household size, city size, and the number of cars in the household.

The fieldwork of the MPN consists of three components: a household questionnaire, a personal questionnaire and a three-day trip diary. At the start of a wave, the gatekeeper is invited to fill out the household questionnaire, which includes questions about the household (e.g. household composition and availability of means of transport). The personal questionnaires are sent out on an individual level two weeks before respondents have to record their trips in the trip diary. The personal questionnaire is extensive and aims to gather detailed information on all individuals within the household (e.g. work status, use of transport modes, health, and life events). Although this extensive personal questionnaire provides a lot of information and allows for many different studies, the response burden in the MPN is higher than in the MOP because of the length of the personal questionnaire. This higher response burden probably affects panel attrition. As the MPN is a web-only panel, all questionnaires and trip diaries are filled out online.

Besides the normal fieldwork considering the daily travel conducted each year between September and November, both panels are used for additional surveys. In the MOP, another survey on car mileage and fuel consumption of cars is distributed to all households that own at least one car. In the MPN additional surveys are used for specific studies (for instance, on navigation systems or Mobility as a Service (MaaS)). Despite the additional response burden, these extra surveys allow to stay in touch with respondents throughout the year and motivate them to remain in the panel.

When operating a panel, it is often argued that no design changes should be made to ensure that time series are not influenced by methodological artefacts. However, the question is whether this is reasonable in the long term as technology is rapidly developing and respondents' expectations are likely to change. In 2018, after the fifth wave of the MPN, the online survey tools were redesigned. Especially with regards to the online travel diary, this resulted in a more user-friendly design with a modern look and more possibilities (e.g. automatically searching for addresses through Google). These changes mostly affected the graphical design, not the methodology behind the diary. The information requested within the diary and the sequence of questions remained the same. An important reason for the redesign was the fear that respondents would drop off due to the old layout not being in line with what people expected based on their overall internet experience.

To increase the willingness and loyalty of respondents, both panels offer incentives. In the MPN, complete households receive an incentive and additionally, there is a raffle among households and individual respondents who completed the questionnaires and the trip diary. In the MOP there is only one incentive on the household level. A literature study by Scheepers and Hoogendoorn-Lanser (2018) showed that, in general, incentives are found to increase response rates. At the same time, conditional incentives could lead to an increase in nonresponse bias. The latter could, for instance, be the case when an incentive is conditional on the complete household participating, regardless of household composition. This may sound unfair to larger households, resulting in higher nonresponse rates among these larger households. Whereas the effect of incentives in both panels is unknown, a change in the MOP in the past from a personal to a household incentive led to a drop in participation. This illustrates that incentives are relevant and must be considered.

It is important to keep the differences between the panels in mind when assessing the different aspects in the following sections. Due to these differences in the set-up of the panels and the fact that they originate from different countries, it is impossible to separate the effects of differences in the design of the panels from other influential factors. Both cultural differences and differences in mobility between the two countries (e.g. in comparison with Germany, the definition of 'long distance travelling' is very different in the Netherlands, with Germany being almost nine times as large as the Netherlands) might influence the way people participate and thus affect data quality. The insights presented in the remainder of the paper are, therefore, purely descriptive and are used to show that despite the differences, there are similar challenges.

3. Representativeness of travel behaviour panels

Since both panels claim representativeness of the survey results, the ability to draw accurate conclusions about a population from a sample is a high priority. As shown in the previous section, both panels have different approaches to data collection. In the MPN, representativeness is assessed based on statistics on the composition of the Dutch population from The Gold Standard (MOA, 2017) and the Dutch national travel survey (OVIN) (Statistics Netherlands, 2017). Underrepresented groups are identified, and new respondents are sampled based explicitly on the characteristics of underrepresented groups. In the MOP, the Mikrozensus (Statistisches Bundesamt, 2017), as well as the sample survey of income and expenditure (for car availability) (Statistisches Bundesamt, 2019), are used to assess a representative target sample. From previous waves, it is well-known which household types are more likely to drop out predominately. The three-years-rotation scheme allows for an anticipation of the composition of households to be recruited to keep the MOP representative.

