

Reaching the target audience: how can we encourage increased mode shift if our travel surveys are biased towards those already using smarter modes?

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Rebecca Fishburn

Abstract

Research on factors affecting mode choice is often based on travel surveys and questionnaires. Surveys and questionnaires are reliant on achieving a representative sample of respondents. Whilst a representative response rate for age and gender is easily achieved, how do we know that the mode choice of the respondents is representative?

The very nature of travel surveys means that it is harder to achieve a desired level of accuracy compared to traditional highway traffic counts. As more pressure and funding is focused on increasing the mode share of smarter choices it is inevitable that a higher standard will be required from the data used in the development of these schemes.

This paper considers whether travel surveys are biased towards particular modes and the impact that such a bias might have on the application of travel survey results. Smarter choice schemes have limited budgets for data collection and this paper seeks to apply a pragmatic approach to addressing survey bias.

The main use of travel surveys is to support measures aimed at increasing the use of smarter modes. It is important to consider who we are targeting with such aims, if certain modes are under-represented in travel surveys then such measures may not be as effective at encouraging mode shift.

The analysis presented in this paper indicates that travel surveys are likely to be biased towards overestimating the mode share of sustainable modes. This bias occurs through a lower response rate for car drivers than for other modes. The way survey data is used, however, means that this bias does not necessarily cause a significant issue in monitoring progress in the increase in sustainable modes. Instead, it makes it difficult to be confident that the survey results are providing as much information on travel behaviour as could be achieved if the bias was not present.

1. Introduction

- 1.1. This paper establishes the extent to which the quality and validity of travel survey data affects the effectiveness of sustainable travel schemes. The key aspect of the survey data considered is survey bias arising from a non-representative response by travel mode. The paper first establishes the mechanisms through which travel survey data is used in the development of transport schemes. The presence of bias in travel survey data and the extent to which this bias affects the application of the data is then considered.
- 1.2. The government recognises the importance that cycling and walking have to play in sustainable transport strategies as demonstrated through its commitment to the Local Sustainable Transport Fund which has a key emphasis on encouraging mode shift¹. The schemes developed on a local scale by Local Authorities and major employers are fundamental to increasing cycling levels. Several obstacles have been identified to increasing cycling including safety, availability of secure parking and infrastructure². Travel surveys are often used to understand site specific issues and obstacles. As such, this paper focuses on travel surveys completed by employers and education establishments and how the results of these surveys are used.
- 1.3. The main theory presented in this report is that travel survey responses are likely to be biased towards a particular mode (or modes) of transport. There are several reasons why this bias may occur, such as:
 - It has been shown that people are more likely to complete a survey about something that they consider themselves to have an interest in³.
 - Social desirability is the tendency of individuals to deny socially undesirable traits and to admit to socially desirable ones⁴. Occasional users may over-estimate their cycling user/under estimate their car use as it is viewed as more socially desirable.

This paper does not seek to determine the specific reasons for bias occurring in travel survey results, but instead considers the extent of this bias and how it affects the use of survey results.

- 1.4. The matter of bias in surveys has been well researched, though this research does not often extend to travel surveys specifically. Available research focusing on travel surveys generally considers household travel surveys⁵. This thesis recognises that shortcomings in travel survey results are often ignored in analysis and that the presence of bias affects the quality of the data. The available research suggests that non-response bias is the most applicable source of bias to this paper. This bias arises if the non-respondents are systematically different from respondents.
- 1.5. Current guidance⁶ on the application of travel survey data states that provided an appropriate survey frame has been followed it is adequate to assume the responses are free of bias. This

¹ DfT, January 2011, Local Sustainable Transport Fund – Guidance on the Application Process.

² DfT, LTN 1/04 – Policy, Planning and Design for Walking and Cycling.

³ Martin, Charles L, October 1994, The impact of topic interest on mail survey response behaviour, Journal of the Market Research Society, Vol 36(4), 327-338.

⁴ M. Randall and Maria F. Fernandes, 1991, The Social Desirability Response Bias in Ethics Research, Donna Journal of Business Ethics 10: 805-817.

⁵ Fahmida Nilufar, August 2003, Assessing sample bias and establishing standardized procedures for weighting and expansion of travel survey data.

⁶ Higher Education Funding Council for England, January 2012, Measuring scope 3 carbon emissions, Transport, A guide to good practice.

paper considers whether this guidance is sufficient in preventing any survey bias from affecting the application of the survey results.

