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Measurement Error Problems in Surveys of Motor Vehicle Usage

A.J. Richardson

ABSTRACT

Travel surveys are subject to a wide range of errors, including sampling error, non-response error and measurement error. This paper considers the issue of measurement error in the estimation of the amount of travel on 'employer's business' by personal vehicle. 'Employer's business' travel is defined as travel on the business of the employer (e.g. trips to meetings, trips between worksites etc), but excludes travel between home and work (i.e. commuting). It uses the example of the Survey of Motor Vehicle Usage conducted periodically by the Australian Bureau of Statistics. It shows that, by comparison with a number of other travel surveys, the Survey of Motor Vehicle Usage considerably over-estimates the amount of travel on 'employer's business' performed in private motor vehicles. Given that 'employer's business' travel is generally accorded a higher value of travel time savings in economic evaluations of road improvements, such an error could have a substantial impact on the viability of various road improvements. A reason for the difference is proposed, based on the wording of the specific question and the type of respondent completing the survey, which leads to a significant source of measurement error.

1. Background

In the conduct of sample surveys in transport, there are a series of errors that might appear in the data. The three major sources of error in a typical sample survey dataset include:

(a) Sampling Error
(b) Measurement Error
(c) Non-response Error

Sampling Error occurs in all sample surveys simply because we are using a sample to represent a population. No matter what size sample we take, chance events will always mean that our sample is not identical to the population. Increasing the sample size, subject to practical considerations and resource constraints, will reduce the sampling error but not eliminate it completely. *Measurement Error* occurs when the question asked of respondents does not measure exactly what the survey designer meant to measure. The error can come about because of the type of question used to collect the information, or because of the detailed wording of the question. *Non-response Error* occurs when households or individuals do not provide a response at all, i.e. no survey form was filled out, and the non-respondents are systematically different to the respondents in terms of the variables of interest (such as trip-making) (Richardson, Ampt and Meyburg 1995).

While consideration of each type of error in the survey process is important, the error to be addressed in this paper is Measurement Error, arising from flaws in the design of the survey instrument.

2. The ABS Survey of Motor Vehicle Usage (SMVU)

The survey that is the focus of attention in this paper is the 1991 Survey of Motor Vehicle Usage (SMVU) conducted by the Australian Bureau of Statistics (ABS). The 1991 SMVU (ABS 1993) is a sample survey of motor vehicle usage in Australia for the twelve months ending September 30, 1991. This was the eighth survey of motor vehicle use since 1963. As in previous surveys, respondents were asked to provide information on the use of selected motor vehicles for the twelve months ended 30 September, or for that part of the year for which they

were the registered owners of the vehicle. Approximately 42,000 vehicles were selected from the population identified by the State motor vehicle registration authorities. The sample design used a stratified sampling process, resulting in 27% of the sample being private passenger vehicles, 58% commercial vehicles and 15% buses. Mail questionnaires were dispatched in October 1991 to registered owners of the vehicles, with a request to record information on distance travelled by that vehicle during the previous twelve months, classified by broad trip purposes and other descriptors. Importantly, the SMVU is a survey of travel by vehicles and not a survey of travel by individual travellers, and the survey was sent to the registered owners of the vehicles and not necessarily to the people who did the driving in those vehicles.

Among a range of issues to be covered in instrument design for travel surveys, a primary focus needs to be placed on the selection of the method by which the travel is to be recorded. Travel can be recorded either by asking respondents to recall what happened at a past time (recall technique), or by announcing to respondents in advance that they will have to report travel about a future time (prospective technique). It is generally recognised that the recall technique**,** by and large, generates the greatest error in reporting of actual travel, unless respondents already have in place a method for recording the information required. While this may have been the case for commercial vehicle operators, who would be more likely to keep log-books of distance travelled, it is unlikely to be the case for most operators of private vehicles.

If respondents are expected to provide details of all their travel over a previous period, without recourse to previously recorded information, this can result in measurement error because of the well-known problems with recall of past events over extended periods (Sudman and Bradburn 1973) where respondents forget about particular events. On the other hand, where respondents are asked for estimates of cumulative travel over an extended period, rather than recall of individual events, there is another problem in the reverse direction due to 'telescoping' (Neter and Waksberg 1964) whereby respondents may over-estimate travel in a period by including travel which may have been made before the start of the survey period. The extent of 'telescoping' depends on the frequency of trip-making and the length of the recall period. The 1991 SMVU used the recall technique, in line with the method used in all previous SMVU surveys.