Sampling new respondents (individuals) is complicated because both panels are household panels. When underrepresented groups of people are targeted, the whole household they live in is added to the sample, directly influencing the sample composition. This could result in other groups being under- or overrepresented. Therefore, sampling new respondents for a household panel is an iterative process.

The recruitment methods of MOP and MPN have advantages and disadvantages in terms of the groups that should be reached to have a representative sample and for re-participation. Because the MPN relies on the existing online access panel provided by Kantar, people who lack digital skills are by definition not included as well as people who are not experienced enough with digital tools to fill out the online survey or travel diary. However, to include these people, high financial costs would be involved. An option to reach these people would be, for instance, to have an interviewer fill out the questionnaire and trip diary either by telephone or face-to-face. Or to introduce a paper version of the survey (which has many limitations, e.g. many online functionalities of the MPN cannot be incorporated in a paper version).

There are also drawbacks to the dual frame approach (using both landline and mobile phone numbers) for recruiting MOP respondents. On the one hand, many people who own a mobile phone do not call back unknown numbers for the initial contact or are not reachable on this device (because the mobile phone is in silent mode). On the other hand, younger people (or households they live in) are hard to reach by landline phone because they have only a mobile phone. However, it is costly to recruit households that are only reachable by mobile phone. To sum up, the dual-frame approach allows for a better representation of the German population because the variance in travel behavior can be better controlled (Chlond et al. 2015) so it is worth spending money on the dual frame approach.

To assess representativeness, (unweighted) samples are compared with the composition of the population in the respective country. Table 2 shows an overview of the representativeness of both panels for household and person level.

Table 2. Representativeness of MPN and MOP on household - and person-level, unweighted

Category [%]	MPN				MOP			
	Gold Standard (2017)	2016	2017	2018	Mikro-zensus 2017	2016	2017	2018
<i>Representativeness Persons</i>								
Gender								
Male	49.4	45.9	45.1	47.0	48.6	49.7	50.5	49.9
Female	50.6	54.1	54.9	53.0	51.4	50.3	49.5	50.1
Age [years]								
< 24	18.4	18.0	13.2	15.2	16.0	10.9	10.7	11.5
25-34	14.0	18.3	16.8	13.9	12.8	7.6	7.1	6.9
35-44	15.5	15.5	16.5	15.6	12.2	10.3	10.9	10.9
45-54	17.6	19.0	15.2	16.8	17.2	19.5	18.2	17.6
55-64	15.2	14.8	17.2	17.4	16.5	24.5	25.6	24.6
> 65	19.3	14.5	21.1	21.1	25.4	27.2	27.5	28.4
Level of education*								
Low	37.1	26.1	31.7	33.3	41.2	23.9	23.5	22.2
Medium	39.9	39.4	36.1	36.6	28.4	30.6	30.1	28.3
High	22.9	34.5	32.2	30.0	30.4	45.6	46.4	49.4

Representativeness Households								
Household size [persons]								
1	37.4	28.5	36.6	35.6	41.8	34.7	34.1	36.0
2	32.9	30.2	32.6	32.6	33.5	40.6	40.9	38.8
3	12.0	14.1	11.2	11.1	12.0	12.4	12.9	12.2
4	12.5	18.7	13.9	14.6	9.3	9.2	8.7	9.3
5 +	5.2	8.5	5.7	5.9	3.4	3.1	3.5	3.6
Car ownership**								
No	24.9	25.0	20.6	17.4	22.6	17.1	17.3	17.3
Yes	75.1	75.0	79.4	82.6	77.4	82.9	82.7	82.7

* Level of education is different in the Netherlands and Germany because of the differences in the education system. The levels are comparable with the official statistics but not among each other.

