

# New Ways of Collecting Individual Travel Information

# Evaluation of data collection and recruitment methods

Jenny Eriksson

Eva Lindborg

Emeli Adell

Andreas Holmström

Ary P. Silvano

Annika Nilsson

Per Henriksson

Mats Wiklund

Lina Dahlberg

#### Foreword

A need to find and develop new solutions for travel surveys (TSs) has been identified within the *Nästa generations resor och transporter* (Next Generation Travel and Transport) cooperative programme. In January 2017, a project plan for the New Solutions for the Future Travel Survey project was submitted to the Swedish Ministry of Enterprise and Innovation, with Transport Analysis being the coordinating body. The project plan was divided into five work packages: (1) coordination, (2) stakeholder and needs analysis, (3) detailed mapping of tools and applications, (4) testing and analysis of tools and applications, and (5) development potential and recommendations. This report pertains to a portion of work package 4 and is funded by 50% in part by the Swedish Transport Administration's Research and Innovation Work portfolio. Transport Analysis is bearing own personal cost and parts of the data collecting. Transport Analysis has also got financial support by Eurostat. Trivector is bearing the cost of the development work for the mobile app. The project has been carried out by the Swedish Road and Transport Research Institute (VTI), Transport Analysis, and Trivector.

Jenny Eriksson has been the project manager at VTI, while Per Henriksson and Ary P. Silvano have participated as project members. Eva Lindborg, Andreas Holmström, and Mats Wiklund from Transport Analysis also took part as project members and were the supervising coordinators for the online questionnaire analyses. Emeli Adell, Annika Nilsson and Lina Dahlberg from Trivector participated as project members and were the supervising coordinators for the mobile app analyses. Everyone helped in various ways with the preparation, execution, analysis, and in authoring the report.

We would especially like to thank the City of Gothenburg, Maria Eriksson, and Jenny Larsson for access to an ongoing travel survey during the same period. We are also very grateful to Enkätfabriken, which collected travel data via the online questionnaire and handled the e-mailing to the web panel for both the mobile app and the online survey. We also wish to thank Annika Johansson of VTI for designing the websites

To ensure the quality and practical applicability of the project, this study has been presented to and feedback obtained from the reference group affiliated with the New Solutions for the Future travel survey project. A hearty thanks to all of you.

Linköping, May 2018

Jenny Eriksson Project manager

# Table of Contents

Summ	ary	7
1. Ir	troduction	9
1.1	Background	9
1.1.	1 Eurostat	9
1.2	Purpose	9
1.3	Terms	10
1.4	Delimitation	10
2 M	lethod, materials, and execution	11
2.1	Summarised study set-up	11
2.2	Set-up of traditional travel surveys	11
2.2.	1 Set-up of the national travel survey	11
2.2.	2 Gothenburg Region Travel Survey 2017	12
2.3	Data collection methods	13
2.3.	1 Online questionnaire	13
2.3.	2 Travel data apps	14
2.4	Recruitment methods	16
2.4.	1 Random sample	16
2.4.	2 Web panel	17
2.4.	3 Crowdsourcing	17
2.5	Summary of data collection and nonresponse	20
2.5.	1 Collection period, number of mailings, and respondents	20
2.5.	2 Item nonresponse	22
2.5.	3 Nonresponse analysis of the random sample	23
2.6	Data processing	24
2.6.	1 Data cleaning and aggregation	24
2.6.	2 Management of multiple trip days from the mobile app	25
2.6.	3 Weighting process	26
2.6.	4 Method for estimation of sampling errors	29
3 R	esults and analysis	30
3.1	Respondent profiles	30
3.1.	1 Gender	30
3.1.	2 Age	31
3.1.	3 Occupation	32
3.1.	4 Driving licence and car access	34
3.1.	5 Type of residence	34
3.1.	6 Household size and type	35
3.1.	7 Municipality of residence	37
3.1.	8 Summary of respondent profiles	37
3.2	Share that did not travel, and reasons why	39
3.3	Average number of trips per day	40
3.4	Average distance travelled per day	50
3.5	Distance travelled per trip	60
3.6	Uncertainty estimates	61
3.7	Estimated collection costs	62
4 D	iscussion	64

4.1 D	ata collection methods	04
4.1.1	Online questionnaire	64
4.1.2	Mobile app	64
4.1.3	Differences in collection methods' response rate and item nonresponses	65
4.1.4	Differences in the data collection methods' respondent profiles	66
4.1.5	Differences in collection methods' trips and trip lengths	67
4.1.6	Comparison with the SPOT project	68
4.1.7	Differences in mode of travel and purpose	68
4.2 R	ecruitment method	69
4.2.1	Random sample	69
4.2.2	Web panel	69
4.2.3	Crowdsourcing	70
4.2.4	Differences in recruitment methods' respondent profiles	70
4.2.5	Differences in recruitment methods' trips and trip lengths	71
4.3 C	ost effectiveness	71
4.3.1	Collection method	71
4.3.2	Recruitment method	72
4.3.3	Comparison	72
4.4 C	oncluding discussion	72
5 Con	clusions	75
5.1 C	onclusions data collection	75
5.1 C	onclusions – data conection	75
5.2 C	onclusions – recruitment	75
5.5 C	onclusions – respondent promes	75
J.+ C		
< a		
6 Sum	mary and recommendations	77
6 Sum 6.1 In	mary and recommendations	<b>77</b> 77
6 Sum 6.1 In 6.2 N	mary and recommendations nportant issues for travel surveys ew methods' potential to overcome current deficiencies	<b>77</b> 77 77
6 Sum 6.1 In 6.2 N 6.2.1	amary and recommendations apportant issues for travel surveys ew methods' potential to overcome current deficiencies Collection method	<b>77</b> 77 77 77
6 Sum 6.1 In 6.2 N 6.2.1 6.2.2	mary and recommendations nportant issues for travel surveys ew methods' potential to overcome current deficiencies Collection method Recruitment method	<b>77</b> 77 77 77 79
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q	mary and recommendations	<b>77</b> 77 77 77 79 81
6 Sum 6.1 In 6.2 N 6.2.1 6.2.2 6.3 Q 6.3.1	mary and recommendations nportant issues for travel surveys ew methods' potential to overcome current deficiencies Collection method Recruitment method uality aspects Relevance	<b>77</b> 77 77 79 81 81
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2	mary and recommendations portant issues for travel surveys ew methods' potential to overcome current deficiencies Collection method Recruitment method uality aspects Relevance Reliability	<b>77</b> 77 77 79 81 81
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3	mary and recommendations	<b>77</b> 77 77 79 81 81 81 82
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4	mary and recommendations	77 77 77 77 79 81 81 81 82 82
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5	mary and recommendations	<b>77</b> 77 77 77 79 81 81 81 82 82 82 82
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro	mary and recommendations	<b>77</b> 77 77 79 81 81 81 82 82 82 82 82 83
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro 6.5 Co	mary and recommendations	<b>77</b> 77 77 79 81 81 81 82 82 82 82 82 83 83
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro 6.5 Co Referenc	mary and recommendations	<b>77</b> 77 77 79 81 81 81 82 82 82 82 83 83 84 85
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro 6.5 Co Reference Appendix	Imary and recommendations         Important issues for travel surveys         Collection method         Important issues for travel surveys         Important issues         Importantissues         Importantissu	77 77 77 77 79 81 81 81 81 82 82 82 82 82 83 84 85 86
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro 6.5 Co Reference Appendix	Imary and recommendations         Important issues for travel surveys         Collection method         Important method <td>77 77 77 77 79 81 81 81 82 82 82 82 82 83 84 85 86 86 81</td>	77 77 77 77 79 81 81 81 82 82 82 82 82 83 84 85 86 86 81
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro 6.5 Co Reference Appendix Appendix	amary and recommendations         apportant issues for travel surveys         ew methods' potential to overcome current deficiencies         Collection method         Recruitment method         uality aspects         Relevance         Reliability         Timeliness and punctuality         Accessibility and clarity         Comparability and co-usability         ecommendations         ontinued research and development         es         x 1 - Online questionnaire         x 2 - Background Questionnaire for TRavelVU         x 3 - Institutions, etc. contacted for crowdsourcing advertisement	77 77 77 77 79 81 81 81 82 82 82 82 83 84 85 86 86 93 95
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro 6.5 Co Reference Appendix Appendix	umary and recommendations         nportant issues for travel surveys         ew methods' potential to overcome current deficiencies         Collection method         Recruitment method         uality aspects         Relevance         Reliability         Timeliness and punctuality         Accessibility and clarity         Comparability and co-usability         ecommendations         ontinued research and development         es         x 1 – Online questionnaire         x 2 – Background Questionnaire for TRavelVU         x 3 – Institutions, etc., contacted for crowdsourcing advertisement	77 77 77 77 79 81 81 81 82 82 82 82 82 82 82 83 84 85 86 93 95 95
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Re 6.5 Co Reference Appendix Appendix Appendix	mary and recommendations         nportant issues for travel surveys         ew methods' potential to overcome current deficiencies         Collection method         Recruitment method         uality aspects         Relevance         Reliability         Timeliness and punctuality         Accessibility and clarity         Comparability and co-usability         ecommendations         ontinued research and development         es         x 1 – Online questionnaire.         x 2 – Background Questionnaire for TRavelVU         x 3 – Institutions, etc., contacted for crowdsourcing advertisement         x 4 – Media impact, etc.	77 77 77 77 79 81 81 81 82 82 82 82 82 82 82 82 82 82 83 84 85 86 93 95 96
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Ro 6.5 Co Reference Appendix Appendix Appendix Appendix	mary and recommendations         nportant issues for travel surveys         ew methods' potential to overcome current deficiencies         Collection method         Recruitment method         uality aspects         Relevance         Reliability         Timeliness and punctuality         Accessibility and clarity         Comparability and co-usability         ecommendations         ontinued research and development         es         x 1 – Online questionnaire         x 2 – Background Questionnaire for TRavelVU         x 3 – Institutions, etc., contacted for crowdsourcing advertisement         x 4 – Media impact, etc         x 5 – Information and expression of interest page posted on www.vti.se/resa in place	77 77 77 77 79 81 81 81 82 82 82 82 82 82 83 84 85 86 93 95 96 hase 96
6 Sum 6.1 In 6.2 No 6.2.1 6.2.2 6.3 Q 6.3.1 6.3.2 6.3.3 6.3.4 6.3.5 6.4 Reference Appendix Appendix Appendix Appendix Appendix	amary and recommendations         aportant issues for travel surveys         ew methods' potential to overcome current deficiencies         Collection method         Recruitment method         uality aspects         Relevance         Relevance         Reliability.         Timeliness and punctuality         Accessibility and clarity.         Comparability and co-usability         ecommendations         ontinued research and development         es         x 1 – Online questionnaire         x 2 – Background Questionnaire for TRavelVU         x 3 – Institutions, etc., contacted for crowdsourcing advertisement         x 4 – Media impact, etc.         x 5 – Information and expression of interest page posted on www.vti.se/resa in planet	77 77 77 77 79 81 81 81 82 82 82 82 82 82 83 84 85 86 93 95 96 hase 97

Appendix 7 – Information page and link to download page for the mobile app posted on	
www.vti.se/resaapp	100
Appendix 8 – Respondent profiles, additional figures, and tables	101
Appendix 9 – Estimated costs of data collection, calculations	105

#### Summary

# New Ways of Collecting Individual Travel Information – Evaluation of Collection and Recruitment methods

by Jenny Eriksson (VTI), Eva Lindborg (Transport Analysis), Emeli Adell (Trivector), Andreas Holmström (Transport Analysis), Ary P. Silvano (VTI), Annika Nilsson (Trivector), Per Henriksson (VTI), Mats Wiklund (Transport Analysis), and Lina Dahlberg (Trivector)

A need to find and develop new solutions for travel surveys (TSs) has been identified within the Next Generation Travel and Transport cooperative programme, for which Transport Analysis is the coordinating body. The background for this consists in part of declining response rates using current methods, which could lead to problems in terms of representativity. The development of new data collection methods for future TSs is viewed as matter of great urgency in both the short and long terms.

The overall purpose of the project is to conduct a demonstration study that shows how two data collection methods that have been developed to collect travel survey data perform in the field, and how they perform compared with traditional TSs (i.e., postal questionnaires and/or telephone interviews). The project is also intended to provide a better understanding of the ways in which different recruitment methods of respondents can be used so that future TSs can be more cost effective.

The two collection methods tested consist of a mobile app and an online questionnaire with a map to assist the respondents to identify travel destinations. Three recruitment methods were used, i.e., recruitment via random sampling, a web panel, and crowdsourcing. The portion of the random sample that received an online questionnaire was divided into two groups. Half the group was given no incentive, while the other half received a gift card worth SEK 100 after answering the questioner. Those who were recruited via a web panel and were to use the mobile app were rewarded in the form of a gift card worth SEK 100 if, at minimum, they made corrections to trips made on one day registered in the mobile app. A nonresponse analysis was performed of the random sample for both the online questionnaire and the mobile app. Cost estimates for each collection method and recruitment method were also performed, as were uncertainty estimates.

The respondents were localised to the Gothenburg region, as a traditional travel survey was being conducted in that region during the same period. The purpose of choosing the same region and time period was to enable comparison of the results of our pilot surveys with those of a larger traditional survey. The target population comprised inhabitants between the ages of 16 and 84 years in municipalities in the Gothenburg region.

Overall, the study shows that the mobile app registered significantly more trips per respondent than did the online questionnaire, while the distances travelled were comparable. There are several possible interpretations of this. One is that people who responded to the online questionnaire either forget about and/or combined short trips (particularly trips made for the purposes of leisure or shopping, and using the travel modes walking and car). One presumable explanation for this is that it is easier to confirm/correct the trips that the mobile app suggests than it is to recall and enter all trips in an online questionnaire. Another possible interpretation is that people responding to different data collection methods have different travel patterns. Yet another explanation is connected to technique issues regarding the different data collection methods.

With regard to the recruitment methods, crowdsourcing netted the highest number of responses compared with both random sampling and a web panel. It was also the least expensive to perform. It

is, however, a problematic method to use if there is a desire to apply statistical theory, as the target population is unknown.

With regard to the response rates, the new collection methods (i.e., online questionnaire and mobile app) perform less well than do the traditional methods (i.e., telephone interviews and paper questionnaires). Incentives are considered to have only a marginally positive effect on the response rate. The basic problem with low response rates is that they increase the risk that the responses will not be representative of the target population.

Compared with the target population, people who have a driving license or are cohabitants without children were over-represented in all the collection and recruitment methods among those who responded to the survey. The group that responded to the online questionnaire after having been recruited via crowdsourcing deviated greatly from the other groups in most of cases. This group contained a higher proportion of women, people of working age, and gainfully employed than did the other groups. On the other hand, this group did exhibit, together with the randomly selected respondents who responded to the online questionnaire, very high correspondence with the breakdown in terms of type of residence according to the register data (i.e., flat versus detached house/townhouse).

One way of dealing with the fact that the respondents do not correspond to the target population is to weight the responses so that those from groups that are over-represented are given lower weights, while the responses from the underrepresented groups are given higher weights. Our work with such weighting shows that the differences between the data collection methods in terms of numbers of trips per person and day become smaller when we weight the results so that they correspond to the target population to a greater extent. However, we can only weight those variables about which we have knowledge in the context of both the target population and the respondents. If our respondents deviate from the target population in some way that we cannot measure, for example, by having other values that in turn affect their travel behaviour, then we cannot address this through weighting, and risk obtaining less valid results.

Deficient representativity has been suspected in connection with traditional travel surveys. In our study, the levels of representativity for the online questionnaire and mobile app were roughly the same as for the traditional survey. It is primarily the mobile app that is considered to deliver higher data quality in terms of travel times and trip lengths, and it can also address the issue of route choice, which traditional methods cannot. The response rate for random sampling was lower for the online questionnaire and mobile app than for traditional methods. Crowdsourcing and web panels do not yield response rates on a par with those of random sampling. Nor are there any proven methods for describing the statistical uncertainties in the results obtained from crowdsourcing or web panels.

The proven collection methods have been evaluated in terms of four statistical quality criteria: relevance, reliability, timeliness and punctuality, and accessibility and comparability. When selecting a method for collecting travel survey data, the purpose of the survey needs to be clear. Depending on the purpose of the survey, the collection and recruitment methods can be chosen based on their various strengths and weaknesses. Nor is there any easy answer when it comes to recruitment methods. In our study, the random sampling method that has so far been completely dominant was no better at representing the target population than was the web panel or data collection via crowdsourcing. Given the low response rates associated with random samples, our recommendation regarding recruitment is to continue studying alternatives to random sampling and to work more on the weighting of received responses. The latter should be done regardless of whether or not random sampling is used.

## 1. Introduction

# 1.1 Background

A need to find and develop new solutions for travel surveys (TSs) has been identified within the Next Generation Travel and Transport cooperative programme. The background for this consists in part of declining response rates obtained using current methods, which could lead to problems in terms of representativity. This problem has led, for instance, to the Swedish Transport Administration not having used the latest national travel survey, TS Sweden 2011–2014, in its socioeconomic models, falling back instead on data from 2005–2006. Transport Analysis has consequently chosen to take a hiatus in collecting data for the national travel survey. The agency will instead put more emphasis on developing new methods that can better address the representativity issue. The development of new data collection methods for future TSs is consequently deemed to be a matter of great urgency, both in the short term, so that data collection can resume, and in the longer term, when techniques that are not yet mature can be utilised.

As a result, Transport Analysis has launched a project with a view to studying and testing new technical solutions for collecting travel data and how various collection methods could be used (alone or in combination) in conducting future travel surveys. The project consists of a number of subprojects (work packages). A stakeholder and needs analysis was initially conducted in parallel with the mapping of tools and applications within this field. The previous subproject (see Eriksson et al., 2017) studied the needs and new users of TSs, and the questions that future TSs should be able to answer. The next subproject (see Clark et al., 2017) performed a broad mapping of various types of traffic and travel metrics and a categorisation of tools and applications for collecting travel data.

In the present substudy, a pilot study has been conducted in which different methods for collecting travel data (i.e., online questionnaire and mobile app) and different methods for recruiting participants (i.e., random sampling, web panel, and crowdsourcing) were tested. The choice was made to site the pilot study in the Gothenburg region, which enabled comparisons of the pilot study results with those of a conventional TS (i.e., paper questionnaire with the option of responding online) that the City of Gothenburg Traffic Administration Office conducted concurrently in the fall of 2017.

The set-up of the national TS is described briefly in the following chapter, which also addresses the harmonisation of these types of surveys within the EU.

#### 1.1.1 Eurostat

National travel surveys are conducted in numerous countries in Europe. In some countries such surveys have a long history, having been conducted since the 1960s, while no data are collected at all in other countries. Eurostat (2016) has set forth guidelines for travel surveys. The guidelines were based on an attempt to harmonise the travel surveys in Europe, and they contain information about desired variables concerning individuals, such as gender and age, and about their modes of travel and the purposes of their trips. The guidelines also document gathered experience and discuss the advantages and disadvantages of various data collection methods (Eurostat, 2016).

Eurostat also provides support for the development of travel surveys. Transport Analysis has received support from Eurostat in advancing its work with travel surveys.

# 1.2 Purpose

The overarching purpose of the project is to conduct a demonstration study that shows how two data collection methods developed to collect travel survey data (i.e., an online questionnaire with a map, and a mobile app) perform in the field, and how they perform versus "traditional" TSs (i.e., postal questionnaire and/or telephone interview). The project is also intended to provide a better

understanding of how different recruitment methods (i.e., random sampling, web panel, and crowdsourcing) can be used so that future TSs can be more cost effective.

# 1.3 Terms

Three terms are used in travel surveys to describe the various levels of travel, i.e., journey, trip, and stage. A *journey* begins and ends at a defined point. For example, in TS Sweden these journey points were the respondent's permanent residence, workplace, school and temporary overnight site. Each journey consists of one or more *trips*. A trip starts and ends at a point where a purpose is fulfilled. A trip consists in turn of one or more *stages*. If only the mode of travel changes and no purpose is fulfilled, a trip is divided into multiple stages.

In this pilot study, the term "trip" serves as the basis for describing respondent trips.

The *purposes* that are fulfilled can be grouped into several main categories, for example, work, business, and school trips, service-related and shopping trips, and leisure and other trips. In connection with travel survey applications developed for smart phones, these can be referred to as *activities*, which can also include waiting times/transfers and parking a vehicle.

In this pilot study, we have used three different *recruitment methods*, i.e., ways of reaching people in our target group. They comprise random sampling from a population register, the use of existing web panels, and announcements/advertisements placed online, in newsletters, in free publications, etc., and collectively referred to here as crowdsourcing. The people who were contacted and were willing to take part in the study were asked to describe/register their trips using one of the two *collection methods* that were tested, i.e., responding to an online questionnaire or downloading a travel survey app to a smart phone.

## 1.4 Delimitation

We will not discuss policies or legalisation regarding data collection or management because the new General Data Protection Regulation (GDPR) has only recently gone into effect in all the EU member states, as of 25 May 2018. This regulation entails sweeping changes for those who manage personal data, and strengthens the rights of the individual in terms of personal privacy. Overall, we can state that any required changes will presumably not entail any major differences from previous regulations. However, consent will be required in a clearer manner, and data security and documentation will be subject to more stringent requirements. More information about this is available on the Swedish Data Protection Authority website.

# 2 Method, materials, and execution

In this study we have tested and evaluated various methods for recruiting participants and collecting data for travel surveys. The study set-up is summarised in Section 2.1. Section 2.2 describes the set-ups of the traditional surveys that we chose. The two data collection methods tested consisted of an online questionnaire with a map, and a mobile app, and they are described in Section 2.3. Three recruitment methods were used, i.e., recruitment via random sampling, a web panel, or crowdsourcing. These three methods are described in detail in Section 2.4. In Section 2.5 we review the post-processing of the collected datasets. We conclude with a comparison of the study set-ups (see Section 2.5).

# 2.1 Summarised study set-up

The evaluation also included a traditional travel survey (TS) set-up (see Table 1). The table shows that six different set-ups will be compared in our study, and that we will also make comparisons with a traditional TS.

Table 1. Summarised study set-ups for the various data collection and recruitment methods to be evaluated and compared.

Data collection method	Recruitment method				
	Random sampling	Web panel	Crowdsourcing		
Traditional TS					
Postal/online questionnaire	$\checkmark$	-	-		
Our study					
Online questionnaire without	$\checkmark$	$\checkmark$	$\checkmark$		
incentive					
Online questionnaire with	$\checkmark$	-	-		
incentive					
Mobile app	$\checkmark$	$\checkmark$	$\checkmark$		

The sample population and the traditional TS comprised people between the ages of 16 and 84 years. The same survey area was also chosen in the studies, i.e., the following 21 municipalities with their environs in the Gothenburg region were included in the surveys: Ale, Alingsås, Bollebygd, Borås, Gothenburg, Härryda, Kungsbacka, Kungälv, Lerum, Lilla Edet, Mark, Mölndal, Orust, Partille, Stenungsund, Tjörn, Trollhättan, Uddevalla, Varberg, Vänersborg, and Öckerö.

