Annualised estimates of personal travel from the Scottish Household Survey Travel Diary

Purpose

This project aimed to investigate methods for arriving at annualised estimates of personal travel from the Scottish Household Survey (SHS) Travel Diary. This paper presents three potential strategies for consideration and discussion.

Summary

This project was undertaken as a result of the discontinuation of the Scottish subsample of the National Travel Survey (NTS). Results from this survey, which had a relatively small (c. 850 households per annum) Scottish subsample, had previously been used to calculate estimates of annual travel. Based on the differences between the SHS Travel Diary results and results from the National Travel Survey's travel diary, it was observed that the SHS travel diary tended to record around 30% fewer journeys than the NTS. The Scottish Household Survey's Travel Diary had not previously been used for generating annualised estimates as it was considered to be representative of the journeys made by a person the previous day, rather than a full year's travel by an individual. The NTS was considered usable despite its small sample size due to the extensive checking procedures built into the NTS and the 7-day nature of its travel diary. It was decided to investigate whether a weighting strategy could be developed for the SHS to create representative estimates of average annual travel behaviours.

Three separate strategies were tested for this, each involving the estimation of the average number of commuting journeys people made in a year to use as a benchmark, which in each case upweighted the SHS estimates by around 30%. This weight was applied to the full SHS Travel Diary to produce initial annualised estimates of personal travel, which, with some exceptions, mostly agreed fairly well with the estimates previously reported by the NTS. The benchmarking strategies used were as follows: a benchmark to estimates of commuting travel from the annual Labour Force Survey, a benchmark to estimates of commuting travel from the Scottish Census and a benchmark to estimates of commuting travel from the Scottish Census, weighted for reported usual method of travel to work and gender.

The initial results indicate that the Labour Force Survey may be the most useful of the three benchmarks as it provides regular updated estimates and has a large Scottish sample, while providing similar results to the Census benchmarks.

Introduction

The Scottish Household Survey is a major Scottish social survey, with an annual sample size of around 10,500 households. A large proportion of the questions are transport and travel related, with the survey being split into the following subsections:

- Household Survey - questions about Scottish households. Includes questions on car, van and bike ownership
- Random Adult Survey - asked of a randomly selected adult from within the surveyed household. Collects information on travel behaviours and attitudes
- Travel Diary - asked of participants in the Random Adult survey. Collects information on the purpose, duration, distance and mode of travel of all journeys made the previous day.

With the discontinuation of the Scottish subset of the National Travel Survey, it was proposed that exploratory work be undertaken to investigate the possibility of using data from the SHS Travel Diary to replace some of the estimates which are being lost. Previously, the SHS Travel Diary has only been used to provide statistics on journey characteristics - for example, the percentage of journeys made by a given mode or for a given purpose. This was because the SHS travel diary was felt to be a good representation of the spread of all journeys made in Scotland, but not necessarily a good representation of each individual's typical travel.

Weighting in the National Travel Survey

The NTS asks a seven day travel diary of every member of the households in its sample, including children. This also includes specific questions on very short and very long journeys, and an interviewer checks up with the family throughout the week of the diary to assist them with recording. The NTS Travel Diary shows a drop-off day-by-day in the number of journeys recorded across the week from an average of 2.15 journeys on the first day to 1.95 on the seventh. The days of response are therefore weighted to account for this. As journeys for different purposes showed different levels of drop-off, these were weighted differently.

Information about all journeys is collected in the travel diary week. In addition, in order to obtain additional information about long distance journeys (LDJs), defined as journeys of 50 miles or more within Great Britain, the NTS collects information on long distance journeys made in the week period prior to the travel diary week. The LDJ records are weighted so that the number of LDJs reported on each day equalled the average number (for a day) reported in the travel diary.

Weighting in the Scottish Household Survey

For the Scottish Household Survey, which asks about journeys made by one randomly selected adult member of the household the previous day, interviews are *not* spread evenly across the week, because some types of people are more likely to be found at home, available for interview, on certain days. Therefore, the results need to be weighted using factors, which depend upon the day of the week and the adult's current economic status, and other factors, so that, within each strata, the weighted interview data is spread more evenly across the days of the week.