- 1.6. After this paper establishes whether the presence of bias affects the use of survey results, methods of overcoming flaws in travel survey data are then considered. The ultimate goal is to identify whether validity issues in the data are limiting the success of the transport measures developed using the travel survey data.
- 1.7. It is important to note that the purpose of this paper is to highlight possible issues in the validity of data and demonstrate how greater consideration of survey results could assist in use of survey data.

2. How is travel survey data used?

- 2.1. To establish whether any bias present in travel surveys affects the development of transport schemes, we must first understand the mechanisms by which survey data is used. This paper considers the types of travel surveys completed by Local Authorities, major employers and universities. Each of these gather travel data through different mechanisms and for different reasons.
- 2.2. This section considers the following three main methods by which travel survey data is used:
- To overcome a particular identified obstacle through face-to-face surveys and focus groups.
 - To fulfil planning application requirements.
 - To monitor travel plan targets and emissions from transport.
- 2.3. The uses of data described above are discussed below in the context of the data collection from different institutions, including a higher education establishment, a local authority and development planners.

Higher Education Establishments

- 2.4. Higher education establishments have a requirement to monitor their carbon emissions⁷ and complete travel plans and as such undertake travel surveys with reasonable regularity, with both staff and students being surveyed. The travel surveys complement the travel plans developed by the universities and are used to assess progress against their objectives and targets. A summary of the travel surveys completed at two universities in Leeds is presented in Table 1.

Table 1 – Summary of University Travel Surveys

University	Frequency of Survey	Response Rate at Last Surveys
University of Leeds ⁸	Every Year	31% staff, 16% students
Leeds Metropolitan University ⁹	Every Year	36% staff, 14% students

- 2.5. The objectives set by the different institutions were fairly consistent and generally desired to increase the mode share of walking, cycling and public transport whilst decreasing the mode share of single occupancy car drivers. These targets are set as percentage mode share targets rather than percentage reduction/increase targets, i.e. the University of Leeds aims to reduce its single car driver mode share to 20% rather than aiming to reduce the number of car drivers by 10%.
- 2.6. The regular repetition of travel surveys allows universities to determine progress against set objectives. It is noted that there has been a decline in the response rate in recent travel surveys. The response rate of University of Leeds staff in 2005 was 37% which had declined to 31% in 2008.

⁷ Higher Education Funding Council for England, 2010: Carbon Reduction Target and Strategy for Higher Education in England

⁸University of Leeds, 2009: Travel Plan. Data also available for the 2010 and 2011 travel surveys, but these are not reported in the latest travel plan.

⁹Leeds Metropolitan University, 2011: Leeds Met Travel to University Survey 2011 Results.

- 2.7. Staff and students are generally invited to complete the survey via the log in screen to the university intranet and other web based advertisements. The most recent travel survey at the University of Leeds was advertised online with respondents being eligible for a £200 prize draw.

City of York Council

- 2.8. The City of York Council (CYC) has a high level of commitment to, and enthusiasm for, sustainable travel schemes; having been declared a Cycling City and received £4.6million in funding from the Local Sustainable Transport Fund¹⁰. Clearly, a council wide data collection exercise would be expensive and the data provided could in effect be taken from the National Travel Survey results or the 2011 Census when the journey to work data becomes available. CYC have instead focused their efforts on gathering data about increased take up in cycling across the city to try and identify the key drivers behind increased cycling.
- 2.9. Interviews took place on key cycling routes into the city; the interviews were conducted by Sustrans. CYC found that the specific nature of the questions did not fully allow them to identify the aspects of their schemes that were providing success in increasing cycling rates. Schemes developed on a city wide scale have been found to require specific group tailored data collection with specific demographics being identified as facing different obstacles to increased cycling.

Development Planning

- 2.10. Travel surveys may also be completed to fulfil planning or funding requirements. For example, in London for businesses to be eligible for funding from Barclay's Cycle Superhighways¹¹ staff must complete a brief online survey about their travel habits. Similarly, the development of i-TRACE¹² was supported by Transport for London (TfL) in recognition of the need for a standardised approach to travel plan development.
- 2.11. i-TRACE is a travel plan management application that is now being rolled-out across the country and allows a like for like comparison of travel plan data over different years, organisations and geographical regions. i-TRACE requires input of travel survey results and is a requirement of most planning applications in London. i-TRACE is combined with i-TRVL, a tool that requires businesses to complete basic surveys such as parking counts. The current method for submitting travel survey results in i-TRACE does not allow for traffic count data such as this to be considered in the calculation of mode shares.
- 2.12. It is evident from the consultation and research shown here that travel survey data is collected in a variety of forms, each tailored to the intended use of the data. The rest of this paper will focus on travel survey data that is then used in the setting and monitoring of travel plan targets.