# 2.2 Set-up of traditional travel surveys

#### 2.2.1 Set-up of the national travel survey

The national travel surveys have been conducted by means of computer-aided telephone interviews since the mid 1990s. The samples of respondents were obtained from the Total Population Register (TPR). Telephone numbers for the sample were then obtained, and several days before the first measurement day, the prospective respondents received, by post, a cover letter along with a travel diary. The respondents were then telephoned the day after the first measurement day for an interview. If a respondent failed to respond to this attempt at contact, new attempts were made for up to six additional days. To a large extent, roughly the same questions were asked regarding trips. One major change occurred from 1998 to 1999, i.e., a transition from a journey-based approach to collecting data to a trip-based approach. Several trip purposes were also added, and the number of modes of travel was increased. Trip data from TS Sweden were compared in some cases with the pilot study and TS Gothenburg results (see following chapters). A sample was drawn from TS Sweden that was limited to

the pilot study survey area and the 2013–2016 period in view of the introduction of the congestion tax in Gothenburg on 1 January 2013.

## 2.2.2 Gothenburg Region Travel Survey 2017

The City of Gothenburg conducted a travel survey in the fall of 2017 at the request of the West Swedish Agreement<sup>1</sup> (hereinafter, "TS GBG"). The 2017 data collection process involved postal questionnaires and a means of answering questions online. The questionnaire consisted in part of a background section containing questions about the respondents and their households, as well as a travel diary containing questions about all the trips made on a particular measurement day. It was possible to fill out the online questionnaire in more languages that just Swedish, i.e., English, Finnish, Arabic, Persian, and Somali.

The sample was drawn from the State Personal Address Register (SPAR). The sample size was 46,620 people. No stratification was performed with respect to age or gender, but rather only geographically, which means that a random sample was obtained within each respective sample area. Gothenburg was divided into 21 sample areas (strata), while the other 20 municipalities each constituted one sample area (stratum). The sample sizes for the various 41 sample areas ranged from 550 to 8,400 people. It was possible for municipalities to order additional samples, as Kungsbacka and Mölndal did.

The measurement period lasted three months. The regular measurement days consisted of the Wednesdays from Wednesday 14 August to Wednesday 15 November. Each person in the sample was contacted via up to three postal mailings (all contact attempts entailed new measurement days):

- The first mailing was a postal invitation, in the form of a postcard, to fill out a questionnaire online.
- The second mailing was a postal questionnaire, but it was still possible to fill out the questioner online.
- The third mailing was a new postal questionnaire. It was also possible to fill it out online.
- The fourth contact attempt was a telephone reminder.

Obviously erroneous information in the response data was corrected, such as implausible time or distance information. New variables for the primary mode of travel were generated based on the mode of travel given for each stage. In those cases in which multiple modes of travel were reported for a trip, the following hierarchy was applied to determine the primary mode of travel:

- 1. boat
- 2. aircraft
- 3. other
- 4. mobility service
- 5. train/tram
- 6. bus
- 7. taxi (non-mobility service)
- 8. car as driver/car as passenger
- 9. moped/motorcycle
- 10. bicycle/electric bicycle
- 11. walking

<sup>&</sup>lt;sup>1</sup> www.vastsvenskapaketet.se

For example, if the respondent walked to the bus, took the bus, and then walked from the bus to his/her destination, the bus would be the primary mode of travel, as it ranks higher in the hierarchy than walking. The modes of travel were then grouped as car (8), public transport (1, 5, 6), walking (11), and other (2, 3, 4, 7, 9).

The individuals were weighted based on gender, age, and geographic area. The trips were weighted on a seasonal basis for all modes of travel except walking, with "bicycle" being corrected with a weighting of 0.8, "public transport" with a weighting of 0.9615, and "car" with a weighting of 0.9756.

# 2.3 Data collection methods

There are data collection methods other than those tested in this study, such as telephone interviews (as in TS Sweden) and paper questionnaires (as in TS GBG). We have used an online questionnaire and a mobile app. The online questionnaire mainly resembles the set-up of a paper questionnaire, but with the difference that the respondent can use an interactive map. However, a feature common to both methods is that they collect data for a trip day. Here the mobile app differs from the other data collection methods, as it is able to collect multiple trip days per individual.

#### 2.3.1 Online questionnaire

An online questionnaire is a questionnaire that is posted on a website. It offers numerous advantages over a paper questionnaire, for example, the responses are registered as soon as the questionnaire is submitted. With respect to the collection of addresses, it is possible to link to a map tool in which the respondents can mark their location directly on a map. Checking to prevent implausible responses can occur directly during the process, and the respondents need not be shown questions that are irrelevant, based on how they answered earlier questions.

In the pilot study, the design of the online questionnaire and its data collection process were the objects of a procurement process carried out by Transport Analysis. Data collection occurred via an online form tool provided by Enkätfabriken AB which had won the procurement process. The tool contains inbuilt support for the collection of origins and destinations for the trips via a map function linked to an address register containing geocoded addresses. One of the requirements in the procurement process was that the web form tool would be designed in such a way that the respondents could provide their answers using the most common web browsers and using smart phones or tablets based on the Android or iOS operating systems.

A web form was used in the pilot study (see Appendix 1) containing 13 background questions concerning gender, age, home address, driving licence possession, etc., plus some 30 questions about the trips made by the respondent. The scope of the form was based largely on the Eurostat travel survey guidelines. In the questionnaire, the respondents first had to answer the background questions regarding themselves and their households. The travel data were collected for a given measurement day, trip by trip. The respondents were to specify the mode of travel used in each trip. However, information as to the order in which these modes were used was not collected, with the result that we obtained no information about the order or number of stages, as it is possible for one mode of travel to be used in multiple stages, for instance, if the respondent walks at both the beginning and end of a trip.

One simplification in the online questionnaire compared with TS Sweden is that no question was asked concerning the purpose of the journey in connection with trips that ended at home or another overnight site. An analysis of TS Sweden response data has identified deficiencies in the responses to the question concerning the purpose of the journey. Many respondents failed to understand the question and indicated "trip home" rather than the primary purpose of the trip. In the online questionnaire, the purpose of the journey was instead estimated based on previously stated trip purposes. It was generally assumed that the purpose fulfilled over the longest period of time was the primary one, unless the trip started at a workplace or school, in which case the purpose of the journey

was to attend work or school. If the journey had no purpose while in process, it was assumed to be a journey made for exercise. This can result in certain differences compared with how such journeys are categorised in TS Sweden.

The people recruited via random sampling had individual logins. The respondents could choose to follow a QR code on their cover letter or enter a web address, user ID, and password. The purpose of the individual logins was to ensure that the respondents would not have to enter information that was already known from the sampling process, such as their age and gender. Two portals to the form were created for those people who had been recruited via a web panel or crowdsourcing, one for each recruitment method. The portal to the form was the same for all respondents recruited using the same recruitment method. After the data collection process was concluded, databases containing the results and an implementation report were submitted to Transport Analysis.

#### 2.3.2 Travel data apps

A number of different mobile phone apps are available to collect travel data for travel surveys. Apps use various sensors in the mobile phone to capture how the phone is being moved, which is interpreted as the individual's movement pattern. The tools provide information about trips and their purposes, and often information about the individual who has the phone as well. Different apps require different levels of user involvement. There are apps that automatically attempt to detect information about both travel made and their purposes, as well as apps that attempt to detect only travel automatically. There are also apps that want the user to turn a logging function on and off so that trip data will be collected (albeit mostly in the research world). Most of these apps have been designed so that the user checks (and optionally corrects) the data. Data correction can occur either in the app or via an online interface. Information about the user is usually collected via a questionnaire in the app or online interface. A complete account of the various types of apps used to collect trip data is given by Clark et al. (2017).

In this study, we have opted for a trip data app that automatically detects trips (the user need not turn the logging on/off). The user reviews the app's analysis and makes changes as needed, and this review process occurs within the app. The chosen app is called TRavelVU (hereinafter, "the mobile app") and was developed by Trivector. This mobile app collects travel data at the stage level, along with information about the start and end times, mode of travel, speed, distance, and route of each stage. Information about the start and stop times and geographic location is available for each activity. The users of the mobile app in our study were asked to register their trips/activities for at least one week.

In its current version the mobile app identifies seven different modes of travel automatically, and efforts are underway to enable the automatic identification of three additional modes (see Table 2). In addition to these ten, the user can choose among seven additional modes of travel when checking/correcting his/her trips (see Table 2 below). The mobile app also has an algorithm for learning the user's travel pattern, which means that it takes into account what the user has previously marked as the correct mode of travel. The user has 17 activities from which to choose. The mobile app does not suggest which activity the user has done at various stops, but rather it is up to the user to enter that. On the other hand, the mobile app does remember what the user has previously entered at a given location and will suggest the same activity the next time the user stops at that location. All activities during the day need to be entered for it to be possible to mark a day as "correct" (i.e., to demonstrate that any errors have been checked and corrected). The activities that can be chosen are: waiting time/transfer, parking, home, temporary residence, work, school/training, business trip, picking up/dropping off someone, shopping, healthcare, other service-related trip, health of friends and relatives, exercise and outdoor activities, restaurants and cafés, hobby activity, entertainment and culture, and other activity. If the user does not wish to specify any activity, it is possible to choose the "Will not specify" option.

Selectable mode of travel	Currently identified	Under development
Walking	Yes	
Exercise and hiking	Yes	
Bicycle	Yes	
Electric bicycle	No	
Bus	Yes	
Train	Yes	
Car	Yes	
Car passenger	No	
Tram	Yes	
Underground	No	Х
Moped	No	
Motorcycle	No	
Ferry/boat	No	Х
Aircraft	No	Х
Mobility service	No	
Тахі	No	
Other	No	

Table 2. The mobile app's selectable modes of travel, the modes currently identified automatically, and the modes under development (lower accuracy at present).

Data are collected via the mobile phone and sent to a server for analysis. The analysis results are then sent back to the mobile phone, at which point the user has the opportunity to correct his/her movements. For the data to be included in the dataset, the user must mark to indicate that the description of the trips and activities for the relevant day is correct. If there are days that have not been corrected, the user will be reminded to make corrections when going into the mobile app. The reminder will recur until the day has been corrected or the respondent indicates no wish to correct it.

GPS data are "cleaned" in three steps. The first step involves removing duplications and implausible responses. For example, the GPS could wander off course without the phone having moved, and sometimes unreasonably high speeds are registered if the GPS point pops up somewhere it should not be. This is performed partly based on earlier work in the field (e.g., Schüessler & Axhausen, 2008), but to optimise this particular mobile app, certain parameters are adjusted, and the data cleaning is also supplemented with other elements. In the second step, the GPS data are smoothed to create a less "choppy" GPS trace. Without this smoothing process, which may be likened to calculating a rolling mean, data may, for instance, show that one has repeatedly moved from the left side to the right side of a street, which can have a major impact on the distance travelled. The disadvantage of this approach is that if one passes a street corner, the GPS track may cut across the corner. The last step in the cleaning process involves determining GPS coordinates for various activities. During an activity, GPS traces are created around the activity site, and these are grouped together so that the activity occurs in one place and does not yield a movement.

At present the algorithms in the mobile app are rule-based, which means that the rules are set in advance and are not altered depending upon various types of input data. The GPS collection process begins when the phone is in motion, and it is the app that launches the GPS collection process. To save the battery, GPS points are not collected while the phone is stationary. Because all trips begin, in principle, with walking and end with walking, for example, from the residence to a bicycle rack, from a train to a bicycle rack, walking trips are identified in order to determine the starts and stops of stages. The mode of travel for the stage is then determined based on an array of different parameters, i.e., different speed and acceleration measurements along the travelled stretch, proximity to public

transport stops, how previous trips were made along the same stretch (when a trip has been corrected), etc. The probabilities of various modes of travel are determined using fuzzy logic,<sup>2</sup> i.e., the mode of travel that is calculated as having the highest probability of being valid is selected and displayed to the user by the mobile app. Previously corrected days and trips of roughly the same length, distance, and with the same start and end points affect the choice of mode of travel.

Appendix 2 contains the background questionnaire used in the mobile app for this study.

# 2.4 Recruitment methods

The traditional way of recruiting people for a survey is via random sampling. We used this as the basis of our study. In addition to this, we tried recruiting people via a web panel and crowdsourcing. The target for the study was to recruit at least 200 people per recruitment and data collection method. Two hundred people per group were considered enough respondents to enable analyses of differences between the groups while keeping within the project budget.

#### 2.4.1 Random sample

In a random sample from, for example, a population register, each individual has a known probability of being included in the sample, and that probability must be greater than 0. Given these assumptions, it is possible to determine the sample error, i.e., the deviation between the value of a parameter to be estimated using the sample and the value that would have been obtained if a total survey had been conducted.

The random samples for the mobile app and the online questionnaire were drawn in the same sampling process using SPAR and distributed to the various platforms by Transport Analysis. In total, the sample comprised 5,600 people, 2,800 of whom were selected to respond via the mobile app, 1,400 via the online questionnaire with no incentive, and 1,400 via the online questionnaire with an incentive. The number of people in the sample for the online questionnaire was calculated based on an anticipated response rate of roughly 15%, which would yield roughly 200 interviewees for the online questionnaire with an incentive and 200 for the online questionnaire without an incentive. We knew less about what the anticipated response rate would be for the mobile app.

To enable comparison with the results of the Gothenburg survey, we used the same target population as in the Gothenburg TS. The sample was stratified into four age groups (i.e., 16–25, 26–44, 45–64, and 65–84 years) and by gender, yielding a total of eight strata. There were 700 people in each stratum, so the sample was not selected proportional to the population. Unfortunately, it was not possible to exclude people who were included in the sample used in the Gothenburg TS. There is thus a risk of double selection, which could reduce the inclination of those people to respond.

In the random sample for the online questionnaire, the respondents were assigned measurement days so that they were uniformly distributed over the two weeks during which the survey was ongoing, in order that each day would have an equal number of respondents. People who failed to complete the questionnaire within a few days of their measurement day were sent a reminder about the survey. The measurement day was moved forward one week in the reminder. There were no specific measurement days for the app, and the thinking was that the respondents would instead start as soon as possible and then use the app for at least one week.

 $<sup>^{2}</sup>$  A mathematical approach for calculating the probability that something is true, in this case, that the mode of travel is, for example, bicycle.

#### Nonresponse analysis

Enkätfabriken performed a nonresponse analysis of those in the random sample who failed to respond. Four hundred telephone interviews were conducted, i.e., 200 interviews among those selected to respond using the mobile app, 100 among those who failed to respond and had been selected to respond via the online questionnaire without an incentive, and 100 among those who failed to respond and had been selected to respond via the online questionnaire with an incentive. The nonresponse analysis is summarised in Section 2.5.2.

#### 2.4.2 Web panel

A web panel is a database containing individual information about people who have expressed willingness to cooperate as respondents in future online surveys in the event that they are selected (Surveyföreningen, 2014). Web panel members can be recruited in two different ways, i.e., as random (i.e., probability-based) or self-recruited (i.e., non-probability-based) panel members (Stern et al., 2014). A third group consists of a mix of randomly recruited and self-recruited members, which is known as a mixed panel.

VTI used a procurement process to gain access to a web panel. The web panel was the object of a direct procurement process involving known web panel companies, with VTI sending out invitations to four different companies along with a description of the job. All the invited companies except one tendered a written proposal. Enkätfabriken submitted the best proposal and was awarded the job. Enkätfabriken conducted the survey using a mixed web panel that was provided by the company CINT, with panel members comprising roughly 200,000 people from throughout Sweden. The web panel members who responded to our survey received compensation of roughly SEK 7 (typical compensation for panel members participating in a survey of this scope).

The aim was to collect responses from 200 web panel participants in the online questionnaire survey and 200 in the mobile app survey. Enkätfabriken sent out an e-mail to all the selected panellists. In the case of the online questionnaire survey, the e-mails were distributed evenly over the days during the measurement period (both weekdays and weekends). A reminder was sent out seven days later if the panellist had not responded to the survey.

Recruitment occurred via an online form in the case of the mobile app survey. If the respondents lived in the study area, they received an invitation to participate in the survey. Those who responded in the affirmative had to enter their e-mail address and mobile number. An SMS was sent out containing a direct link to the mobile app, along with an e-mail containing information about the survey and instructions for downloading and using the mobile app. As an additional incentive, the participants were offered a gift card worth SEK 100. This was issued to participants who corrected at least one day in the mobile app.

#### 2.4.3 Crowdsourcing

Crowdsourcing is a relatively new mode of online participation. In brief, it is based on an organisation asking a group of people to voluntarily achieve a goal or perform a given activity, with both parties viewing the process as mutually beneficial (Estelles-Arolas & Gonzalez-Ladron-de-Guevara, 2012). Generally, recruitment occurs and announcements/advertisements are published via social media (e.g., Facebook and Twitter) and periodicals (e.g., free newspapers and classified ad newspapers).

A message and a channel strategy were created to inform people of the study. The message was intended to pique the target group's interest and induce its members to answer the online questionnaire or use the mobile app. The channel strategy was employed to disseminate the editorial material, which was both published via periodicals and linked to in social media that reached the target group.

Contacts and channels were obtained partly via the City of Gothenburg Traffic Administration Office and partly via a web search of existing periodicals available in the relevant region. Because a large share of the target population lives in Gothenburg, it was considered reasonable to disseminate a relatively large amount of information there. The Gothenburg Region Local Federation (GR) was also viewed as an important channel, as it comprises 13 municipalities, two of which, i.e., Kungsbacka and Mölndal, have large populations. Channels to municipalities with relatively high numbers of inhabitants, i.e., Borås, Kungsbacka, Mölndal, Varberg, Trollhättan, and Uddevalla, were prioritised as well. It was considered that covering all the municipalities would not be particularly efficient. The entities contacted to disseminate our information are listed in Appendix 3. The listed municipalities and media companies were contacted by e-mail roughly three weeks before the start of the collection period. They were asked to disseminate information about the project; this e-mail was followed up with telephone calls. The periodicals viewed this mainly as an advertisement for which they sought payment, while channels with more public orientations chose to disseminate the information free of charge. GR did not disseminate information itself, but rather provided an address list containing some 60 representatives in their sustainable travel network. The list included officials from municipalities, the Swedish Transport Administration, the National Society for Road Safety (NTF), Region Halland, Framtiden Byggutveckling AB (residential development), and the Västra Götaland Region. These people received an e-mail roughly two weeks before the start of the data collection period, and the mailings were coordinated with the TS for the West Swedish Agreement.

VTI used its Facebook page to attract participants to the survey. An advertisement was created containing a brief description of the purpose of the project. The advertisement was linked to VTI's crowdsourcing website (see Figure 1). VTI's and Transport Analysis's Twitter accounts were also used, although few people learned of the survey via that channel. In addition to these channels, people residing in the survey area who had previously expressed an interest in participating in VTI studies (e.g., simulator studies and group discussions) were also notified of the opportunity to take part in the pilot study.

The impact in the form of publications on municipality websites, newsletters, and periodicals may be viewed as good. To our knowledge, some 20 mentions (see Appendix 4). During the period from 9 to 30 October, VTI's Facebook advertisement resulted in 2,953 people clicking on the advertisement/post, 47 sharing it, 37 commenting on it, and 88 "liking" it. A total of 57,661 people were exposed<sup>3</sup> to the post, 53,031 from the post. The advertisement was ultimately viewed<sup>4</sup> 89,730 times.

A strategy involving two different phases was employed in order to achieve a more even distribution of start days over the measurement period, particularly for the online questionnaire survey. Those interested could express their interest prior to the start of the measurement period and could begin collecting their data immediately during the measurement period. First, an expression of interest page (<u>www.vti.se/resa</u>, see Appendix 5 and the left-hand column in Figure 1) for the study was created, setting out the criteria that had to be met to participate and containing descriptions of the two methods for collecting trip data. Those interested could fill out a form and choose whether they wished to complete the online questionnaire, download the mobile app, or do either (i.e., no preference). All advertisements and promotional items referred to that page. The page had the following appearance from 25 September to 16 October 2017.

<sup>&</sup>lt;sup>3</sup> Exposure refers to how many times an advertisement has been displayed on a screen, which could be the same screen multiple times.

<sup>&</sup>lt;sup>4</sup> How many times an advertisement is viewed refers to how many people have seen it at least once (i.e., reach).



Figure 1. Schematic of the portal to the study's two data collection methods for those recruited via crowdsourcing: phase 1 – when the expression of interest was submitted (25 September to 16 October 2017, left); phase 2 – when those interested could choose one of the direct links to how they wanted to describe their trips (16 October to 16 November 2017, right).

The data from the expression of interest form were downloaded on the morning of 16 October 2017. The output data file contained 687 items. After the file was cleaned (13 people failed to provide an e-mail address and 23 duplications were removed), 651 people remained. The breakdown of their responses into the options in the expression of interest form is presented in Table 3.

	Responses (number)	Responses (%)
a) Answer an online questionnaire and describe my travels during one day at the end of October	180	27.6
<ul> <li>b) Download a mobile app and collect trip data over one week at the end of October</li> </ul>	193	29.6
Do either a) or b) (i.e., no preference)	278	42.7
Total	651	100.0

*Table 3. Data collection method that those interested indicated in the expression of interest form.* 

Interest was roughly equally strong in completing the online questionnaire and in using the mobile app. Those who indicated that they could provide trip data using either of the two collection methods (i.e., had no preference) were divided so that each municipality was uniformly split between the online questionnaire and the mobile app. The people were also distributed as uniformly as possible over the 14-day period. As a result, 326 people were asked to download the app and 325 were asked to complete the online questionnaire.

Half of all the expressions of interest up to 16 October came from people who reported that they resided in Gothenburg Municipality. Just over 30 expressions of interest were received from people residing in each of the following municipalities: Kungsbacka, Kungälv, Mölndal, and Stenungsund. In addition, all the municipalities in the Gothenburg Region and its environs that participated in the survey were represented by those who expressed interest. An e-mail was sent out between 16 and 29 October to those who had expressed interest in the study. Between 45 and 47 people received this e-mail each day. Five e-mail messages failed to reach their intended recipients. We learned that one person had chosen not to answer the online questionnaire after having been informed that there would be no compensation for participating, but it is unknown whether this attitude was present among more of those who had expressed interest.

A new version of the webpage was launched at the same time as the data from the expression of interest form were downloaded. The visitors who came to www.vti.se/resa from 16 October on were able to choose the method by which they wished to report the trip data. Clicking on any of the descriptions of the data collection methods linked them to either <u>www.vti.se/resaenkat</u> or <u>www.vti.se/resaapp</u> (see Appendices 6 and 7, respectively, and the right-hand column in Figure 1); these pages were live until 16 November. After that date, visitors to <u>www.vti.se/resa</u> were informed that the data collection period had ended, and were thanked for their interest.

# 2.5 Summary of data collection and nonresponse

This section summarises the data collection process in its entirety, and the item nonresponse is examined here as well. The results of the nonresponse analysis are also presented here. The cost estimate for the data collection process is found in Section 3.7. Those responses that were implausible or could not be used in the analysis for some other reason were eliminated (see further in Section 2.6.1).