The specific format of the question used is shown in *Figure 1*. The recall technique question places great onus on the vehicle owner to remember how many kilometres were done by that vehicle in the past year. In addition, the owner is expected to be able to subdivide that distance by trip purpose.

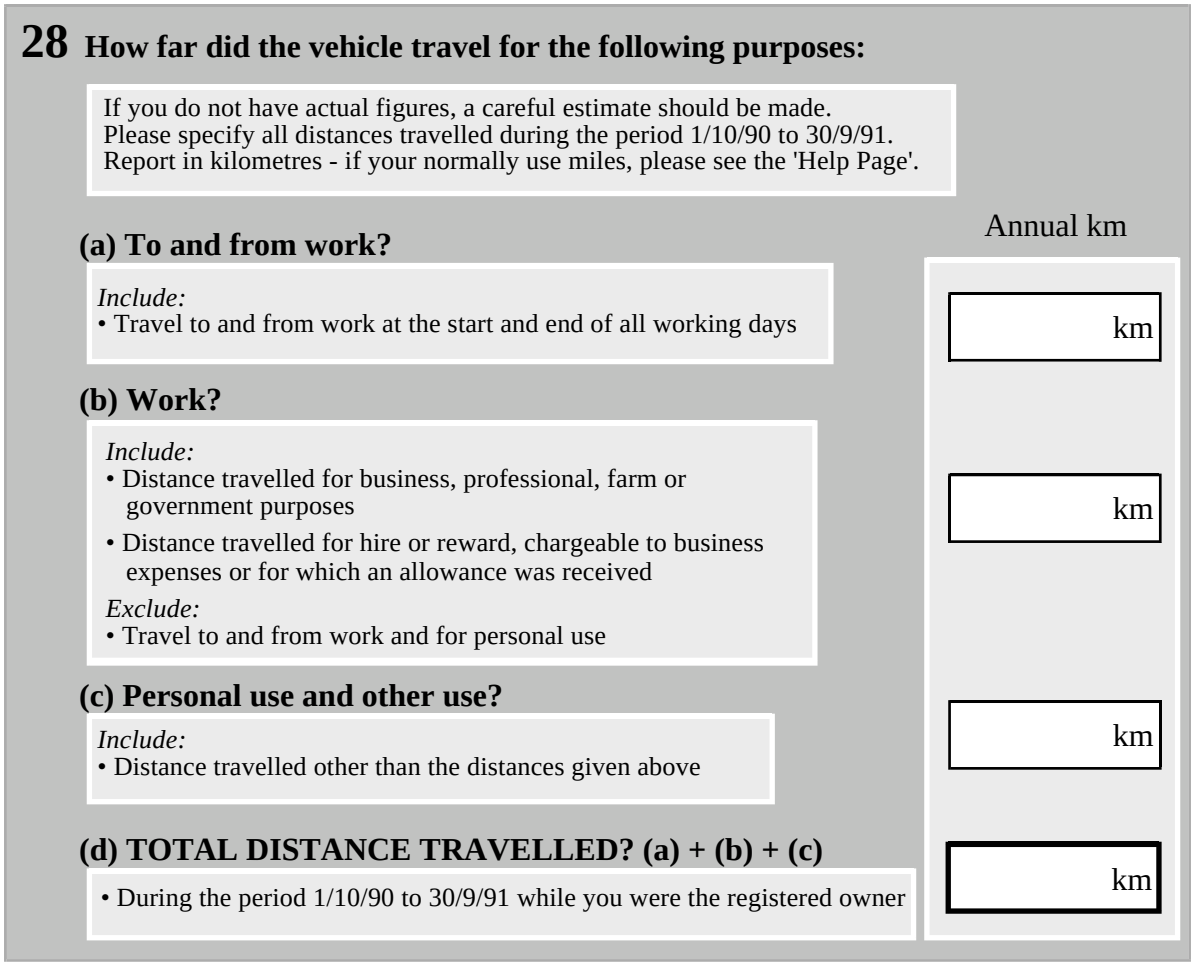

Figure 1 The SMVU Travel Distance Question

The ABS recognises that this method has its problems, and notes that their own tests have shown that the recall question results in an overestimate of distance of 12%, compared to a diary survey method (Roberts and Haines 1997). Interestingly, however, the ABS makes no allowance for this overestimation when they give the results of the survey. What then is the user of the results to do: use the reported figure or reduce it by 12% because of the admitted overestimation?