**MOP: Data based on the sample survey of income and expenditure (Statistisches Bundesamt, 2018) MPN: based on data from the Dutch national travel survey (Statistics Netherlands, 2017)

Concerning the representativeness of both panels in terms of gender, we can see that female and male participants are well-represented and the deviation from the official statistics are small for both samples. Regarding the representativeness for different age groups, we see for both panels that the share of people under 25 years is lower than the official statistics. This underrepresentation of young people also results in problems with representativeness on education level as age and education are highly correlated. It is difficult to motivate low-educated people, including pupils in the group of people younger than 25 years, to participate and keep participating. Furthermore, when children move out of the household they cannot be further surveyed and as a result, drop out of the panel. This complicates representativeness on age and education even further.

Representativeness also deviates at the household level. Both panels suffer from a low share of single households and households without a car. For the MPN, the underrepresentation of one-person households is corrected mainly from 2017 onwards, by adding new one-person households to the panel. For the MOP, however, the difference between the sample and the Mikrozensus is always higher than 5.0%. A strong reason for the underrepresentation of certain groups is recruitment costs, as the financial efforts to recruit hard-to-reach groups are high. Especially for the MOP, one-person households are hard to reach because only one person has the chance to answer the phone. Both panels suffer from an underrepresentation of households without a car (correlated with one-person households). This might be an indication of some form of self-selection.

Another important limitation for both panels is that immigrants are not represented well in the panels (not shown in the table). It is known that immigrants, especially those of a non-western origin, have different travel behavior compared to native Dutch and German people (e.g. (Kennisinstituut voor Mobiliteitsbeleid, 2008; Welsch et al., 2018)), so this introduces a bias in the data. Unfortunately, their willingness to participate is very low in both panels.

Summing up, we see in particular young people or people with a low level of education as well as one-person households and households without a car are underrepresented in both samples. Having a rotating scheme does not result in a different level of representativeness compared to not having such a rotating scheme. Experience from both panels shows that relatively high financial costs will be involved to have a representative sample regarding the target values of the specific groups. However, depending on the panel's goal, it might not be an issue to have some underrepresentation of certain groups. Underrepresentation can be largely dealt with by weighting the data as long as a reasonable number of respondents represents all interest groups. However, one should always realize that having a representative sample on socioeconomic variables does not necessarily mean that the sample is also representative regarding travel behaviour.

4. (Non-random) attrition between waves

Typically, we can observe fatigue in multi-period surveys on mobility. Fatigue effects can be observed as participants report inaccurately or stop reporting at all (attrition within wave). Attrition within waves has been analyzed e.g. by Meurs et al. (1989) and Kitamura and Bovy (1987), measuring the level of fatigue on a relative scale by using the decline of mobility figures as an indicator.

Attrition between waves can be observed in panel surveys as participants who are expected to report repetitively in the next wave do not participate anymore. It can be assumed that this is caused by a selective dropout of participants depending on sociodemographic characteristics. Literature attests that attrition between waves is often non-random and certain sociodemographic groups tend to drop out while others remain (e.g. (Kitamura & Bovy, 1987)). Previous

studies, however, showed that attrition is not, by definition, negative as it can positively influence data quality. It was found that those who are likely to report with lower accuracy are more likely to drop out in the next wave, whereas those who report with higher accuracy are more likely to report for a second and third time (Chlond et al., 2013; de Haas et al., 2017).

In this section the focus is on attrition between waves. For both mobility panels, MOP and MPN, panel attrition between waves is expected. If attrition were random, it would not influence representativeness and the consequences would be limited to recruiting new respondents yearly. However, attrition between waves is not random as it is probably influenced by several factors (e.g. survey design, sampling frame and level of motivation among respondents). As there are relatively large differences between the MPN and MOP in terms of the process of data collection (e.g. mixed mode versus online-only and response burden) (see section 3), it can be expected that attrition between the panels is also different.

