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STARS

Shared mobility opporTunities And challenges foR European citieS

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Mobility scenarios of car sharing: gap analysis and impacts in the cities of tomorrow

Deliverable D5.1

Version n° 1

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Acronyms

ACI	Automobile Club d'Italia	**LTZ**	Limited Traffic Zone
BL	Binomial Logit	**NH_3**	Ammonia
CATI	Computer Assisted Telephone Interview	**NMVOC**	Non-methane Volatile Organic Compounds
CAWI	Computer Assisted Web Interview	**NO_x**	Nitrogen oxides
CO	Carbon monoxide	**$PM_{2.5}$**	Particulate Matter
CO_2	Carbon dioxide	**PT**	Public transport
CS	Car sharing	**RTSB**	Roundtrip station-based
FFOA	Free-floating with operational area	**SP**	Stated-Preferences
FFPS	Free-floating with pool stations		

SUMMARY

The present deliverable encompasses the work carried out by the STARS consortium in three different tasks, namely 5.1, 5.2 and 5.3. The main objective is to give more insights about what role car sharing services would play in cities of tomorrow, especially in tackling the environmental and climate impacts deriving from the whole transport system and in improving the use of public spaces.

In particular, this work evaluates the potential role of different kinds of car sharing services, as defined in previous STARS deliverable 2.1 (Rodenbach, Mathijs, Chicco, Diana, & Nehrke, 2018), in satisfying the travel demand needs of European cities. Attention is paid not only to estimate the potential market share of such services, but to clarify the substitution patterns that will potentially decrease the travel demand for all competing modes (active means, private cars and public transport). Differently from existing studies, this document seeks to clarify substitution and complementarities at the individual trip level. Furthermore, impacts that each system has on car ownership, mobility habits and the consumption of public space are investigated in three different case studies, adding new insights to the previous findings of STARS deliverable 4.1 (Bergstad et al., 2018).

Travel demand models are used to evaluate different car sharing scenarios and therefore to assess the impact of car sharing on air pollutants emissions, use of public spaces and congestion. The quantification of these impacts leads the STARS consortium to individuate the rupture scenario, which represents the mobility scenario where car sharing benefits are maximised. In order to evaluate the maximum benefits, a gap analysis between the predicted scenarios and the business as usual one, defined in the previous STARS deliverable 2.3 (Chicco, Diana, Rodenbach, Mathijs, & Nehrke, 2018), is carried out.

In order to reach such objectives, a mobility survey has been designed, implemented and distributed among different European cities individuated within each case study. The questionnaire contents allowed us to cover many car sharing aspects, which can be divided in two main lines of research: on the one hand, person-level analyses that allows to evaluate what impacts car sharing is producing on personal (or household) and long-term mobility choices, such as the subscription to other mobility services, the ownership of public transport season passes or the reduction of private car ownership and how these changes are influencing the use frequency of different travel modes.

On the other hand, trip-level analyses focus on everyday mobility decisions and how these latter are impacted by the use of car sharing. The number of trips that might be performed with shared cars was therefore estimated, along with the related environmental, congestion and parking demand impacts of those potential switches.

The main findings of this deliverable at person-level are:

- In the three case studies, in general, the number of cars owned by car sharing members on average is lower compared to non-members.
- Results from Frankfurt and the Belgian case study confirm that car ownership among roundtrip station-based users is far lower than among free-floating users. In particular, free-floating users have the same level of car ownership of non-users in Frankfurt. However, car ownership level of free-floating car sharing members is significantly lower if they are using station-based and/or combined models at the same time.
- Roundtrip and combined car sharing users reported that the most significant changes took place between one year before registration and the time of the registration.
- It is, however, hard to state people own fewer cars due to car sharing. It can also be the other way around: people that decided to own fewer cars for whatever reason use car sharing as a replacement. Although roundtrip and combined car sharing customers in interviewed in the Frankfurt case study seem to consider these car sharing models to be a full-fledged substitute for their own car, carsharing is only seldomly the one cause to abandon a car. Reasons to abandon a car are manifold and the existence of the car sharing offer is only one among them.
- Almost no changes in car ownership took place among free-floating users of the three case studies: customers of free-floating offerings had the same number of cars as they did 12 months before registering with car sharing.
- Free-floating car sharing members interviewed within the Italian case study even reported a slight increase in the number of cars owned. However, framing this result in the car ownership trends of the whole population, it can be noted that the growth rate of cars owned by car sharing members is smaller than that of non-members. Thus, car sharing might have a higher impact on postponing the purchase of additional cars.
- Roundtrip and combined services seem to have a dramatic impact on car ownership compared to free-floating ones, but on the other hand, a lower number of members. Therefore, there is a clear trade-off between the market penetration of a service and its impact in terms of car ownership changes for its customers, such that the aggregate impacts at the level of the overall urban area could be of the same order of magnitude.
- The ideal situation would be a complete complementarity of the different car sharing schemes, which would happen if these are more appealing to quite different market segments both in terms of individuals and of mobility patterns. In such a case, the estimated aggregated impacts would sum up and the policy indication would be to promote both as much as possible, keeping in mind that a massive number of customers needs to be reached for free-floating to have an appreciable effect, whereas more targeted and "in-depth" actions are appropriate for station-based services, since they can radically change the mobility styles of their customers.

- The analysis of public transport season ticket ownership led to slightly different results among case studies, but in general car sharing users have more transit passes than non users. Therefore, having a dense and reliable public transport offer seems to be more relevant than car sharing membership.
- When differences in PT season tickets were analysed (Frankfurt case study) it is notable that the number of public transport annual passes has increased in almost all groups since registering for car sharing.
- Much higher bike sharing membership is reported among car sharing members, proving that this group is more open to sharing all transport modes, not only cars.
- Apart from ownership of PT season passes and other mobility membership (bike sharing and so on), car sharing members more frequently use active modes and public transport than non-members.
- Differences in the use of private cars as drivers are encountered among car sharing user groups: more than 80% of users of the roundtrip and combined systems use their own car (almost) never or less than monthly; a further 8% drive a private car less frequently than once a week. By contrast, 43.9% of users registered exclusively for free-floating services drive a private car (almost) daily.

Trip-level outcomes presented in this deliverable derive from the Italian case study only, which refers to free-floating car sharing services. The main findings are:

- The application of switch models shows that, globally, free-floating car sharing has the potential to attract up to 8.6% of the current daily travel demand estimated from Milan respondents and up to 9.5% of the Turin daily travel demand.
- According to the model explanatory variables, the rupture scenario might be reached by changing car sharing and private car costs, which should induce citizens to adopt more sustainable transport modes.
- The car sharing rupture scenario in both Italian cities analysed would generate an increase of CO_2 emissions along with a reduction of all main pollutants, which are however negligible compared to the amount currently produced.
- Anyway, this can be evaluated in economic terms as saving for both cities (about 8827€ in Milan and 3607€ in Turin every day), which is obtained by summing up the savings produced by the reduction of pollutants' emissions and the cost deriving from the increase in CO_2 emissions.
- Greenhouse gas and air pollutants emissions might be even lower (at least at the tailpipe), if current fleets would be substituted with electric ones (such reductions can be quantified in savings of 26000€ and 13000€ for the cities of Milan and Turin respectively).
- On the other hand, a scenario in which car sharing does not exist anymore would produce higher costs for society compared to the current situation.

- Concerning the use of public spaces, in the rupture scenario free-floating car sharing might produce positive impacts on daily parking eventsin central areas, therefore where mobility attractors are concentrated.. On the contrary, higher negative impacts on both on-street and dedicated parking events might be encountered in more peripheral areas.

1 Introduction

Car sharing is one of the first mobility services constituting the ever-growing shared mobility ecosystem. The phenomenon has growth dramatically during the last decade in European cities, due to the advent of new enabling technologies, the increasing cost of the ownership and the paradigm switch that lead to the concept of mobility-as-a-service, already showed in previous STARS deliverables (Rodenbach et al., 2018; Sanvicente, Kielmanowicz, Rodenbach, Chicco, & Ramos, 2018). Car sharing is steadily growing year by year, in line with the service providers' expectations presented in (Chicco et al., 2018) and as confirmed in some other studies (Ciuffini et al., 2019).

Previous STARS studies have investigated the differences in car sharing business models and which impacts car sharing might have on the automotive and automobility sectors (Wells, Liu, & Beccaria, 2018; Wells, Tart, Beccaria, & Sanvicente, 2018). In addition, other STARS researches focus on the behavioural factors that affect the decision to enrol in car sharing, showing that the level of past car-based travel and trust in the quality of the service delivered are strong predictors. On the contrary, the number of car sharing operators in the city was not a predictor of behaviour. Only increasing the number of operators within cities or fleet sizes would not be enough to induce a behavioural change, while it became evident that it is necessary to increase the perceived usefulness of car sharing services for people's travel necessities (Bergstad et al., 2018; Ramos et al., 2019).

Beyond the car sharing growth and the behavioural elements that enhance its usefulness and therefore its use, it is important to try to understand the impacts that car sharing is having on both travel behaviours and on the environment, in order to correctly define transport policies that might maximise its benefits. In fact, several studies have analysed car sharing impacts on congestion and public spaces (Clewlow, 2016). Some of them reported that car sharing reduces car ownership (Becker, Ciari, & Axhausen, 2018; Ko, Ki, & Lee, 2019; E. Martin & Shaheen, 2016), as long as the service has a high level of reliability (Schreier et al., 2018b). As a consequence, car sharing might reduce the need of parking space (Millard-Ball, Murray, ter Schure, Fox, & Burkhardt, 2005) and it may produce additional traffic-relieving effects, such as the reduction of the congestion (Dowling & Kent, 2015), and vehicle-miles travelled (E. Martin & Shaheen, 2016). Moreover, if car sharing services are provided with electric vehicles, they contribute to decrease air pollutions emissions (Hu, Lin, Xie, Chen, & Shi, 2018), even promoting the acceptance of private electric vehicles (Schlüter & Weyer, 2019).

However, the possibility of achieving these positive impacts depends on the type of car sharing service analysed and on the context where car sharing is operating (rural or urban area). Especially in urban areas, where all forms of car sharing could be encountered (namely free-floating, roundtrip

station-based, roundtrip homezone-based and peer-to-peer car sharing), the impacts of each service may vary depending on the combination with other shared mobility services (car sharing and beyond) and with the public transport offer (Bergstad et al., 2018).

In addition, in order to understand substitution and complementarity patterns deriving from the adoption of car sharing, it is crucial where travel demand is originated (Chapleau, Gaudette, & Spurr, 2019; Heilig, Mallig, Hilgert, Kagerbauer, & Vortisch, 2017). Car sharing should not erode travel demand from more sustainable modes (e.g. active means and public transport) indeed. However changes in travel demand, and in particular for public transport, after the introduction of car sharing are often reported (Clewlow, 2016), even with contrasting results (Ceccato & Diana, 2018). Understanding these relationships is therefore useful for both policy makers, whose target is to promote sustainable travels, and car sharing providers, who aim to increase as much as possible the use of their fleets.