#### 2.5.1 Collection period, number of mailings, and respondents

The portion of the random sample that received an online questionnaire was divided into two groups. Half of the group was offered no incentive, while the other half received a gift card worth SEK 100. Those who were recruited via a web panel and were to use the mobile app received compensation in the form of a gift card worth SEK 100 if they corrected at least one day's trips in the mobile app. The starting date for the collection period was the same regardless of the data collection method, but the group that was to use the mobile app could start using it at any time throughout the collection period. One day's trips were to be described by those who participated in the online questionnaire, while the members of the mobile app group were asked to register their trips over at least a week. The collection period for our study fell within the collection period for the TS conducted in the Gothenburg Region,

which was a goal. Table 4 shows when the data collection occurred, and when and how many reminders were sent out. Table 5 shows the sample size and the numbers and proportions of respondents. Appendix 8 provides a summary of when the responses were received (cumulative total).

Collection method	Recruitment method	Ordinary collection period	Reminder
	Random sample	15/10–28/10	7 days after mailing
Online	Web panel	15/10–28/10	7 days after mailing
quoonormano	Crowdsourcing	15/10–15/11	N/A
	Random sample	15/10-4/11	7 days after mailing
Mobile app	Web panel	15/10–4/11	After 3 and 7 days for downloading and corrections, respectively
	Crowdsourcing	15/10–15/11	N/A

Table 4. Collection period and reminder strategies for each data collection and recruitment method.

*Table 5. Sample size, number of respondents, and response rate for each data collection and recruitment method.* 

Collection method	Recruitment method	Sample size	Number of respondents	Response rate
	Random sample (w/o incentive)	1,400	192	14%
Online	Random sample (with incentive)	1,400	222	16%
questionnaire	Web panel	1,519	221	N/A
	Crowdsourcing	N/A	407	N/A
	Random sample	2,800	70	3%
Mobile app	Web panel	5,085	198	N/A
	Crowdsourcing	N/A	279	N/A

The overall response rates were low, 14–16% for the online questionnaire and 3% for the mobile app. An incentive had a marginal effect on the inclination to complete the questionnaire. The response rate was only just over 2% higher in the randomly sampled group that received a gift card worth SEK 100 than among those who were given no incentive. The response rate for the mobile app could have been negatively affected by a mistake made with regard to the mailing. In the mailing, the respondents were asked to download the app and start registering their trips on 15 October. The intention from the start was to send out the cover letter before 15 October to all respondents in the group, but the mailing was instead divided into four parts, which were sent out on 13, 16, 20, and 23 October. October 13 was a Friday, which meant that all the people in the sample received the cover letter after 15 October but were asked to respond starting on 15 October. The fact that the respondents were asked to respond several days before they received the mailing could have given an impression of ineptitude and negatively affected the response rate. The mistake was handled by updating the text in the reminder mailing. That this affected the response rate is evident in part in the large volume of e-mails received containing comments indicating that the survey looked to be inept. A more reasonable response rate for the app should be considered to be roughly 8%, i.e., the rate achieved in a study in Umeå, where the random recruitment process functioned as intended (Indebetou & Börefält, 2018).

Response rates for both the web panel and crowdsourcing are not relevant, as there was no random sampling. On the other hand, it is evident that more mailings to app users (5,085) were required than was the case with the online questionnaire to achieve the target of at least 200 responses (5,085 versus 1,519 mailings).

Table 6 shows how many people downloaded the mobile app and how many of them corrected at least one day of data. The desired target of 200 respondents was not achieved in the case of the random sample, although the target of 200 was achieved for both the web panel and crowdsourcing.

Recruitment method	Downloaded the mobile app	Number of net responses	Average number of reported days per person
Random sample	99	70	9
Panel	246	198	11
Crowdsourcing	410	279	16

*Table 6. Numbers of people who downloaded the mobile app and corrected data (at least one day), and number of reported days per person, broken down by recruitment method.* 

#### 2.5.2 Item nonresponse

Item nonresponse arises when a respondent fails to answer certain questions, or if an answer contains something implausible. This could be because the respondent misunderstood a question, or because of unwillingness to provide an answer.

Table 7 presents both the numbers and percentages of item nonresponse in the trips with respect to mode of travel, travel time, and geocoding. For geocoding, the item nonresponse is presented broken down by start point, end point, or if both pieces of information are lacking. The item nonresponse with respect to geocoding was higher for the online questionnaire, i.e., 1-10%, than for the mobile app, where the item nonresponse was 1-2%. The highest item nonresponse with respect to geocoding is found in the responses from the web panellists who used the online questionnaire. Crowdsourcing had the lowest item nonresponse among the respective collection methods. The item nonresponse with respect to geocoding was higher in the online questionnaire and the mobile app than in the Gothenburg travel survey. The highest item nonresponse in the Gothenburg survey pertained to travel times.

		Online questionnaire random without incentive	Online question- naire random with incentive	Online question- naire web panel	Online question- naire crowd- sourcing	Mobile app random	Mobile app web panel	Mobile app crowd- sourcing	TS GBG
Lacking	Lacking (number)	5	6	5	15	0	2	1	-
mode of	Total (number)	373	441	316	1,045	2,726	8,544	29,286	-
travel	Share (%)	1%	1%	2%	1%	0%	0%	0%	-
	Lacking (number)	5	5	4	11	47	160	190	1,920
Travel time	Total (number)	373	441	316	1,045	3,104	8,770	18,160	26,829
unio	Share (%)	1%	1%	1%	1%	2%	2%	1%	7%
_	Lacking (number)	13	6	6	17	53	185	256	54
Start point	Total (number)	373	441	316	1,045	2,963	8,799	19,755	26,829
P	Share (%)	3%	1%	2%	2%	2%	2%	1%	0%
	Lacking (number)	9	5	7	11	1	19	35	62
End point	Total (number)	373	441	316	1,045	2,963	8,799	19,755	26,829
	Share (%)	2%	1%	2%	1%	0%	0%	0%	0%
Neither	Lacking (number)	13	7	32	11	54	201	290	-
start nor	Total (number)	373	441	316	1,045	2,963	8,799	19,755	-
end point	Share (%)	3%	2%	10%	1%	2%	2%	1%	-

Table 7. Incidence of item nonresponse for the trips with respect to mode of travel, travel time, and geocoding for online questionnaire and mobile app.

Table 8 presents the item nonresponses for implausible distance travelled values.<sup>5</sup> The "on foot" mode of travel had the most implausible values, regardless of data collection or recruitment method. The online questionnaire had a higher share of item nonresponses due to implausible distances travelled than did the mobile app, i.e., between approximately 2–3% versus 0.1%. In the case of TS GBG, the share was essentially twice as high as for the online questionnaire.

		Online questionnaire random without incentive	Online questionnaire random with incentive	Online questionnaire web panel	Online questionnaire crowd- sourcing	Mobile app random	Mobile app web panel	Mobile app crowd- sourcing	TS GBG
king ode	On foot	6	8	6	11	1	4	9	-
ole values/Lack travelled per mo of travel	Bicycle	0	1	0	4	0	0	0	-
	Car	0	0	1	0	0	1	0	-
	Public transport	2	2	1	5	0	0	0	-
lausi ance	Train	0	0	0	0	0	0	1	-
lmpl dista	Other	0	1	0	0	0	0	0	-
Total		8	12	8	20	1	5	10	1,465
Share lacking distance travelled		21%	2.7%	2.5%	1.9%	0.0%	0.1%	0.1%	5.5%

Table 8. Incidence of item nonresponse for trips based on distance travelled, broken down by mode of travel.

It was not possible to skip any background questions in the online questionnaire, with the result that there is no item nonresponse in that portion. That was not the case with respect to the background questions in the mobile app, i.e., all the questions were voluntary and could thus be skipped, but the item nonresponse was still limited in scope.

#### 2.5.3 Nonresponse analysis of the random sample

Enkätfabriken contacted a total of 400 people by telephone; they were divided into two groups of 100 who were asked to complete the online questionnaire with and without incentive, respectively, and 200 who were asked to use the mobile app. The telephone interviews were conducted in November 2017. First, the contacted people were asked if they had seen the mailing saying that they had been selected for inclusion in the pilot study: 70% of those selected to complete the online questionnaire knew of/recalled the mailing; the corresponding share among those who were invited to use the mobile app was nearly 80%.

Of those who <u>had seen</u> the invitation to complete the online questionnaire and had been offered an incentive (64 people), just over 40% accepted the offer. We also studied whether the group that had seen the survey invitation regarding the online questionnaire had made any trips during the measurement day. Of those who had <u>not seen</u> the invitation to complete the online questionnaire (61 people), 36% would have responded had they known that they had been selected. Those who answered NO were asked a follow-up question as to whether the gift card had motivated them to take part. Of those belonging to the group that was to receive the incentive, 1/3 indicated that they would have received an incentive would have participated. It was found that nearly half had travelled/undertaken

<sup>&</sup>lt;sup>5</sup> Reasonable distances (km): on foot  $\leq 25$ , bicycle  $\leq 100$ , and car  $\leq 1,500$ ; public transport: bus  $\leq 1,500$ , ferry/boat  $\leq 1,000$ , tram  $\leq 250$ , and train  $\leq 2,000$ ; and Other: moped  $\leq 10$ , motorcycle  $\leq 1,500$ , taxi  $\leq 500$ , mobility service  $\leq 500$ , aircraft  $\leq 25,000$ , and other  $\leq 10,000$ .

movements during the day, roughly 30% had not, and just over 20% could not recall. Corresponding questions were not posed to those invited to respond via the mobile app, as they did not have a specifically designated measurement day.

Of the just over 20% who had <u>not seen</u> the invitation to use the mobile app, the vast majority (93%, corresponding to 42 people) still would not have participated. The reason for this was most often a lack of time (31%) or that they had no access to a smart phone (12%; see also Figure 2). A gift card worth SEK 100 would have induced nearly one out of every four people who did not participate to use the mobile app. Others who <u>had seen</u> the invitation to download the mobile app still chose overwhelmingly (92%) not to download it. The most common reasons for this were unspecified, i.e., "Other reason" (37%), followed by a lack of time (21%). A gift card worth SEK 100 would have induced just over one out of every four people in this group to download the mobile app.



Figure 2. Reasons why people did not download the mobile app, broken down by whether or not they had seen the invitation; results of Enkätfabriken's nonresponse interviews.

# 2.6 Data processing

A portion of the data collected via the online questionnaire and the mobile app contains information that is not deemed plausible, or that derives from people who do not meet the established criteria for data collection. The processes applied to the collected data material are described below. Respondents who ended the online questionnaire before reaching the questions having to do with their travel were naturally excluded. This same is true for those who used the mobile app.

#### 2.6.1 Data cleaning and aggregation

The mobile app collects data at the stage level. Trips are created by aggregating the stages present in the trip chain by adding times and distances. The mode of travel is set to the mode of travel that was used over the longest distance in the trip chain.

Table 9 shows the numbers of people from the online questionnaire and the mobile app who were excluded from this pilot study. The grounds for exclusion were that the respondents lived outside the study area, that they did not fall within the age group (16–84 years), or that their answers applied to days outside the study period. The two most common grounds for exclusion were that the respondents did not live in the study area (geography) or that their answers did not apply to the study period (date). One person was excluded because he/she did not fall into the relevant age group. The highest loss for

such grounds pertains to crowdsourcing, regardless of the data collection method, although the highest numbers of responses were also found within these groups. The loss attributable to these grounds was also comparatively high in the web panel groups. The random sample exhibited almost no loss, regardless of the collection or recruitment method.

Grounds for exclusion	Online questionnaire random without incentive	Online questionnaire random with incentive	Online questionnaire web panel	Online questionnaire crowd- sourcing	Mobile app random	Mobile app web panel	Mobile app crowd- sourcing	Total
Geography (people)	0	0	4	19	1	6	7	37
Age (people)	0	0	0	0	0	0	1	1
Date (people)	0	0	10	0	0	1	2	13
Total	0	0	14	19	1	7	10	51

Table 9. Number of people (online questionnaire and mobile app) who did not belong to the target population or meet the criteria and were consequently excluded from the analysis.

With respect to the online questionnaire, information about the municipality of residence for the web panel groups was obtained from registers, and not from the questionnaire answers. The remaining responses from people who thus belong to the target group and were included in the analysis are referred to hereinafter as "net responses". The six categories of trip purposes used in the results were derived based on the types of purposes specified in the online questionnaire and the mobile app (see Table 10).

Table 10. Categorisation of trip purpose types.

Main category of purpose of trip	Description of included purpose types
Work	Work; school/training; on-the-job training/work-related travel
Leisure trips	Friends and relatives; hobbies, courses, club activities, religious practice; restaurant, café; exercise/outdoor life; entertainment and culture
Service-related trips	Healthcare; other services
Shopping trips	
Picking up/dropping off someone	
Other	

The modes of travel have also been aggregated into a few main categories. The category designated "public transport" in the results chapter includes bus, tram, boat, or other means of public transport, while "train" is reported separately. The category "Other" also encompasses moped, motorcycle, mobility service, taxi, aircraft, and other mode of travel. "Bicycle" also includes electric bicycles.

In certain cases, there is insufficient data material for a breakdown into multiple subgroups to be meaningful, i.e., the number of individuals drops too low in the case of some subgroups. As a result, the bars that are based on responses from fewer than five individuals are made less prominent with the help of patterns of diagonal stripes in the diagram describing the numbers of trips and their lengths.

#### 2.6.2 Management of multiple trip days from the mobile app

In the data collection process with the mobile app, data are collected for a number of days. The intent was that the respondents would collect data over a week, but some respondents collected data for fewer days, and many for more. To compensate for respondents having collected data for different numbers of days and to generate results that are capable of comparison with the web data and traditional TS data, the data processing was performed in three steps: In step 1, a mean value was calculated for each individual for each day of the week (Monday to Sunday); for example, the average

number of trips for respondent X on Mondays, Tuesdays, and so on. In step 2, a mean value was calculated for all respondents for each day of the week; for example, the average number of trips on Mondays, Tuesdays, and so on. In step 3, the mean values for days of the week are derived.

Example:

- 1. Average number of trips for respondent X on Mondays:  $N_{X\_MON} = mean (N_{X\_1:a MON} N_{X\_N:e MON})$
- 2. Average number of trips on Mondays:  $N_{MON} = mean (N_{X_{MON}} N_{X+N_{MON}})$
- 3. Average number of trips per day:  $N = mean (N_{MON} N_{SUN})$

#### 2.6.3 Weighting process

Experience has shown that certain groups within the population differ in terms of their inclination to respond to travel surveys. For example, women respond to a greater extent than men, and older people to a greater extent than younger ones. Moreover, the travel undertaken by different groups can vary. One way of managing such potential skews is to assign the respondents different weights based on background variables, so as to obtain a more representative sample of the target population. Such weighting is traditionally performed on the basis of gender, age group, and geography. Certain age groups and geographical levels that are used vary from survey to survey.

Because this survey involves not only randomly selected respondents but also partially self-selected respondents (web panel) and completely self-selected respondents (crowdsourcing), the weighting process becomes even more important if the results are to be capable of being considered representative of the target population. The aim is to get the respondents in each group to reflect the target population to the greatest possible extent.

A number of different weights have been derived for and applied to each respective survey group. These weights consist of various combinations of the following parameters: gender, age group, area of residence, type of residence, driving licence possession, whether there are children in the household, and occupation (see further Appendix 8). The weighted survey groups were then compared with the register data, and the smaller the difference between the register data and the survey group, the better the weighting was considered to have worked. We refer to the weight that creates a group that most closely resembles the target population as the "optimal weight". If two different weights have yielded the same result, then the less complex weight is given preference (i.e., fewest parameters involved).

The results show that the random samples are most like the target population before weighting, even though there are major deviations there as well. The survey groups recruited via crowdsourcing exhibit the largest difference from the target population prior to weighting.

In a traditional weighting process, all the survey groups become more like the target populations. Weighting has the greatest impact on the survey groups recruited via crowdsourcing and the least effect on the group that was selected randomly and used the app. When the optimal weight for each respective survey group is used, the correspondence with the target population becomes stronger across all survey groups, with a maximum deviation of roughly 5%.

Table 11. Percentage differences between respondents and register data with respect to the factors of gender, age group, residence in Gothenburg, type of residence, type of household, driving license possession, and occupation: unweighted, traditional weights, and optimal weights for the various survey groups.

	Unweighted	Traditional weight (i.e., gender-age- geography)	Optimal weight	
Online questionnaire – random without incentive			Traditional + flat-licence- employed	
Mean deviation	6%	3%	3%	
Median deviation	7%	2%	2%	
Largest deviation	13%	11%	5%	
Total	26%	16%	10%	
Online questionnaire – random with incentive			Traditional + licence	
Mean deviation	6%	2%	2%	
Median deviation	5%	2%	1%	
Largest deviation	11%	6%	5%	
Total	21%	10%	8%	
Online questionnaire – web panel			Traditional + flat-licence- employed	
Mean deviation	7%	5%	2%	
Median deviation	7%	4%	3%	
Largest deviation	14%	11%	4%	
Total	28%	19%	9%	
Online questionnaire – crowdsourcing			Traditional + flat-licence- children	
Mean deviation	11%	4%	2%	
Median deviation	10%	5%	2%	
Largest deviation	20%	10%	5%	
Total	41%	19%	8%	
Mobile app – random			Traditional + flat-licence- employed	
Mean deviation	7%	5%	2%	
Median deviation	4%	4%	2%	
Largest deviation	13%	12%	5%	
Total	23%	21%	9%	
Mobile app – web panel			Traditional + flat-licence- children	
Mean deviation	9%	5%	3%	
Median deviation	7%	3%	3%	
Largest deviation	16%	14%	6%	
Total	31%	22%	12%	
Mobile app – crowdsourcing			Traditional + flat-licence	
Mean deviation	12%	5%	3%	
Median deviation	12%	1%	3%	
Largest deviation	23%	16%	5%	
Total	48%	22%	11%	

If we study the effects on the results of applying the various weights, we can see that the differences in the results that are attributable to the recruitment method used decrease the more optimal the weight. An example regarding the number of trips per person and day is presented in Table 12.

Table 12. Example of effects of using different weights. Number of trips per person and day, broken down by the various survey groups. \*The mean value pertains to the number of trips per person using different recruitment methods.

	Random without incentive	Random with incentive	Web panel	Crowd- sourcing		
Online questionnaire – unweighted						
Number of trips per person and day	2.39	2.44	1.87	2.80		
Deviation from mean value*	0.02	0.06	-0.51	0.43		
Largest difference between two groups	0.93					
Online questionnaire – Traditional weight						
Number of trips per person and day	2.48	2.44	1.89	2.76		
Deviation from mean value*	0.09	0.05	-0.50	0.37		
Largest difference between two groups	0.87					
Online questionnaire – Optimal weight						
Number of trips per person and day	2.39	2.42	1.90	2.55		
Deviation from mean value*	0.07	0.11	-0.42	0.23		
Largest difference between two groups	0.65					
Mobile app – Unweighted						
Number of trips per person and day	5.12		5.28	6.35		
Deviation from mean value*	-0.46		-0.30	0.77		
Largest difference between two groups	1.23					
Mobile app – Traditional weight						
Number of trips per person and day	5.07		5.31	6.16		
Deviation from mean value*	-0.44		-0.20	0.65		
Largest difference between two groups	1.09					
Mobile app – Optimal weight						
Number of trips per person and day	5.14		5.33	5.90		
Deviation from mean value*	-0.32		-0.13	0.44		
Largest difference between two groups		0.7	6			

Based on these results, the flexible weighting process stands out as the best means of reflecting the target population. However, the ability to weight in this manner presumes knowledge of both the respondents and the target population, and it is possible to weight the variables only if knowledge about both is available. We consequently recommend that the register data that are available should be checked at the time the questionnaire is being prepared, so that existing register data can be utilised. In this study we found that driving licence possession and type of residence were two parameters that were included in the optimal weightings for most of the groups. Whether this is also the case in other surveys remains to be studied.

However, based on the results of this study, we propose that more in-depth analyses be considered in connection with the weighting process, primarily with regard to respondents from web panels and crowdsourcing, although this might be of interest in connection with random samples as well. Because

the main purpose of this study is to investigate different collection and recruitment methods, we have opted to report results that are based on the traditional weightings, as this will shed light on method-related differences rather than travel behaviour in Gothenburg.

#### 2.6.4 Method for estimation of sampling errors

The theoretical derivation of uncertainty estimates from the collected material is difficult. One approach is to use the bootstrap method. This has been done by assuming that the observed distribution of the respondents corresponds to the actual distribution of the target population. Under this basic assumption, 10,000 new samples of the same size were created (so-called bootstrap samples) by extracting, via replacement, respondents from our original observations. A weighted mean value

estimate,  $\hat{x}$ , is then calculated for each sample. This yields a sequence of estimates,  $\hat{x}_1, \hat{x}_2, \ldots$ . Under the basic assumption that the observed distribution of the respondents corresponds to that of the target population, it is possible, using this sequence of mean values, to generate the distribution function for the mean values. The 2.5 and 97.5 percentiles are then selected from this distribution function as a 95% confidence interval. This was done for the share that had made at least one trip during the measurement day and for the number of trips per person who had made at least one trip during the measurement day. The results are presented in Section 3.6.

#### 3 Results and analysis

The results obtained in the study are presented in this section. Certain results are compared with register data, as well as with TS GBG and TS Sweden data. Any results that were implausible or were not considered usable for some other reason have been excluded from the analysis (see further Section 2.6.1). Appendix 8 contains tables of the basic data on which the figures in this section are based.

# 3.1 Respondent profiles

In this section a number of background variables are compared among the seven groups that were formed based on the three recruitment methods and the two collection methods. A comparison was also made (when data were available) with the results of Gothenburg TS and with official statistics from Statistics Sweden (hereinafter, "register data"). The results are based on unweighted data. The random sample was drawn with an equal number of individuals from eight strata, which were broken down by gender and age. The distribution of these background variables is thus not proportional to the population in the survey area. The number of corrected days per person was also studied in the case of those who downloaded the mobile app. Those results are presented in Appendix 8.

#### 3.1.1 Gender

The gender distribution was most uniform in the subgroup that downloaded the mobile app and was recruited via random sampling (see Figure 3). A uniform gender distribution corresponds to the distribution in the area as per the register data. The most skewed gender distribution is found in the group that completed the online questionnaire and had been recruited via crowdsourcing, only 30% of whom were men. There was a slight preponderance of women in the other groups that completed the online questionnaire app.



Figure 3. Gender distributions (men, women, and other) for the different survey groups and as per register data.

#### 3.1.2 Age

Four age groups were created in this study in accordance with the breakdown used in TS Sweden, i.e., 16–24, 25–44, 45–64, and 65–84 years of age. Figure 4 shows how the respondents break down into these age groups within each survey group. The age group distribution of those who used the mobile app and belonged to the random recruitment method group most closely resembled the distribution as per the register data. In general, a smaller share of those in the 65–84-year age group used the mobile app. A greater share of those who responded to the online questionnaire belonged to the oldest age group, even as 25–44-year-olds were underrepresented compared with the register data, except for those recruited via crowdsourcing. The highest proportions (over 85%) of those of active working age, corresponding here to 25–64-year-olds, were found in the groups recruited via crowdsourcing, regardless of the collection method used.