3. Estimates of Employer's Business Travel Distances

While there are problems with the recall of the total amount of travel, as noted in the previous paragraph, the major problem with the SMVU lies in their estimates of the amount of 'employer's business' travel in cars. The 1991 SMVU estimated that 23.7% of all travel by passenger cars is for the purpose of 'employer's business' (or 'Work' as they call it in Question 28, shown above in *Figure 1*). This estimate was consistent with previous SMVU estimates, and is continued in the results from the 1995 SMVU reported on the ABS website (www.statistics.gov.au) where the proportion is given as 21.1%. However, this does not agree with many other sources of information on travel by car. For example, the 1994 Victorian Activity & Travel Survey (VATS) estimates that only 6% of all distance travelled by car (including home-based private cars, home-based company cars and non-home-based company cars) is for the purpose of 'employer's business' (non-home-based-work). The breakdown of car driver trips and distance by purpose from VATS94 is shown in *Table 1*.

Table 1 Car Driver Trip Purposes

Trip Purpose	% Trips	% Distance
Home-based-work (i.e. Journey-to-Work)	18%	31%
Home-based-education	1%	2%
Home-based-shopping	19%	10%
Home-based-other	30%	28%
Non-home-based-work (i.e. Employer's Business)	6%	6%
Non-home-based-other	27%	23%

It is possible that some home-based employer's business trips may be included in home-based-other trips (particularly for those who work from home). However, given that the 1996 ABS Census estimated that only 4.5% of the population worked from home on Census day, this is unlikely to be a significant effect. It is also possible that VATS and other household-based travel surveys suffer from an under-reporting of employer's business trips made in non-home-based company cars (since respondents may not see them as part of their household travel). However, given the small proportion of trips reported in non-home-based cars, even a doubling

of these trips would make no significant difference to the overall proportion of employer's business trips recorded in household-based travel surveys.

Because of the large discrepancy between the SMVU estimates and the VATS94 data, further sources of information were checked to determine the likely order of magnitude of the percent of car trips which were for 'employer's business'. *Table 2* shows a selection of such estimates.

Table 2 Other Estimates of Employer's Business Trips

Data Source	% Employer's Business
1978 Melbourne Household Travel Survey	4.8% (trips, by all modes)
1991 Sydney Household Travel Survey	10% (trips, by car)
1981 London Household Travel Survey	6% (trips, by all modes)
1990 USA National Personal Travel Survey	4.2% (distance, by all modes)
1994 Swiss National Travel Survey	12% (distance, by all modes)

Sources (in order): Ministry of Transport (1981); Itorralba, E. and Balce, M. (1992); London Research Centre (1992); Hu, P.S. and Young, J. (1993); Federal Office for Statistics & Bureau for Transport Studies (1996).

Clearly, the VATS94 data and the other sources referenced in *Table 2* point to the proportion of all car trips, or car trip distance, for 'employer's business' lying between 5% and 10%, rather than above 20% as quoted in the SMVU reports. How, then could such a discrepancy occur? To answer this, we need to look in more detail at the survey procedure employed in the SMVU.

The SMVU survey process involved sending questionnaires to the registered owners of vehicles on the motor vehicle registers. For private cars, this would mean that the survey would go to the home address of the owner, who was also most likely to be the main driver of the vehicle. For company cars, however, the survey would go to the owner (the company) and not to the driver. Since there was no instruction that the survey should be passed on to the most frequent driver, it was most often a representative of the company (e.g. the fleet manager) who filled out the form. (Informal checking with the ABS, and with officers within the University of Melbourne who filled out the forms for vehicles in the University fleet, confirm that this occurred on many

occasions). Alternatively, for vehicles on lease, the leasing company would have received the survey and completed it. This in itself was not necessarily a problem, since all but one of the questions on the survey could reasonably have been completed by the company representative. In fact, the company representative may well have had much better information (e.g. vehicle logs and service records containing distance measurements) than the driver to complete some parts of the survey.

However, with respect to the question about trip purpose for company cars, having the answers provided by the company representatives (in conjunction with the wording of the question) may give misleading information. For example, the question about distance travelled for 'work' purposes (see Figure 1) states that 'distance travelled... (that was)... chargeable to business expenses' should be included as 'work' (i.e. 'employer's business') travel. Since, in many cases, all distance covered in a company car (whether it be for work or not) is chargeable to business expenses (i.e. the driver pays neither for the car nor for operating expenses), it would be quite reasonable for the company representative to answer that all distance covered by the company car was for 'work' purposes (according to the definitions supplied with the question).