Beyond previous works where changes in travel habits are observed in before-after scenarios (Ko et al., 2019; E. Martin & Shaheen, 2016; Shaheen, Cohen, & Chung, 2010), some authors tried to forecast car sharing potential demand through the use of models, which allow to predict both membership (Costain, Ardron, & Habib, 2012; Efthymiou & Antoniou, 2016) and future trips (Heilig et al., 2017; Rotaris, Danielis, & Maltese, 2019). However, some studies were focused on a specific sample of the population, such as students, thus results cannot be generalised (Rotaris et al., 2019). Furthermore models trip predictions were not considering the travel modes previously used (El Zarwi, Vij, & Walker, 2017; Li, Liao, Timmermans, Huang, & Zhou, 2018), thus without giving information about the substitution relationships. Finally, modelling results sometimes are not used to quantify car sharing impacts in under different scenarios (Costain et al., 2012; Heilig et al., 2017).

Given the above state of the art, we aim to answer the following question: what role car sharing services can play in cities of tomorrow to minimise the environmental and climate impacts of transport systems and to help relieving infrastructural congestion?

This main question can be appropriately answered by looking at the impacts both at the personal level, i.e. how car sharing influences long term mobility related choices, and at the trip level, i.e. the impacts in everyday travel. Concerning the person level analysis, the car sharing impacts on car ownership are obviously of key interest and they will be mainly assessed in this report. Additional research questions are the following: What are the impacts on the ownership of public transport season passes and on other mobility subscriptions (such as bike sharing)? Are mobility habits of car sharing users different compared to non-users? How do they change after the car sharing subscription? Do car sharing users of different service typologies behave differently? Is there an optimal mix of car sharing services that might increase the positive impacts of such changes?

On the other hand, considering trip level aspects we want to determine modal diversion patterns from existing services to car sharing. Related open issues are the following: Which are the impacts in terms of air pollution and greenhouse gas emissions deriving to these changes? Which are the impacts on public spaces and on congestion? How can we quantify these impacts and determine the scenario that maximise the positive impacts of car sharing?

In order to give answers to the above research questions, this deliverable is structured in seven main sections, including this one. The six remainder are the following:

- Section 2 describes the design and implementation of the STARS mobility survey used to gather the data in three different case studies, which are at the basis of all the analysis carried out in this document. Study areas selected within case studies were urban areas with a good public transport network and where different car sharing typologies coexists. The use of different European cities was considered a plus to check for eventual differences. In this section, firstly some issues related to the correct identification of the impacts of car sharing services that constitute the conceptual framework of the survey are discussed, then questionnaire contents are presented (2.2). Furthermore, due to different local conditions among the three case studies, minor changes made in the survey contents are described (2.3). The last part of this section assesses to which extent the proposed investigation could be expanded to additional cities with different settings, with particular reference to the uptake cities that were identified in the project (2.4).
- Section 3 presents the methodologies used to analyse both person-level and trip-level information. The former allows understanding the car sharing impacts on mobility choices and car ownership levels and changes, while the latter allows quantifying substitution and complementarity patterns between transport modes through the definition of a set of mobility scenarios and to quantify car sharing potential impacts on air pollution, use of public space and congestion.
- Section 4 presents the results from the person-level analyses of the three case studies. In particular, the section starts with a brief description of the user characteristics in the different case studies (4.1). Then car ownership levels and trends are presented (4.2), followed by the impacts of car sharing on public transport season tickets ownership and bike sharing membership (4.3). Furthermore, car sharing users mobility habits and their changes after subscription are presented (4.4), along with the assessment of some car sharing features by non-members' (4.5). The section ends giving some insights about the optimal mix of car sharing variants to be implanted in an urban area, based on person-level impacts in terms of car ownership that were estimated in the three case studies.
- Section 5 presents the results of the trip-level analyses that were carried out on the Italian dataset only, because of the lack of detailed information about the last trip performed in the two other case studies. In particular, the potential travel demand that might be attracted by car sharing in some mobility scenarios built under different conditions is presented (5.1). Like

the previous section 4, also this section ends by giving some insights on the optimal mix of car sharing variants that might increase the benefits of such systems at the individual trip level (5.2).

- Section 6 completes the results from section 5 by showing the impacts in terms of air pollution and greenhouse gas production of different car sharing scenario, individuating the rupture scenario (6.1 and 6.2). This scenario is defined on the basis of the economic quantification of those impacts and its maximisation compared to the business as usual scenario (gap analysis). In the last part of this section, impacts on public spaces are quantified within the rupture scenario (6.3).
- Section 7 closes the document with the feedback received from the uptake cities about how the project contents and results helped them to understand, on the one hand, what kind of mobility options are available in terms of shared mobility and in particular of car sharing, and on the other hand, what are positive and negative impacts of different car sharing variants, as well as what conditions they still have to achieve in order to introduce the optimal car sharing mix in their city.

The general findings of the whole research activity are then summarised in the conclusions.

2 Data collection and field activities

The first activity of WP5 was the design and implementation of a mobility survey aimed at understanding the impacts of car sharing on mobility habits, changes in car ownership and in the use of public spaces. Additionally, this survey provided the information needed to define some car sharing scenarios, where car sharing impacts are analysed considering daily trip patterns. The population targets were people with a car driving licence living in some European cities where different car sharing variants are available (as defined in previous STARS deliverables) together with a good public transport offer. As discussed in the introduction, it is essential to address those people that have a real choice of different travel modes to correctly assess car sharing impacts.

Section 2.1 discusses some issues related to the correct identification of the impacts of car sharing services that constitute the conceptual framework of the survey, while section 2.2 presents the questionnaire contents. The survey format followed the cross-sectional travel survey standard practice (BMVI, 2019; Cornick, Cant, Byron, Templeton, & Hurn, 2019; Ortúzar & Willumsen, 2011) adding specific car sharing questions in line with some existing studies (Ceccato & Diana, 2018; Schreier et al., 2018a).

The STARS members directly involved in this activity decided to administer the questionnaire mainly through a web survey (with additional telephone interviews in one case), with minor changes in the contents related to local conditions, in three case studies depicted in the below section 2.3. Section 2.4 assesses to which extent the proposed investigation could be expanded to additional cities with different settings, with particular reference to the uptake cities that were identified in the project.

2.1 How to correctly consider car sharing impacts?

2.1.1 Sample self-selection and the issue of the causality effect

Along with the issues related to the use of web surveys, such as selection bias and under-coverage (Bethlehem, 2010), sample self-selection needs to be considered to understand if observed differences in characteristics and behaviours of respondents might be imputable to car sharing membership.

The sample self-selection bias can arise when research participants choose their own treatment condition, in this case the fact of subscribing or not to a car sharing service, rather than being randomly assigned to one of the two groups (i.e. users and non-users) as it usually happens for example in clinical studies. Due to self-selection, there may be significant differences in covariates (e.g. the number of vehicle owned) between the group of people who decided to be car sharing members and those who have not, independent on the fact that a car sharing service is existing and

in use. For example, respondents enrolled to a CS service might have owned less cars anyway (E. Martin, Shaheen, & Lidicker, 2010; E. W. Martin & Shaheen, 2011; Mishra, Clewlow, Mokhtarian, & Widaman, 2015). Thus, self-selection bias affects the evaluation of whether or not a given treatment (car sharing membership) has a causal effect on differences observed between users and non-users samples.

To reduce the effects of self-selection, the matched sampling strategy was used in the survey. Matched sampling consists in identifying a control group that is similar to the treated group with respect to the distribution of observed covariates, so that the resulting differences in outcomes between the groups may be attributed to the treatment under study, i.e. car sharing membership in our problem (Ho & Rubin, 2011; Rosenbaum & Rubin, 1985).

2.1.2 Identification of users, non-users and control groups

As the survey was targeted to both car sharing members or non-members, a propensity score-based matching algorithm was used to create the matched sample. The propensity score, defined as the probability of receiving treatment conditional on the covariates, is calculated for each observation using a logistic regression model based on several covariates. Unlike those models that aim to predict probabilities parsimoniously, all potential confounders should be included in the specification of propensity score models (Mishra et al., 2015). In this study, since the control group is used to compare different levels of car ownership, frequency of use of transport means, season ticket ownership and bike sharing membership, the covariates where selected among an array of socioeconomic characteristics (please refer to Appendix 4 for detailed information).

Finally, a nearest-neighbour matching algorithm based on the smallest propensity score difference was used. The matching was undertaken using the MatchIt package in R (Ho, Imai, King, & Stuart, 2007, 2011). Due to the sample dimensions, the algorithm was set to find one control match for each individual in the treatment group. At each matching step, the unmatched control individual that is closest to the treated individual on the distance measure was chosen.

2.1.3 Person level versus trip level analysis

As mentioned in the introduction many studies focus on the characterisation of car sharing users according to their socioeconomic characteristics, on the effects of car sharing membership on users' travel habits and on changes in mobility choices, including car ownership decisions. These aspects were also covered in this study since information at both person and household level were collected. However, differently from existing studies that consider rather aggregate measures of mobility, the aim of this study was also to evaluate the role of car sharing in terms of substitution and complementarity patterns (which might change the travel demand for all competing modes) at the

individual trip level. Therefore trip level information was collected partially following the current best practices (Ortúzar & Willumsen, 2011), as far as collecting data with that level of detail did not make too hard to convince a sufficiently large sample of individuals to participate to the survey. For this reason, the focus has been only on one trip rather than on all trips completed in a given time period through the compilation of a full travel diary.

Such trip level information allowed quantitatively evaluating the car sharing impacts in terms of congestion, greenhouse gas and pollutants emissions and all those parameters that are related to the trip distances, through a definition of a set of mobility scenarios. In order to do that, data coming from this survey have been complemented with information coming from a set of SP experiments contained in another dataset, which was available at Politecnico di Torino. Please refer to par. 2.2 for more information about the collected trip data and to par. 3.2 for details on the analyses performed with them.

2.2 Questionnaire contents

Before starting to answer the questions, participants were informed about the purpose of the project, the leading institutions involved in the project and whom they could contact for additional information. Moreover, respondents were informed that their answers would be made anonymously and stored encrypted in agreement with Regulation (EU) 2016/679 of the European Parliament on the protection of natural persons with regard to the processing of personal data.

The questionnaire consisted of 56 questions divided into four sections. Filters were applied in accordance with respondents' answers in order to avoid questions that did not apply for a respondent circumstance. Please refer to Appendix 1 for the full list of questions, while in the following we recap the four sections.

2.2.1 Travel behaviour and mobility habits

In this section, the questions were focused on the use frequency of different travel modes, public transport (PT) season ticket ownership, car sharing and bike sharing membership and, for CS members only, on the changes of travel habits after the registration to a car sharing service.

2.2.2 Compact travel diary

Only information about the last trip performed with car sharing (for users) and with any other travel mode (non-users) was asked in order to achieve the highest possible response rate (minimising the non-response bias). Additionally, the used means of transport, the trip duration and the trip purpose were collected in this section, along with the GPS positions of trip origin and destination that were recorded through an interactive map on which the respondents could click.