¹⁰ DfT, September 2012, LSTF All Funding Decisions

¹¹ <http://businessoffers.tfl.gov.uk/barclayscyclesuperhighways/home.html>

¹² <http://www.itrace.org.uk/>

3. Are travel surveys biased?

3.1. This section considers whether travel surveys are likely to be biased towards a particular mode of transport; this is a form of non-response bias. That is, the results of the travel survey are biased because it has been assumed that the mode choices of the non-respondents are the same as those that have completed the survey, whereas certain modes may be less likely to respond. Before considering this one specific form of bias we first look at the different sources of bias in travel surveys. Nilufar (2003)¹³ identified the following key sources of bias in travel surveys:

- Coverage Error – the omission of sections of a defined survey population from the sampling frame.
- Non-response bias – bias arising through the assumption the respondents are representative of the non-respondents.
- Geographic bias – location is a key part of trip behaviour, a non-representative response by location can result in bias.
- Time bias – travel surveys completed at different times of the year may have different responses due to changes in travel behaviour over the year. For example, the University of Leeds used to complete their travel survey every 18 months alternating between spring and autumn, the survey is now completed every 12 months at the same time of year.
- Instrument bias – poorly designed surveys can cause respondents to give the wrong answers.

3.2. Coverage and geographic errors can be estimated through comparison of key characteristics of responders with those of the population as a whole. For example, a university knows the departments and postcodes of all staff and students so would be able to determine a response rate by group. This sort of weighting may be sufficient provided that the respondents by demographic are representative of the mode shares in the demographic as a whole. This is also the recommended methodology provided the appropriate sampling frame has been used.

3.3. This paper is predominantly concerned with non-response bias in travel surveys, with the key component of bias being the mode choice of respondents. In other words, does the mode share of respondents to a travel survey provide an accurate representation of the target population as a whole?

3.4. The main issue with determining survey bias is that either a very high response rate or a comprehensive set of traffic surveys would be required for an accurate assessment of the actual mode shares of a population. A recent data collection exercise was completed by a major employer, with a 56% response rate to the travel survey and comprehensive set of traffic surveys allowing a comparison of the mode share of the responders to the travel survey and that of the work force as a whole. The study found that nearly a 100% response rate was achieved for cycling, rail and bus whereas there was a much lower response rate for single occupancy car drivers (under 45%). Had the results from the travel survey been applied without consideration of this bias, then the resulting travel strategy would have underestimated the dependency on car use.

3.5. In determining the mode shares resulting from a travel survey, the degree of bias is dependent on two factors: firstly, the proportion of non-respondents in the population by mode, and

¹³ Fahmida Nilufar, August 2003, Assessing sample bias and establishing standardized procedures for weighting and expansion of travel survey data.

secondly, the difference between the mode share of respondents and the mode share of non-respondents. From this we identify the two key issues with achieving a representative survey:

- Response rates; and
- Likelihood of one mode responding more than another.

3.6. But, as Nilufar (2003) also identified, increasing response rates do not necessarily reduce the non-response error. If a systematic bias is occurring towards one mode, then increasing response rates may instead exacerbate this error.

3.7. Table 2 compares the travel survey results for the University of Leeds and Leeds Metropolitan University to 2001 journey to work census data. The response rate in Yorkshire and Humber to the 2001 Census was 96%. The method of travel to work is asked as a question on the census form. The online tool Nomis¹⁴ allows census data to be output by ward. The universities in Leeds are an output ward for employment destination, so this data provides the journey to work mode for university employees.