*Figure 4. Distribution (in %) of age groups for the various survey groups and as per register data.* 

When the data material from Figure 4 is also broken down by gender, we can see that the share of men decreases with age among those recruited randomly who completed the online questionnaire, with the exception of the oldest age group, in which the gender distribution is uniform. Furthermore, men were underrepresented in the age categories up to 64 years of age among those who responded via the online questionnaire in the crowdsourcing group. The highest share of men (60%) is found in the group of web panellists in the 65–84-year age group who completed the online questionnaire. However, the number in each subgroup will be quite small when the material is divided (see further Appendix 8), and we should consequently be wary of drawing overly confident conclusions from the results.

#### 3.1.3 Occupation

The online questionnaire and the background questionnaire in the mobile app offered the respondents the opportunity to state their occupation based on a number of set answer choices. The answers were both coded into two categories (i.e., gainfully employed versus not gainfully employed) and also reported with no division into categories. The "gainfully employed" category includes employed people and the self-employed. The coarse division into two categories was performed to enable comparison with register data. The distribution for the survey groups according to this division is presented in Figure 5. The best agreement with register data is found among the groups that used the mobile app and were randomly selected, and among the web panellists. The most skewed distribution is seen among those who completed the online questionnaire or used the mobile app and were recruited via crowdsourcing, i.e., just over 80% and 85% were gainfully employed, respectively, compared with 64% in the register data.



*Figure 5. Distribution (in %) of two occupational categories for the various survey groups, and for register data.* 

In Figure 6, with its finer breakdown into occupational categories, we can see that those recruited via crowdsourcing deviated somewhat from the other survey groups in that a higher percentage of them was employed, while a lower percentage was retired.



*Figure 6. Distribution (in %) of occupations among the various survey groups. Striped bars indicate that the results are based on responses from fewer than five people.* 

#### 3.1.4 Driving licence and car access

In our study, the share of those possessing a driving licence was higher than in the target population in the region across all survey groups (see Figure 7). This applied to both men and women. The difference approaches 20 percentage points for women and 16 for men, compared with register data. In addition to the level deviation from the register data, the relationship between genders within one survey group was also discordant, i.e., women were more likely than men to possess driving licenses in the online survey without incentive.



*Figure 7. Shares (in %) of women and men with a driving licence, broken down by the various survey groups and register data.* 

Household car ownership differed among the survey groups (see Table 13). Respondents who completed the online questionnaire (except those from the crowdsourcing group) were more likely to own a household car than the average according to the register data. Car ownership was as high as or lower than in the register data for the other groups.

Survey group	Average number of cars in household
Online questionnaire, random sample, no incentive	1.3
Online questionnaire, random sample, incentive	1.3
Online questionnaire, web panel	1.3
Online questionnaire, crowdsourcing	1.2
Mobile app, random sample	1.1
Mobile app, web panel with incentive	1.1
Mobile app crowdsourcing	1.2
Register data	1.2

Table 13. Household car ownership in various survey groups.

#### 3.1.5 Type of residence

There were three different options in terms of type of residence from which the respondents could choose, i.e., flat, detached house/townhouse, and other type of residence. However, only the first two types of residence are available in register data. As there were fairly few in the survey who chose "Other residence", the register data are still useable for comparison. The distribution of these types of

residence for each of the subgroups is presented in Figure 8. Excellent agreement with register data was obtained for the individuals in the random sample and crowdsourcing groups that completed the online questionnaire. With respect to the other groups, the respondents living in flats were over-represented, particularly among web panellists who downloaded the mobile app.



*Figure 8. Distribution (in %) of residence types for the various survey groups and as per register data. Striped bars indicate that the results are based on responses from fewer than five people.* 

The distribution of the number of corrected days is broken down by type of residence in Appendix 8 for the groups that used the mobile app. We can see that the share of trip days corrected in the mobile app by the web panellists who live in flats is greatest when the comparison is made with regard to the recruitment method. Fewer than half of such days were derived from those living in flats among the group recruited via crowdsourcing.

#### 3.1.6 Household size and type

The respondents have been divided into five household types, i.e., living alone without children, living alone with children, two cohabitants with children, two cohabitants without children, and other households with or without children (see Figure 9). Information regarding household type is lacking for 4% of the respondents in the survey group that was selected randomly and was to use the mobile app.

It is evident that the household type "Two cohabitants without children" is over-represented among our respondents, regardless of the collection or recruitment method. The category comprising two cohabitants with children is at the same time underrepresented; this applies to all groups that responded to the online questionnaire, and to those from the random sample who used the mobile app.



*Figure 9. Distribution of household types for the various survey groups, and for register data. Striped bars indicate that the results are based on the responses of fewer than five people.* 

We have also studied what the distribution looks like in relation to household size (there are no register data against which to compare in this case; see further Appendix 8). What is notable with respect to household size is that the highest share of large households (i.e., five or more people) is found in the three subgroups that downloaded the mobile app. We also note that those who were recruited randomly and completed the online questionnaire lived, in large measure (61%), in two-person households.
### 3.1.7 Municipality of residence

In this case the respondents were divided into two groups, i.e., residents of Gothenburg Municipality and residents of one of the other 20 municipalities included in the survey area (see Figure 10). A larger share resided in Gothenburg Municipality in the study than was the case for the register data, regardless of the collection tool or recruitment method. This was most evident among those who downloaded the mobile app. Not all the municipalities are represented in all the survey groups (see Appendix 8).



Figure 10. Distribution by area of residence, i.e., Gothenburg Municipality versus other municipalities, for the survey groups and for register data.

# 3.1.8 Summary of respondent profiles

In summary, we can see that the groups recruited via crowdsourcing deviate extensively in a majority of cases from other groups and register data when the distributions for various background variables are compared with register data. These groups consisted of higher proportions of women, people of active working age and the gainfully employed than did other groups. On the other hand, the crowdsourcing group that responded to the online questionnaire, along with the randomly selected group that responded to the online questionnaire, exhibited very good agreement with the distribution by type of residence per the register data (i.e., flat vs. detached house/townhouse). The crowdsourcing group that used the mobile app exhibited better agreement with register data in terms of type of residence than did other groups that used the mobile app. Elderly respondents and households consisting of two cohabitants without children were overrepresented among those who were selected at random and responded to the online questionnaire. Gothenburg's traditional TS also exhibits major deviation from register data with regard to household composition. The share of people living in Gothenburg municipality is, consistently and regardless of collection or recruitment method, higher than the share of the target group living in Gothenburg municipality according to register data

Table 14 summarises the differences between the register data and the results for the survey groups; the results of the Gothenburg TS have been included here as well. Positive numbers indicate overestimates relative to the register data, while negative numbers are underestimates. The table shows that all the survey groups included in our study contained more respondents who had a driving licence VTI PM 37

and lived in Gothenburg Municipality compared with the register data. Those who completed the online questionnaire were women and older to a greater extent (65–84 years of age, albeit not in the crowdsourcing group). That greater number of older people who responded is also reflected in the fact that fewer gainfully employed people and more people without children living at home responded. The gender and age group breakdowns among those who responded via the mobile app were roughly the same as in the register data, with more living in flats, more being gainfully employed, and more not having children living at home. The results indicate that web panellists who used the mobile app account for the most cases in which there are small differences compared with the register data, even as there are fewer major differences than in other survey groups.

	Online questionnaire			Mobile app					
	Random without incentive	Random with incentive	Web panel	Crowd- sourcing	Random	Web panel	Crowd- sourcing	TS GBG	Register data
Share of men	-7.4	-4.6	-3.0	-19.8	-0.8	-6.0	-8.3	-4.1	50%
Share of women	+7.4	+4.6	+3.0	+19.6	+0.8	+6.0	+8.3	+4.1	50%
16–24 years of age	-2.9	+3.7	+1.5	-9.9	+2.6	+3.8	-10.9	-7.4	14%
25–44 years of age	-12.3	-14.0	-7.1	+4.7	+3.6	+2.1	+14.4	-11.4	35%
45–64 years of age	+1.2	0.0	+1.1	+14.3	+0.3	+7.8	+10.6	+4.8	31%
65–84 years of age	+13.9	+10.3	+4.5	-9.1	-6.5	-13.7	-14.1	+14.1	20%
Gainfully employed	-6.3	-10.9	-13.8	+18.5	-2.2	+2.0	+22.8	Lacking	64%
Not gainfully employed	+6.3	+10.9	+13.8	-18.5	+2.2	-2.0	-22.8	Lacking	36%
Women with driving licence	+18.8	+7.7	+9.8	+15.1	+12.5	+0.3	+17.7	+12.2	73%
Men with driving licence	+10.1	+13.6	+13.0	+15.0	+10.8	+11.8	+16.4	+11.3	80%
Flat	+0.5	+0.6	+12.1	+0.4	+13.4	+16.9	+4.1	-2.9	44%
Detached house/townhouse	-0.7	-0.8	-12.3	-0.7	-13.6	-17.2	-4.4	+2.6	56%
Living alone w/o children	-4.0	-1.3	+6.1	+4.1	+8.4	+1.7	+0.8	+3.8	17%
Living alone with children	-3.0	-1.9	-1.4	-1.3	-3.7	+2.4	-2.8	-6.0	8%
Cohabitants w/o children	+29.8	+21.2	+12.8	+5.6	+16.6	+2.5	+8.0	+31.5	21%
Cohabitants with children	-11.9	-10.5	-13.5	+1.2	-9.8	+2.8	+4.0	-16.3	41%
Other households with or w/o children	-10.7	-7.4	-3.7	-9.3	-11.3	-9.2	-9.9	-12.8	13%
Gothenburg Municipality	+2.1	+6.6	+3.2	+9.0	+12.7	+11.5	+12.8	-2.4	41%
Other municipalities	-2.1	-6.6	-3.2	-9.0	-12.7	-11.5	-12.8	+2.4	59%
Number diff. ±2.0% points	3	5	3	4	3	2	1	0	
Number diff. ±2.1–4.9% points	5	3	6	2	5	7	4	8	
Number diff. ±5.0% points	11	11	10	13	11	10	14	9	

Table 14. Differences between percentage distributions for the pilot study and register data, expressed in percentage points, for a number of background variables. Green cells: the differences are at most 2.0 percentage points; yellow cells: the differences are 2.1–4.9 percentage points; red cells: the differences are 5.0 percentage points or more.

# 3.2 Share that did not travel, and reasons why

One way of comparing the different groups is to study the shares that did not travel. A trip-free day can also include those trips that started and ended at home, with no purpose being fulfilled en route. Data were drawn from TS Sweden for the years 2013–2016 and for people 16–84 years of age in the Gothenburg region between 15 October and 15 November in order to enable comparison with a traditional survey. There the share of those who had made no trips during the measurement day was 20.7% (weighted). The figure was somewhat higher in TS Gothenburg, i.e., 24.8%.

In our survey, 11–23% of those who completed the online questionnaire reported a trip-free day (see Table 15). The corresponding figure was 8–15% for the mobile app. The group that was recruited via crowdsourcing posted the highest figure, while the web panellists reported the most trip-free days, regardless of the data collection method. Roughly equal percentages of those who had been recruited randomly and via crowdsourcing reported trip-free days using the mobile app, i.e., 8–9%. The percentage was nearly twice as high in the web panel group.

*Table 15. Total number of net responses and numbers and percentages of trip-free days reported by those who completed the online questionnaire and used the mobile app, traditional weighting* 

Collection method	Recruitment method	Net number of responses	Number that did not travel	% that did not travel
	Random sample without incentive	192	32	16.6%
Online questionnaire	Random sample with incentive	222	39	17.9%
	Web panel	221	51	23.3%
	Crowdsourcing	407	44	11.1%
	Random sample	691	68	9.8%
Mobile app	Web panel	2517	377	15.0%
	Crowdsourcing	4526	372	8.2%

In the online questionnaire a follow-up question was posed to those who reported that they had not travelled on the measurement day, i.e., "What was the reason?" The predominant reason among the randomly selected groups and the web panel group was that there was no need, i.e., they had no errands to run (see Figure 11).



Figure 11. Reasons why respondents did not travel on the measurement day among groups that were to complete the online questionnaire. Striped bars indicate that the results are based on responses from fewer than five people.

In summary, we may note that the online questionnaire web panellists were the only survey group that had a higher share of trip-free days than did the TS Sweden respondents and was on a par with the TS Gothenburg respondents. The group with the lowest share of trip-free days was the one recruited via crowdsourcing (regardless of the data collection method). Of all respondents reporting trip-free days most reported that they had no errands to run. It would have been interesting in this context to know whether a portion of these people were working from home temporarily.

# 3.3 Average number of trips per day

This section describes how many trips were made per day and person, and the results have been adjusted using traditional weighting. When available, results of Gothenburg's TS have been entered in the figures for the sake of comparison. The results are based on people who travelled (in the case of the online questionnaire this means that an individual reported for one day, while with the mobile app the individual reported for multiple trip days), and the average number of trips is calculated as a mean value for the days of the week (see further in Appendix 8).

The people included in the groups that completed the online questionnaire made between two and three trips per day/person (see Figure 12). Those who used the mobile app reported more than twice as many trips per day and person. The biggest difference between the data collection methods was seen in connection with the web panellists. The results of TS Sweden 2013–2016 have been included in the figure as well. The respondents who were recruited via crowdsourcing reported more trips, regardless of the data collection method. In the case of the mobile app, the difference was one trip compared with the groups recruited randomly or via the web panel.



Figure 12. Average number of trips per day and person broken down by the various survey groups plus TS Gothenburg and TS Sweden. Traditional weighting, and without days on which no trips were made.

Figure 13 shows the average number of trips per day and person, broken down by gender. The biggest difference between genders in the number of trips per day is seen in the group that used the mobile app and was recruited via random sampling. In contrast to the mobile app users, among whom the women made more trips than the men, such a pattern is not as obvious among those who completed the online questionnaire.



Figure 13. Average number of trips per day and person broken down by gender for the various survey groups and TS Gothenburg. Traditional weighting, and without days on which no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

The respondents were divided into four different age categories, i.e., 16–24, 25–44, 45–64, and 65–84 years of age (see Figure 14). Major variation is seen within the youngest group, with the web panellists reporting the lowest number of trips both in the online questionnaire (1.2 trips) and via the mobile app (4.2 trips). The variation is not as great within the other age groups, with the exception of the oldest group that was recruited randomly to the mobile app, which made the lowest number of trips (3.7) compared with the other two recruitment methods.



Figure 14. Average number of trips per day and person broken down by age group for the various survey groups and TS Gothenburg. Traditional weighting, and without days on which no trips were made.



On average, those who lived in a detached house or townhouse made somewhat more trips than did those who lived in a flat (see Figure 15), although the differences were usually quite small.

Figure 15. Average number of trips per day and person broken down by type of residence for the various survey groups and TS Gothenburg. Traditional weighting, and without days on which no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

When broken down by occupation, the situations are fairly consistent within each collection method, with a few exceptions (see Figure 16). Major variation in the number of trips is seen among those who worked in their own household and were to complete the online questionnaire; this is presumably attributable to the lower number of respondents in that group. Students also reported varying numbers of trips in the various subgroups. Data broken down by occupation are lacking from the Gothenburg TS.



Figure 16. Average number of trips per day and person broken down by occupation for the various survey groups. Traditional weighting, and without days when no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

The numbers of trips reported for the various household types are presented in Figure 17, where we see that cohabitants with children make as many as or more trips per day than do cohabitants without children. No similar pattern is seen with respect to those living alone with versus without children. The differences between the household types within each survey group are relatively small, however, with the exception of the randomly recruited group that used the mobile app.



Figure 17. Average number of trips per day and person broken down by household type for the various survey groups and TS Gothenburg. Traditional weighting, and without days on which no trips were made. The category "Other" is lacking for Gothenburg's TS. Striped bars indicate that the results are based on responses from fewer than five people.

Between two and three trips were made per day and person among those who completed the online questionnaire, regardless of the number of cars in use in the household (see Figure 18). The mobile app groups reported the most trips, i.e., 4–6 per day and person, with individual exceptions.



Figure 18. Average number of trips per day and person broken down by number of cars in the household for the various survey groups and TS Gothenburg. Traditional weighting, and without days on which no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

On average, respondents who had a driving licence for passenger cars made more trips than did those who had no driving license (see Figure 19). The differences in the number of trips for each collection method were fairly small for the group that did not have a Class B driving licence, but larger for those that did. Those who were recruited via crowdsourcing and used the mobile app reported an average of nearly 6.4 trips per day, as compared with the randomly selected people who used the mobile app, who made 5.2 trips per day and person.



Figure 19. Average number of trips per day and person, broken down based on whether or not the respondent has a Class B driving licence for the various survey groups and TS Gothenburg. Traditional weighting, and without days on which no trips were made.

A combined bar has been created for each survey group to show the number of trips per mode of travel (see Figure 20). The biggest differences between those who used the mobile app and those who completed the online questionnaire are seen with respect to trips made on foot or by car. The mobile app users reported upwards of five times as many trips made on foot and nearly twice as many trips made by car than did the online questionnaire groups.



Figure 20. Average number of trips per day and person broken down by mode of travel for the various survey groups and TS Gothenburg. The mode of travel "Train" is included in "Public transport" in Gothenburg's TS.

The percentage distributions by mode of travel within each survey group are presented in Figure 21. The most common trips are made using the mode of travel "Car", regardless of the data collection or recruitment method. In the case of the online questionnaire, public transport comes next, followed by walking, and the same patterns are evident in TS GBG. In the case of the mobile app, trips made by walking place second, with public transport coming in third.



Figure 21. Percentage distribution of average number of trips per day and person, broken down by mode of travel for the various survey groups and TS Gothenburg. Traditional weighting, and without days on which no trips were made. The mode of travel "Train" is included in "Public transport" with respect to Gothenburg's TS.

Figure 22 shows the distribution of trip purposes based on the main categories of such purposes that have been chosen. The biggest differences between the data collection methods are seen with regard to trips for leisure or shopping. The mobile users made significantly more trips for such purposes than did the groups that completed the online questionnaire. Data broken down by type of purpose are lacking in Gothenburg's TS.



*Figure 22. Average number of trips per day and person broken down by purpose of trip for the various survey groups.* 

In summary, we can see that the mobile app collected twice as many trips as did the online questionnaire. The most common trip was made by car, and that applies across all survey groups and the traditional survey. Trips made on foot are more prominent with respect to the mobile app. The most common purpose in the case of the online questionnaire was travel for work, albeit with the exception of the web panellists, among whom the most common category was "Other". Conversely, the most common purpose of a trip in the case of the mobile app group was leisure.

# 3.4 Average distance travelled per day

This chapter presents the distance travelled per day (based on lengths of trips and days on which the respondent travelled) and person, and the results are adjusted using traditional weighting. The average distance travelled per person and day varied from 42 to 85 km in the seven survey groups (see Figure 23). In the case of the crowdsourcing recruitment method, there was a major difference in average distance travelled between the two collection methods, i.e., 85 km per day for the mobile app versus 53 km per day for the online questionnaire. There was also a difference in the average distance travelled for the random sample with and without incentive in the case of the online questionnaire, i.e., 68 km versus 42 km per day. Dramatically deviant distances travelled (e.g., air travel) can have an impact on the total values, given the relatively low numbers of respondents in each survey group and some subgroups.



*Figure 23.* Average distance travelled per day and person for the various survey groups. Traditional weighting, and without days on which no trips were made.

Figure 24 shows how the distances travelled differ between the genders. The differences were smallest between men and women who used the mobile app and were recruited via crowdsourcing. Otherwise the men's distances travelled were 50–60 km per day, with the exception of the group that completed the online questionnaire and was randomly recruited, in which the average distance was just under 40 km. The women reported significantly longer distances travelled (78 km/day) than did the men in the group that was randomly recruited and completed the online questionnaire but were given no incentive. The average distance travelled among other women who completed the online questionnaire was 40–50 km per day.



Figure 24. Average distance travelled per day and person broken down by gender for the various survey groups. Traditional weighting, and without days on which no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

There were often major variations in the average distances travelled within an age group when the different collection and recruitment methods were compared (see Figure 25). The largest difference is found among those aged 16–24 years. People aged 16–24 years who were recruited by random sampling and responded via the online questionnaire travelled only 20 km per person, while those who responded using the mobile app travelled a full 96 km per person. The age group with the least variation in average distances travelled across the survey groups was those aged 45–64 years. The distances travelled for three of the age groups were equal in the survey group that used the mobile app and was recruited via crowdsourcing, i.e., roughly 90 km per person and day, while those aged 16–24 years travelled an average of 50 km per in this survey group.



*Figure 25. Average distance travelled per day and person broken down by age group for the various survey groups. Traditional weighting, and without days on which no trips were made.* 

People who lived in a detached house or townhouse reported roughly the same or longer average distances travelled than those who reported that they lived in a flat (see Figure 26). A dramatically deviant average distance travelled is noted with respect to the subgroup that completed the online questionnaire and was recruited from a web panel.



Figure 26. Average distance travelled per day and person broken down by different types of residence for the various survey groups. Traditional weighting, and without days on which no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

Figure 27 shows a breakdown based on respondent occupation. It is difficult here to discern any clear correlation, as the variation is considerable between the survey groups for each of the occupation types, probably because the numbers of people in the individual subgroups are low (in one case, an occupational subgroup for a given recruitment method has no members). Employed people did, however, report the most stable average distances travelled/day across the subgroups, which is to be expected, as they may be assumed to be travelling regularly to and from their place of work on weekdays.



Figure 27. Average distance travelled per day and person broken down by occupation for the various survey groups. Traditional weighting, and without days on which no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

Figure 28 shows how travel depends upon household type. Those living alone with or without children travelled shorter distances per day than did cohabitants with or without children. The only exception was the survey group that used the mobile app and was recruited via a web panel, with those living alone with children travelling some 20 km farther per day than did the other groups (except for the household type "Other"). As a rule, cohabitants without children travelled farther than did cohabitants with children, with one exception, i.e., the situation was reversed in the randomly recruited group that used the mobile app.



Figure 28. Average distance travelled per day and person broken down by household type for the various survey groups. Traditional weighting, and without days on which no trips were made. Striped bars indicate that the results are based on responses from fewer than five people.

Figure 29 shows how the average distance travelled varied based on the number of cars available for use by the household. There is no clear pattern to indicate that the household distances travelled increase when those who own no car are compared with those who own one. On the other hand, the results do show that those households that own two cars travel farther than do those that own only one, regardless of the data collection or recruitment method. This applies across all survey groups with the exception of web panellists who used the mobile app, for whom the distances are nearly the same. The biggest difference, 70 km, is seen in the online questionnaire group recruited via random sampling with no incentive. Households that own two cars also travel farther than do those that own none, regardless of the collection or recruitment method. The distances travelled vary a great deal between the survey groups in the case of the group that owns three or more cars, and there is no clear pattern to indicate that these people travel farther than do those that own two cars. However, those households that own three or more cars do travel farther than those that have one car or no car, with the exception of those that own one car and belong to the crowdsourcing via mobile app group and those that own no cars in the online questionnaire group.



Figure 29. Average distance travelled per day and person, broken down by number of cars available to the household for use for the various survey groups. Traditional weighting, and without days on which no trips were made.

As a rule, those who had a driving licence travelled farther per day than those who did not (see Figure 30). The differences were, however, small in two of the survey groups, i.e., those who were selected at random and completed the online questionnaire (and were given an incentive) and those who used the mobile app. Otherwise the differences between the driving licence groups ranged between 20 and 30 km, with the exception of the survey group that completed the online questionnaire but was given no incentive, in which those with a driving licence travelled an average of just over 40 km farther per day than those who did not have one.