The extent of company cars, for which the above problem would exist, is quite significant. Data from the 1994 VATS survey and the 1992 South-East Queensland Household Travel Survey (SEQHTS) shows that approximately 10% of all home-based cars (i.e. cars which are garaged overnight at home) are company cars, while nearly 50% of all new home-based cars (i.e. cars which were purchased in the year of the survey) are company cars (Luk and Richardson 1997). In addition, analysis of the VATS94 data shows that home-based company cars are not used solely for 'employer's business' purposes. As shown in *Figure 2*, only 14% of all distance covered in home-based company cars is for 'employer's business' purposes. The majority of distance travelled by home-based company cars (37%) is for journeys to and from work (which is excluded from employer's business travel in the SMVU) while 49% of the distance was for purposes unconnected with work. By comparison, only 3% of the distance covered by home-based private cars was for employer's business, while 26% of the distance covered by non-home-based cars (which would include work-based company cars and friends' cars) was for

employer's business. This implies that about one-quarter of the non-home-based-cars were probably work-based company cars being used exclusively for employer's business.

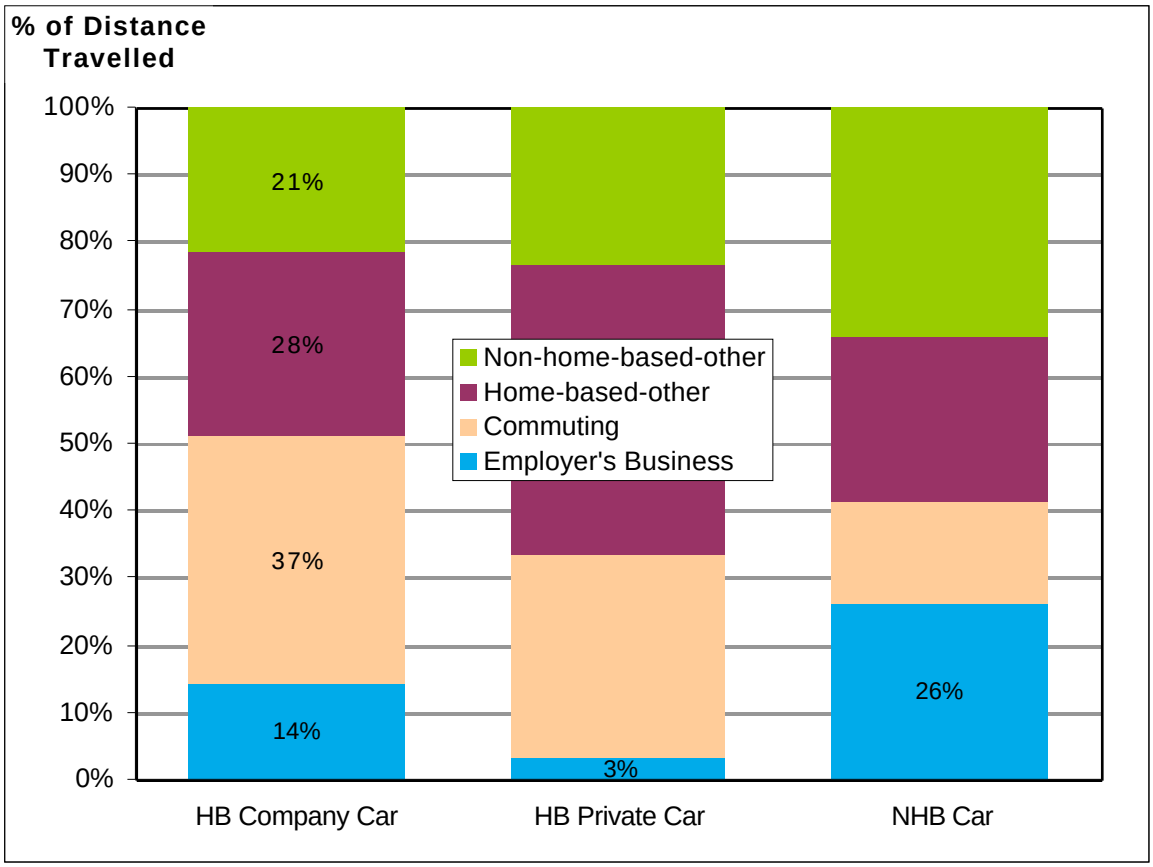

Figure 2 Actual Use of Various Types of Cars (VATS 1994)