This results in two stages of rescaling the random adult weights for travel diary analysis. To ensure the travel diary was representative of travel patterns for the week as a whole, the random adult weights were rescaled so that the weighted number of interviews was equal for each day of the week. To ensure the travel diary was representative of working status across each day a second scaling factor was derived such that the working status breakdown for each day was equal.

This approach produces a large range of travel diary weighting values, and there are significant outlier effects where high Random Adult weights are compounded by high Travel Diary scaling. Several changes have been made to the Travel Diary and broader SHS sampling strategy over the years - further information on the methodology of the SHS can be found here.

Comparing the results of the SHS and NTS – initial assumptions

Rough estimates of annualised travel were made from the SHS Travel Diary for comparison with the NTS estimates as a first step. Previous analysis has shown that the SHS data suggest an average of about 750 journeys per adult per year for the years 1999-2003 (560 on weekdays and 190 on weekends) compared with figures of 1,096 from the Scottish results of the NTS for 1999-2001 (808 on weekdays and 288 on weekends) and 1,007 for 2002-2003 (756 on weekdays and 251 on weekends): about 41 per cent more (slightly higher on weekends). The NTS estimates were compared with both weighted and unweighted annualised STS estimates and, where possible, administrative data. The SHS tends to estimate fewer journeys and shorter journey distance compared to the NTS and administrative data.

The main assumptions made regarding the SHS travel diary data for the proposed methods described below are as follows:

- That the Travel Diary underrepresents journeys of all modes and purposes by roughly the same amount, and as such a benchmark for the number of commuting journeys can be used to weight up the rest of the journeys

- That the composition of the existing Travel Diary data is representative of journeys made by members of the population and that the main soruce of error comes from factors affecting the representativeness of the Travel Diary interview day, leading to fairly low estimates when the data are used to calculate annualised personal travel.

- That the average number of days worked in a week is calculable based on the average number of hours worked per week and a working day of 7.5 hours. Although this rough estimate has been used for the benchmarking above to demonstrate the methodology, a more robust measure could be arrived at by the inclusion of a question in the social survey which asked how many days the respondent had travelled to work in the previous week.

Method One – Benchmarking to the Labour Force Survey

It was decided to focus on only the Travel Diary data gathered since the changes made to the questionnaire in 2012, and to begin by concentrating on commuting journeys. The assumption was made that the information on journey characteristics collected was of good quality and that the main source of error was in a general “under-counting” of journeys due to factors affecting the representativeness of the day of interview and respondent recall. This meant that, given certain assumptions, a “grossing weight” based on an external benchmark could be calculated.

Commuting journeys were chosen as a starting point as they make up a substantial proportion of the journeys recorded in the Travel Diary and there were several high-quality potential benchmarks available (from the Census and the Labour Force Survey). The method shown below uses the figures for weekly hours worked from the Labour Force Survey to arrive at an average number of commuting journeys made per year by people in work. This was chosen as a benchmark as the LFS estimates of average number of weekly hours worked are available annually and are relatively reliable, being based on a large sample in Scotland, and assessed as National Statistics.

This was then used with the Travel Diary estimates of number of commuting journeys made per person per year to arrive at a benchmarking weight, which could be applied to all the journeys in the Travel Diary (assuming that under-counting is relatively constant across different types of journey) to correct for under-counting. This model assumes that an average working day lasts 7.5 hours. It is possible that a substantial improvement to this weighting scheme could be made by the inclusion in the SHS of a question “How many commuting journeys do you make every week?” or “How many days per week do you work?”.

As an initial step, the SHS Travel Diary data were grossed up to annual estimates using only the Travel Diary weight (*trav_wt*). These estimates were produced by calculating the sum of the Travel Diary weights for all commuting journeys in the 2012 Travel Diary to produce a weighted number of journeys, which was then divided by the number of respondents to the Random Adult survey (9893) to give an estimate for the number of commuting journeys made by the average surveyed adult the previous day to the interview. This was multiplied by 365 to give an estimate of yearly commuting travel amounting to 170.06 commuting journeys per person per year.

For benchmarking, estimates of yearly commuting travel were produced from the 2014 Labour Force survey. This used the information on hours worked per week to generate an estimate of how many commuting journeys were made in a year. Assuming an average of two commuting journeys per day worked (not including those who worked from home or unemployed people), this allowed the calculation of a gross number of days worked per week for the population, which could be converted into the gross number of commuting journeys made in Scotland in one week. This gave an average of 218.29 commuting journeys per person per year.