Figure 30. Average distance travelled per day and person, broken down for the various survey groups based on whether or not the respondent had a Class B driving licence. Traditional weighting, and without days on which no trips were made.

Figure 31 presents the average distance travelled per mode of travel category. Regardless of the data collection or recruitment method used, the respondents travelled an average of 3–40 km per day by car (as either the driver or a passenger). Travel using the public transport or train modes of travel was most prevalent in the group that was recruited via crowdsourcing and used the mobile app. The longest distances travelled using these modes of travel are seen in the group that completed the online questionnaire without being given any incentive and was recruited randomly. Note that the mobile app users reported walking and bicycling trips that were up to twice as long as those made in the groups that completed the online questionnaire.



*Figure 31.* Average distance travelled per day, person, and mode of travel for the various survey groups. Traditional weighting, and without days on which no trips were made.

The percentage distribution of distances travelled broken down by mode of travel within each survey group is presented in Figure 32. Car trips are predominant in all the survey groups, ranging from 47% to 69% of the distance travelled. "Other" places second among the randomly sampled online questionnaire without incentive group (26%). Distances travelled either by public transport and/or train place second in the other survey groups. Walking and bicycle trips account for a small share of the distances travelled.



Figure 32. Percentage distribution based on distance travelled per day, person, and mode of travel for the various survey groups. Traditional weighting, and without days on which no trips were made.

Finally, the distribution based on type of purpose is presented (see Figure 33). Those who used the mobile app reported longer trips made for leisure, services, or shopping than did those who completed the online questionnaire. On the other hand, the groups that completed the online questionnaire reported longer trips made for some purpose other than those listed.



*Figure 33.* Average distance travelled per day, person, and purpose for the various survey groups. Traditional weighting, and without days on which no trips were made.

Generally, the results show that the average distance travelled per person and day varied from 42 to 85 km in the seven survey groups. There are no differences between the data collection methods, although there are differences with regard to the recruitment methods. The random sample without incentive completing the online questionnaire and the crowdsourcing group using the mobile app exhibited the longest distances travelled. The mode of travel "Car" accounted for the longest distances travelled in the case of the mobile app was leisure. The purpose associated with the longest distances travelled in the random sampled with and without incentive groups, and by the web panellists. In the case of the crowdsourcing group, trips for work accounted for the longest distances travelled.

# 3.5 Distance travelled per trip

The ways in which the average distance travelled per trip varied with the mode of travel and purpose are investigated in this chapter. Overall, the trip lengths were, on average, roughly twice as long in the online questionnaire groups as in the mobile app groups. Table 16 presents the average distance travelled per trip, broken down by mode of travel. The trip lengths varied to a lesser extent when collected via the mobile app with regard to the modes of travel car, bicycle, walking, and public transport, than when collected via the online questionnaire. Furthermore, somewhat longer trips by car and significantly longer trips on foot were reported via the online questionnaire than with the mobile app. The results of TS Gothenburg are most reminiscent of the pilot study's mobile app data, with the exception of trips made on foot, which were at least twice as long on average. One explanation could

be that the travellers forget to include the short movements made on foot in the online questionnaire, and that a trip/purpose may be forgotten, resulting in longer car trips. See more about this reasoning in the discussion in Section 4.1.5.

Mode of travel	Online questionnaire random without incentive	Online questionnaire random with incentive	Online questionnaire web panel	Online questionnaire crowd- sourcing	Mobile app random	Mobile app web panel	Mobile app crowd- sourcing	TS GBG
Walking	2.7	1.9	3.1	1.6	0.6	0.7	0.5	1.4
Bicycle	3.9	3.1	7.2	5.5	2.9	4.3	4.4	3.8
Car	24	20	28	22	17	16	17	17
Public transport	15	9	35	17	13	11	12	14
Train	67	92	72	64	116	58	72	58
Other	1.015*	7*	0	14	9	17	212	43
All	27	17	28	19	10	11	12	15

Table 16. Average distance travelled (km) per trip for the various survey groups and TS Gothenburg, broken down by mode of travel. Traditional weighting, and without days on which no trips were made. \* indicates that the value was originally based on fewer than five respondent answers.

Corresponding results broken down by purpose are presented in Table 17. If we ignore "Other purpose" then the average trip length reported via the mobile app is in the range of 8–15 km, with little variation within each purpose type. In the case of the online questionnaire, the trip lengths fall within a broader range, 7–28 km. The variations in trip length were also large within the purpose types, although the service-related and shopping trips were, on average, roughly 10 km long according to those who completed the online questionnaire.

Purpose	Online questionnaire random without incentive	Online questionnaire random with incentive	Online questionnaire web panel	Online questionnaire crowd- sourcing	Mobile app random	Mobile app web panel	Mobile app crowd- sourcing
Work	20	12	21	20	10	11	14
Leisure	18	28	16	16	12	15	15
Service- related	11	10	7	12	10	12	10
Shopping	10	9	11	8	10	9	8
Pick up/ drop off	15	10	22	15	10	8	9
Other purpose	32	24	34	23	7	8	14
All	27	17	28	19	10	10	12

Table 17. Average trip length (km) per trip broken down by purpose for the various survey groups.

# 3.6 Uncertainty estimates

The results of the variance estimates made using the bootstrap method (see Chapter 2.5.4 for details) are presented in Table 16 with regard to the share of respondents who travelled. The panellists in the online questionnaire stand out with a relatively small share, i.e.,  $76.5\% \pm 5.5$  percentage points, who made at least one trip on the measurement day. This confidence interval is distinct from the confidence interval that can be generated for the group recruited via crowdsourcing. This means that, for the random groups (with and without incentive) and the crowdsourcing group, there was no "significant" difference in the share that travelled according to this estimating method.

Table 18. Upper and lower limits of confidence interval using bootstrap for the share that travelled on the measurement day.

	2.5 percentile	97.5 percentile
Online questionnaire random without incentive	77%	89%
Online questionnaire random with incentive	76%	87%
Online questionnaire web panel	71%	82%
Online questionnaire crowdsourcing	84%	93%

Corresponding results for the uncertainty estimate of the number of trips are presented in Table 19. Here again the web panel group differs from the crowdsourcing group in having a significantly lower number of trips per person on the measurement day. However, the web panel group trips are also significantly fewer than is the case for those who were recruited randomly and given an incentive. In the case of the mobile app groups, the number of trips per person and day is significantly higher for the crowdsourcing group than for either the randomly recruited group or the web panel group.

Table 19. Upper and lower limits of confidence interval using bootstrap for the number of trips per person among those who travelled on the measurement day.

	2.5 percentile	97.5 percentile	Mean value
Online questionnaire random without incentive	2.13	2.89	2.50
Online questionnaire random with incentive	2.18	2.71	2.40
Online questionnaire web panel	1.66	2.15	1.90
Online questionnaire crowdsourcing	2.53	3.02	2.80
Mobile app random	4.70	5.49	5.07
Mobile app web panel	5.06	5.57	5.31
Mobile app crowdsourcing	5.89	6.54	6.20

# 3.7 Estimated collection costs

Before a description of the estimated costs is provided, we need to outline the assumptions that were made when determining them. Our survey was predicated on obtaining 200 respondents per group. Normally one would prefer to have significantly more respondents than this, with a view to achieving higher precision in the individual point estimates than in our case. This means that the cost per collected response is normally lower than that reported here. We have determined both the external and internal costs of conducting our pilot surveys. We believe that we have estimated the external costs relatively accurately, as the expense items are clearly defined. The internal costs are, on the other hand, more difficult to estimate. For the sake of comparability, an estimate is made per respondent, and the definition of the number of respondents here is the number of net responses. We are reporting only estimated collection costs, to which the following costs are additional:

- Preparations for and execution of the procurement process
- Formulation of survey questions
- Preparation of cover letters
- Support under the collection period
- Analyses and compilations of the results
- Standard report

In addition there was an increase in the postal rate, which was not taken into account in our cost summary. Appendix 9 provides a summary of how we estimated the costs. Note that this estimate applies solely to these surveys and their associated circumstances; if one were to repeat the surveys the results would probably be different. Table 20 below presents the estimated data collection cost per survey group. There are two breakdowns, i.e., per respondent and per trip day. The mobile app is more expensive per respondent than the online questionnaire, but less expensive per trip day. A trip day from each of many individuals is something that is valued highly, although multiple trip days from a single individual are valuable as well. This reasoning is described in greater detail in the discussion chapter.

	Per resp	ondent	Per trip day**		
Recruitment method	Online questionnaire	The mobile app	Online questionnaire	Mobile app	
Random sample without incentive	350	433–1,420*	350	47–153*	
Random sample with incentive	400		400		
Web panel	330	690	330	61	
Crowdsourcing	230	390	230	25	

Table 20. Summary of the estimated costs (in SEK) for the various groups, broken down by respondent and trip day. Based on net responses.\*

\*The cost calculation for the random sample with the mobile app is based on a response rate of 3–8%. The response rate in this pilot survey was 3%, but all of the cover letters were, unfortunately, sent out too late, which led to numerous complaints and is probably the reason for the low response rate. The response rate achieved in a concurrent study in Umeå was 8%, and there the cover letters were sent out in a timely fashion (however, the study targeted only the population between the ages of 30 and 49 years).

\*\*The mobile app collected multiple trip days, while the online questionnaire collected one trip day per individual.

The crowdsourcing recruitment method had the lowest cost per respondent with respect to both the online questionnaire and the mobile app. The crowdsourcing involved "editorial material". This could be compared to the cover letter for the web panel and random sample, which were not included in the costs above, i.e., the cost of crowdsourcing could be considered to be even lower. There were no major cost differences between web panel and random sample without incentive in the case of the online questionnaire.

The random sample for the mobile app exhibits a difference of roughly SEK 1,000 per correspondent and roughly SEK 100 per trip day, depending on whether a 3% response rate or 8% response rate is assumed. This is considered to be more expensive than crowdsourcing, but we cannot speak to the cost differences with regard to the web panel. The cost of the web panel is roughly 70% higher per respondent than in the case of crowdsourcing.

#### 4 Discussion

In this chapter we will discuss the results we obtained and the conclusions that can be drawn from them. We have divided it into four subsections, with the first focusing on the data collection methods, the second on the recruitment methods, and the third on cost effectiveness, which is followed by a concluding discussion.

#### 4.1 Data collection methods

#### 4.1.1 Online questionnaire

The online questionnaire that was designed contained an interactive map on which the respondents were to mark the start and end points of their trips. In paper questionnaires, such as Gothenburg's TS, the respondents are instead asked to provide addresses for these points. A map can be helpful to respondents who do not know the address of a place they have visited. In the online questionnaire a question was posed as to the "main purpose" of the trip. This wording was, unfortunately, incorrect, and it should have been expressed simply as the "purpose". One consequence of this could be that fewer trips were reported than would otherwise have been the case, as a comparison with the results of TS Gothenburg and TS Sweden indicates.

The respondents were instructed to describe their trips over a given measurement day. Twenty people submitted responses before their actual measurement day. Half responded the day before, although there were some who responded up to five days before their measurement day. Of these 20 people, 17 had been given an incentive. Their choice of trip day could have been influenced by, for example, their having travelled in their customary way on the very day reported, and by their then having found it easier to fill out the questionnaire/recall how they had travelled. We have opted to keep these travel data in the analyses and treat them as though these individuals had responded on their selected measurement day. This has probably not affected the results as a whole. It does, however, call into question to some extent how certain we can be as to whether the reported trips actually took place on the stated day.

#### 4.1.2 Mobile app

When a mobile app is used, all movements are registered based on the mobile app settings. In our case the mobile app began registering a movement automatically as soon as it was detected. A trip purpose was registered whenever the subject had been in the same location for at least two minutes. This means, for example, that a shopping trip in a downtown area can generate many trips with shopping and/or service-related purposes. This is consistent with the definition of purpose, which is a movement that starts and ends to achieve a single aim. In contrast to the travel survey app, a round of shopping will probably be reported as a trip when the respondents report their travel themselves in an online or hardcopy questionnaire.

One assumption associated with the registering of movements by the mobile app is, of course, that the individuals have the mobile phone with them as they move about. It is, however, possible for them to register their movements in the app after the fact, which is the behaviour sought. However, it is not possible to add a GPS trace in the mobile app that we used, with the result that this information is lacking for any trips registered after the fact.

Various levels of involvement are required on the part of the respondents depending on the complexity of the trips they make during a day, i.e., everything from looking through and making sure that everything is correct and marking that the day is correct, to changing the mode of travel, times, distances, and splitting up or consolidating trips. As a result, there may be a risk that more complicated trip days will not be corrected to the same extent as more typical and uncomplicated days. One potential consequence of this is that too few trips will be registered (if more complicated days contain VTI PM 64 more trips). It is difficult to assess the scope of this problem. The mobile app provides significantly more trips than do the online questionnaire or traditional methods, but it is not possible to check what the actual number of trips is.

A few respondents provided feedback concerning their problems in using the mobile app. They found that it was draining too much battery power when the GPS function was activated, and they consequently uninstalled the mobile app. One person pointed out that the mobile app had repeatedly incorrectly registered movements made by bicycle. These are both known challenges, and various mobile apps have chosen somewhat different designs. Using GPS requires energy, which means that the challenge lies in finding a trade-off whereby the GPS can be used as little a possible while still ensuring that the information collected still suffices to enable a description of the trips that is as sound and accurate as possible. With regard to the accuracy associated with identifying various modes of travel, it is not currently possible to estimate it with 100% certainty. Research tests in the field identify up to 85–90% of the trips. The problem can have to do with GPS traces (e.g., lost trace, no data underground, the mobile app fails to start collecting GPS data, or the GPS is blocked for some reason) or problems resulting from similarities in modes of travel (e.g., difficulties in finding algorithms of sufficient quality). Short bus and bicycle trips in an urban environment often resemble one another, as is also the case with lengthier bus and car trips. In addition to algorithms for classifying the mode of travel, the mobile app used in this study also has a learning function, with the result that, overall, we achieve 80-85% accuracy in terms of mode of travel detection.

A mobile app should offer more reliable estimates of trip lengths by bus, bicycle, and on foot in urban environments. The geocoding of addresses should be more accurate with a mobile app. That the geocoding is sometimes absent may be because the respondents entered a trip themselves, with the result that it lacks geographical information. However, in future it may be possible for respondents to enter their own geographical data in a mobile app. Travel time registration should also provide for more reliable estimates, as estimating how long a trip has taken is often difficult if one does not note that during the course of the trip.

One advantage associated with travel data collected via the mobile app is that entire trip chains are obtained. It is not possible, based on the travel data collected via the online questionnaire used in the pilot study, to determine which modes of travel have been used, or in what order.

Another advantage of a mobile app versus a questionnaire is that a person's movements can be collected for more than a single measurement day. This may be of interest in a number of contexts, for example, if one is interested in whether and how people use various modes of travel over time. In our study there was a broad spread in the number of days corrected per person. It ranged from a single day to the duration of the entire collection period (31 days); at least seven days were sought. The different recruitment methods resulted in different numbers of corrected days per person, with those who participated in the crowdsourcing correcting an average of 16 days. The averages were in excess of seven days (9 and 11, respectively) in the random sample and web panel groups as well. This indicates that, for many people, using the mobile app for a week is not overly onerous.

#### 4.1.3 Differences in collection methods' response rate and item nonresponses

One general problem with current sample surveys is a declining response rate. If the number of respondents falls too low, problems in terms of heavy skewness can arise, so that the results do not correspond with what is being sought, i.e., the target population. Certain groups may be left out partly or entirely if there are too few respondents. The response rate has decreased dramatically over a short time in the case of the national travel survey, i.e., from 68% for RES 2005–2006 to just 32% for the 2016 TS Sweden. These surveys were conducted via telephone interviews at a time when we were seeing a trend towards fewer and fewer fixed telephone subscriptions. One partial explanation for the low response rate could be that the selected individuals chose not to answer incoming calls to their mobile phones that are made from unfamiliar numbers. Caller ID technology has also contributed to VTI PM

people declining to answer calls from unfamiliar numbers (Braunsberger, Wybenga & Gates, 2007). Another common method for collecting travel data is via paper questionnaires, and here again we are seeing declining response rates. TS Gothenburg was carried out concurrently with our pilot study, and there data were collected using both paper and online questionnaires. Gothenburg's TS saw a response rate of 27% in the fall of 2017.

In this pilot study we have studied two data collection methods that offer alternatives to the aforementioned traditional methods (i.e., telephone interviews and paper questionnaires with travel diaries). These two alternatives were an online questionnaire and a mobile app. The response rate can be calculated only in those cases in which the number of people included in a sample is known. The response rates were 14% and 16% for the groups that were selected at random and completed the online questionnaire, respectively, and 3% for the mobile app. However, there were problems in connection with the mailing of the cover letter about the mobile app, and we believe that the response rate should have been 5-10%.<sup>6</sup> The response rates for these two data collection methods were considerably lower than for the traditional ones. One partial explanation could be that, in our pilot studies, we made just two attempts at contact via letters, while TS Gothenburg made three attempts at contact via letters and a fourth by telephone.

Which way of reporting their movements is preferred by the respondents? In the nonresponse analysis conducted by Enkätfabriken, the participants were able to pick the data collection method they preferred. Online and paper questionnaires were equally preferred (i.e., 30% versus 29%); somewhat fewer preferred to be interviewed by telephone (24%), while 11% preferred a mobile app and 7% answered "Other". In TS Gothenburg, where the option of completing an online questionnaire instead of the paper one was offered, 60% chose the paper questionnaire, with 40% providing their responses via the online questionnaire. Those who were recruited via crowdsourcing and expressed interest prior to the start of the data collection period were evenly distributed in terms of which collection method they preferred, i.e., online questionnaire or mobile app. In the nonresponse analysis, people were also asked why they did not download the mobile app. One of the reasons given was secrecy/privacy, with roughly 3% citing that as the reason. In the SPOT study that was conducted in 2015, people were asked which travel data collection method they considered to be more intrusive from a privacy standpoint; 43% answered that they saw the mobile app as being more intrusive than the online questionnaire (Allström et al., 2016).

The item nonresponse was lowest for the mobile app, although it was low for the online questionnaire as well. The online questionnaire had the most problems in terms of a lack of both start and end points. The problems encountered in the traditional survey, i.e., TS GBG, had to do primarily with erroneous/lacking travel times.

### 4.1.4 Differences in the data collection methods' respondent profiles

Traditional travel surveys are conducted in the form of sample surveys. We want to say something about all the trips that are made by questioning a sample of the population. It is consequently important that those who respond to the survey are representative in terms of their travel behaviour. One common perception is that people who are similar to one other or live under similar conditions

 $<sup>^{6}</sup>$  The response rate for the random sample with the mobile app was 3% in this study, but unfortunately all the cover letters were sent out too late, which led to many complaints and is probably the reason for the low response rate. A more reasonable response rate would be 5–10%, based on a response rate of 8% in a concurrent study in Umeå, where the cover letters were mailed out properly (however, only people between the ages of 3 and 49 years were targeted). The study in Umeå also involved one original mailing and one reminder, i.e., the same set-up as in this study.

have similar travel behaviour; background questions are consequently posed to the respondents regarding their family circumstances, job situation, residence, etc.

When the respondent profiles are compared, we can see that the groups recruited via crowdsourcing exhibit greater deviations from the target populations (per register data) than do the groups recruited via random sampling or the panel. The group that used a mobile app and was recruited randomly is the one that best reflects the gender and age distributions in the target population, followed by the group that responded via the online questionnaire and was recruited via the panel. Women are more preponderant for the online questionnaire than the mobile app (although this does not apply to the panel). The age distribution is skewed in the older direction for people who responded via the online questionnaire and was mappling, but is skewed toward the middle ages (i.e., 25–64 years old) in the case of crowdsourcing (both online questionnaire and mobile app). The respondents are significantly more likely to possess driving licenses than is the target population, across all groups.

The groups that used the online questionnaire and were recruited at random or via the panel comprise the gainfully employed to a lesser extent than does the target population, while the groups recruited via crowdsourcing comprise the gainfully employed to a greater extent than does the target population. The groups that used the mobile app and were recruited at random or via the panel reflect the target population relatively well with respect to gainful employment. The groups that used the online questionnaire better reflect the target population in terms of type of residence (i.e., flat or detached house/townhouse) and place of residence (i.e., Gothenburg municipality/Other municipalities) than do those that used the mobile app. Households comprising cohabitants without children are overrepresented across all groups.

It is also evident that Gothenburg's traditional survey has problems with representativity as well, i.e., women and the elderly are overrepresented, as are people with driving licenses and cohabitants without children.

If the respondent profiles are not representative of the population the sample is to reflect, this can be addressed by weighting the results so that responses deriving from an underrepresented group are ascribed more importance in the overall results. However, it is not possible to weight for properties that are unknown, for example, if people who travel less are less inclined to respond.

Based on the work done in this study on the various weighting methods, it is clear that there is much to be gained from working more with weighting, perhaps even in the context of traditional collection methods that employ random sampling. The results indicate that, regardless of recruitment method, the estimates grow more alike the more closely the target population can be approximated via weighting, which could open the door for more recruitment methods. This is an interesting area in which more work should be done. However, there are limitations in that not all differences between individuals can be discerned in background variables and register data, i.e., there is a risk of a skewed nonresponse of significant factors of which we are unaware and/or cannot correct for.

### 4.1.5 Differences in collection methods' trips and trip lengths

When analysing the number of trips, the clearest difference between the two collection methods is that the mobile app groups registered approximately twice as many trips as did those who completed the online questionnaire. This difference is attributable mainly to the fact that the mobile app groups made roughly one more trip by car and 1–1.5 more movements on foot than did the online questionnaire groups. We also see that, on average, the mobile app groups made, in round numbers, one more leisure trip and one more shopping trip per person and day than did the online questionnaire groups.

No similar such clear pattern in terms of the average trip lengths is evident between the groups created using different collection methods, particularly if we ignore the "Train" and "Other" modes of travel, where individual longer trips can have a major impact on the mean trip length. The average distances VTI PM 67

travelled per trip varied less in the mobile app data for the car, bicycle, walking, and public transport modes of travel compared with the online questionnaire data. We can also see that the average trip length of car and walking trips was longer for the online questionnaire than for the mobile app, i.e., the mobile app captured more short trips.

Respondents using the online questionnaire had more days without trips, than did the respondents who used the mobile app (11-23% versus 8-15%). In the nonresponse analysis, 29% of those who were invited to respond via the online questionnaire reported having made no trips during the measurement day. It was not possible to pose a corresponding question to those who were invited to respond via the mobile app, as they were assigned no specific measurement day. A higher share of days without trips among those who did not respond could yield a skewed nonresponse, and lead to an overestimation of the number of trips per day.

Overall the study shows that a mobile app registers significantly more trips than does an online questionnaire, while the trip lengths are comparable. If we do not believe that major persistent differences are present in the compositions of the groups after weighting, this means that similar travel patterns are being registered differently, depending on the data collection method. One possible interpretation is that people who respond to the online questionnaire to some extent forget or conflate short trips (particularly trips made for the purposes of "leisure" or "shopping" and with the modes of travel "walking" or "car"). One explanation for this is presumably that it is easier to confirm/correct the trips that the mobile app proposes than it is to recall and enter all one's trips in an online questionnaire.