On the one hand this approach substantially reduces the time required to complete the survey (compared to traditional travel diaries); on the other hand, fewer trips are recorded and they might be biased if there is no control on the time when the survey is administered (e.g. if all respondents take the survey in evening hours, work back home trips will be mainly collected).

2.2.3 Changes in car ownership

In this section, the number of cars owned at the household level at the time of the interview was firstly asked and stored in a variable named HH_CAR_NOW. Then, information about past car ownership levels was collected according to the status of the respondent.

Car sharing members had to state the number of cars at the household level in two other periods, namely at the time of the first registration to a car sharing service (variable HH_CAR_REG) and one year before the first registration (variable HH_CAR_BACK), in line with (Schreier et al., 2018b). On the one hand, changes in car ownership levels after the subscription, which can be captured by comparing the values of HH_CAR_NOW and HH_CAR_REG, might be a consequence of the subscription itself whereas, on the other hand, changes shortly before the subscription are observed by comparing HH_CAR_REG and HH_CAR_BACK and they might be the reason behind the decision of becoming a member of a car sharing service. Therefore different combinations of changes might happen especially considering before-after registration periods (e.g. one could reduce the number of cars owned within one year before the registration and increase it after the registration). Those cases are defined in the right part of the flowchart reported in Figure 1 below.

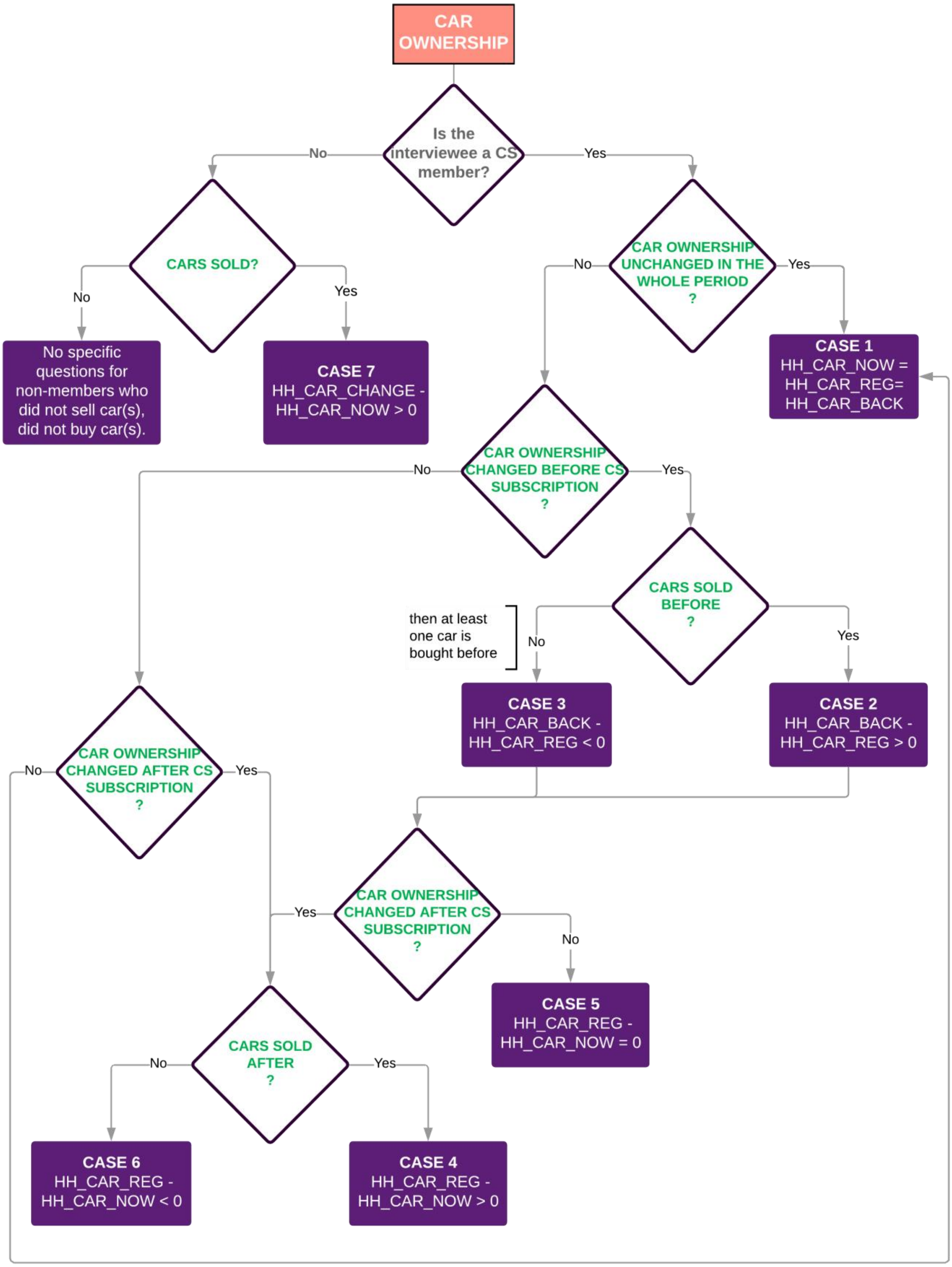

Figure 1: Flowchart defining different cases of changes in car ownership

Nine cases have been evaluated for car sharing users according to what is presented in Figure 1. Three of them are simple cases (Case 1, Case 4 and Case 6), while the remainder is obtained as a combination of one of these simple cases plus an additional one, namely either Case 2, or Case 3, or Case 5:

- Case 1: the number of cars is unchanged in the whole period (since one year before the first car sharing registration);
- Case 4: the number of cars decreased after the first registration to a car sharing service (no changes before such registration);
- Case 6: the number of cars increased after the first registration to a car sharing service (no changes before such registration);
- Case 2 + Case 4: the number of cars decreased both before and after the first registration to a car sharing service;
- Case 2 + Case 5: the number of cars decreased before the first registration to a car sharing service, but it did not change after;
- Case 2 + Case 6: the number of cars decreased before the first registration to a car sharing service, while it increased after;
- Case 3 + Case 4: the number of cars increased before the first registration to a car sharing service, while it decreased after;
- Case 3 + Case 5: the number of cars increased before the first registration to a car sharing service, but it did not change after;
- Case 3 + Case 6: the number of cars increased both before and after the first registration to a car sharing service.

Those cases have been already described in section 3.3 of the STARS Deliverable 6.1 (Melis et al., 2019) and are not reported here. However, specific questions aimed at understanding to what extent car sharing subscription affected or might affect the decision of selling, not changing or even buying a car were asked for all cases, and they will be analysed in section 4.2.

Concerning non-members, the survey asked the number of cars owned the last time when a change in the number of cars occurred in the respondent's household. Furthermore, non-members were asked to rate the importance of car sharing improvements on specific aspects that might influence their future registration to car sharing.

Finally, in order to evaluate the impact of car sharing on the use of infrastructures and public spaces, questions about where household cars are usually parked were asked to both car sharing members and non-members.

2.2.4 Socio-economic characterisation

In this section, both individual and household socio-economic characteristics of the respondent were asked. Besides, a specific question about the number of car sharing members within the household was inserted in order to understand the impact of car sharing membership on household car ownership.

2.3 Survey implementation and local variants to the design

2.3.1 Italian case study

The cities selected within the Italian case study were Milan and Turin. The former represents the Italian city with the largest car sharing services offer, in terms of operational schemes that coexist (free-floating and roundtrip station-based services), fleet dimensions and number of customers (Ciuffini et al., 2019). The latter, despite the lower number of services (3) is one of the main car sharing market in Italy. In addition, data of the city of Turin were already collected through another survey carried out in a previous study (Ceccato & Diana, 2018), and they will be used to calibrate some switching models in the following (paragraph 3.2).

In order to obtain a representative sample of the population living in the two cities of the Italian case study, the complete version of the survey was administered by an external poll firm, which could rely on more than 60000 panellists in the whole Italy. Sampling and weighting methods were employed to match citywide individual population distributions on two key demographic variables, namely gender and age. Both computer-assisted web interviews (CAWI) and computer-assisted telephone interviews (CATI) were used to maximise the coverage.

Along with those respondents who declared of being enrolled in a car sharing service that was encountered by chance during the survey distribution, car sharing users were oversampled to obtain a more consistent group. The use of a panel allowed to gather answers from different users of car sharing, reducing the self-selection bias produced by the frequent-users answer rate (members that use the service more frequently are usually more willing to take part in a survey). However it was not possible to obtain a completely representative sample of the users' population since users of the services in Milan and Turin might live in other cities (even region).

The data collection activity started on the 13th of May 2019 and ended the 28th of the same month. During this period 1474 completed questionnaires were collected within the two cities: 666 respondents declared of being registered to a car sharing service while 808 did not. A breakdown of the collected answers is reported in Table 1 below.

City	Survey protocol	Members	Non-members	Total
Milan		**485**	**553**	**1038**
	CAWI	105	278	383
	CATI	75	275	350
	CAWI (oversampling)	305	0	305
Turin		**181**	**255**	**436**
	CAWI	40	140	180
	CATI	42	115	157
	CAWI (oversampling)	99	0	99
Total		**666**	**808**	**1474**

Table 1: Number of completed questionnaires collected in the Italian case study

Although the survey appeared quite long (56 questions according to the worse combination) the time of completion was about 16 minutes on average, therefore fatigue effects were not expected. Table 2 shows the number of car sharing users, split according to the car sharing variant according to the STARS classification (Ramos et al., 2019).

Car sharing variants	Milan	Turin	Total
Roundtrip station-based	9	0	**9**
Free-floating with an operational area	439	151	**590**
Free-floating with pool stations	0	14	**14**
MultiOC[1]	37	16	**53**
Total	**485**	**181**	**666**

Table 2: Respondents per car sharing variant in the Italian case study

Even if one of the objectives of the survey was to collect information about users of different car sharing variants, at least in Milan where all those variants exist, just a few users of station-based services were interviewed given the limited diffusion of such services. Thus, results coming out from the Italian case study, can only be referred to free-floating services.

2.3.2 German case study

The research area of this study encompasses the entire urban area of the city of Frankfurt am Main, defined by postal codes.

[1] As defined in (Ramos et al., 2019) MultiOC users are people enrolled to more than one car sharing service with different operational characteristics.

The city was chosen for the study because all the different car sharing systems have already existed here for many years, thus offering a different viewpoint from the above introduced Italian case studies where free-floating services prevail. The city of Frankfurt, with its 753056 inhabitants (as of 31/12/2018), is the fifth-largest city in Germany, covering an area of 248 km^2. In Frankfurt, seven providers operate a car sharing offer with a total of nearly 900 cars. Measured by the number of station-based vehicles, book-n-drive and stadtmobil Rhein-Main are by far the largest companies with station-based vehicles in Frankfurt. DB Connect (Flinkster) Ford Carsharing, Mazda Carsharing and Mobileeee augment this supply with additional cars. A total of 457 station-based cars are available. SHARENOW and book-n-drive operate another 440 cars as free-floating vehicles.