The question then arises of whether this ambiguity about what is or is not 'employer's business' travel in a company car could make such a difference to the overall estimates of employer's business travel. If, based on the VATS94 results, one assumes that about 16% of all distance travelled is performed by home-based company cars, and that another 81% is done by home-based private cars, and the remaining 3% is made by non-home-based cars, then using the employer's business percentages of 14%, 3% and 26% as obtained from the VATS94 data, one obtains an overall percentage of 6% employer's business travel (as already noted in *Table 1*). However, if, as shown in *Table 3*, one assumes that all travel by home-based company cars is recorded in the SMVU as being for employer's business purposes (because all of it is chargeable to business expenses and because the registered owner completing the form would not know how the car is actually used by the driver) then one obtains an overall percentage of

20% employer's business travel (a figure that is of the same order of magnitude as the 1991 SMVU estimate of 23.7%).

Table 3 Employer's Business Travel under Different Assumptions

	% Distance Travelled	% Employer's Business	
		VATS94	SMVU
HB Company Car	16%	14%	100%
HB Private Car	81%	3%	3%
NHB Car	3%	26%	26%
Average % Employer's Business		6%	20%

4. Conclusion

The conclusion to be drawn from this analysis (albeit one that must be drawn with extreme trepidation) is that the SMVU estimates (up to 1995, at least) of employer's business travel are in error (by a significant amount). While a plausible hypothesis has been presented in this paper, further investigation needs to confirm the exact reasons for the difference in the estimates. This conclusion has two major implications. First, many studies have adopted the SMVU estimate and subsequently used it in a variety of projects to evaluate a wide range of projects. Since time saved on 'employers business' trips is generally accorded a higher value of time than time saved on private trips (e.g. Hensher 1997), the over-estimation of 'employers business' trips will result in a higher value of total time saved from any road improvement. The SMVU estimate has entered the transport evaluation folklore in Australia, and has been quoted in many places. For example, The Allen Consulting Group (1993) state that 'the main commercial wage cost for drivers is not in trucks but in the more numerous cars which are used for business purposes and the light commercial vehicles, particularly in rapidly growing service industries. ABS statistics indicate that 23 percent of all passenger car travel is for business purpose'. It would be interesting, for example, to conduct a citation index search to see how far the SMVU results have penetrated the profession. Second, and the reason for the trepidation, is that many people adopt ABS results without question. If the results are shown to be in error on this major survey, this blind faith in the ABS surveys may be brought into question.

Perhaps this questioning of ABS survey results is not a bad thing, and maybe it will improve the quality of their procedures in this area of transport data. A new quarterly survey methodology,

based on odometer readings, has been introduced for the SMVU by the ABS from August 1997 (Sutcliffe 1998). While this may reduce the recall problem, it will not improve the estimate of 'employers business' unless the wording of that question is also changed. ABS perhaps recognise this when they say that 'further form design work is required to improve the responses for Purpose of Travel' (Roberts and Haines 1997). However, until the results are obtained from the 1997 SMVU, it is unclear whether such changes in methodology have brought about the necessary improvement in understanding of the travel purpose question. Only then, will the SMVU give estimates of this important information that is consistent with estimates obtained from numerous other sources.

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Postscript

Since this paper was originally written, the results of the 1997 SMVU, based on the new survey methodology, have been released by the ABS (ABS 2000). Unfortunately, the results for the business use of private cars have not shown any move towards a value which is more in line with other data sources, with 24% of private car use being attributed to business use. The ABS does include a definition of 'business use' in a Glossary in the documentation of the survey, as 'distance travelled for hire and reward, or charged to a business expense, or for which an allowance was received'. While their results might be accurate, given this definition, the problem

is that no one else in the transport profession would accept this as a reasonable definition of 'business use' of private vehicles, given that it includes all travel in company cars, whether it be on employer's business, or driving to and from work, or taking the family to the beach on the weekend (all of which would be charged to the employer who would pay for the vehicle and the running expenses). Most people would assume, as did The Allen Consulting Group (1993), that the 'business use' of private vehicles would relate more specifically to the use of those vehicles on 'employer's business'. Therefore, until the definition of 'business use' is changed in the SMVU, and the question regarding purpose of travel modified accordingly, the travel purpose results from the SMVU should be used with great caution.

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