Dividing the LFS estimate by the Travel Diary estimate gave a grossing weight (*J_WT*) of 1.28. Further weighting by gender was considered, but the additional weighting factors involved were found to be so small that the effects were considered to be negligible.

Results

As shown in Table 1, the results are mostly similar to those from the Scottish subsection of the National Travel Survey, and display fairly low year-on-year variability. The benchmarking weight, shown in Table 4, shows little variation across the three years for which this calculation was performed, remaining at around 1.3. This is fairly consistent with the assumption that roughly 30% lower estimates of journeys were observed in the SHS compared to the NTS.

The general trend is an increasing number of journeys per person per year. The main differences between the surveys appears to be lower estimates of car passenger journeys and distance travelled in the SHS. As the NTS specifically asks about long-distance trips made in the previous month, it is unsurprising that estimates of journey distance for car, train and “other” (including air) travel are lower in the SHS.

The lower estimates of car passenger journeys compared to the NTS is likely due to the fact that the SHS travel diary is asked of one randomly selected adult from a household, while the NTS travel diary is asked of all members of the household,

including children, who are likely to make a higher proportion of car passenger journeys than adults. When the annualised estimates from the SHS are compared with estimates from the NTS for those over 16, the results agree much more closely.

Using the simple benchmarking weight arrived at above (in conjunction with the travel diary weight), a series of estimates of annual travel were produced. These are shown in Table 1 below:

Table 1 – Estimated number of journeys (of all purposes) per person per year (weighted and benchmarked to LFS)

	SHS Travel Diary		NTS	NTS (16+)
	2012	2013	2012	'08-'12
Weighted journeys per person per year	959	1,011	1,010	998
Weighted journeys per person per year by mode:				
Car driver	463	506	427	499
Car passenger	122	138	210	146
Walking	249	235	235	214
Bus	77	86	81	85
Train	17	17	18	
Bike	12	10	9	
Other	19	19	30	

Table 2 – Estimated distance travelled per person per year (weighted and benchmarked to LFS)

	SHS Travel Diary		NTS	NTS (16+)
	2012	2013	2012	'08-'12
Weighted total distance (km)	214,635	234,498		
Weighted total distance per person per year (km)	7,919	8,630	11,525	12,439
Weighted distance per person per year by mode (km):				
Car (all)	6,016	6,928	8,554	9,395
Car driver	4,700	5,436	5,769	6,926
Car passenger	1,316	1,492	2,784	2,469
Walking	277	246	249	248
Bus	641	661	652	761
Train	524	576	777	
Bike	58	43	56	
Other	403	175	1,236	

Table 3 – Number of hours travelled per person per year (weighted and benchmarked to LFS)

	SHS Travel Diary		NTS
	2012	2013	2012
Weighted hours travelled per person per year	369	390	367

Table 4 – Benchmarking information for LFS

	2012	2013
Benchmark - number of commutes per person per year (from the Labour Force Survey)	218	223
Number of TD respondents	9,893	9,918
Unweighted total TD journeys	19,739	20,183
Weighted total TD journeys	25,990	27,460
Grossing weight J_WT	1.28359	1.32574

Method Two – Benchmarking to the Census

As an initial step, the SHS Travel Diary data were grossed up to annual estimates using only the Travel Diary weight (*trav_wt*). These estimates were produced by calculating the sum of the Travel Diary weights for all commuting journeys in the 2012 Travel Diary to produce a weighted number of journeys, which was then divided by the number of respondents to the Random Adult survey to give an estimate for the number of commuting journeys made by the average surveyed adult the previous day to the interview. This was multiplied by 365 to give an estimate of yearly commuting travel amounting to 170.06 commuting journeys per person per year.

For benchmarking, estimates of yearly commuting travel were produced from the 2011 Scottish Census. This used the information on hours worked per week to generate an estimate of how many commuting journeys were made in a year. Assuming an average of two commuting journeys per day worked (not including those who worked from home, it was assumed that the following relationship between hours worked and days worked in a week would be suitable:

Hours worked weekly	Days worked weekly	Number of commuting journeys in a week per person
1-2 hours	1	
3-5 hours	1	2
6-15 hours	1.5	2
16-30 hours	2.5	3
31-37 hours	4	5
38-48 hours	5	8
49-59 hours	6	10
59+ hours	6	12

This allowed the calculation of a gross number of days worked per week for the population, which could be converted into the gross number of commuting journeys made in Scotland in one week. Dividing this by the over-16 Scottish population and multiplying by 52 to give a yearly estimate gave an average of 220.79 commuting journeys per person per year.