The data of the study were collected between the 28th of March 2019 and the 1st of May 2019 through a simplified web version of the travel survey described in 2.2. Car sharing members were mainly invited to take part in the survey per e-mail sent from the car sharing provider whose they were customer at the time of the survey distribution. The providers Stadtmobil Rhein-Main (Roundtrip station-based), book-n-drive (Combined roundtrip and free-floating car sharing) and Drivy (Peer-to-peer) actively participate to the survey distribution, while the providers Flinkster (Station-based car sharing), SnappCar (Peer-to-peer) and Car2Go (Free-floating car sharing), which also operate in the urban area, did not take part in this study of the STARS project. Following the provider's rejection, Car2Go customers and non-members were invited by post to partake in the online survey.

The identification of customers living in the city area was undertaken by the car sharing providers. Here, the aim was to concentrate on private households. The providers were asked not to include members who were as pure business customers or employees of companies clearly identifiable.

A total of 16803 car sharing members in the city of Frankfurt am Main were contacted in writing by the providers.

Car sharing non-members were contacted using an address record containing 12297 postal addresses for private households in the urban area. The address record was compiled according to the following selection criteria: foreign language: German [Deutschland], aged 18 to 59, 16 selected postcode districts. Thus, respondents were asked at the beginning to give the postal code of their place of residence. On the one hand, this serves to ensure that only customers with a current residence in Frankfurt are taken into account in the evaluation. On the other hand, it is also possible this way to see whether, for example, feedback was received from all parts of the city and not only from inner-city districts.

In fact, there were fully completed questionnaires from all postcode areas with the exception of the airport (60549). There were only single-digit responses from Zeilsheim (65931), Sossenheim (65936),

Nied (65934), Griesheim (65933) and Schwanheim (60529) in the west of the city, and from Fechenheim (60386) and Bergen-Enkheim (60388) furthest to the east of Frankfurt.

These households were invited by the German Car sharing Association by letter to participate in the survey.

In the survey of non-customers, a filter question was asked at the beginning. Persons who stated here that they were already registered with a car sharing provider were not admitted to the survey. An exception was made for Car2Go customers who were redirected to the user survey. Some 211 non-users contacted answered the survey. 204 questionnaires were completed in full by non-users. Additionally 63 questionnaires were completed by Car2Go customers.

Members and non-members collected answers are summarised in Table 3 below.

City	Survey protocol	Members	Non-members	Total
Frankfurt	CAWI (by CS operator email)	1037	0	1037
	CAWI (by postal address)	63	204	267
Total		**1100**	**204**	**1304**

Table 3: Number of completed questionnaires collected in the German case study

Since the aim of this study is to determine more accurately the differences between the users of different car sharing services, a distinction was first made between users who are registered with only one car sharing system and those who are registered with several alternatives. Different combinations of car sharing systems were then distinguished within the group of multiple registered users. If respondents were registered with several providers of the same car sharing variant (for example: stadtmobil and nimbler), they were counted as registered with one alternative. Respondents breakdowns according to the car sharing variant they belong to are reported in Table 4 below.

Of those surveyed in the sample, 68.9% are registered with only one car sharing system. 31.1% of respondents are registered with two or more car sharing systems at the same time. Among the users who are multiply registered, all the combinations considered were of similar size (between 5.9% and 8.5%). Exception: all groups in which users are also registered for the peer-to-peer option account for 1.1% or significantly less.

Combination of subscriptions	Number of respondents	% of all respondents
only roundtrip services	406	36.9%
only combined services	304	27.6%
only free-floating services	41	3.7%
only peer-to-peer services	7	0.6%
Total	**758**	**68.9%**
roundtrip + combined services	93	8.5%
roundtrip + free-floating services	65	5.9%
combined + free-floating services	72	6.5%
peer-to-peer + another services	12	1.1%
Total	**242**	**22.0%**
roundtrip + combined + free-floating services	80	7.3%
peer-to-peer + two other services	10	0.9%
Total	**90**	**8.2%**
all car sharing services	**10**	**0.9%**

Table 4: Classification of the respondents in car sharing user groups

A clear distinction must be made between users of the combined car sharing system, which offers station-based and free-floating vehicles from a single source, and users who are registered with several different car sharing alternatives. Although both groups of users combine car sharing systems, our analysis shows that some of them differ significantly from one another. So, from here on out, we will talk about the "combined car sharing" users on the one hand and the "multiple users" or "parallel users" on the other.

For most groups, the number of cases is sufficiently large, however due to the very small number of cases in all groups containing peer-to-peer users, these were no longer considered in the further evaluation. In addition, since the groups "roundtrip + free-floating", "combined + free-floating" and "roundtrip + combined + free-floating" behave very similarly in individual questions. Where this is the case, these three groups were combined into one group "free-floating +”

2.3.3 Belgian case study

During the design phase of the survey, the people living in the city of Brussels were targeted since both roundtrip station-based and free-floating services were active. In order to collect information from car sharing users, the service providers were contacted and informed about the STARS survey. Car sharing operators were not able to spread the questionnaire among their users, since they had

already collected similar information for an internal study. However they were willing to share some of these results. Additional issues came out during the data collection activities in Brussels. Thus, instead of having only information about a specific city, the Belgian case study was enlarged. Three different surveys were integrated, all starting from the same contents mentioned in section 2.2. To ensure both car sharing users and non-users would be sufficiently represented in the case study, different sampling strategies were used to gather data.

1. Panel survey

The target of this survey were people not enrolled in any car sharing service. Thus, the first survey was executed among an online panel of 1000 inhabitants of the Flanders region in Belgium, between September 26th and October 7th 2019. This sample is representative in terms of age, gender, residence and education degree. Most of the non-user questions from the survey mentioned in section 2.2 were included in this Flanders non-user panel study. For example, questions about the intention to become a customer of a car sharing platform, about their mobility behaviour or about the features of car sharing that would entice them to use the service were retained. Due to survey length restrictions, detailed information about their last trip performed in the city was not asked here. For a more detailed look at the questionnaire and its differences compared to the Italian case study, see Appendix 2.

Within the sample of 1000 inhabitants, 15 respondents (1.5%) indicated to be member of a car sharing service in Belgium: nine respondents were members of a roundtrip station-based service (RTSB), one of a free-floating service (FFOA), three of an organisation facilitating car sharing among neighbours, while the last two car sharing users are not linked to an organisation mentioned in the survey, probably doing car sharing on an informal way. For a more detailed explanation of these different forms of car sharing, please refer to (Bergstad et al., 2018; Nehrke et al., 2018; Ramos et al., 2019; Rodenbach, Mathijs, Chicco, Diana, & Nehrke, 2018).

2. Internal surveys of car sharing operators

The other group of interest were car sharing users. Therefore car sharing operators active in Belgium were asked to participate in the STARS research. A couple of them wanted to cooperate, but none of the car sharing organisations was able to spread the full survey (see section 2.1.3), due to the length of the original survey. However some car sharing operators were willing to share data gathered during internal surveys carried out in 2019, on the condition that only comparative analyses could be carried out. Thus, data of more than 3200 respondents from internal researches of both RTSB and FFOA services operating in the Capital Region of Brussels were accessed.

The topics covered by the internal surveys of the car sharing operators were very similar to those of the STARS full survey, for example information about changes in mobility habits and car ownership of car sharing users were available. Clearly, the quantity and quality of information collected depend on the deepening done by the car sharing operator. For instance, no information about the last trip performed in the city was collected and a more detailed and chronological view on the change of car ownership due to the subscription to car sharing was also missing.

However, through these datasets it was possible to compare members of roundtrip station-based and free-floating car sharing operators, which is the main lack in the Italian case study that is presented in the following. As for the above panel survey, for a more detailed look at the questionnaire, see Appendix 2.

3. Full version of the STARS web survey

At last, the full survey as described in section 2.1.3 was also distributed in Dutch within the Flanders region of Belgium. From September 9th till October 20th 2019 Autodelen.net, the network of car sharing in Belgium, circulated a link to the online survey via their own channels (newsletter, social media, network, …). This inquiry resulted in a sample of 175 respondents, of which 65 car sharing members enrolled in different car sharing operators.

Overall number of observations for the Belgian case study

Information coming from the previous three sources were merged in order to have a wider picture of the car sharing impacts in Belgium. The full breakdown of the collected answers by different surveys is reported in Table 5 below.

Area	Survey protocol	Members	Non-members	Total
Flanders		**80**	**1095**	**1175**
	CAWI (Panel)	15	985	1000
	CAWI (Full version)	65	110	175
Brussels Capital region		**3215**	**0**	**3215**
	CAWI (CS operators survey)	3215	0	3215
Total		**3295**	**1095**	**4390**

Table 5: Number of completed questionnaires collected in the Belgian case study

In addition respondents breakdowns according to the car sharing variant they belong to are reported in Table 6.

Car sharing variants	Brussels Capital region	Flanders region	Total
Roundtrip station-based	2396	52	**2448**
Roundtrip homezone-based	-	11	**11**
Free-floating with an operational area	819	15	**834**
Car sharing among neighbours	-	45	**45**
Peer-to-peer car sharing	-	9	**9**
Total	**3215**	**80**	**3295**

Table 6: Respondents per car sharing variant in the Belgian case study

2.4 Method to assess the replicability of the case studies for “uptake” cities

Beyond the above introduced main case studies, an additional activity carried out in WP5 was to establish a small group of “Uptake” cities. The purpose of establishing the Uptake cities group was to check the replicability and understanding of the STARS project results by external local authorities. Since the scope, size and number of the cities needed for the project were not defined in the DoA, the consortium reached an agreement that cities less than 50000 inhabitants will not be included, since that is the minimum number to cover all car sharing business models identified earlier in the project (in WP3). Another desirable characteristic in screening cities for the Uptake cities is that they are from Eastern Europe. According to (Nehrke et al., 2018; Rodenbach et al., 2018) car sharing in Eastern European countries, compared to the rest of the EU, is well underdeveloped. Thus including a high number of Uptake cities from these countries presented additional value for testing the project results and understanding from these city representatives what is needed. The cities recruitment started in January 2019 due to the nature of communication with city representatives mainly in their availability, responsiveness and general interest in joining the STARS project.

After the initial approach made by ICLEI to 10 Eastern European cities with a population greater than 50000 inhabitants, a Letter of Interest was sent to the city representatives, to create a form of commitment towards the project and the obligations that may arise during their involvement. The Letter of Interest was comprised of a section where the city representatives sign to indicate their involvement, which means they promise to do their best in attending designated webinars and workshops. In the second part of the Letter of Interest, the cities had to answer questions that describe their interest and expertise in the topic of car sharing. ICLEI managed to collect four letters of interest by City of Budapest (HU), Cluj-Napoca (RO), Oradea (RO) and Sofia (BG), while only email exchange was conducted with the cities of Warsaw (PL), Varna (BG) and Bratislava (SK) where they have expressed their interest in following the project, mainly webinars and workshops.