Another difference is that the mobile app has the ability to collect multiple days per individual. A desire for the ability to track individuals in both the short and long terms over time was expressed repeatedly by stakeholders interviewed in work package 2 (Eriksson et al., 2017) with regard to future TSs. The mobile app can make this desire a reality. On the other hand, the response rate from the random sample was low in the case of the mobile app.

### 4.1.6 Comparison with the SPOT project

A similar study conducted in the SPOT project compared a mobile app (MEILI) and on online questionnaire, both of which collected a person's travel activity over one day. There were 431 people who completed an online questionnaire and 293 who used the MEILI app. The average trip length per trip was 16.9 km for the online questionnaire and 11.8 km for the mobile app. Here it was found that the trip lengths in the online questionnaire could vary because the respondents estimated and approximated their own trip lengths, while the trip lengths in the mobile app were based on an algorithm that provided more precise lengths (assuming a good GPS signal). The group that completed the online questionnaire tended to miss trips home, while the mobile app tended to miss trips made for the purpose of picking up/dropping off someone. However, the mobile app did capture detailed information about trips (Allström et al., 2016). In our study, the trip lengths per trip ranged from 17 to 28 km (depending on the recruitment method), and from 10 to 12 km for our mobile app. The trip lengths for the online questionnaire were longer than for the mobile app in both the SPOT study and our study.

### 4.1.7 Differences in mode of travel and purpose

The greatest differences in the number of trips between those who used the mobile app and those who completed the online questionnaire are seen with respect to the trips made on foot or by car. This is probably attributable to those who completed the online questionnaire having forgotten short trips made on foot, and having forgotten some trip purposes when they travelled by car. The number of trips made on foot in the case of the online questionnaire ranged from 0.2 to 0.4 (TS GBG 0.4 trips), while the corresponding figure for the mobile app was 1.5-2.1, i.e., the online questionnaire misses roughly 1–2 trips per person and day. In the case of trips made by car, the corresponding figure was VTI PM

1.1–1.5 in the online questionnaire (TS GBG 1.7 trips) and 2.4 in the app. Here the online questionnaire respondents missed roughly one trip by car per person per day. It appears that it is mainly trips made for purposes of leisure or shopping that the online questionnaire misses. One explanation for this could be that the online questionnaire participants shop in multiple locations with several short intervening trips on foot, but when they register their trips they ignore/forget the short trips on foot and, in turn, the other shopping. With respect to there being a lower number of trips for leisure in the case of the online questionnaire participants, this could be attributable to their perhaps having gone to their leisure destinations directly from work, without thinking to split the work-related travel into two trips. This possibility is supported by the fact that the trip length per day and person is roughly equal regardless of the data collection method, as well as the fact that the trip lengths are longer for the online questionnaire participants.

# 4.2 Recruitment method

### 4.2.1 Random sample

A probability sample offers a major advantage in that uncertainty estimates can be generated based on established statistical sampling theory. The sample in our case was drawn from the State Personal Address Register (SPAR) in eight strata by gender plus four age groups, and was not entirely proportional to the population in the survey area. It was then broken down based on the two collection methods, i.e., online questionnaire  $(1,400 \times 2)$  and mobile app (2,800). The sample sizes for the two online questionnaire groups proved to have been weighted well, as the target of roughly 200 responses was achieved. We got 70 respondents for the mobile app, with the result that our target of 200 responses was not achieved. This was largely attributable to the cover letter process not having worked as intended, and all the cover letters for the mobile app users were, unfortunately, sent out too late in relation to the desired starting date. This was pointed out by a large number of people via the e-mail stated in the cover letter. It is difficult to say what response rate would have been achieved had the mailings worked properly, but one indication may be found in a study in Umeå that was conducted over the same time period and in which the response rate was 8% (sample of population aged 30–49 years). Given a response rate of 7%, 200 people would have collected data, i.e., the target would have been achieved.

The study design involved one regular mailing and one reminder. Traditional surveys usually have more reminders; for example, Gothenburg issued two reminders by postal letter plus a final reminder by telephone. Our response rate would likely have increased somewhat had we had more reminders.

We could not identify and, consequently, could not exclude people in our sample who were also included in the Gothenburg TS sample, which could have led to these individuals' inclination to respond being lower than it would normally have been. However, this would have pertained only to the small number of people who would have been included in the samples for both surveys.

An incentive in the form of a gift card worth SEK 100 was tested with a view to increasing the response rate, but its effect was marginal, i.e., the response rate was only two percentage points higher in the group that received the incentive than in the group that did not. On the other hand, it appears that the 16–24-year age group did find this incentive attractive, as there were somewhat more respondents in the incentive group than in the group with no incentive in this age range.

### 4.2.2 Web panel

In our case we opted for a so-called mixed panel consisting partly of randomly recruited individuals and partly of self-recruited individuals. Opting for a completely randomly recruited panel or a completely self-recruited panel was not considered to be an alternative, as the recruitment methods in our study may be said to be represented by the random sample versus those recruited via crowdsourcing.

VTI PM

Those people who become members of a web panel and are attracted by incentives to participate in surveys, for example, in the form of points exchangeable for goods, may deviate from the rest of the population. There is a risk that panellists will evolve into "opinionators", i.e., people who fill out online questionnaires by providing the minimum essential information in order to amass points quickly and with the least possible effort. This phenomenon could explain why the web panel group that reported its trips via the online questionnaire had the most trip-free days and, at the same time, the lowest number of trips per day. With regard to the mobile app, the web panellists reported roughly the same number of trips as did the random sample group, which could be attributable to the greater difficulty of "coming up with" a behaviour when the mobile app proposes how one has travelled.

Numerous mailings to people in the web panel were needed, i.e., over 5,000, plus an extra incentive (i.e., a gift card worth SEK 100) before the target of 200 people who had downloaded the mobile app was achieved. The working method employed by web panel companies tends to involve directing the mailings towards the types of respondents who are underrepresented among those who have responded up to that point.

Membership in a web panel is subject to an age limit of 16 years. If this recruitment method is chosen, trips made by children between the ages of 6 and 15 years will not be captured (such trips have been deemed important to capture; see Transport Analysis, 2018, with regard to bicycle trips), and a different recruitment method must then be considered.

#### 4.2.3 Crowdsourcing

This recruitment method is based on people actively choosing to participate after having noticed the study mentioned in social media, a newsletter, etc., while receiving nothing in return (with the possible exception of the mobile app users, who received a summary of their travel behaviour). Among these people there may be those who are heavily engaged in the topic in question, and some may take notice of the opportunity and utilise it for their own purposes. That this was also the group that reported the highest number of trip days per person via the mobile app (16 days per person versus 9 and 11, respectively) indicates that these people have a strong interest in contributing to research and/or are have a greater than average interest in transport-related data.

It turned out that the target of 200 respondents per data collection method was surpassed using crowdsourcing. The most successful channel for acquiring potential respondents proved to be a Facebook advertisement to which a large number of people were exposed. Before recruiting via crowdsourcing, the conceivable channels should be mapped carefully with a view to reaching, to the greatest possible extent, people who are representative of the target population. It would, for example, have been unsuitable to advertise for travel survey participants on buses or at bus stops, as that would probably result in public transport passengers being over-represented. However, recruitment via crowdsourcing is likely to reach few, if any, people in the 6–15-year age group. Using crowdsourcing it is also possible, as it is with a web panel, to direct recruitment efforts towards groups that are underrepresented.

#### 4.2.4 Differences in recruitment methods' respondent profiles

When we compare the respondent profiles, we see that the groups that were recruited via a web panel or by random sampling better reflect the population (as per register data) in terms of age and gender distribution than do those recruited via crowdsourcing. Moreover, crowdsourcing was the least effective at achieving a representative distribution for the two employment categories (i.e., gainfully employed/not gainfully employed), while the other two recruitment methods were roughly equivalent. The groups recruited via the web panel were skewed the most in terms of distribution by type of residence, while the random sample and crowdsourcing groups generally fared better (this does not apply to the mobile app users in the random sample group, which was also severely skewed). Crowdsourcing was the least successful in recruiting people who reflected the distribution of the VTI PM population in Gothenburg versus other municipalities, while the web panel and the random sample were roughly on a par in terms of their deviations. Randomly recruited and web panel-recruited groups exhibited somewhat better agreement with register data than did the crowdsourcing group across all studied background variables. It is interesting that the random sample is so skewed with respect to a number of background variables above and beyond gender, age, and geography, as these are the only parameters that are adjusted for in the traditional weighting process.

### 4.2.5 Differences in recruitment methods' trips and trip lengths

Any differences in the numbers of trips that are attributable to the different recruitment methods are easily "drowned" in the major differences that emerge when the data collection methods are compared. On the other hand, if we compare the recruitment methods within each data collection method we see that those recruited via crowdsourcing had the highest average number of trips per day, and the lowest number of trip-free days. Crowdsourcing is based on interest and voluntarism, and most respondents were obtained using this recruitment method (407 for the online questionnaire, 284 for the mobile app). That they also take the most trips could be interpreted to mean that members of this group want to influence the outcome, or that those who travel the most are the most interested in participating, as they believe that they have the "most" to contribute to or the "most" to gain from improving knowledge of the transport system. Members of this group were gainfully employed to a high degree, and many of them have their driving licence, factors that could indicate frequent travel. This is the group whose data deviate the most from the register data, and this recruitment method is completely open and difficult to control; what we can do is expand recruitment initiatives in locations and forums in which underrepresented groups are present.

The differences are not as great when the trip lengths are compared, with one exception, i.e., those who were recruited via crowdsourcing and used the mobile app travelled farther than did the others, primarily by train and other modes of travel (e.g., aircraft). These people were largely of working age, and a high percentage had their driving licence, which could be indicators of people who travel great distances.

This pilot study shows how the results are affected depending upon the three recruitment methods. The three methods perform differently, and it is not possible to determine which one is best. Crowdsourcing appears promising in terms of the number of respondents, and if the deviations from register data are corrected via weighting. However, the possible presence of undiscerned skewness in the relevant background variables should be taken into consideration.

#### 4.3 Cost effectiveness

## 4.3.1 Collection method

In the traditional travel surveys (e.g., telephone and postal questionnaires), travel movements are obtained for just one selected day. The associated costs tend to include those of interviewers, hardcopy mailings, etc. Using the Internet makes it possible to collect data in a different way, i.e., by sending out questionnaires to the respondents via their computers and smart phones. Online questionnaires are considered to be inexpensive and fast in comparison with traditional data collection methods (Börkan, 2010). In this pilot study, we can see that both the online questionnaire and the mobile app are less expensive than traditional mailings of paper questionnaires. The costs of large traditional surveys are estimated at SEK 120–170 per respondent. A large survey is always less expensive per respondent, as there are significant cost factors that are not driven by the number of participants (i.e., fixed costs), and because larger runs of, for example, printed questionnaires result in a lower price per questionnaire.

If we compare the online questionnaire and the mobile app, the online questionnaire yields a lower cost per respondent, while the mobile app yields a lower cost per collected trip day. The cost estimate VTI PM 71 is heavily affected by the response rate, with the result that it is difficult to speak to the cost per respondent in the random sample for the mobile app. There is a difference of SEK 1,000 per respondent if we assume a response rate of 3–8%.

If we compare the data collection methods by collected trip day, the mobile app is significantly less expensive, with a collected trip day costing between one-tenth and one-fifth as much as in the case of the online questionnaire. The question that we need to ask ourselves is this: How valuable are five days from one person compared with one day each from five people? This study offers no answer to that question, but it is likely that five days from one person are not as valuable as one day each from five people, but significantly more valuable than one day from one person. The answer also probably depends on the questions to which one is seeking answers in the material. Beyond containing more data, more days from the same person also enable new types of analyses. A desire for multiple days from the same individual was expressed in the stakeholder analysis (Eriksson et al., 2017).

### 4.3.2 Recruitment method

Traditional travel surveys are based on random samples, but there are different ways of recruiting respondents/participants for travel surveys. Our results indicate that the traditional recruitment method (random) and a web panel are roughly equally expensive to conduct per respondent. Collection via crowdsourcing is somewhat less expensive.

When collecting data for a real travel survey, a significantly higher number of responses than the 200 we had in this pilot study is sought, i.e., normally between 2,000 and 3,000 respondents. Different recruitment methods scale well to differing degrees and in different ways. The random sampling as configured here necessitated postal mailings, the costs of which scale nearly one to one (some savings may be realised in the form of lower printing costs with large print runs), while the costs of web panel and crowdsourcing recruitment increase in different ways, as it is less expensive to duplicate electronic messages. On the other hand, there may be an upper limit on what it is possible to achieve via a web panel, and this may be true of crowdsourcing as well. A web panel contains a given number of people, and if the data collection process requires responses from too high a proportion of them, it may be difficult to achieve success. Knowledge of how crowdsourcing scales is limited, but it is reasonable to imagine that here again there is an upper limit on the number of people who can be induced to participate.

## 4.3.3 Comparison

When it comes to the differences between them, both data collection methods have their advantages and disadvantages, but one of the most important differences has to do with the number of days they collect. This means that it is more difficult to compare the two data collection methods from a cost effectiveness standpoint. The mobile app is more expensive per respondent, regardless of recruitment method; conversely, the mobile app is less expensive per trip day across all recruitment methods.

With regard to the recruitment methods, crowdsourcing is less expensive than a random sample or a web panel. The web panel is roughly twice as expensive for the mobile app as for the online questionnaire. A web panel and crowdsourcing can be performed quickly. Web panel surveys have grown dramatically in recent years (Braunsberger, Wybenga & Gates, 2007), while crowdsourcing as a recruitment method is relatively new, and less pertinent knowledge is available. Although web panels and crowdsourcing are less expensive, problems can arise in reflecting a target population.

# 4.4 Concluding discussion

The response rates for both the online questionnaire and the mobile app in our study were lower than those achieved in the Gothenburg travel survey, which used a paper questionnaire, or in Transport Analysis's telephone-based travel survey. Any hopes that new data collection methods such as mobile
apps and online questionnaires could achieve higher response rates thus appear to have gone unfulfilled. The basic problem of a low response rate and the risk that the responses will not be representative of the target population remain, despite the new data collection methods.

Our analysis of how well the respondents correspond to the target population based on comparisons with register data shows that there are relatively numerous deviations, some major and some systemic, such as the over-representation of people who have a driving licence and of cohabitants without children across all recruitment and data collection methods. Even though the respondents do not fully reflect the target population, it is difficult to rule out the possibility that a web panel and/or crowdsourcing could provide additional information with respect to traditional probability-based methods.

One way of dealing with the failure of the respondents to reflect the target population is to weight the responses so that those groups that are over-represented become less important, while the responses from those groups that are underrepresented become more important. Our weighting efforts show that the differences between the data collection methods in terms of the number of trips per person and day are diminished once we have weighted the results so that they reflect the target population to the best of our ability. However, we can only weight variables about which we possess knowledge in the contexts of both the target population and the respondents. If our respondents deviate from the target population in some way that we cannot measure, for example, by having different values that in turn affect their travel behaviour, then we cannot address the problem through weighting, and run a risk of obtaining less reliable results. This applies across all the data collection methods, and even though the mailings to respondents can be done randomly, we have no guarantee that those who respond constitute a random subset of the sample. Those who respond may have underlying values that lead them to respond, and that could also affect the ways they travel. One example where the random sample did not result in representative respondents is seen in the nonresponse analysis with respect to the number of trip-free days. In the nonresponse analysis of the random sample for the online questionnaire, nearly twice as many (29%) people reported having not travelled on their measurement day compared with those who completed the online questionnaire from the random sample, in which 16-18% of the respondents had trip-free days. If it is true that those who responded to our survey travel to a greater extent than those who did not respond, and that this cannot be explained using the variables that we used in weighting the results, then our survey will overestimate the number of trips in the target population.

With regard to travel, the data collection methods exhibited major differences in the numbers of trips. The mobile app captures nearly twice as many trips as the online questionnaire or traditional TSs, although the trip lengths do not differ as much (crowdsourcing stands out somewhat in terms of the number of trips and trip length). It appears that the mobile app is better at capturing short trips made on foot or by car, often for the purpose of "leisure" or "shopping".

The large difference in the number of trips per person and day between the mobile app and the online questionnaire points to how we define a trip. A trip is currently defined as a movement that begins and ends to fulfil a purpose, and by this definition a stop on the way to work to drop children off at preschool, a stroll between different downtown businesses and a stop to fuel the car are all purposes that will generate new trips. Mobile apps measure trips in this way, and ignore whether they involve a quick stop to do something minor or something that constitutes a key errand. The situation may be different if the respondents themselves are reporting. The stop at the preschool will likely be reported in most cases, while the trips made downtown between various business are less likely to be. The question is thus whether the stop to fuel the car will or will not be reported by those who complete an online questionnaire/paper questionnaire/telephone interview. We go through a self-selection process when we report our trips, so that only those movements that we view as proper trips are included. It is thus not odd that we measure more trips via the mobile app than when self-reporting (regardless of

whether it occurs via an online or paper questionnaire). To this must be added human forgetfulness and, in various cases, laziness as well.

The questions we should ask will address what we are interested in knowing. Short walking trips are very important in certain contexts, but not in others. If we do not want all of these small trips (e.g., between businesses) or trips involving short stops (e.g., fuelling the car) to be included, then the definition of what constitutes a trip needs to be changed. If we keep the current definition, then we have to concede that self-reporting is underreporting, and consider how we can work to reduce the loss of trips.

Given the large differences in the number of trips per person and day among the various data collection methods, we may ask ourselves which one comes closest to the truth. Unfortunately this is a question that cannot be answered, as we do not know what the reality is like. The results of the online questionnaire are those that most resemble the results of traditional travel surveys. At the same time, there are GPS traces that indicate that the actual trips could be higher in number, and the reasoning offered above provides a partial explanation for why self-reported trips could involve underreporting. The results we have obtained here are consistent with a Canadian survey in which an online questionnaire and mobile app were also used (a different app from the one we used in this study). This study's results indicate that the online questionnaire yielded between 2.2 and 2.8 trips per person and day, and the mobile app 5.5 trips per person and day.

## 5 Conclusions

## 5.1 Conclusions – data collection

- In this pilot study, the online questionnaire and mobile app data collection methods yielded significantly lower response rates than did the traditional surveys conducted using paper questionnaires or telephone interviews, but this could be due in part to having sent out fewer reminders than is customary, and the fact that the mailing of information to the respondents did not go according to plan.
- An incentive of SEK 100 appears to have had a marginal effect on the response rate.
- According to the nonresponse analysis performed in the study, time issues were cited as the main reasons why the people in the random sample did not download the mobile app (20–30%). On the other hand, there was a small percentage (just over 3%) who refrained from participating on privacy grounds.
- One group of people that is not reached if a mobile app is chosen naturally consists of those who do not have access to a smart phone. One out of ten people who were queried in the nonresponse analysis were unable to participate for that reason.

## 5.2 Conclusions – recruitment

- A random sample has an advantage in that everyone in the target population can be reached by postal mailings. People who are not participants in digital society are more difficult to reach by web panels and crowdsourcing.
- Crowdsourcing can be a successful recruitment method in terms of obtaining a high number of responses, but it requires a well thought-out strategy when disseminating information about the survey, and the data material may subsequently need to be weighted in some way other than the traditional manner.
- Reaching children under the age of 16 years can be problematic when using web panels (age limit for registering) or crowdsourcing (particularly those in primary and middle school).

## 5.3 Conclusions – respondent profiles

We had access to distributions for a number of background variables from register data, which we then compared against our survey groups. The comparisons were made using unweighted data. We reached the following conclusions regarding the respondent profiles:

- In all the survey groups included in our study, more of the respondents had a driving licence, were cohabitants without children, and resided in Gothenburg Municipality than was the case in the register data.
- The most people responded in the crowdsourcing group, but those respondents also exhibited the most deviations from the register data.
- People who used the mobile app and were recruited by random sampling exhibited gender and age group distributions similar to those of the register data.

## 5.4 Conclusions – travel habits

- The share of those who had travelled on the measurement day was significantly lower in the group that was recruited from the web panel than among those who were recruited via crowdsourcing and were among those who completed the online questionnaire.
- Trips were usually made by car, and this applies across all survey groups and in traditional surveys. Trips made on foot were more prominent when the mobile app was used.
- The mode of travel "Car" had the longest trip length, regardless of survey group.
- There were twice as many trips per day and person with the mobile app, but roughly the same trip length as with the online questionnaire. The mobile app yielded one more trip by car and 1–1.5 more movements on foot per person and day. The online questionnaire respondents probably forgot some trip purposes.
- The number of trips reported via the online questionnaire was significantly lower among those recruited via a web panel than among both those recruited via crowdsourcing and those who were randomly recruited and given an incentive.
- The most common purpose of trips reported in the online questionnaire was for work, albeit with the exception of the web panellists, among whom the category "Other" predominated. On the other hand, the most common purpose of a trip in the case of the mobile app was for leisure.
- The purpose that was associated with the longest trip length in the case of the mobile app was leisure. There was more variation in the online questionnaire, where the purpose "Other" dominated with the longest trip length for the random sample with or without incentive, and for the web panellists. In the case of crowdsourcing, work trips were associated with the longest trip lengths.

## 6 Summary and recommendations

The earlier studies conducted within this cooperative programme are summarised in this chapter. A link to the pilot study will be made as well, and we will review the quality aspects on which the official statistics are based. We will conclude by offering a number of recommendations.

## 6.1 Important issues for travel surveys

The following information needs came to light in the two earlier work packages (Adell et al., 2017; Eriksson et al., 2017) within the framework of the Next Generation Travel and Transport cooperative programme:

- Choice of mode of travel
- Purpose
- Timepoints of the travel (start and end times)
- Travel time (duration)
- Geographical location (origin and destination)
- Trip lengths
- Who is travelling (gender, age, income, occupation, driving license, etc.)

In addition, there is also interest in knowing more about:

- Type of vehicle (e.g., electric car)
- Choice of route
- Trip chains to understand the entire journey, and not just stages and trips
- Changes over time

## 6.2 New methods' potential to overcome current deficiencies

Several deficiencies and problems with current travel survey methods were addressed in Work Package 3:

- Suspicions of deficient representativity
- Deficiencies in data quality with respect to trip lengths and travel times
- Deficiencies in information regarding route choices
- Heavy reporting burden
- Long intervals between the measurements
- High costs

In the following sections (6.2.1 and 6.2.2), the tested collection and recruitment methods will be compiled and compared with the traditional methods based on deficiencies and problems that have emerged. Assessments may be difficult in some cases.

### 6.2.1 Collection method

The representativity, i.e., how well the respondents correspond to the target population for the survey with respect to the parameters studied,<sup>7</sup> of the online questionnaire and the mobile app is on a par with that of the traditional methods. Deficient representativity can be addressed to some extent by weighting the results (see Section 6.3.2).

<sup>&</sup>lt;sup>7</sup> These parameters are: gender, age, occupation, driving license possession, type of residence, type of household, and municipality of residence.

Parental approval is required to collect data from people under the age of 16 years. This has not been implemented at present in the TS app we use, making it difficult to reach people under the age of 16 years. However, this could be resolved in the long term in a manner similar to that used in situations in which parental approval is required to download an app.