Dividing the 2011 Census estimate by the Travel Diary estimate gave an initial grossing weight (*J_WTinit*) of 1.30.

Results

Table 5 – Estimated number of journeys per person per year (weighted and benchmarked to Census 2011)

	SHS Travel Diary		NTS
	2012	**2013**	**2012**
Weighted journeys per person per year	969	989	1,010
Weighted journeys per person per year by mode:			
Car driver	468	495	427
Car passenger	123	135	210
Walking	252	230	235
Bus	78	84	81
Train	17	17	18
Bike	12	10	9
Other	19	18	30

Table 6 – Estimated distance travelled per person per year (weighted and benchmarked to Census)

	SHS Travel Diary		NTS
	2012	**2013**	**2012**
Weighted total distance (km)	217,045	229,592	
Weighted total distance per person per year (km)	8,008	8,449	11,525
Weighted distance per person per year by mode (km):			
Car (all)	6,083	6,782	8,554
Car driver	4,753	5,322	5,769
Car passenger	1,330	1,460	2,784
Walking	280	241	249
Bus	649	647	652
Train	530	564	777
Bike	58	43	56
Other	408	172	1,236

Table 7 – Number of hours travelled per person per year (weighted and benchmarked to Census)

	SHS Travel Diary		NTS
	2012	2013	2012
Weighted hours travelled per person per year	373	381	367

Method Three – Benchmarking to the Census with correction for modal share and gender

This approach could also be used with the LFS data and is provided here as an example of the impact on the outputs of using additional weighting factors.

As an initial step, the SHS Travel Diary data were grossed up to annual estimates using only the Travel Diary weight (*trav_wt*). These estimates were produced by calculating the sum of the Travel Diary weights for all commuting journeys in the 2012 Travel Diary to produce a weighted number of journeys, which was then divided by the number of respondents to the Random Adult survey to give an estimate for the number of commuting journeys made by the average surveyed adult the previous day to the interview. This was multiplied by 365 to give an estimate of yearly commuting travel amounting to 170.06 commuting journeys per person per year.

For benchmarking, estimates of yearly commuting travel were produced from the 2011 Scottish Census. This used the information on hours worked per week to generate an estimate of how many commuting journeys were made in a year. Assuming an average of two commuting journeys per day worked (not including those who worked from home, it was assumed that the following relationship between hours worked and days worked in a week would be suitable:

Table 8 – Hours worked per week to commuting journeys conversion (Census)

Hours worked weekly	Days worked weekly	Number of commuting journeys in a week per person
1-2 hours	1	
3-5 hours	1	2
6-15 hours	1.5	2
16-30 hours	2.5	3
31-37 hours	4	5
38-48 hours	5	8
49-59 hours	6	10
59+ hours	6	12

This allowed the calculation of a gross number of days worked per week for the population, which could be converted into the gross number of commuting journeys made in Scotland in one week. Dividing this by the over-16 Scottish population and multiplying up to give a yearly estimate gave an average of 220.79 commuting journeys per person per year.

Dividing the 2011 Census estimate by the Travel Diary estimate gave an initial grossing weight (*J_WTinit*) of 1.30.

It was found on inspection that different modes of travel were underreported to different degrees in the SHS Travel diary compared to the estimates from the 2011 Census. The next stage, therefore, involved the production of a grossing weight for each mode of transport. Following the same procedure as above, but calculating a gross number of journeys for each mode of transport individually for the Travel Diary (using the travel diary weight *trav_wt*), produced an estimate of the number of yearly commuting journeys by each mode of travel. These estimates were also produced from the 2011 Census by multiplying the reported modal share for each mode by the total gross number of commuting journeys to give a figure for each mode of transport, as shown in the table below:

Table 9 – Weighting to Census by modal share

Mode	Number of journeys per person per year (Census 2011)	Modal share	Number of journeys per person per year (SHS TD 2012)	Modal share	Calculated grossing weight (*J_WT01*)
Train	9.88	4%	5.18	3%	1.91
Bus	24.83	11%	16.94	10%	1.47
Car driver	138.60	63%	101.97	60%	1.36
Car passenger	14.34	6%	15.53	9%	0.92
Bicycle	3.49	2%	3.22	2%	1.08
Walking	24.57	11%	24.30	14%	1.01
Other	5.08	2%	2.92	2%	1.74
Total	220.79	100%	170.06	100%	1.30

A grossing weight *J_WT01*, displayed above in the rightmost column of Table 9, was calculated for each mode by dividing the 2011 Census estimate for number of journeys per person per year by the estimate from the SHS Travel Diary.