The main activities designed for the Uptake cities were two webinars and a 3.5-hours workshop within the Innovation camp held in Paris on the 15th October 2019.

The first webinar, titled "Car sharing outlook in the EU", was attended by 22 participants, out of which 5 Uptake cities: Budapest (HU), Cluj-Napoca (RO), Oradea (RO), Sofia (BG) and Warsaw (PL). During the webinar, Uptake cities had a designated slot to give a short presentation about their cities' mobility outlook and their expertise on car sharing. After the webinar, as mentioned, a short questionnaire was sent to the Uptake cities. Some of the comments were useful for organising the second webinar in selecting topics and speakers.

The second webinar, titled "Bringing car sharing into the European cities" was attended by 20 participants, out of which five uptake cities: Warsaw, Cluj-Napoca, Budapest, Varna and Sofia. Similar to the 1st webinar, the Uptake cities had been given a dedicated timeslot for their introduction and reflection on urban mobility situation in their city, with special focus on car sharing in case it operates there.

The two webinars were followed by a survey that Uptake cities filled in, expressing their thoughts about the webinar and recommendations for the future steps. Both questionnaires are reported in Appendix 3.

Webinars were 90 minutes long organised via online platform GoToWebinar and they were recorded and uploaded on the CIVITAS Learning platform.

Additionally, Uptake cities were asked to write a document of about a couple of pages related to a potential car sharing implementation scenario in their respective cities, with the deadline set for at the end of the year 2019. The aim of this document is to help the consortium to understand how well did the Uptake cities understand the STARS project results and what would be the procedure in case they decide to implement a certain car sharing business model. The cities were provided with a template comprised of five guiding questions. Uptake cities representatives were not obliged to follow the guiding questions and they could choose another form of the document. Moreover, ICLEI stood available and invited the Uptake cities representatives for a one-to-one phone call meeting to assist them in writing the document.

3 Data analysis methods

3.1 Descriptive statistics, statistical testing and person-level analyses

Person and household level data collected through the survey implemented for the different case studies were firstly analysed by considering descriptive statistics on each question and comparing car sharing users versus non-users. Concerning the Frankfurt and the Belgian case studies were different operational forms of car sharing are in place, observed differences among users of such different services were also noted. Additionally, for the Italian case study a control group was extracted from the non-members sample by implementing a propensity score-based matching, as described in 2.1.2, while we also have an oversample of car sharing users.

We therefore have four different sets of observations in Milan and Turin: a random sample of car sharing users, an additional "oversample" of car sharing users, a random sample of non-users and a control group made of non-users. According to the kind of analysis, it is more sound to jointly analyse two of those groups. More specifically, whenever the use of a control group is useful to evaluate the causality of car sharing membership (e.g. car ownership), differences were evaluated between the group of non-oversampled car sharing members and non-members of the control group only. It is worth stressing that even using this approach it is not possible to fully guarantee to correctly capture the causality effect, because there might be other underlying factors that were not taken into consideration in the control group definition, such as differences in lifestyles, personal norms, values and attitudes.

In other analyses at a rather disaggregate level (e.g. by geographic zone), where more observations were necessary to reduce the sampling error, all car sharing users' observations (both oversampled and not oversampled) and all non-members observations were used. In other cases, all four groups will be shown together (e.g. in the use frequencies reported in Figure 15 and Figure 16) to have a broader view and better interpret the difference among these groups, or to check the effects of the oversampling on the analysed statistics.

When average values were compared, t-tests or non-parametric Wilcoxon signed-rank tests were performed to check for statistical significance (e.g. the average number of cars owned by respondents evaluated in 4.2), whereas Chi-square test was performed to check for significance in frequencies (proportions) differences (e.g. the use frequency of different transport modes in 4.4.1). All the analyses were carried out and plotted with R, which is an open-source software environment for statistical computing and graphics (R Core Team, 2013).

Finally, since the Belgian case study is based on three different data sources, different methods of analysis were applied. For the panel survey, univariate relative frequencies for every variable and cross tabulations (bivariate relative frequency distributions) were evaluated for the most relevant relations between dependent and independent variables. Only significant frequencies[2] are reported in this document.

The data obtained from internal surveys of car sharing operators were already analysed and presented in tables with univariate relative frequencies for every separate question. For this part of the case study, different research samples' results were just compared.

Some other descriptive statistics and cross tabulations were done with data coming from the full survey. Only the most relevant variables will be presented in the following.

3.2 Modal switch models and trip-level analyses for the mobility scenarios

Data coming from the survey described in chapter 2 are also providing information for a representative set of trips done in the study area. In order to avoid having a too complex survey and given the level of detail that was already requested to correctly observe car ownership changes, this survey did not include questions related to the future mobility scenarios. Therefore, wishing to evaluate the potential of car sharing in attracting the existing travel demand, a previous study carried out in the city of Turin was considered (Ceccato & Diana, 2018). In that research, an extensive travel survey was administered in the city of Turin through both CAWI and CATI protocols, seven days a week in three different 4-weeks periods (September–October 2016, February 2017 and June 2017), to a representative sample of the population living in the Turin metropolitan area. 4466 complete questionnaires were collected but only 3280 (73.4%) were retained, since respondents that did not travel the day before the interview or had only trips longer than 50 km or travelled outside the car sharing operational area of the existing services were not considered.

Along with a complete travel diary and questions about socioeconomic characteristics of the respondents and of their households, one section of such previous survey focused on a randomly selected trip among those listed in the travel diary. Attitudinal questions on this trip and stated-preference (SP) experiments were used to investigate related mode switching attitudes. Since car sharing was one of the alternative modes proposed in the SP experiments, it was possible to evaluate the attributes that influence the switching intentions towards car sharing. In particular, respondents were asked to state their willingness to switch to car sharing from the "base mode", represented the currently used mode, to car sharing under a particular condition obtained as a combination of trip

[2] Reliability level of 95%.

cost and travel time. These two trip attributes were computed for the new mode by following an experimental design that is based on cost and time functions that are reported in Appendix 5, together with the positive switch results of SP experiments. The reader is referred to (Ceccato & Diana, 2018) for additional details on this survey.

Then, binomial logit models were calibrated using this dataset in order to predict switching intentions from the currently used mode to car sharing. Both socioeconomic characteristics of the respondent, of her household and trip characteristics (distance, duration, generalised cost, purpose) were considered as explanatory variables during the calibration phase. The complete list of these variables is reported in Table 7 below.

Variable	Description	Type	Level
AGE	Age	Metric	Individual
BASE_COST	Current mode trip cost [€]	Metric	Trip
BASE_DIST	Current mode trip distance [m]	Metric	Trip
BASE_DUR	Current mode trip duration [min]	Metric	Trip
BASE_LEG	Current mode trip legs	Metric	Trip
BASE_WAIT	Current mode waiting time [min]	Metric	Trip
BASE_WALK_DIST	Current mode walking distance [m]	Metric	Trip
BASE_WALK_DUR	Current mode walking duration [min]	Metric	Trip
BIKE_SHARING	Bike sharing subscription (Y: yes, N: no)	Categorical	Individual
CARPERLICENCE	Number of cars per driving licences	Metric	Household
CS_COST	Car sharing trip cost [€]	Metric	Trip
CS_DIST	Car sharing trip distance [m]	Metric	Trip
CS_DUR	Car sharing trip duration [min]	Metric	Trip
CS_LEG	Car sharing trip legs	Metric	Trip
CS_WAIT	Car sharing waiting time [min]	Metric	Trip
CS_WALK_DIST	Car sharing walking distance [m]	Metric	Trip
CS_WALK_DUR	Car sharing walking duration [min]	Metric	Trip
EDUCATION	Level of education (NE: no education, PRIM: primary school diploma, SEC: secondary school diploma, HS: high school diploma, UNI: university degree, master or Ph.D.)	Categorical	Individual
EMPLOYEMENT_AGGR	Job status (RET: retired, STN: student, UNE: unemployed, WAH: work at home, WOOH: work out of home)	Categorical	Household
F_BIKE	Bike monthly use frequency	Metric	Individual

F_BS	Bike sharing monthly use frequency	Metric	Individual
F_CAR	Car monthly use frequency	Metric	Individual
F_PT	Public transit monthly use frequency	Metric	Individual
GENDER	Gender (M: male, F: female)	Categorical	Individual
HH_CAR	Number of cars	Metric	Household
HH_CHILDREN_U	Number of children (<18 years)	Metric	Household
HH_DRIVLICENCE	Number of driving licences	Metric	Household
HH_SIZE	Number of members	Metric	Household
HH_WORKERS	Number of workers	Metric	Household
INCOME_AVG	Average monthly income [1000€]	Metric	Household
MODE_USED	Current mode used (CAR: private car as a driver/passenger, PT: public transit)	Categorical	Trip
NO_WORK_DAY	Holiday (Y: yes, N: no)	Categorical	Trip
PT_SEASON_TICKET	Public transit pass (Y: yes, N: no)	Categorical	Individual
TRIP_PURP	Trip purpose (HBW: home-based work, HBEd: home-based education, HBO: home-based other, NH: not home-based)	Categorical	Trip
ZTL_TO_AP	Destination within a limited traffic zone (Y: yes, N: no)	Categorical	Trip

Table 7: Candidate explanatory variables

In particular, four different models were estimated by considering the four main travel means reported by the respondents in their travel diary, namely walk, bike, car and public transport. More details about the variables that significantly affect the switch toward car sharing and their coefficients are reported in Appendix 5.

Models calibrated with these data were then applied to the data collected within the STARS Italian case study, which contained all the required information about the respondent and the trip characteristics and that was presented in section 2.2.3. This procedure might raise some spatial transferability issues for the data collected in the city of Milan, since the population of the two cities, their characteristics and travel habits might be different. For this reason and because of the lack of detailed information about the last trip performed, the two case studies in Germany and Belgium were excluded from the estimation of the travel demand that may potentially switch to car sharing. However, for the Italian case study the larger sample collected in (Ceccato & Diana, 2018) was considered more reliable than a calibration based on the data collected through the survey described in 2.1.

The entire population living in the two cities was obtained by weighting the sample observations according to the two representative variables (gender and age). Therefore each weight represented the number of people living in one of the two cities having the same characteristics in terms of gender and age of the respondents.

Then the total amount of daily trips within the two cities was evaluated by simply summing up the observation weights and then multiplying the result times the number of average daily trips per person. According to the information reported by the mobility agency of Milan[3], 2.69 trips per person per day were made in that city by people with more than 18 years. On the other hand, the estimated number of daily trips per person (over 18) in Turin was 2.3, according to the report of the Turin metropolitan mobility agency (Agenzia per la Mobilità Metropolitana e Regionale, 2015).

The population-level modal split of Turin and Milan resulting from the survey, presented in Figure 2 below, was compared to existing statistics[4,5] to check for consistency.