The two new collection methods, i.e., online questionnaire and mobile app, are compared here with the traditional method. The response rate among the random sample was lower for the online questionnaire, and significantly lower for the mobile app.

The traditional method for collecting travel data collects data from an individual's travels on a single day. This approach was used in the online questionnaire. Several days were collected per person in the case of the mobile app, and in this way each individual's travels over a longer period were obtained.

The manner in which the online questionnaire was configured in this study did not yield greater precision in terms of trip lengths or travel times. This could be improved in an online questionnaire if functions were included in which choice of route checks and reasonability checks of travel times based on pertinent modes of transport could be included, and choice of route information could potentially be incorporated as well. However, to our knowledge, there are no ready tools that can manage this. The data quality for the mobile app in terms of trip lengths and travel times is significantly higher than for traditional methods in which such measurements are possible. Because the data need to be approved by the respondent, gross errors that the respondent discovers should be eliminated in most cases. Only a few unreasonable trip lengths needed to be removed in a subsequent reasonability check. Choice of route information is included, and this works extremely well in most cases. However, problems can arise when the GPS trace is poor.

We consider the reporting burden for both the online questionnaire and the mobile app to be somewhat lighter than with traditional methods. Many individuals presumably find them easier to use, as all the communication takes place electronically, with the result that one "always" has access to the survey (i.e., one can respond when it is convenient), and one need not, for example, submit responses by post. At the same time, there are those who find the reverse to be the case, i.e., that electronic access is more trouble than physical access to hardcopy questionnaires and letter boxes. Data collection took place over a longer period for the mobile app (the requirement was at least one week), increasing the reporting burden. However, on average those who used the TS app provided data for longer than the requested seven days, which is indicative of a reasonable reporting burden.

Because the cost of conducting a survey with a web questionnaire is lower than that of a traditional survey, surveys could be conducted more often. This would lead to shorter intervals between surveys, yielding more continuous data. The cost of data collection using a mobile app varies depending on the number of respondents. The added cost per respondent is relatively low, and the added cost for more days of data collection is also low. A lower cost than that of traditional methods means that data collection could occur more often. The fact that data are collected for several days also enables new types of analyses, such as determinations of what distinguishes those who change modes of travel from one day to another from those who usually use the same mode of travel, or comparisons of travel behaviours at the individual level as a function of the weather.

*Table 21. Comparison of the tested methods (i.e., online questionnaire and mobile app) in terms of the deficiencies and problems of the traditional data collection method.* 

	Online questionnaire	TS app
Representativity	Same	Somewhat better
Response rate	Lower	Significantly lower
Data volume	Fewer questions than TS Sweden	Fewer questions than TS Sweden, but more travel data from each individual
Data quality for trip lengths and travel times	Potentially somewhat better if a map is used	Significantly better
Information on choice of route	No differences, also lacking here	Present
Reporting burden	Possibly somewhat lower	Possibly lower, but for more days
Cost	The cost depends on the sample size and response rate.	The cost depends on the sample size and response rate.
	Less expensive than telephone interviews. Less expensive than hardcopy questionnaires, as questionnaires and response envelopes need not be sent out. In addition, some of the coding has already been done.	Potentially less expensive than the other methods, particularly in connection with larger surveys.

### 6.2.2 Recruitment method

If we consider the recruitment methods used in this study, in which random sampling represents the traditional recruitment method, while the web panel and crowdsourcing represent the new methods, we see certain differences. The biggest problem with the new methods is that they are based on self-recruited respondents, meaning that the sample is unknown. In the case of random samples, proven statistical methods are available to calculate the random errors in the statistics. No corresponding proven methods exist for data from panels or crowdsourcing, making it more difficult to describe and assess the degree of uncertainty. Systematic errors can arise if those who respond to the survey have a travel pattern differing from that of the target population. If those who respond travel more than the target population does there will be a risk of overestimating the total travels undertaken by the target population.

	Random sample	Web panel	Crowdsourcing
Representativity	Response rate and respondent profiles depend on collection method. Can calculate response rate and use statistical methods based on random sample.	Respondent profiles depend on collection method and instructions to the panel company. Size and design of panels determine possible number of respondents. More difficult to apply traditional statistical methods, as the panel is not recruited by random sampling.	Respondent profiles depend on collection method, and representativity can be improved through active recruitment and optimised weighting. Potential overrepresentation of people who travel a great deal, which could result in overestimation of the total travels undertaken by the target population. More difficult to apply traditional statistical methods, due to self-recruitment.
Response rate/response volume	Response rate depends on collection method. The response volume depends on the number of surveys sent out, with the population size constituting a maximum limit.	Response rate not relevant. Depending on the panel size, there is a maximum response volume that can be achieved using this method.	Response rate not relevant. The actual willingness to participate is unknown.
Data quality for trip lengths and travel times	Depends on collection method.	Depends on collection method. Without electronic trip logging, there are signs that respondents may display resistance, and thus report fewer trips. With the TS app, people in the web panel respond, on average, for more days than in the random sample.	Depends on collection method.
Information on choice of route	Depends on collection method.	Depends on collection method.	Depends on collection method.
Reporting burden	Depends on collection method.	Depends on collection method.	Depends on collection method.
Time interval for data collection	Depends on collection method.	Possibly somewhat more often, as people have consented to be questioned.	Possibly somewhat more often; unclear what will happen to interest in participating if surveys are conducted more often.
Cost		At same level as the traditional method.	Could be less expensive, but depends on recruitment strategy

Table 22. Comparison between the tested methods (i.e., web panel and crowdsourcing) and the traditional recruitment method (i.e., random sampling).

#### 6.3 Quality aspects

The concept of quality for official statistics comprises the following five main components, according to Statistics Sweden regulations (SCB, 2016):

- Relevance
- Reliability •
- Timeliness and punctuality
- Accessibility and clarity
- Comparability and co-usability

#### 6.3.1 Relevance

Relevance has to do with information needs and the purpose and content of the statistics. The objective of a travel survey is to obtain knowledge of how travel is undertaken in the transport system. Telephone interviews, hardcopy questionnaires, online questionnaires, and TS apps can all answer the more important questions identified in the stakeholder analysis. However, only the TS app can describe the respondents' travel routes (Eriksson et al., 2017). The accuracy of the collected data material also differs somewhat between methods.

There are also differences in how much travel data are collected from each individual, depending on the collection method used. In interviews and questionnaires, the respondents are asked to respond about how they travelled on a predetermined day. TS apps collect data over multiple days, usually over one to two weeks. This means that data are available on their travel behaviour over a week for the same person. Detail-rich material that can be aggregated based on need enables a broader range of use.

#### 6.3.2 Reliability

Reliability has to do with accuracy, or how well a statistical value estimates its target parameter, i.e., what we seek to measure. The various collection methods have different ways of estimating travel parameters. Interviews and questionnaires depend on the ability of the respondents to recall what they have done, and their ability to estimate trip lengths and travel times. A TS app measures using GPS traces, and offers suggestions in terms of movements, distances, and times. The quality of selfreported estimates depends on the ability of the respondents to recall their movements. This can vary between different types of trips, depending on how important they are perceived to be by the respondent. We as humans also have difficulty estimating distances and times accurately. This is evident, for instance, in how self-reported trip lengths and travel times are often expressed in whole kilometres and even five-minute intervals, even though travel distances and times do not break down that way in reality. The same grouping of measurement data around whole kilometres and even fiveminute intervals is not seen in data from the TS app.

There are also certain differences in how the terms "movement" and "purpose" are interpreted, for example, when someone stops and posts a letter on the way to work in a car. According to the definition of movement, this should constitute two trips, as a purpose was being fulfilled when the person posted the letter. In telephone interviews, the interviewer might ask whether the respondent stopped along the way to work, capturing this type of purpose. In responding to a questionnaire, the respondent would not likely report the stop, but rather would register this as a journey to work, i.e., the interpretation is that only a purpose with a certain degree of importance is to be registered. This stop would be registered by the TS app, and the app would suggest two journeys to the respondent, who would probably accept the suggestion. Similarly, the respondent could assume that only journeys of a certain length are to be reported. There are thus certain differences in what is captured, depending on the collection method. Whether such differences create a problem depends on the questions posed to the material. Such a failure to distinguish and include short journeys is not a major problem in terms of estimating emissions; on the other hand, it could be a problem if we are seeking to understand how walking and bicycling are being used. VTI PM

The differences in trip length are less than the differences in the number of trips. One interpretation of this is that, on average, the over- and underestimates of the respondents cancel each other out. However, it is not certain that over- and underestimates are distributed uniformly across all ages, genders, modes of travel, purposes, etc.

With regard to different recruitment methods, it is clear that there is reason to suspect that journeys are reported somewhat differently, often depending on the recruitment method used. Web panel respondents tend to report fewer journeys if they have not received prompts regarding their travels via the TS app. The fact that the number of journeys does not differ when the web panellists use TS apps suggests that the differences are not attributable to people travelling less, but rather to their not reporting all of their trips.

The partial loss in the study was relatively low, and just a few percent of the trips lacked a mode of transport, travel time, geographic origin, and/or destination. However, there is a tendency for data from the web questionnaires to lack origins and/or destinations more often. This is most evident when recruitment occurs via the web panel, in which case 10% of the reported journeys lack origins and/or destinations.

Representativity, i.e., how well the respondent group represents the target population, is an important aspect, as the objective of travel surveys is to speak about the target population, not the respondent group. Gender, age, occupation, driving license possession, type of residence, household composition, and place of residence were studied in this project. Individuals with driving licenses were generally overrepresented, regardless of the collection or recruitment method used (including in Gothenburg's traditional TS). Households comprising cohabiting adults without children were similarly overrepresented. Overall, it is also clear that neither the collection nor recruitment method negatively affected representativity compared with Gothenburg's travel survey. In the case of the web questionnaire, the registered type of residence more closely reflected that of the target population, while the age and gender distributions for the TS app agreed extremely well with those of the target population.

None of the recruitment methods succeeded in satisfactorily representing the target population without weighting. This can be addressed by weighting the responses to compensate for certain groups being underrepresented. However, heavy weightings are not desirable, as they increase the variance and confidence intervals of the estimated variables. Gender, age, and geography are traditionally weighted, but the analyses in this project revealed the potential of weighting more than just those aspects. Because people with driving licenses are so heavily overrepresented, and as we also know that being licensed plays a major role in mode of transport choices, weighting for this factor should be considered.

## 6.3.3 Timeliness and punctuality

Timeliness and punctuality have to do with how often recurrent statistics need to be generated to be considered relevant and up to date. Collecting and generating official statistics takes a relatively long time, as it is important to ensure the quality of the data material. The process can be expedited to some extent by coding the material more quickly, which can happen if routines for more digital means of collecting data are put in place.

## 6.3.4 Accessibility and clarity

Accessibility and clarity have to do with where and how the statistics are reported. The methods tested in this project had no impact on the accessibility or clarity of the statistics.

## 6.3.5 Comparability and co-usability

Comparability pertains to the enabling of comparisons between different groups or points in time. Cousability has to do with the feasibility of combining and analysing different statistical values derived from the same or different surveys. Because "movement" and "purpose" are understood in somewhat different ways in practice, the numbers of journeys are not fully comparable when different collection methods are used. This became very clear in this project, in which the number of journeys differed between the web questionnaire and the TS app by roughly a factor of two. On average, the web questionnaire also yielded somewhat fewer journeys per person and day compared with the travel survey in Gothenburg.

If surveys involving different methods are to be possible, more experience regarding how they differ is needed, so that journeys registered via the TS app can be aggregated to enable comparison with journeys registered using traditional methods.

Travel surveys conducted using the same data collection and recruitment methods should generally be capable of comparison. We have seen tendencies toward differences based on recruitment method, such as fewer journeys among those recruited to web questionnaires via web panels, or more journeys among those recruited via crowdsourcing. This indicates that the comparability among the recruitment methods is also limited, although more and larger studies would be needed to evaluate this more closely.

## 6.4 Recommendations

When selecting a method for collecting travel survey data, the purpose of the survey must be clear. Different collection and recruitment methods have different strengths and weaknesses, and the question of which one comes closest to creating a true, representative sample is not an easy one to answer.

If the purpose is broad in scope, the data collected should be as detailed as possible, so that they can subsequently be aggregated to the relevant level. Different data collection methods offer different opportunities in this regard. It is possible to aggregate finely grained data, but impossible to divide data that are aggregated upon collection. The level of detail in the data may, at the same time, be a cost driver, depending on the method used.

If the ability to make comparisons with older data is key, then one may opt to again use the same method as was used to collect that older data. One conceivable alternative is to map how "movement" and "purpose" are interpreted differently in the various methods and then create a translation key. A greater understanding of how different data collection methods collect data will make the data more comparable between collection methods.

The TS app is currently the only method that can collect data about routes. It may similarly be useful to use the TS app if knowledge of walking and cycling journeys is sought, as the app appears to be better than other collection methods at capturing short journeys.

There are no simple answers regarding recruitment methods either. In our study, the random sampling that has so far been completely dominant did no better at representing the target population than did the web panel or data collection via crowdsourcing. Random sampling does have an advantage in that it is indeed random, meaning that all the differences within the target population can be assumed to have the same chance of being considered. On the other hand, we know that not all types of individuals choose to respond, which means that the sample will automatically be unrepresentative. This project shows that individuals who have driving licenses respond to a greater extent than do those without licenses (this applies to traditional data collection as well). At the same time, we also know that driving license possession plays a major role in how people choose to travel. The testing in this project indicates that when the respective respondent groups are weighted using weights optimised for the data material, the results in terms of the number of journeys per person and day become more alike.

Given the low response rates associated with random samples, our recommendation with respect to recruitment is to continue to study alternatives to random sampling, and to work more on weighting

the received responses. The latter should be done regardless of whether or not random sampling is used.

# 6.5 Continued research and development

Developments in this field will continue, and finding methods to enable comparisons of data obtained using different collection and recruitment methods is of great interest. This work should continue so that time series are not at risk of being interrupted as collection and recruitment methods are developed.

### References

Allström, A., Gidofalvi, G., Kristoffersson, I., Prelipcean, A.C., Rydergren, C., Susilo, Y. & Widell, J. (2016). *Experiences from smartphone based travel data collection – System development and evaluation*. Final report from the SPOT project. Version 1.0.

Braunsberger, K., Wybenga, H. & Gates, R. (2007). A comparison of reliability between telephone and web-based surveys. *Journal of Business Research*, Vol. 60, pp. 758-764.

Börkan, B. (2010). The mode effect in mixed-mode surveys. *Social Science Computer Review*, Vol, 28(3), pp. 371-380.

Clark, A., Adell, E., Nilsson, A. & Indebetou, L. (2017). *Detaljerad kartläggning av verktyg and applikationer för resvaneundersökningar*. [Detailed mapping of tools and applications for travel surveys] 2017:32. Lund: Trivector.

Eriksson, J., Henriksson, P., Rogerson, S., Sörensen, G., Silvano, A. P., Nilsson, A, Wahl, C., Ullberg, M. & Adell, E. (2017). *Intressent- och behovsanalys för resvaneundersökningar: resultat from intervjuer and enkätundersökning*. [Stakeholder and needs analysis for travel surveys: results from interviews and questionnaire study] VTI Report 939. Linköping: Swedish Road and Transport Research Institute.

Estelles-Arolas, E. & Gonzales-Ladron-de-Guevara, F. (2012). Towards an integrated crowdsourcing definition. *Journal of Information Science*, Vol. 38(2), pp. 189-200.

Eurostat, 2016. *Eurostat guidelines on Passenger Mobility Statistics; EU Transport Statistics*. Eurostat Manuals and Guidelines. July 2016.

Indebetou, L. & Börefält, A. (2018). *Resvanor invånare 30–49 år i Umeå tätort - Kartläggning med hjälp av ny datainsamlingsmetod hösten 2017*. [Travel habits of inhabitants 30-49 years of age in urban Umeå – Mapping with the help of new data collection method, fall 2017]. Report 2018:08, Version, 1.1 – Trivector.

Transport Analysis Report (2018). *Cykeltrafik – mätmetoder och nationella mål*. [Bicycle traffic – methods of measurement and national goals]. Report 2018:1. Stockholm: Transport Analysis.

## Appendix 1 – Online questionnaire

#### Questions about the individual and household

Questions 1-13 are about the individual and his/her household. All respondents must answer the questions about the individual and his/her household.

Question 1 is posed only to those who were recruited via the random sample.

#### **Question 1**

Is it true that you live at [TS\_personal address]?

Yes 1 2 No

#### **Question 2**

Use the search field or mark your residence on the map. Then click "Select location".

Questions 3 and 4 are posed only to those who were recruited via crowdsourcing.

#### **Question 3**

Are you a man or a woman?

1	Man
2	Woman
2	Other

Other 3

#### **Question 4**

What year were you born?

#### **Question 5**

Do you live in a flat or in a detached house/townhouse?

- Flat 1
- 2 Detached house/townhouse
- 3 Other type of residence

#### **Question 6**

Do you have a driving licence for cars?

- 1 Yes No
- 2

#### **Question 7**

What is your primary occupation?

- 1 Self-employed
- 2 Employed (also new-start job, etc.)
- 3 Work in own household (also care of a relative, parental leave)
- 4 Retired (also activity or sickness compensation, early retirement)
- 5 Student (also labour market training programmes)
- 6 Other

#### **Question 8**

How many other people live in the same household as you?

#### VTI PM

Question 9 is posed only if there are other people in the household.

#### Question 9

A person's trips are often connected with the other people in the household. Because of this, we have a few questions about that person/those people.

Questions 9.1–9.4 are to be posed to up to 10 people, depending on the number of people stated in Question 8.

Question 9.1

What year was/were he/she/they born?

Question 9.2

Is/are he/she/they male or female?

1	Male
2	Female

3 Other

#### Question 9.3

What is/are his/her/their relationship/s to you?

		•
1	Husband/wife/coh	abitant
-	<u> </u>	

- 2 Child/cohabitant's child
- 3 Parent
- 4 Sibling
- 5 Other relationship

Question 9.4 is to be posed only to those born before the year 2000.

#### Question 9.4

Does/do he/she/they have a driving licence for cars?

- 1 Yes
- 2 No

#### **Question 10**

Are there any personal cars in the household?

1	0 cars
2	1 car
3	2 cars
4	3 cars
5	4 cars
6	5 cars
7	6 cars
8	7 or more cars

Question 11 is posed only if there are cars in the household.

#### Question 11

Now there will be a few questions about the car or cars. If the household has access to multiple cars that are in use, we would like to know what make or model they are so that we can distinguish between them later on in the questionnaire.

Questions 11.1–11.4 are to be posed up to three times, depending on the number of cars stated in Question 10.

Question 11.1

What is the first car's make/model/nickname?

Question 11.2

What is the model year of the car?

Question 11.3

Is the car in use?

1 Yes

2 No

Question 11.4

What type of fuel does the car use?

•••	
1	Petrol (only)
2	Diesel (only)
3	Electric
4	Electric hybrid (not rechargeable via electrical outlet)
5	Rechargeable hybrid (rechargeable via electrical outlet)
6	Ethanol/Ethanol flexifuel
7	Natural gas/natural gas bi-fuel
8	Other fuel

#### **Question 12**

We would now like to talk about the movements you made on [TS\_measurement day]. By "movements" we mean everything, even short movements made, for example, on foot or by bicycle. Did you make any trips or movements on [TS\_measurement day]?

1 Yes

2 No

Posed only to respondents who answered No to Question 12. These respondents end the questionnaire after Question 13.

#### **Question 13**

What was the main reason you did not make any movements?

- 1 Had no errands
- 2 Stayed home because of my own or someone else's illness
- 3 Was abroad
- 4 The weather
- 5 Other reason

Question 13.1

Comments (Other reason)

#### **Questions about trips**

Questions 14–44 about trips are posed only to respondents who reported having made a trip in Question 12. The respondent is able to enter up to 30 trips. Questions 14 and 15 are posed only with regard to the first trip. Subsequent trips begin at the same point where the previous trip ended.

#### **Question 14**

Where did you begin the first movement?

- 1 Your residence
- 2 Another overnight location
- 3 Another location

Question 15 is posed only if the location is not known from before. For example, the residence address is already known.

#### **Question 15**

Where did the trip start? [indicate on map]

#### **Question 16**

Question 16.1 is posed in the first round of questions, Question 16.2 in subsequent rounds.

Question 16.1

At what time did you begin the movement?

Question 16.2

When did the next movement begin?

#### **Question 17**

Where did the movement end?

- 1 Your residence, [TS\_personal address]
- 2 Other overnight location
- 3 Other location

Question 18 is posed only if the location is not known from before. For example, the residence address is already known.

#### Question 18

Where did the trip end? [indicate on map]

Question 19 is posed if the respondent answered "Other location" in Question 17.

#### **Question 19**

What was the main purpose of the trip?

1	Work
2	School/training
3	Business trip /Travel for work
4	Shopping, groceries
5	Shopping, other
6	Healthcare
7	Picking up/dropping off children
8	Other service-related errand

- 9 Driving (following)/picking up another person
- 10 Visiting friends and relations
- 11 Hobbies, Courses, Club activities, Religious practice
- 12 Restaurant, Café
- 13 Exercise/Outdoor activities (sport, walking, excursion, sunbathing, swimming, fishing, walking the dog)
- 14 Entertainment and culture (museum, concert, cinema, sporting event, exhibition, lecture)
- 15 Participation in (accompanying) child's leisure activity
- 16 Other leisure activity
- 17 OTHER PURPOSE

Question 19.1

Comments (OTHER PURPOSE)

#### **Question 20**

At what time did the movement end?

#### Question 21

What mode of travel was used in the movement?

1	Walking
2	Bicycle
3	Electric bicycle
3	Moped
4	Car
5	Motorcycle
6	Train
7	Underground
8	Tram
9	Bus
10	Aircraft
11	Leisure boat
12	Commercial vessel
13	Taxi (not mobility service)
14	Mobility service
15	Other

Which of follow-up questions 22–42 are posed to the respondent will depend on the mode of travel used as per Question 21.

#### **Question 22**

How far did you walk during this movement?

#### **Question 23**

How far did you cycle during this movement?

### **Question 24**

How far did you travel by moped during this movement?

#### **Question 25**

How far did you travel by motorcycle during this movement?

### **Question 26**

What type of train was it?1Regional or commuter train (e.g., Västtåg or Öresundståg)

2 Long-distance train (e.g., Intercity, SJ express train, or MTR Express)

#### **Question 27**

How far did you travel by train during this movement?

#### **Question 28**

How far did you travel by underground during this movement?

#### **Question 29**

How far did you travel by tram during this movement?

#### **Question 30**

What type of bus was it?

1	City or downtown bus,
2	Regional or rural bus
3	Long-distance bus with regular service
4	Other bus, charter or other bus, charter or hire service

#### **Question 31**

How far did you travel by bus during this movement?

#### **Question 32**

How far did you travel by aircraft during this movement?

#### **Question 33**

How far did you travel by leisure boat during this movement?

#### **Question 34**

How far did you travel by commercial vessel during this movement?

#### **Question 35**

What car was it?