Weighting by gender

It was then decided to check if using the new *J_WT01* weight gave the same estimates for yearly travel by gender as the Census. Producing gross estimates of annual travel using the 2011 Census and the 2012 Travel Diary (weighting by *TRAV_WT* and *J_WT01*) as above, but splitting by gender, gave the following results:

Table 10 – Weighting to Census by gender

Men

	Census 2011 benchmark - number of commuting journeys by mode per person (all 16+ yr olds) per year	calc. modal share	SHS Travel Diary 2012 number of commuting journeys by mode per person (all 16+ yr olds) per year, weighted	calc. modal share	Calculated grossing weight (*J_WT01G*)
Train	12.5	5%	11.7	5%	1.07
Bus	22.8	9%	22.3	9%	1.02
Car driver	175.0	66%	166.1	66%	1.05
Car passenger	16.3	6%	16.3	6%	1.00
Bicycle	6.3	2%	5.2	2%	1.21
Walking	23.3	9%	25.3	10%	0.92
Other	9.2	3%	6.3	2%	1.45
Total	265.4	100%	253.2	100%	1.05

Women

	Census 2011 benchmark - number of commuting journeys by mode per person (all 16+ yr olds) per year	Calc. modal share	SHS Travel Diary 2012 number of commuting journeys by mode per person (all 16+ yr olds) per year, weighted	Calc. modal share	Calculated grossing weight (*J_WT01G*)
Train	7.0	4%	8.2	4%	0.86
Bus	23.5	14%	27.3	14%	0.86
Car driver	98.8	59%	113.3	59%	0.87
Car passenger	11.5	7%	12.6	7%	0.91
Bicycle	1.2	1%	2	1%	0.61
Walking	22.7	14%	23.9	13%	0.95
Other	1.8	1%	3.4	2%	0.52
Total	166.5	100%	190.7	100%	0.87

As can be seen, the grossed results from the Travel Diary with the new weighting gave encouragingly similar modal shares to the 2011 Census. There was, however, a gender disparity in magnitude – travel by women seemed to be over reported by the Travel Diary compared to travel by men. A second series of weights was therefore produced to account for this disparity, *J_WT01G*, which, when combined with *TRAV_WT* and *J_WT01* would give the new grossing weight *J_WT02*:

*J_WT02 = TRAV_WT * J_WT01 * J_WT01G*

Results

Table 11 – Estimated number of journeys per person per year (weighted and benchmarked to Census with correction for mode of travel and gender)

	SHS Travel Diary	NTS
	2012	**2012**
Weighted journeys per person per year	747	1,010
Weighted journeys per person per year by mode:		
Car driver	361	427
Car passenger	95	210
Walking	194	235
Bus	60	81
Train	13	18
Bike	9	9
Other	15	30

Table 12 – Estimated distance travelled per person per year (weighted and benchmarked to Census with correction for mode of travel and gender)

	SHS Travel Diary	NTS
	2012	**2012**
Weighted total distance (km)	167,215	
Weighted total distance per person per year (km)	6,169	11,525
Weighted distance per person per year by mode (km):		
Car (all)	4,687	8,554
Car driver	3,662	5,769
Car passenger	1,025	2,784
Walking	216	249
Bus	500	652
Train	408	777
Bike	45	56
Other	1,338	1,236

Table 13 – Number of hours travelled per person per year (weighted and benchmarked to Census with correction for mode of travel and gender)

	SHS Travel Diary	NTS
	2012	**2012**
Weighted hours travelled per person per year	288	367

Discussion and concluding thoughts

Of the three methods indicated, only the Labour Force Survey is suitable for annual updates as the Census is asked every ten years. Use of a Census benchmark would therefore assume that the reduction in estimated journeys per year due to factors affecting the representativeness of the SHS Travel Diary was consistent from year to year – though annual changes to modal shares could be obtained from the social survey portion of the Scottish Household Survey. The Labour Force and Census simple benchmarks both weight the total number of journeys up by around 30%, producing results which agree broadly with the National Travel Survey estimates.