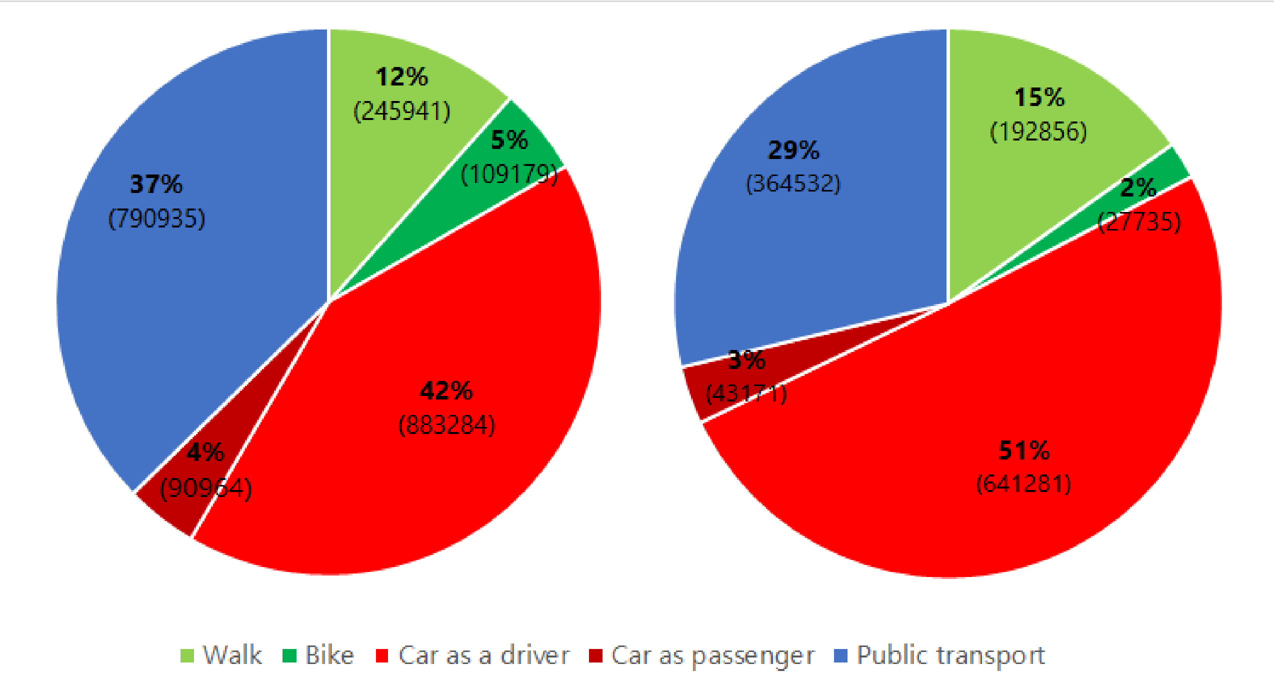

Figure 2: Modal split in Milan (left side) and Turin (right side) estimated from the trips registered in the 2019 STARS survey

[3] https://www.amat-mi.it/it/consultazioni/pums/documenti/ddp1/45/ - Accessed September 5th, 2019

[4] https://www.eiseverywhere.com/file_uploads/d23dc9cc58635262e5d20a4e48f4d087_MILANO_LONG.pdf (Berrini (AMAT) The challenge: tranform the Urban Mobility model to make Milano a more Livable city) - Accessed September 5th, 2019

[5] http://www.epomm.eu/tems/result_city.phtml?city=279&map=1 (EPOMM - Turin modal split) - Accessed September 5th, 2019

A good match was found, especially for Turin, even if the STARS survey recorded a larger proportion of walk trips, probably because these trips are traditionally under-reported in official statistics (Agrawal & Schimek, 2007; Westat, 2019). The proportion of trips made by car as a passenger is also quite low, probably due to a trip selection bias of respondents that tended to more easily recall a trip as a driver when asked to report about the last trip they made.

Finally, applying the switching probabilities it was estimated the number of trips that might be potentially substituted using car sharing.

3.3 Definition of the five mobility scenarios

Different mobility scenarios were set up for both Turin and Milan. Some of them derive from the application of the switch models presented in the previous subsection 3.2, whereas others are directly based on the survey data, since they represent either the current situation or an hypothetical situation with no car sharing services operating in the two cities. It is worth stressing that the predicted number of switches in different scenarios does not refer to any specific time point, so understanding "when" such scenarios could take place is beyond the scope of the present research. Additionally, the nature of the switch models used in this study allows to predict changes in the travel demand among existing modes, but not to forecast increasing in the overall travel demand. Therefore the overall travel demand in the two cities is considered constant in all designed scenarios.

Five different scenarios have been defined and evaluated in this research.

3.3.1 Business as usual scenario

The first scenario is called business as usual, since it represents the situation in a short-medium term, where car sharing will evolve according to the action already being planned from car sharing operators without proper policies aimed to maximise its positive impacts. This scenario is based on the outcome of the in-depth survey to car sharing operators that was implemented at the beginning of the project (Chicco, Diana, Rodenbach, Mathijs, & Nehrke, 2018).

Despite business as usual scenario and current scenario are conceptually different according to the previous definition, because the former is the projection in the near future of the latter with steady growth rates, in this study the two scenarios were considered as a unique scenario. This assumption derives from the fact that it is not the focus of the project to anchor the mobility scenarios to a specific time point. More precisely, the BAU scenario is informed by the STARS survey where observed mobility patterns of the sample are expanded to the universe of daily trips (presented in Figure 2 of par. 3.2), with the addition of the number of car sharing daily trips available for the two Italian cities reported in (Ciuffini et al., 2019), since car sharing trips are too few to be reliably observed through a sample survey.

3.3.2 All switch scenario

The second scenario is called "all switch" and it was directly derived from the application of the switch models to the daily trips performed by non-members survey respondents, then expanded to the universe of daily trips of Milan and Turin. Therefore, the scenario estimates the potential number of daily trips that might be performed with car sharing under current conditions. Since discrete choice models sitting behind switch models are based on the random utility theory, the "all switch" scenario is the one where individuals would maximise their systematic utility, perfectly knowing the transport alternatives and their objective costs (Ortúzar & Willumsen, 2011) and in presence of a car sharing offer that can serve all trips in the study area with the same levels of service of private cars (in terms of travel times including walk times to/from the parking spots at origins and destinations) and costs (compared to the actual fare structure).

These latter two conditions are not met in reality. On the one hand, travellers are different from the postulated ideal consumers and they make their choices also based on imperfect knowledge, personal norms and attitudes, habits. On the other, existing car sharing systems cannot provide the pervasiveness of private cars in the whole city to be economically viable. Therefore, we expect to observe a gap between business as usual and all switch scenario, with many more trips assigned to car sharing in the latter one.

3.3.3 Rupture scenario

The "all switch" scenario is providing an upper bound for the market share of car sharing systems, however it is not necessarily leading to a maximisation of its benefits in terms of reduction of the externalities of the transport system in a city. The latter depends on the switching patterns between different modes and car sharing, where a maximisation of diverted trips from private cars and a minimisation of diverted trips from public transport and active means is clearly desirable. The scenario that seeks to maximise such benefits is named rupture scenario.

The rupture scenario is defined as the scenario that maximises the overall car sharing benefits, expressed in terms of greenhouse (CO_2) and pollutants (NMVOC, NOx, NH_3 and $PM_{2.5}$) reduction. As it will be further clarified in the following subsection 3.4.1, other benefits and especially changes in the spatial and temporal configuration of the demand for parking spaces will be quantified as well for this scenario, but do not concur in its definition since they cannot be easily monetised and jointly considered with the variations in emissions.

Considering the explanatory variables that came out from the switch models calibration (reported in Appendix 5), two of these variables were individuated to run a sensitivity analysis and check how the car sharing demand is affected. The first one is the cost of car sharing, whose increase will reduce

the overall number diverted trips, especially those performed with null-cost modes (at least in terms of out of pocket cost), namely walk and bike. However the increase of car sharing cost will impact also on the number of trips that might be diverted from PT and private car. Although the reduction of switches from PT is desired, the one from private cars is not. In this perspective, the second variable that might help to reach the goal is the private car trip cost, whose increase would obviously cause an increase in the number of diverted trips proportional to the switch model calibration coefficients reported in Table 55: Car to car sharing switching model - significant coefficientsTable 55 of Appendix 5.

Car sharing costs were directly determined from the average operators' tariff of each city. Thus an increase of this cost is simply obtained by multiplying those tariffs by a growth coefficient. The increase of private car trip costs is, on the other hand, a bit more complex, since it was estimated according to the general population perception of costs when using a private car. It is in fact well known that behavioural choices are linked for private modes to perceived rather than real costs. Following standard practice in transport planning a generalised cost, which represents the sum of the fuel cost, of the parking (if any), of toll (if any) and of the pass to enter in limited traffic areas (if any), was used.

Among these four generalised cost components, only changes in parking costs were considered as potentially changing. Many reasons were at the base of this assumption: firstly, the fuel price is not dependent on city administration policies, and will directly impact car sharing operators' costs too. Secondly, since the considered trips were mainly carried out inside the two cities, no impact of an increase in the toll was expected. Finally, limited traffic zones (LTZ) in the two cities are different: in Turin this area is not accessible in certain hours of the day, except for public transport lines and people living inside that area[6]. Other people are not allowed to enter. In Milan, there are two different areas: the area B that is a central city area working with similar traffic limitations as the LTZ of Turin, and the area C, which is more similar to a pollution charge zone, in which more pollutant vehicles have to pay to access it. The city administration regulates the change of the price of this pass, thus it can be ideally evaluated in this study; however it was not considered since the two cities are not directly comparable regarding this regulation.

In order to evaluate the potential effects of an increase of both car sharing and parking costs on diverted trips to car sharing from different modes, the two costs were both varied in a range from 0% (all switch scenario) up to 100% of increase with 5% increasing steps.

[6] http://www.gtt.to.it/cms/ztl/permessi-di-circolazione-ztl - Accessed December 4th, 2019

The rationale of such variations is the following. Although the considered modelling framework assumes a fully compensatory choice protocol, thereby assuming that any variation in the costs of the alternatives has an impact on the probability that the individual is making a choice, it advisable to limit the range of cost variations when defining realistic policy scenarios rather than simply doing marketing research. On the one hand, there is a threshold below which changes are not perceived and therefore no behavioural changes are observed, leading to a well-known habit or behavioural inertia phenomenon. On the other, too sharp increases of parking costs might be considered unrealistic by respondents, and in any case they would not be implemented by the relevant stakeholders. Given the fact that a hourly parking fare consists in a relatively small amount of money in absolute terms, previous research (Tsamboulas, 2001) has shown that an increase of up to 50% had little effect in changing behaviours, while the effect became substantial for increases of around 100%. Therefore we retain the latter as an upper bound, considering that policy-makers are probably not willing to increase costs even more than that but only to a (much) smaller amount. To sum up, and we simulate the effect of increasing parking fares from 0% to 100% to study what would happen in a realistic policy scenario, however anticipating that cost changes of less than 50% would probably produce no effect independently on the modelling results.