Table 2 – Comparison of Staff Mode Shares in Survey Responses for University of Leeds and Leeds Metropolitan University

Mode	2001 Census	2004 Travel Survey University of Leeds	2002 Travel Survey Leeds Metropolitan University
Car – driver	58%	46%	46%
Car – passenger	7%	9%	11%
Train	4%	11%	5%
Bus	19%	18%	18%
Bicycle	2%	5%	5%
On foot	8%	10%	15%
Other	2%	1%	0%
Total	100%	100%	100%
Response Rate	96%	29%	~600 responses

3.8. It should be noted that this census ward extends beyond the university boundaries and includes several neighbouring areas. The universities are the major employment centres in the ward and the accessibility of public transport is similar across the ward, though other workers in the area may work unsociable hours that result in a heavier reliance on car use. The example presented here is using the census information to demonstrate the potential impact of non-response bias and as such it is considered appropriate to use the mode shares from this census ward despite the issues highlighted above.

3.9. It is acknowledged that the sources of data above are taken from different years. More detailed research is required into whether adjustments are needed to account for changes in mode between the survey years, but for the purposes of this exercise it has been decided to adjust the data as little as possible.

3.10. The level of bias in travel survey responses can be expressed as $\bar{Y}_1 - \bar{Y}$ where \bar{Y} is the measure of the population that we are trying to determine (for example, the percentage of employees travelling to work by bicycle) and \bar{Y}_1 is the same measure for the respondents¹⁵ (in our example

¹⁴ <https://www.nomisweb.co.uk/Default.asp>

¹⁵ Fahmida Nilufar, August 2003, Assessing sample bias and establishing standardized procedures for weighting and expansion of travel survey data. Pg 8.

this would be the mode share of cyclists in survey respondents). Applying this expression, we get the following level of bias by mode for the two travel surveys:

Table 3 – Bias by Mode in Travel Survey Results

Mode	2004 Travel Survey University of Leeds	2002 Travel Survey Leeds Metropolitan University
Car – driver	-12%	-12%
Car – passenger	+2%	+4%
Train	+7%	+1%
Bus	-1%	-1%
Bicycle	+3%	+3%
On foot	+2%	+7%

- 3.11. We can see from Table 3 that there is general bias towards public transport and walking/cycling, with car drivers being underrepresented in both travel surveys. Even accounting for any reduction in car use between the survey years, we would still find this bias against car drivers. A chi-squared statistical test has been complete to demonstrate that the difference between the travel survey results and the census results could not have occurred through chance alone.
- 3.12. This section has already considered the motivation of survey respondents, but a possible reason for non-response bias occurring by mode is that people may think that the organisation don't want to know about their particular form of transport. Nilufar identified that those who travel little as they believe their lack of travel would be of little interest to the survey team. Car drivers may perceive that a travel survey is focused towards those who use public transport or cycling facilities.

4. Impact of bias on the application of results

- 4.1. To determine whether the presence of bias affects the application of travel survey results, we must reassess an institution's progress against travel plan targets with and without an adjustment for bias. It should be noted that this exercise is purely for demonstration purposes to explore the possible impacts that the presence of bias in travel surveys can have on how we measure the effectiveness of transport schemes. For the purpose of this exercise the travel plan objectives for staff at the University of Leeds¹⁶ will be considered, specifically the aim to reduce the proportion of single occupancy car drivers travelling to the University to 20%.
- 4.2. The level of non-response bias can be used to calculate a bias adjustment factor for each mode. After applying this adjustment factor the results are then rebased to the population total to calculate the revised mode splits. Table 4 presents the bias adjustments calculated for the University of Leeds 2004 travel survey, these adjustment factors can then be used to calculate revised mode shares for further travel surveys. The application of the bias adjustment in this way relies on the assumption that the level of bias for each mode remains constant between travel surveys. This is unlikely to be the case but for the purposes of this exercise it is considered that it is not practicable to determine the non-response bias for each survey year.

Table 4 – Bias Adjustments

Mode	Travel survey response	Non-response bias	Bias adjustment factor*
Car – driver	46%	-12%	1.26
Car – passenger	9%	2%	0.78
Train	11%	7%	0.36
Bus	18%	-1%	1.06
Bicycle	5%	3%	0.40
On foot	10%	2%	0.80

*1+Non-response bias/travel survey response

- 4.3. Table 5 presents the unweighted mode shares as taken from the travel survey responses and Table 6 presents the weighted mode shares that have been calculated by applying the bias adjustment factors presented in Table 4 according to the methodology outlined above. Figure 1 presents the car driver mode share and the percentage change since the first travel survey.

¹⁶ University of Leeds, 2009, Travel Plan.