The third method benchmarks to the census as described above, then corrects the distribution of the weighting by gender and mode of travel (based on reported hours worked and main mode of travel to work by gender from the census). This is likely to have the effect of "smoothing out" the estimates so that modal share contributions of journeys by alternative modes which may not be the respondent's usual mode of travel are lost. It also assumes that the relationship between under-counting and mode of journey is the same for journeys of different modes, which may not be the case.

Overall, it would appear initially that the method of benchmarking to the Labour Force Survey is the most viable for producing annual estimates of personal travel from the SHS Travel Diary. This method produces similar results to the NTS Travel Diary, with a noticeable difference in estimates of car passenger travel, however given the differences between the two surveys this is to be expected. While the SHS collects information about one randomly selected adult from a household, the NTS collects a travel diary from every member of the household, including children, who will likely make more car passenger journeys than adults. When estimates from the NTS are presented on a similar basis (travel by adults) the estimates are encouragingly close, and, given the small sample size of the NTS in Scotland (only 6,507 adults when combining 2008-2012 data compared to nearly 10,000 adults annually from the SHS travel diary), a benchmarked SHS travel diary may actually provide more robust estimates of personal travel, despite its one-day nature.

Benchmarking to the census would appear to support the validity of the results from the Labour Force Survey, producing similar estimates. Benchmarking by gender and reported usual mode of travel to work was considered for the LFS method, however this was found to have a negligible effect on the estimates produced in the case of gender and to reduce the reliability of the estimates in the case of mode.

Feedback

We would welcome any thoughts, comments or criticisms on the methods described above – they represent a starting point for further development. It appears that the data from the Scottish Household Survey Travel Diary is of high quality despite the potential for under-counting or representativeness of annual personal travel behaviours and, while it may be suitable for collecting information on longer or more infrequent journeys, it appears that it may be possible to work towards developing a weighting methodology which could provide estimates of respondents annualised travel.

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Annex 1 – Comparing the SHS and the NTS Travel Diary

NTS data	SHS / TD equivalent	Notes
Number of trips / head and by mode, distance, purpose, income (GB), car access, household size and composition, urban/rural, working status, age, gender, concessionary pass possession *	Can't calculate per person due to 1 day nature of diary	Collect all variables via the SHS but can't extend to number of trips as TD not representative of whole week
Miles travelled / head (or average distance) and by mode, purpose, age, gender, NS-SEC, income (GB), car access **	Can't calculate per person due to 1 day nature of diary	Collect all variables just not representative of whole week
Average length (distance) of trip and by mode, purpose ***	Report proportions of trips (by characteristic) by length	
Hours travelled / head and by purpose	Can't calculate per person due to 1 day nature of diary	Collect all variables just not representative of whole week
Average time (duration) / trip and by purpose	Report proportions of trips (by characteristic) by duration	Collect all variables just not representative of whole week
Average speed	Could calculate from distance and time information we have in TD, however, would have concerns about the accuracy of this.	Never been asked for this from SHS, limited requirement for this information.
Vehicles / household	Currently only collects number of cars but question for new survey will include vans	
Cars / household	See above	
Individuals / household	Collected via main SHS	
Annual mileage / 4-wheeled car	Do not have	This is self reported in NTS so unsure of accuracy.
Bus frequency	Collect via main SHS	
Company cars	Collect via main SHS	
Concessionary pass possession	Collect via main SHS	
Driving licence	Collect via main SHS	
Frequency of walking 20 minutes or more by age and gender	Collect via main SHS	
Trips to and from school	Collect via main SHS	Collect information about travel to school and reasons why/why not use PT

* affects 21 tables in Scottish NTS 2007/08 publication which details number of trips by characteristics (including combination of characteristics)

** affects 10 tables in Scottish NTS 2007/08 publication which details miles travelled or average distance by characteristics (including combination of characteristics)

*** affects 3 tables in Scottish NTS 2007/08 publication which details miles travelled or average distance by characteristics (including combination of characteristics)