On an aggregate level, respondents in the MPN show a higher dropout rate after the first year they participate. After the first year of participation, 25% to 51% of respondents drop out in the MPN. The remaining respondents tend to be more loyal, as dropout rates decline after the second wave of participation (between 12% and 22%). In the MOP, the share of people that drop out after the first year of report is lower (between 19% and 31%) and the decline after the second year is also lower (between 9% and 17%). These differences in attrition rates after the first year might result from differences in the recruitment process but could also be caused by, for instance, cultural differences. Recruiting respondents from an existing access panel makes it relatively easy to bring in people for the MPN. However, dropout rates are higher. It might be that the phone and paper-based recruitment of the MOP is more "binding" as people confirm their interest to another person by phone instead of online. However, this approach is more time-consuming. It might also be the case that there is more self-selection in the MOP as respondents are specifically recruited for the MOP. At the same time, respondents from the access panel for the MPN also participate in other surveys with varying topics. As shown by (Kuhnimhof et al. 2006), self-selection in the MOP results in positively motivated participants with interest in mobility issues. It was found that self-selection does not negatively affect mobility indicators on an aggregate level. However, this introduces a bias towards better education and – correlated with this – more wealthy people with a more modern car fleet.

Here, we analyze the composition of the dropouts between waves. Table 3 shows the composition of two survey waves and the group that dropped out prematurely. The analysis is based on sociodemographic characteristics (age, gender, work status, level of education, household composition and car availability). It should be noted that the MOP respondents who naturally drop out after their third wave are not included in the table.

Table 3. Composition of respondents that dropped out after wave in the MPN and MOP

Category [%]	MPN				MOP			
	Sample comp. 2016	Dropout-share (2016/2017)	Sample comp. 2017	Dropout-share (2017/2018)	Sample comp. 2016	Dropout-share (2016/2017)	Sample comp. 2017	Dropout-share (2017/2018)
Gender								
Male	45.9	46.5	45.1	45.0	49.7	49.7	50.5	51.7
Female	54.1	53.5	54.9	55.0	50.3	50.3	49.5	48.4
Age [years]								
< 24	18.0	21.4	13.2	16.5	10.9	15.6	10.7	13.4
25 - 34	18.3	16.1	16.8	19.4	7.6	8.6	7.1	8.3
35 - 44	15.5	12.7	16.5	18.0	10.3	12.0	10.9	13.2
45 - 54	19.0	22.7	15.2	12.9	19.5	18.8	18.2	18.2
55 - 64	14.8	14.9	17.2	12.4	24.5	20.2	25.6	20.9
> 65	14.5	12.3	21.1	20.8	27.2	24.8	27.5	26.1
Work status								
Employed	57.8	59.2	51.0	52.2	51.5	49.7	53.8	54.2
Housework, voluntary work or unknown	8.0	8.1	10.0	9.1	3.5	2.3	3.2	3.0
Student	13.9	15.9	11.0	12.9	10.9	14.5	10.3	12.9
Unemployed/disabled	7.1	6.1	8.5	7.4	2.2	3.1	2.6	3.2
Retired	13.3	10.7	19.4	18.4	30.6	27.7	29.7	26.3
Unknown					1.3	2.7	0.4	0.5

Level of education									
Low	26.1	29.7	31.7	35.4	23.9	30.0	23.5	26.2	
Medium	39.4	40.1	36.1	34.8	30.6	27.9	30.1	29.2	
High	34.5	30.2	32.2	29.8	45.6	42.1	46.4	44.6	
Household composition									
Single household	18.3	9.6	23.7	19.5	21.2	17.7	20.5	16.2	
Adult	47.4	52.8	43.8	41.4	52.6	51.3	53.3	53.9	
Household with youngest child ≤ 12 years old	19.4	18.1	20.8	25.6	11.3	14.7	11.7	15.0	
Household with youngest child 13 to 17 years	14.9	19.6	11.3	12.2	14.9	16.4	14.5	14.9	
Unknown	0.0	0.0	0.4	1.3	0.0	0.0	0.0	0.0	
Car availability									
No	19.8	11.1	12.9	15.3	12.8	11.1	12.3	8.4	
Yes	80.2	88.9	86.6	83.0	87.2	88.9	87.7	91.6	

Our differentiation of the dropout composition shows that in both panels, primarily the same groups are likely to drop out at a high/low rate. Younger people seem to be less bound to the panels as they consistently drop out at a higher rate, whereas older people (especially those of 65 years and older) tend to stay. While dropout rates of 25 to 65 years differ over the years in the MPN, in the MOP, dropout rates of people up to 45 are consistently higher and those of 45 years and older are always lower.