As a result, a 21x21 matrix of candidate rupture scenarios was created. Travelled distances, the quantity of each pollutant mentioned above, greenhouse gas and respective costs were assessed for each scenario, following the methodology reported in subsection 3.4.1. Then, to identify the maximum impact (or rupture) scenario, a cost evaluation of the related externalities was carried out by considering the coefficients reported in Table 10 of par. 3.4.2 (see subsection 3.4.2 for the methodological steps). In particular, the monetary costs of greenhouse and pollutants emissions for the society were summed up. The rupture scenario was then identified within the matrix as the scenario that minimises the cost for the society; the minimisation of the costs guarantees the maximisation of the gap between the BAU and the rupture scenario indeed. Furthermore, impacts on congestion and on the use of public spaces have been evaluated for the rupture scenario.

3.3.4 All electric scenario

A fourth "all electric" scenario is derived from the rupture scenario presented in the previous section, by using a fully electrified fleets instead of the current car sharing fleets composition. Travel demand invariance is assumed, which seems reasonable since electric vehicles performances are comparable to internal combustion engine ones in a free-floating scheme in urban areas, where trip lengths and rental durations are limited. This assumption might clearly not hold for roundtrip services, where the limited autonomy of electric cars might be an issue making EV fleets less attractive for car sharing customers. Actually, a recent study found that after experiencing car sharing, members would switch

to car sharing with electric vehicles if possible (Schlüter & Weyer, 2019). As a result, electric vehicles would not produce tailpipe exhaust emissions, therefore the increasing use of car sharing deriving by the switch from any other mode would never correspond to an increase in the emissions. On one hand, the real application of this scenario would probably require an improved, wider and denser network of charging stations. On the other hand, it requires substantial investments from operators' side to substitute the entire fleets. However the local reduction of air pollutions' emissions of this scenario gives an idea to the policy-maker about how big car sharing benefits might be in case of full electrification.

3.3.5 No car sharing scenario

In previous scenarios, only potential trips switching from different travel means toward car sharing were considered. However, to have a more comprehensive view of the car sharing phenomenon, it is worth mentioning that also the opposite switch from car sharing to other travel modes may take place. In fact, decision-makers should also consider what would be the consequence of a service suspension or even shut-down. Therefore, a "no car sharing" scenario was evaluated to understand how current car sharing users will change their travel choices in case of the absence of car sharing and to assess the overall impact of car sharing, rather than the incremental impact compared to the actual situation. Consistently with previous scenarios, an overall travel demand invariance is assumed.

Instead of using switching models to estimate switches of all trips from car sharing to other modes, responses to some attitudinal questions were exploited to define such scenario. Respondents enrolled in a car sharing service were in fact asked to indicate what they would have done if car sharing had not been available for the specific trip, by using a 5-points Likert scale (1 strongly disagree – 5 strongly agree). Descriptive statistics related to such answers will be then analysed to define the "no car sharing" scenario.

3.4 Evaluation of the mobility scenarios

The evaluation of the above defined scenarios was based on a partial application of standard methods for the evaluation of externalities in the transport sector (European Commission, 2019), considering data availability and the specific framework of the present research. In particular, emissions of pollutants and greenhouse gases were quantified and monetised through unit costs, and the optimal "rupture scenario" was based only on these externalities This is due because the other considered impacts, namely on public spaces and on congestion, are either not easily monetisable or not quantifiable in such scenario. Therefore, the impact on public spaces was directly assessed in the final rupture scenario.

3.4.1 Estimation of greenhouse gas and pollutants emissions in the different scenarios

The trip origin and destination information collected within the last trip section of the Italian case study survey was elaborated through the Google Directions API, which enriched the dataset information with additional information such as trip duration, trip distance, number of trip legs (if any), waiting time and on-vehicle time (for transit trips). Trip distances thus elaborated were used to estimate the exhaust emissions of both greenhouse gas (carbon dioxide or CO_2) and some pollutants according to different mobility scenarios, by simply multiplying such distances times the exhaust emission coefficients in grams per kilometres [g/km] which are available in the literature according to different vehicles characteristics. In this research, we only consider tailpipe emissions of both CO_2 and pollutants, without considering e.g. the well-to-tank emissions related to conventionally fuelled vehicles or the emissions due to electricity production related to electric vehicles..

The pollutants that were considered in this study are those typically used in the estimation of the external costs of transport, which are reported in (European Commission, 2019), namely non-methane volatile organic compounds (NMVOC), particulate matter under 2.5 micrometres ($PM_{2.5}$), nitrogen oxides (NOx) and ammonia (NH_3).

Exhaust emission coefficients of CO_2 and pollutants were calculated by considering the fleet composition of both car sharing and private fleets in terms of number of electric and conventional cars (typically petrol ones), and computing the average of the emissions of different car models composing the fleet. Such averages are weighted by the number of private cars belonging to each emission class, whereas simple averages are considered for shared vehicles since the consistency of each model in the fleet of each operator is not known.

Pollutants exhaust emissions coefficients for conventionally fuelled cars that are considered here are the limit values defined by the European Environment Agency (EEA) (Ntziachristos et al., 2018), while electric vehicles obviously have no tailpipe emissions.

Through such method, average exhaust emission coefficients were estimated for both car sharing and private car fleets in the cities of Milan and Turin.

Car sharing fleets exhaust emission coefficients used in this study are summarised in below Table 8. Please refer to Table 62 in Appendix 9 for more information about European emission standards and CO_2 emissions considered in the car sharing fleet coefficients estimation.

City	Average CO_2 exhaust emission [g/km]	Average CO exhaust emission [g/km]	Average NMVOC exhaust emission [g/km]	Average NO_x exhaust emission [g/km]	Average NH_3 exhaust emission [g/km]	Average $PM_{2.5}$ exhaust emission [g/km]
Milan	87.7	0.487	0.043	0.074	0.027	0.005
Turin	87.9	0.474	0.041	0.072	0.0264	0.005

Table 8: Car sharing average exhaust emissions in Milan and Turin

Concerning private cars, firstly the car fleet composition of the two cities in 2018 was obtained from the annual statistics produced by the *Automobile Club d'Italia* (ACI)[7]. Thanks to this information, it was possible to have a segmentation of the car fleet in terms of EURO emission standards, type of fuel and year of first registration. A full breakdown of the car fleet segmentation in Milan and Turin is reported in Table 65 in Appendix 9.

Secondly, as already done for car sharing cars, European emission factors for passenger cars (Ntziachristos et al., 2018) were considered to determine the exhaust emission reference values for some pollutants (CO, NMVOC, NO_x, NH_3 and $PM_{2.5}$), which will be considered as the real emissions in our scenario. Indeed, it might be argued that emissions in real traffic conditions are different from such values that are obtained through standard driving cycles. However it is important to note that in our framework what matters are the differences between scenarios, and the same approximation is consistently done in all these.

Finally, since there is not a direct link between EURO categories and CO_2 limit values, the CO_2 exhaust emission coefficients for private cars were evaluated considering the year of registration of the cars (ACI[8]) and the average value of CO_2 of the vehicles produced in Europe in that year according to the information reported in "Monitoring of CO_2 emissions from passenger cars – Regulation 443/2009[9]" provided by EEA, while for passenger cars registered before the year 2000 information reported in the document "Implementing the Community Strategy to Reduce CO_2 Emissions from Cars: Fifth annual Communication on the effectiveness of the strategy[10]" was considered. Please refer to Appendix 9 for more information about European emission standards and CO_2 emissions considered in the city car fleet estimation.

Private car fleet exhaust emission coefficients used in this study are reported in Table 9 below.

[7] http://www.opv.aci.it/WEBDMCircolante/ - Accessed November 29th, 2019
[8] http://www.opv.aci.it/WEBDMCircolante/ - Accessed November 29th, 2019
[9] https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-16 - Accessed November 29th, 2019
[10] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0269:FIN:en:PDF - Accessed November 29th, 2019

City	Average CO_2 exhaust emission [g/km]	Average CO exhaust emission [g/km]	Average NMVOC exhaust emission [g/km]	Average NO_x exhaust emission [g/km]	Average NH_3 exhaust emission [g/km]	Average $PM_{2.5}$ exhaust emission [g/km]
Milan	149.9	1.856	0.217	0.478	0.019	0.009
Turin	146.9	1.543	0.177	0.437	0.020	0.010

Table 9: Car fleet average exhaust emissions in Milan and Turin

Concerning other modes of transport used in the last trip recorded within the survey, CO_2 and pollutants emissions produced in trips performed by bicycle or on foot were assumed negligible. In addition, emissions deriving from trips performed with public transport services were considered constant in all scenarios, therefore assuming the public transport offer fixed. Thus, the contribution of these modes in the CO_2 and pollutants balance when changing the number of passengers is null.

3.4.2 Economic evaluation of air pollutions and greenhouse gas externalities

The application of the coefficients determined in the previous section to the distance travelled in different scenarios by shared cars and private cars allowed the CO_2 and air pollutants quantification (tons or kilograms) in the two cities of the Italian case study. However the impact of tons of CO_2 cannot directly be compared (or even summed up) with tons of other pollutants since the effects they have on the human health and on the environment are significantly different. In order to correctly evaluate the impact of each pollutant to the overall balance and therefore understand which scenario may lead to the maximisation of the benefits for the society, all the emissions quantified were converted in monetary terms, following the cost benefits analysis workflow. Therefore, a cost evaluation of the externalities due to emissions in all scenarios was carried out by considering the cost coefficients (European Commission, 2019) reported in Table 10 below.

CO_2	NMVOC	NO_x transport city	NH_3	$PM_{2.5}$ transport city
€/ton	€/kg	€/kg	€/kg	€/kg
100.0	**1.1**	**25.4**	**21.6**	**132.0**

Table 10: Average Italian air pollution costs in 2016 (source: European Commission, 2019)

The estimated cost for the society in each evaluated scenario is obtained by multiplying the amount of CO_2 and pollutants emissions by the respective cost coefficient and finally summing up all the costs.

3.4.3 Estimation of the impacts on the use of public space due to modal diversion

In order to estimate the impact of car sharing modal diversion on public spaces, the results of the switch models, combined with the reported parking habits and trip characteristics of respondents (as stated in Q41 and Q42 of the questionnaire), were used to quantify how many "parking events" can be saved after the switch from private car towards car sharing in the Italian case study. Please note that the effects on public spaces related to a reduced number of private vehicles are not considered here, since it can be directly expressed by the private car ownership variation due to car sharing that is examined elsewhere (sections 2.2.3 and 4.2). Here we are rather concerned by trip-level impacts on parking spaces in the mobility scenarios, that might happen even if car ownership levels are unchanged, due to a different spatial configuration of the demand for parking spaces.