1	Household	car	1

- 2 Household car 23 Household car 3
- 4 Borrowed car
- 5 Rental car
- 6 Co-passenger's car
- 7 Other car
- 8 Employer's car

#### **Question 36**

How many other people were there in the car?

### **Question 37**

Were you the driver or a passenger?

1 Driver

2 Passenger

#### **Question 38**

How far did you travel by car during this movement?

Question 39 is posed only if the car does not belong to the household as per Question 34

#### **Question 39**

What type of fuel did the car use?

1	Petrol (only)
2	Diesel (only)
3	Electric
4	Electric hybrid (not rechargeable via electrical outlet)
5	Rechargeable hybrid (rechargeable via electrical outlet)
6	Ethanol/Ethanol flexifuel
7	Natural gas/natural gas bi-fuel
8	Other fuel

#### **Question 40**

How far did you travel by taxi during this movement?

#### Question 41

Were you the driver or a passenger?

- 1 Driver
- 2 Passenger

#### **Question 42**

How far did you travel by mobility service during this movement?

### **Question 43**

How far did you travel by some other mode of travel during this movement?

#### **Question 44**

Did you make any more trips during [TS\_measurement day]?

1 Yes

2 No

Respondents who answer Yes to Question 44 start over from Question 16. Respondents who answer NO to 44 end the questionnaire.

## Appendix 2 – Background Questionnaire for TRavelVU

- 1. Are you a man or a woman?
- Woman
- Man
- Other
- 2. What year were you born?
- Year of birth: YYYY
- 3. Where do you live?
- Flat
- Detached house/Townhouse
- Other type of residence
- 4. Do you have a driving licence for cars?
- Yes
- No
- 5. What is your primary occupation?
- Self-employed
- Employed (also new-start job, etc.)
- Work in own household (also care of a relative, parental leave)
- Retired (also activity or sickness compensation, early retirement)
- Student (also labour market programmes)
- Other
- 6. How many other people live in the same household as you? Do not count yourself.
- Number: XXXX

Questions 7–10 are posed to those who report that there are more people in the household. The questions are repeated a number of times equal to the number of additional people in the household, up to 10 people.

# A person's trips are often associated with the other people in the household. Because of this, we have a few questions concerning that person/those people.

We will now ask about each person in the household other than yourself (up to 10 people). The order in which you describe the people does not matter.

- 7. What year was that person born?
- Year of birth: YYYY
- 8. Is that person a man or a woman?
- Woman
- Man
- Other
- 9. What relationship does that person have to you?
- Husband/wife/cohabitant
- Child/cohabitant's child
- Parent
- Sibling
- Other relationship
  - Specify

10. Does that person have a driving licence for cars?

- Yes
- No
- Too young to have a driving licence

**11.** Are there any personal cars in the household?

- 0 cars
- 1 car
- 2 cars
- 3 cars
- 4 cars
- 5 cars
- 6 cars
- 7 or more cars

Questions 12–14 are posed to those who report that there are personal cars in the household. The questions are repeated a number of times equal to the number of personal cars in the household, up to three cars.

Now we have a few questions about the car(s).

We would like to know a little more about up to three cars.

- 12. What model year is the car?
- Year: YYYY
- 13. Is the car in use?

by "in use" we mean that it is not deregistered.

- Yes
- No
- 14. What type of fuel does the car use?
- Petrol (only)
- Diesel (only)
- Electricity
- Electric hybrid (not rechargeable via electrical outlet)
- Rechargeable hybrid (rechargeable via electrical outlet)
- Ethanol/Ethanol flexifuel
- Natural gas/Natural gas bi-fuel
- Other fuel

# 15. How did you come into contact with this survey? (Multiple answers possible)

- Read about it in periodical/free newspaper
  - Which periodical?
- Saw information on Facebook or Twitter
  - Who posted it?
  - Got a tip from a friend/colleague/family member
- Other

•

• Specify:

# Thank you for using TRavelVU and helping us to understand how the transportation system is being used!

# Appendix 3 – Institutions, etc., contacted for crowdsourcing advertisement

- 1. The Traffic Administration Office's Facebook and Twitter accounts, "For life & movement"
- 2. City of Gothenburg's intranet
- 3. City of Gothenburg's website: Göteborg.se
- 4. Gothenburg Region Local Federation GR's Network for Sustainable Travel
- 5. Periodical Vårt Göteborg
- 6. *Göteborg Direkt*, five periodicals in Gothenburg
- 7. Metro Pling (Västtrafik's own page in the periodical)
- 8. *GP*, Bohusläningen, Hallands Nyheter, Hallandsposten, Trollhättan 7 dagar, TTEL, Uddevalla 7 dagar, Varbergsposten, and V-TAB
- 9. Mölndals Posten
- 10. Alingsås Tidning
- 11. Borås Tidning
- 12. Norra Halland
- 13. Härryda posten
- 14. Lerums Tidning
- 15. Alekuriren
- 16. Local periodicals Stenungsund, Tjörn, and Orust
- 17. Kungälv Tidning
- 18. Torslanda Tidning
- 19. Partille Tidning
- 20. Kungsbacka posten
- 21. Västsverige
- 22. Varbergs posten
- 23. Xtra Borås, AlingsåsKuriren, and Bollebygd
- 24. Trollhättan 7 dagar
- 25. Uddevalla 7 dagar

# Appendix 4 – Media impact, etc

Date	Where
25-Sep	City of Gothenburg's website: Göteborg.se
28-Sep	Transport Analysis newsletter
29-Sep +	VTI's newsletter
26 Oct	
29 Sep	VTI's Twitter
29 Sep	87 people who expressed an interest in participating in VTI studies (e.g., simulator studies and
	group discussions) were contacted by e-mail and informed about the expression of interest page
29 Sep?	Transport Analysis's Twitter
02-Oct	Vårt Göteborg, full page
03-Oct	Trivector's Facebook
04-Oct	För liv och rörelse [For a thriving, forward-looking city]
05-Oct	Stengungsund Municipality's website
06-Oct	Vänersborg Municipality's website
06-Oct	NTF Väst's Facebook page
09-Oct –	Facebook advertisement, VTI
30 Oct	
10-Oct	Ale Municipality's website + intranet
11-Oct	Sustainable Travel West's Facebook page
11-Oct	Reportage about the study on Trivector's website
17-Oct	Trollhättan Municipality's website
17-Oct	City of Gothenburg's intranet
19-Oct	Pling periodical advertisement, full page in Metro
19-Oct	Kungälv Municipality's website
19-Oct	Kungälv Municipality's Facebook
25-Oct	Reportage about the study on VTI's website

# Appendix 5 – Information and expression of interest page posted on <u>www.vti.se/resa</u> in phase one

[Do you live in the Gothenburg Region or surrounding area? We need your help!]



# Bor du i Göteborgsregionen med omnejd? Vi behöver din hjälp!

Vill du bidra med värdefull information om hur du reser? Just nu söker vi deltagare till en forskningsstudie kring framtidens resvaneundersökningar. Vi söker dig som är 16-84 år och bor i någon av kommunerna Ale, Alingsås, Bollebygd, Borås, Göteborg, Härryda, Kungsbacka, Kungälv, Lerum, Lilla Edet, Mark, Mölndal, Orust, Partille, Stenungsund, Tjörn, Trollhättan, Uddevalla, Varberg, Vänersborg eller Öckerö.

Oftast används pappersenkäter eller telefonintervjuer när man gör undersökningar om resvanor. Men idag finns det andra metoder som kräver mindre resurser. I den här studien testar vi två metoder: en webbenkät och en mobil-app. Resultatet hjälper oss att förstå hur liknande undersökningar bör göras i framtiden. Vi får också information om hur transportsystemet används i Göteborgsregionen. Det kan vara till nytta i planeringen av framtidens region. Samtidigt gör Trafikkontoret i Göteborg också en stor resvaneundersökning, något som ger oss möjlighet att jämföra resultaten från den studien med vad vår studie visar.

### Du får möjlighet att lämna resdata på något av följande sätt:

#### Via en app

Du laddar ner appen TRaveIVU till mobilen. Under en vecka samlar appen in information om hur du rör dig och försöker avgöra vilket färdmedel du använder – du granskar resultatet och justerar vid behov. Appen frågar också lite om dig och ditt hushåll – detta gör vi för att förstå hur olika grupper använder transportsystemet. Det tar cirka fem minuter per dag och du får instruktioner om hur du ska göra.

#### Via en webbenkät

Du svarar på en webbenkät och redogör för dina resor under en dag samt ger lite bakgrundsinformation om dig och ditt hushåll – detta för att vi ska förstå hur olika grupper använder transportsystemet. Det beräknas att ta 7-8 minuter för de flesta att fylla i enkäten.

1) Ja, jag är intresserad av att delta genom att:

O a) svara på en webbenkät och beskriva mitt resande under en dag i slutet av oktober

O b) ladda ner en mobilapp och samla in resdata under en vecka i slutet av oktober

O göra antingen a) eller b)

OBS att du ska komma till en sida med en bekräftelse på din anmälan när du klickat på skicka. Om inte, gå tillbaka till formuläret och kolla om du har glömt att fylla i något fält.

# Stort tack på förhand!

Undersökningen genomförs av Trafikanalys, VTI- Statens väg- och transportforskningsinstitut och Trivector och är medfinansierad av Trafikverket.

Jenny Eriksson, VTI, projektledare: jenny.eriksson@vti.se

Eva Lindborg, Trafikanalys, biträdande projektledare: eva.Lindborg@trafa.se



Emeli Adell, Trivector, biträdande projektledare: emeli.adell@trivector.se



# Appendix 6 – Information page and link to the online questionnaire posted on www.vti.se/resaenkat

[Complete the online questionnaire]



# Besvara webbenkäten

Så här fyller du i webbenkäten:

#### Gå till enkäten

 Vi vill att du utförligt beskriver dina förflyttningar för den aktuella dagen. Har du inte gjort några förflyttningar antecknar du detta.



• En förflyttning är när du tar dig från en punkt till en annan för att utföra ett ärende. Gör du något ärende på vägen, t.ex. lämnar barn på förskola, blir det två förflyttningar. Hemresan är ytterligare en förflyttning.

Beskriv de förflyttningar som du gjort under dagen, även om du inte förflyttat dig som du brukar göra.

Kom ihåg dina resor till fots! Om du gjort en förflyttning helt till fots räknas den. Likaså om du gått till fots en del av en förflyttning.

· Du ska inte ta upp förflyttningar som du gjort som chaufför i yrkesmässig trafik.

#### Undrar du något?

Om du har några frågor är du välkommen att kontakta Enkätfabriken:

Telefon: 020-12 10 28, måndag-fredag mellan kl. 09:00-16:00

E-post: support@enkatfabriken.se

#### Tack på förhand!

# Appendix 7 – Information page and link to download page for the mobile app posted on www.vti.se/resaapp

#### [Use TRavelVU]



# Använda TRavelVU

#### Så här laddar du ner TRavelVU:

TRavelVU finns för både Android och Iphone:

- · Android: hämta TRavelVU på GooglePlay
- iPhone: hämta TRavelVU på AppStore
- När du öppnar appen ange undersökning Resor i väst

Eftersom TRavelVU använder GPS för att följa dina förflyttningar kan du behöva ladda din telefon lite oftare än annars. Du måste också tillåta appen åtkomst till din platsinformation. Datainsamling pågår till mitten av november, och du får gärna delta hela perioden, men vi är

glada om du vill registrera och granska dina resor under en vecka.

#### Så här kontrollerar och rättar du dina resor i TRavelVU:

TRaveIVU analyserar dina GPS-spår för att försöka avgöra var du stannar och vilka färdmedel du använder. Ibland lyckas det inte riktigt. Därför är det viktigt att du som vet hur du åkt kontrollerar TRaveIVU och bekräftar att resorna är rätt/ändrar de som är fel.

 Dagen är rätt: Du markerar att beskrivningen av dina förflyttningar och aktiviteter under en dag ovanför varje aktuell dag.

 Ange aktivitet: Tryck på aktiviteten och välj för att ange rätt aktivitet. Nästa gång du är på samma stalle kommer TRaveIVU komma ihåg vad du gjorde sist och föreslå det.

 Ändra färdmedel: Tryck på resan du vill ändra. Här kan du ändra färdmedel, tid, sträcka, slå ihop och dela upp resor.

#### Håll koll på dina resor

I TRaveIVU kan du också se var du rest och få en sammanställning av dina resor i tid eller sträcka uppdelat på dag, vecka eller månad. Dessa data kan du också ladda ner.

#### Undrar du över något?

på www.travelvu.se/ finns mer information om appen.

Du är varmt välkommen att höra av dig till travelvu@trivector.se för frågor om appen TRavelVU och Emeli Adell för frågor om studien i stort.

Du kan också använda dig av online-forumet för att få svar på frågor.

#### Tack på förhand!

Emeli Adell, biträdande projektledare

#### emeli adell@trivector.se

Foto Annika Johansson





Appendix 8 – Respondent profiles, additional figures, and tables

Figure 34. Cumulative total number of respondents who completed the online questionnaire per day during the survey period, 15 Oct (= day 1) to 15 Nov (= day 32).



Figure 35. Cumulative total of number of "trip days" per day from respondents who downloaded the mobile app during the survey period, 15 Oct (= day 1) to 15 Nov (= day 32).

Days	Online questionnaire random without incentive	Online questionnaire random with incentive	Online questionnaire web panel	Online questionnaire crowdsourcing	Mobile app random	Mobile app web panel	Mobile app crowdsourcing	Register data
Weekday	69%	71%	65%	79%	73%	73%	74%	71%
Weekend day	31%	29%	35%	21%	27%	27%	26%	29%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Table 23. Distribution of respondents broken down by weekday and weekend day per survey group.

Date	Online questionnaire random without incentive	Online questionnaire random with incentive	Online questionnaire web panel	Online questionnaire crowd- sourcing	Mobile app random	Mobile app web panel	Mobile app crowd- sourcing
2017-10-15	17	0	12	17	0	16	2
2017-10-16	0	30	16	65	4	39	14
2017-10-17	20	0	20	37	4	54	46
2017-10-18	0	27	24	36	6	74	67
2017-10-19	23	0	27	30	8	76	90
2017-10-20	0	24	15	17	15	80	93
2017-10-21	20	0	30	24	16	85	91
2017-10-22	18	27	8	23	15	94	105
2017-10-23	19	13	14	39	16	113	141
2017-10-24	3	22	3	27	21	138	150
2017-10-25	21	6	2	24	24	135	176
2017-10-26	7	22	6	17	28	125	190
2017-10-27	11	3	11	9	28	117	192
2017-10-28	5	22	17	14	28	117	182
2017-10-29	0	12	10	7	25	123	181
2017-10-30	15	0	1	5	21	111	187
2017-10-31	0	6	1	2	21	96	192
2017-11-01	9	0	1	2	21	88	196
2017-11-02	0	5	3	1	21	78	188
2017-11-03	4	0	0	1	20	69	171
2017-11-04	0	3	0	1	18	56	157
2017-11-05	0	0	0	1	18	54	152
2017-11-06	0	0	0	2	24	48	161
2017-11-07	0	0	0	2	30	41	157
2017-11-08	0	0	0	1	31	36	160
2017-11-09	0	0	0	3	29	32	154
2017-11-10	0	0	0	0	26	31	148
2017-11-11	0	0	0	0	29	28	142
2017-11-12	0	0	0	0	29	28	141
2017-11-13	0	0	0	0	28	27	138
2017-11-14	0	0	0	0	26	25	131
2017-11-15	0	0	0	0	19	23	109

Table 24. Responses received per day and survey group.



Figure 36. Distribution of number of people per household type.

Table 25. Number of respondents broken down by gender.

	Online questionnaire random without incentive	Online questionnaire random with incentive	Online questionnaire web panel	Online questionnaire crowd- sourcing	Mobile app random	Mobile app web panel	Mobile app crowd- sourcing	TS GBG	Register data
Men	82	101	104	123	33	86	114	5,514	542,407
Women	110	121	117	283	34	109	159	6,539	540,884
Other	0	0	0	1	0	2	2	27	0
Missing values	0	0	0	0	3	1	4	31	0
Total	192	222	221	407	70	198	279	12,111	1,083,291

	Age (years)	16–24	25–44	45–64	65–84	Mean age	Median age
Online	Number of men	9	18	22	33	52.8	55.5
questionnaire random without incentive	Number of women	12	26	40	32	51.2	54
Online	Number of men	12	25	29	35	51.4	55
random with incentive	Number of women	27	22	40	32	47.3	50
Online	Number of men	16	28	31	31	49.7	51
questionnaire web panel	Number of women	18	36	40	23	46.7	49
Online questionnaire crowdsourcing	Number of men	5	42	56	20	49.4	50,5
	Number of women	11	120	131	21	46.2	47
Mobile app random	Number of men	4	13	11	5	-	-
	Number of women	7	13	10	4	-	-
Mobile app web panel	Number of men	11	29	36	8	-	-
	Number of women	23	41	38	4	-	-
Mobile app crowdsourcing	Number of men	5	53	47	8	-	-
	Number of women	3	81	67	8	-	-
	Number of men	334	1,277	1,945	1,958	-	-
IS GBG	Number of women	434	1,582	2,379	2,143	-	-

Table 26. Number of respondents broken down by gender and age.

	Table 27. Numbe	r of corrected	days in the n	nobile platform	by type of residence
--	-----------------	----------------	---------------	-----------------	----------------------

Type of residence	Mobile app random	Mobile app web panel	Mobile app crowdsourcing
Flat	353	1,402	2,001
Detached house/townhouse	249	798	2,365
Other type of residence	23	41	28
Total	625	2,241	4,394

## Appendix 9 – Estimated costs of data collection, calculations

With regard to the calculation of the extracted sample we refer to SPAR's website, from which we retrieved relevant information.<sup>8</sup> Note that the response rate has a marked effect on the costs, including what we view as fixed and variable costs, as well as on the calculations if, for example, we want to scale up to 1,000 respondents.

#### Online questionnaire - Random sample without incentive

This calculation is based on 1,400 mailings and 192 net responses. The reminder is calculated at 1,400 mailings. All data collection costs are external. Additional to this are costs of procurement, increase in postal rates, preparation of the cover letter, and support during the data collection period.

*Table 28. Estimated costs of online questionnaire via random sample without incentive.* 

	Internal/external cost	Fixed costs	Variable costs
Sample – SPAR	External	500	840
Mailings of cover letter + 1 reminder,			
printing costs	External		15,500
Online questionnaire with map function +			
question set-up	External	50,000	
Total		50,500	16,340
		Total:	66,840
		Per respondent:	348

#### Online questionnaire – Random sample with incentive

This calculation is based on 1,400 mailings and 222 net responses. The reminder is calculated at 1,400 mailings. All collection costs are external. Incentive of SEK 100/respondent. Additional to this are costs of procurement, increase in postal rates, preparation of the cover letter, and support during the data collection period.

Table 29. Estimated costs of online questionnaire via random sample with incentive.

	Internal/external cost	Fixed costs	Variable costs
Sample I – SPAR	External	500	840
Mailings of cover letter + 1 reminder,			
printing costs	External		15,500
Online questionnaire with map function +			
question set-up	External	50,000	
Incentive	External		22,200
Total		50,500	38,540
		Total:	89,040
		Per respondent:	401

#### Online questionnaire – web panel

This calculation is based on 1,519 mailings (e-mail) and 221 net responses. All collection costs are external. Calculated "set-up" costs of obtaining access to the web panel are based on proposals we received during the simplified procurement process. The variable external cost of SEK 55,000 (we procured a web panel for both app and online simultaneously, and it was not possible to differentiate

<sup>&</sup>lt;sup>8</sup> https://www.statenspersonadressregister.se/root/vara-tYesnster/priser/prislista.html 2018-03-01

between the related costs) was split 75/25 based on the number of mailings before 200 was reached (5,085 mailings for the app, 1,519 for the online questionnaire). Additional to this are costs of procurement, preparation of the cover letter, and support during the data collection period.

	Internal/external cost	Fixed costs	Variable costs
Online questionnaire with map function +			
question set-up	External	50,000	
Access to web panel	External	10,000	13,750
Total		60,000	13,750
		Total:	73,750
		Per respondent:	334

Table 30. Estimated costs of online questionnaire via web panel.

### Online questionnaire - crowdsourcing

This calculation is based on 407 net responses. The only cost that we viewed as variable was the Facebook advertisement on VTI's Facebook, which totalled SEK 10,000. This cost was split 40/60 (online/app), based on the number of respondents. The fixed internal costs were difficult to estimate. The hourly rate for in-house hours worked was set at SEK 600/hour. Additional to this is support during the data collection period.

Table 31. Estimated costs of online questionnaire via crowdsourcing.

	Internal/external cost	Fixed costs	Variable costs
Channel strategy + website + editorial			
material	Internal	34,200	
Facebook advertisement	External		4,000
Online questionnaire with map function +			
question set-up	External	50,000	
Daily mailings to those who had pre-			
registered	Internal	4800	
Total		89,000	4,000
		Total:	93,000
		Per respondent:	229

### Mobile app - random sample

This calculation is based on 2,800 mailings and 70 net responses. The reminder is calculated at 2,800 mailings. Additional to this are costs of procurement, increase in postal rates, preparation of the cover letter, and support during the data collection period. The response rate was low (3%). This may have been attributable to problems with the mailings and chosen trip days.

Table 32. Estimated costs of mobile app via random sample.

	Internal/external cost	Fixed costs	Variable costs
Sample – SPAR	External	500	1,420
Mailings of cover letter + 1 reminder,			
printing costs	External		31,000
App, set-up	Internal	66,500	
Total		67,000	32,420
		Total:	99,420
		Per respondent:	1,420

#### Mobile app – web panel

This calculation is based on 5,085 mailings (e-mail) and 199 net responses. All data collection costs are external. Calculated "set-up" costs of obtaining access to the web panel are based on proposals we received via the simplified procurement process. The variable external cost of SEK 55,000 (we procured a web panel for both app and online simultaneously, and it was not possible to differentiate the related costs) was split 75/25 based on the number of mailings before 200 was reached (5,085 mailings for the app, 1,519 for the online questionnaire). Additional to this are costs of procurement, preparation of the cover letter, and support during the data collection period.

	Internal/external cost	Fixed costs	Variable costs
App, set-up	Internal	66,500	
Access to web panel	External	10,000	41,250
Incentive	External		19,900
Total		76,500	61,150
		Total:	137,650
		Per respondent:	692

Table 33. Estimated costs of mobile app via web panel.

#### Mobile app - crowdsourcing

This calculation is based on 284 net responses. The only cost that we viewed as variable was the Facebook advertisement. Facebook advertisement via VTI incurred SEK 10,000 in advertising costs. Broken down by respondents, i.e., the more respondents the lower the cost. Roughly 40/60 split (online/app). The fixed internal costs were difficult to estimate, hourly rate SEK 600/hour. Additional to this is support during the data collection period.

Table 34. H	Estimated	costs o	f mobile	app via	crowdsourcing.
-------------	-----------	---------	----------	---------	----------------

	Internal/external cost	Fixed costs	Variable costs
Channel strategy + website + editorial			
material	Internal	34,200	
App, set-up	Internal	66,500	
Facebook advertisement	External		6,000
Daily mailings to those who pre-registered	Internal	4,800	
Total		105,500	6,000
		Total:	111,500
		Per respondent:	393