Also, students and low-educated people show higher dropout rates in both panels. The higher dropout rate might be partly caused by students moving out of their parents' home and therefore dropping out of the panel by definition (as they are no longer part of the participating household). While section 4 showed that single households are underrepresented in both panels, it is interesting that their dropout rates are considerably lower than expected.

Overall, it may be concluded that in both panels, the same groups tend to drop out at a higher rate; young and low-educated people. The MPN shows a higher dropout rate in total, especially after the first year of participation, which may result from a higher response burden or different self-selection effects compared to the MOP. Similar to representativeness, there is a trade-off between financial costs and keeping respondents in the panel. Although the exact effects of incentives are unknown, increasing the incentive among these groups that drop out at a higher rate will probably have a positive effect. Thus, options to introduce different incentives for different groups should be explored.

5. Diary fatigue effects

Keeping a travel diary in which all trips must be reported for several days can result in a substantial response burden, especially among highly mobile respondents. Respondents may become less motivated to report all their trips after several days. To ease the response burden, respondents sometimes report only a part of their trips or no trips at all. Earlier research has shown that multiday travel surveys may suffer from diary fatigue effects (Chlond et al., 2013; Golob & Meurs, 1986). While the MOP asks respondents to report for seven consecutive days, in the MPN, it was decided to include only three days in the travel diary to minimize possible fatigue effects (Hoogendoorn-Lanser et al., 2015). If diary fatigue effects are present within a panel, this negatively influences data quality. When respondents start underreporting their trips, the data is no longer an accurate representation of respondents' travel behaviour. In this section, diary fatigue in both panels is addressed by assessing the average trip rates throughout the trip diary. As

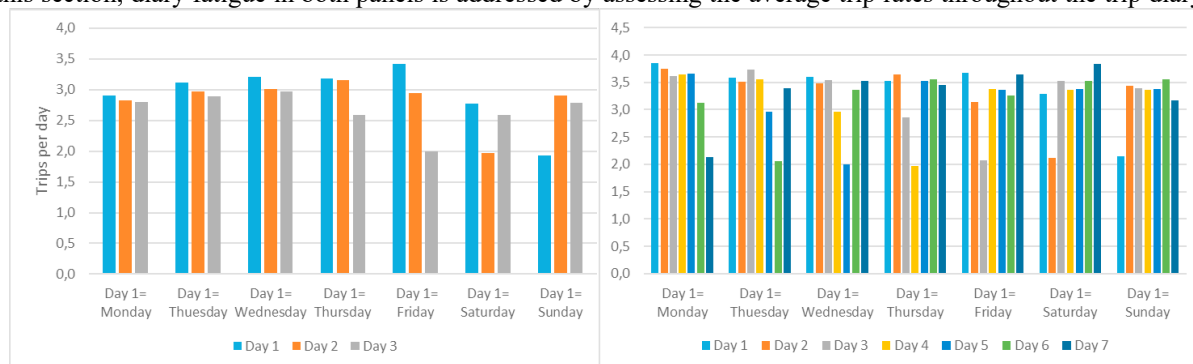


Figure 1. Trips per person per day per starting day (left: MPN 2019, n = 5.731, right: MOP 2018, n = 3.188)

the MOP includes a longer trip diary, it may be expected from previous literature that diary fatigue effects are more apparent in the MOP compared to the MPN and result in a significantly declining trip rate over the days.

Figure 1 shows the number of trips per person per reporting day in the MPN and the MOP. Because the MPN only includes three days, some respondents report only working days, while others also report one or two weekend days (depending on their starting day). In both panels, the trip rates on Saturday and Sunday are significantly lower compared to working days. This is not surprising, as it may be expected that activity patterns (and the resulting mobility) during weekend days is different compared to working days. Therefore, weekend days are not considered to assess whether diary fatigue is present. From the graphs, it can be seen that trip rates seem to be quite stable. For some starting days, a small decline can be observed over working days (for instance, Tuesday in the MPN and Monday in the MOP).