Table 5 – Unweighted Survey Responses

Mode of Transport	2004	2005	2007	2008	2010	2011
Car driver only*	46%	33%	28%	23%	27%	27%
Car sharing**	9%	16%	15%	15%	13%	14%
Train	11%	14%	17%	19%	19%	19%
Bus	18%	18%	19%	20%	15%	18%
Bike	5%	6%	6%	8%	9%	8%
Walk	10%	12%	14%	13%	15%	14%

*2004 car driver, **2004 car passenger.

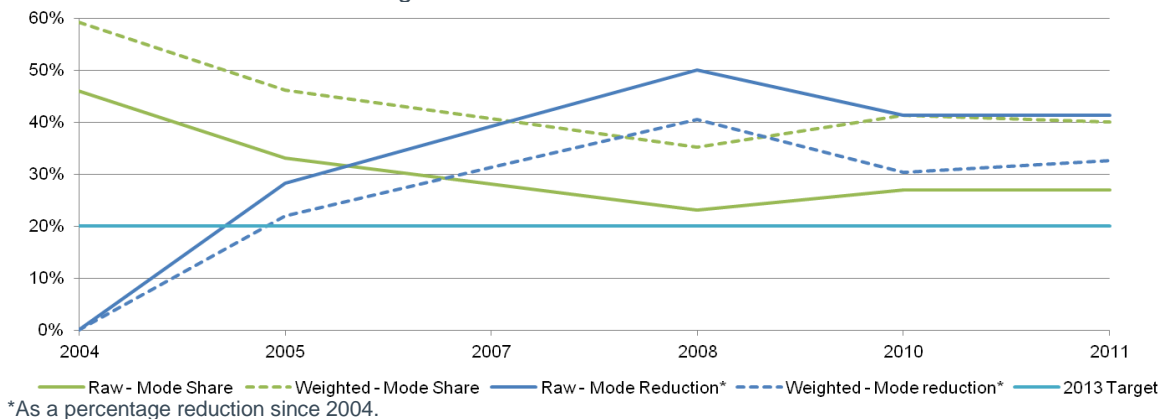
Table 6 – Weighted Survey Responses

Mode of Transport	2004	2005	2007	2008	2010	2011
Car driver only*	59%	46%	41%	35%	41%	40%
Car sharing**	7%	14%	13%	14%	12%	13%
Train	4%	6%	7%	8%	8%	8%
Bus	19%	21%	23%	26%	19%	22%
Bike	2%	3%	3%	4%	4%	4%
Walk	8%	11%	13%	13%	15%	13%

*2004 car driver, **2004 car passenger.

- 4.4. Note that after the bias adjustment factors have been applied to the unweighted mode shares in Table 5, the total by year has been re-based to 100% to get the values in Table 6.

Figure 1 – Car Driver Mode Shares



- 4.5. We can see from Figure 1 that by applying the bias adjustment factors the reduction in car driver mode share is lower than the unadjusted reduction in mode share. The stated targets of the Travel Plan aimed to reduce the mode share of car drivers to 20%, from the most recent travel survey this would require a 7 percent point drop in mode share based on the unadjusted survey responses. Accepting that the travel survey is likely to under-represent the mode share of car drivers, it is unlikely that the travel plan would have aimed to reduce the mode share to 20% had the starting point been higher.
- 4.6. It is interesting to note that there was a large reduction in car driver mode share in 2008. Anomalous results such as these could be explained with much greater confidence if non-response bias was not considered to be an issue.
- 4.7. As travel plan objectives are set based on the survey data collected, provided a similar level of bias by mode occurs in each survey, realistic targets can still be set and monitored. Indeed, even if non-response bias had been calculated separately for each survey year, it is still likely that a

reduction in the mode share of car driver will have been observed. If travel plan targets were set as percentage reduction targets then this would limit the impact of non-response bias on the monitoring of targets. For example, rather than aiming to reduce the car driver mode share to 20%, the University of Leeds travel plan could instead aim to reduce the number of car drivers by 10%.

- 4.8. Without greater confidence in the validity of the travel survey data we cannot be sure that targets are being met, or that overall increase in cycling as observed by travel survey responses represents a corresponding reduction in single occupancy car drivers. The reduction in car use contributes to the reduction in emissions, rather than the increase in cycling. As such, it is important that the car use of employees is estimated as accurately as possible.
- 4.9. The target audience of travel plan measures must also be considered. In addition to monitoring changes in mode share, travel surveys are also used to gather opinions on obstacles preventing people reducing their reliance on cars. The success of the survey on meeting these requirements is reliant on enough non-cyclists/sustainable travellers responding. As important as the monitoring of different mode shares is, to achieve an increase in smarter choices it is vital that the opinions of those still using their cars are collected.