An explanation for the seemingly small problems found with diary fatigue might result from some form of self-selection. Respondents interested in the study might be more inclined to remain in the panel. Especially for the MOP, where respondents are solely recruited for the MOP, the sample may primarily consist of motivated people interested in mobility. Furthermore, earlier research has shown that the seven-day trip diary in the MOP causes a certain amount of panel-conditioning (Chlond et al., 2013). To lower the response burden, respondents will, for instance, sum up several short trips to a longer trip. This may result in a situation where diary fatigue is present but can not be observed on the individual level.

Still, it is somewhat surprising that fatigue effects seem to be of the same magnitude in the MPN and the MOP. Previous studies expected that the MOP would show larger fatigue effects due to the longer reporting period. However, due to the differences between the panels (e.g. being from different countries), it cannot be concluded that it does not matter whether the trip diary is three or seven days. It might be the case that a seven-day trip diary in the Netherlands may lead to greater fatigue effects than observed in the MOP. As discussed earlier, dropout rates in the MPN are relatively high. It can be expected that increasing the length of the trip diary from three to seven days would negatively affect panel attrition as the response burden is increased.

6. Conclusion/discussion

This study discusses several aspects of longitudinal travel surveys using insights from two large-scale panels. As it is essential to understand the underlying mechanisms of travel behaviour changes, people should be followed over time to capture changes and relate them to specific events in an individual's life. Travel behaviour panels are time-consuming and costly, so they are not widely available. This paper aimed to show several points that must be considered when setting up a new travel behaviour panel.

Although the MOP and MPN are similar in their aim to gather longitudinal data on travel behaviour of households and individuals, there are differences in the set-up and in the data collection process. Most of these differences result from the MPN starting almost twenty years after the MOP. For instance, the MPN is online-only, whereas the MOP offers both an online and a paper version (before 2013, only a paper version was offered). Furthermore, the MOP includes a seven-day diary and the MPN a three-day diary. Also, the panels are from different countries. As these differences make it impossible to separate the effects of differences in the design of the panels from other influential factors, this study aimed to compare the panels concerning several aspects, keeping these differences in mind.

It was found that both panels suffer from underrepresentation regarding similar characteristics. Primarily young people, low-educated people, single households and households without a car are underrepresented in both panels. It does not seem to matter for representativeness whether a rotating scheme is used in operating a panel. The budget for recruiting and managing the sample is probably a more critical factor. Hard-to-reach groups require a lot of effort to be recruited and less motivated groups need more effort to keep them in the panel. When operating a panel, it is therefore essential to know that, depending on the goal of the panel, perfect representativeness is not always required.

When comparing attrition between the panels, somewhat surprising results were found. Due to the relatively large differences between the panels, attrition was expected to differ. Especially the difference in survey modes (online-only vs mixed-mode) was expected to result in different groups dropping out of the panel. However, both panels showed the same groups dropping out at a higher rate: young and low-educated people. After the first year of participation, respondents in the MPN show a higher dropout rate than in the MOP. Respondents who remain in the MPN after this first year tend to be more loyal, resulting in a lower dropout rate which is comparable to the dropout rate in the MOP. Several factors might cause this. First of all, recruitment by phone in the MOP might be more binding

compared to online recruitment. Second, there could be more self-selection in the MOP as these respondents are recruited explicitly for the MOP while MPN respondents are part of an access panel and fill out surveys with varying topics.

A well-discussed issue in the literature is diary fatigue within multiple-day surveys. As the MPN includes a three-day diary as opposed to a seven-day diary in the MOP, it was expected that diary fatigue effects would be considerably larger in the MOP. However, it was found that diary fatigue (in terms of trip rates) is not a big problem in both panels. Only slight decreases in trip rates are observed in both panels for a selection of starting days. This suggests that no conditioning of the panels during the reporting period (e.g., by combining short trips into one long trip) endangers the reliability of the data.

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