5. The consideration of bias in future travel surveys

- 5.1. The analysis presented in this paper indicates that travel surveys are likely to be biased towards overestimating the mode share of sustainable modes. This bias occurs through a lower response rate for car drivers than for other modes. It has also been shown that due to the way travel plan targets are set, this bias does not necessarily cause a significant issue in monitoring progress in the increase in sustainable modes. Instead, it makes it difficult to be confident that the survey results are providing as much information on travel behaviour as could be achieved if the bias was not present.
- 5.2. It is important to consider who we are targeting with aims to increase the use of more sustainable modes. This increase in such modes goes hand in hand with a reduction in lone car drivers. Having identified that there is a lower response from car drivers, it is clear that the key obstacle to enabling more car drivers to switch to sustainable modes is acquiring the appropriate information on what incentives/schemes would be required.
- 5.3. Overcoming this obstacle could be achieved through several methods, including:
- Targeted focus groups specifically aimed at current car drivers. Target groups such as these are favoured by local authorities such as City of York Council.
 - An additional question in the travel survey to determine if someone has switched from a mode since the last travel survey and what their reasons were for doing so.
- 5.4. The second point in particular highlights the importance of scheme evaluation as well as monitoring. It is likely that, even with the presence of non-response bias, current travel surveys are doing an acceptable job of monitoring how schemes are working, but they could be doing more to evaluate why they are working or how they could be working better. City of York Council has recently produced a monitoring and evaluation framework which follows the national guidance¹⁷, highlighting the importance of scheme evaluation.
- 5.5. This paper has explored the presence of bias in major travel surveys completed by higher education establishments. Ideally future travel surveys would acknowledge the presence of non-response bias. Without achieving much higher completion rates to travel surveys it would be virtually impossible to remove all bias. Similarly, without a comprehensive set of traffic surveys, that would be both time consuming and costly, it would be very difficult to determine the extent to which a travel survey is biased. In lieu of these measures the following could be used to improve the validity of travel surveys:
- Employment based travel surveys should aim to achieve a much higher response rate;
 - Improved use of GIS/postcode analysis on survey results;
 - Complete basic control counts, such as parking and cycle counts;
 - Applying weights by demographic/department; and
 - Comparison of recent travel surveys against the 2011 National Census, which will be released early in 2013, to allow a 'sense check' of results.
- 5.6. The measures discussed above will not necessarily be appropriate in all travel surveys and, as is highlighted in Section 2, the collection of travel survey information should be tailored to the end

¹⁷ DfT, September 2012, Monitoring and evaluation framework for Local Authority Major Schemes.

use of the data. For example, if a sufficiently high response rate is achieved it may not be necessary to apply weights. The budget/resources for travel surveys and smarter choices do not always allow for parking surveys. In such cases, it must be accepted that a certain level of non-response bias will be present in surveys and the measures discussed in Section 4 on limiting the impact of this bias becomes imperative.

- 5.7. As travel surveys are increasingly completed online, higher response rates should be easier to achieve. Staff and students at higher education establishments are generally prompted to complete the survey upon logging in to the intranet system. Completion of the survey could be made compulsory at this stage, or departments could be tasked with ensuring that their staff members have completed the survey. Prize draws are often used to encourage people to respond to surveys, though care must be taken to ensure that the prize does not appeal to one mode more than others; for example, a free bus pass would be expected to result in more bus users completing the survey.
- 5.8. This paper has used a basic example to demonstrate how travel survey results may be biased towards particular modes. As well as the measures outlined above to improve the validity of individual surveys further measures could be taken on a wider scale to address the presence of bias in travel surveys:
- Research on why the non-response bias is occurring and how it varies between travel surveys.
 - Research into whether certain survey techniques reduce non-response bias.
 - Improvements to guidance to encourage validation of survey responses.
- 5.9. The very nature of travel surveys means that it is harder to achieve a desired level of accuracy compared to traditional highway traffic counts. As more pressure and funding is focused on increasing the mode share of smarter choices it is inevitable that a higher standard will be required from the data used in the development of these schemes.

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