Therefore, quantitative results will be provided in terms of number of saved parking events (both on-street parking and on-surface dedicated parking), which are defined as a parking space that is not any more occupied by a vehicle since the related trip was switched to car sharing. The number of parking events is a conceptual measurement unit that is not equivalent to the number of parking spaces (one parking space can host several events since the latter are defined on a temporal basis), but this quantification is a useful input to a GIS-based analysis to make decision-makers aware of the reduced parking pressure in a city, especially near mobility attractors. In addition, this kind of unit measure can be evaluated only by comparing two different scenarios, because the consideration of just one scenario would only lead to a positive number of consumed parking events. On the other hand, the current parking habits of respondents that might switch towards car sharing instead of using a private car (as stated in Q41 and Q42 of the questionnaire) might individuate combinations that positively impact on public spaces, even if on a temporary basis. Thus, the analysis of daily parking events was carried out once the rupture scenario has been defined on the basis of the maximisation of benefits in terms of emissions. This is mainly due to the fact that is quite difficult to monetise changes on parking events, which could be added to the previous monetary external costs and benefits of car sharing for the society.

Switch from other modes to car sharing, namely walk, bike and public transport, were not considered in this analysis since private cars parking habits for those specific trips would have not been affected anyway.

Not only positive effects are expected: in some cases, the diversion to car sharing for a specific trip might result in an increase of the private car parking time in the area where the trip is originated. Thus, the parking location at both origin and destination of the trip is an important aspect that needs

to be considered. Table 11 below summarises how switching a trip to car sharing impacts in terms of parking events according to the kind of parking area at both the origin and the destination.

Parking at the trip origin	Parking at the trip destination	Impact on parking at the origin	Impact on parking at the destination
Garage	Street	Neutral	Positive
Garage	Dedicated on-surface parking area	Neutral	Positive
Garage	Garage	Neutral	Neutral
Dedicated on-surface parking area	Street	Negative	Positive
Dedicated on-surface parking area	Dedicated on-surface parking area	Negative	Positive
Dedicated on-surface parking area	Garage	Negative	Neutral
Street	Street	Negative	Positive
Street	Dedicated on-surface parking area	Negative	Positive
Street	Garage	Negative	Neutral

Table 11: Impacts on parking events according to parking areas characteristics

In particular, the car sharing impact is considered positive at destination when the origin parking is a garage (private or owned by the work company) and the destination is a roadside or a dedicated parking area. Indeed in these cases, if the shift occurs, the private car would remain parked in a garage at the origin (neutral impact on public space) while the shared car would be parked for less time at destination (Millard-Ball, Murray, ter Schure, Fox, & Burkhardt, 2005). For the same reason, car sharing impact is considered neutral when the destination is a private garage independently from the origin car parking location, even if car sharing vehicle would not be parked in a private garage but on public space. On the contrary, the impact of the diverted trip is considered negative, if the car is parked on the roadside at the origin, because it would keep on occupying public space.

Clearly the above evaluation criteria are an approximation, since the complete trip chain should be considered rather than focusing on a trip-level analysis as done here. However trip-level rather than trip chain-level analyses are the state of the art in transport modelling, despite well-known limitations for example concerning the study of modal choices.

Once determined the effects of car sharing on public spaces at the origin and destination of each recorded trip, the results were expanded to the universe of trips, therefore assuming that groups of individuals having the same characteristics of the respondents in terms of gender and age have also

the same parking habits. Then positive, negative and neutral impacts were aggregated in each of the two cities according to some zoning and to the kind of parking place where the parking events happened, thus obtaining three values for each zone representing the impacts on street, parking or garage, respectively. The zoning used for the city of Milan divides the city in its nine neighbourhoods (Municipi) according to the map available on the geoportal of the city administration[11]. The zoning of Turin was chosen in order to have a comparable level of detail. The zoning divides the city in nine areas (Circoscrizioni) according to the open data maps available on the geoportal of the city administration[12].

Finally, the open-source software QGIS (QGIS Development Team, 2019) was used to generate spatial representations of the results.

3.4.4 Impacts on travel times and congestion

Data collected through the survey and used in the trip level analysis carried out in this study are not sufficient to run a formal traffic simulation model. Therefore a quantitative measurement of car sharing impacts on congestion simply due to patterns of modal diversion at the individual trip level is not feasible, and it would in any case be negligible given the relatively low number of diverted trips compared to the overall traffic flows at least in uncongested streets, given the nature of the speed-flow relationship. On a logical viewpoint, the impact cannot in any case be positive, since substituting private car trips with shared car trips has a neutral effect, while the effect of substituting any other travel means is negative. Indeed, please consider again that we are only focusing on the trip-level analysis, rather than considering the more indirect impacts on traffic due to the reduction of car ownership levels in the city.

[11] https://geoportale.comune.milano.it/sit/open-data/ - Accessed January 13th, 2020
[12] http://geoportale.comune.torino.it/web/cartografia/cartografia-scarico - Accessed January 13th, 2020

4 Person-level analysis: differences between users and non-users and among car sharing forms

4.1 Sociodemographic characterisation of respondents

The main socioeconomic characteristics of car sharing users and non-users who answered to the STARS travel survey will be presented in this introductory section. Some aspects here introduced will be analysed more in detail in later sections of chapter 4.

4.1.1 Car sharing members and non-members of the Italian case study

As already presented in par. 2.3.1 respondents interviewed within the Italian case study are citizens of the city of Milan or Turin. Concerning the individual characteristics, in both cities the majority of respondents not enrolled in a car sharing service is female, in line with the gender distribution of the general population[13]. Not surprisingly, the majority of respondents having a car sharing membership is male (Le Vine, Zolfaghari, & Polak, 2014). Most of car sharing members interviewed have an age between 25 and 34 years in Turin, slightly younger compared to the members of the city of Milan (mostly ranging between 35 and 44 years). Anyway, car sharing members are younger compared to non-members and have a high level of education (in both cities over 50% has a degree), as reported in available studies from Italy (Ciuffini et al., 2018, 2019) and other countries (Becker, Ciari, & Axhausen, 2017; Clewlow, 2016; E. Martin & Shaheen, 2011; E. Martin et al., 2010; Mishra et al., 2015).

The majority of car sharers owns a public transport season ticket (69.7% in Milan and 61.3% in Turin), which is far higher compared to non-members (47.4% and 38% respectively). In this case, the city Turin has a lower percentage of respondents owning a PT season ticket compared to Milan. Considering the registration time to a car sharing service, most of users interviewed in Milan subscribed the service 2 to 3 years before the survey time, while the figure lowers to 1 up to 2 years in Turin; indeed, currently car sharing operators, kicked off in 2013 in Milan and in 2015 in Turin. In addition, car sharing members seem more willing to share transport means than non-members: 53% of car sharers also has a subscription to a bike sharing service while only 10% of non-members is using bike sharing in Milan; in Turin these percentages are 45.3% and 8.6% respectively. Further information about season ticket ownership and bike sharing membership will be analysed in 4.3.

In the sample of the city of Milan the majority of households has two members with two licensed drivers and owns one car in both CS members and non-members groups; however car sharing members own fewer cars on average, since a higher presence of car free households (10.9%) and a lower proportion of two and three-cars households was registered in this group. The results coming

[13] http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPRES1 – Accessed October 8th, 2019

from the samples of the city of Turin are comparable to those reported for the city of Milan, except for the car-free households proportion. The percentage of households that do not own a car is similar between CS members and non-members of Turin (9.9% and 8.2% respectively). These groups differences will be analysed more in detail in section 4.2.

The household income distribution is quite dispersed in both members and non-members groups but more shifted to higher values in the former; consequently, car sharing members live in households with a higher average income compared to non-members, in line with findings coming from others studies (Clewlow, 2016; Efthymiou & Antoniou, 2016). Lastly, strong differences between car sharing members and non-members households were found in the number of car sharing memberships in both cities. The 40% of CS members in Milan (37% in Turin) stated that another person of the household has a car sharing subscription; these percentages fall to 11.6% and 9.8% in non-members households of Milan and Turin respectively, confirming the importance of subjective norms in the attitudes towards car sharing (Bergstad et al., 2018).

For other descriptive statistics about these groups from the Italian case study, please refer to the tables reported in Appendix 6.

4.1.2 Frankfurt car sharing users

Differently from the Italian case study, the comparison of sociodemographic characterisation has been carried out not only considering the two groups, namely users and non-users, but also differentiating by user group of different kinds of car sharing services that are offered in Frankfurt.

Most car sharing users are between the ages of 30 and 65. As shown in the previous Frankfurt study (Bergstad et al., 2018), car sharing is by no means, as is often assumed, primarily aimed at young target groups.

In the group that only uses free-floating, the proportion of 50-65 year-olds is by far the largest among the comparison groups. This does not correspond to the age structure of this group in other researches, including the above presented Italian case study, and also in the previous study (Bergstad et al., 2018). It is probably due to the nature of the invitation to the survey. In contrast to all other groups, this group of customers was invited exclusively by post. This obviously had a strong influence on the target group section. This also ties in well with the fact that a very high proportion of non-users are between 50 and 65 years old (65 %).

A comparison of the other user groups shows that higher proportions of younger people (age groups 18-29 and 30-49) are found in the groups that use several car sharing systems at the same time ("roundtrip + free-floating" and "combined + free-floating"), while the proportion of older people (65 and older) is higher/ highest in the "roundtrip only" and "combined only" groups.

Similarly to what was found in Milan and Turin, the proportion of men among car sharing users lies well above the proportion within the total population in Frankfurt. 60.6% of the users is male, while males represent the 49.6% of the Frankfurt population. However, there are some significant differences between the user groups. While in the "only roundtrip" group the proportion of car sharing users is still comparable with the figure for the Frankfurt population, in the "only free-floating" group three out of four users are men (75.6%).

In the user groups that use free-floating car sharing and that use several car sharing alternatives at the same time, the male excess is particularly high in the comparison of the groups.

Concerning the household size, interviewed users (as well as non-users) live in a household composed by 2.2 persons on average. Thus, in a car sharing household there are living more people than on average in the city of Frankfurt (1.8).[14] The household sizes do not vary significantly between the individual user groups.

Measured against the total number of households surveyed, the proportion of one-person households is 28.2%. This value differs significantly from the average value for one-person households in the city of Frankfurt am Main (53.7%).

Minor children live in 28.6% of the households surveyed that use car sharing. The differences among the surveyed user groups range from 25.1% ("combined only") to 32.5% ("roundtrip + combined + free-floating"). There is no clear trend between the proportion of family households and the type of car sharing use. Here there are clear differences with the first study of the bcs within the framework the STARS project (Bergstad et al., 2018).

As already mentioned in the Italian case study, car sharing customers have a higher-than-average academic background. Beyond the previously mentioned references, a whole series of German studies have already come to this conclusion (Belter et al., 2015; Follmer, Gruschwitz, & Hölscher, 2015; Loose, 2016; Probst, Utzmann, & Kipp, 2015; Riegler et al., 2016). In the present survey, 71.2% of surveyed users hold a graduate or university degree or are pursuing one. Another 18.3% do not have an academic degree but have a general higher education entrance qualification. By contrast, only 8% of those surveyed have a general certificate of secondary education, and only 1.4% have a certificate of basic secondary education. By comparison: In the city of Frankfurt, the number of people with a certificate of basic secondary education was 22% in 2011, whereas only 39% of the total population (aged 15 and over!) had a general university entrance qualification.[15]

[14]Data status: City of Frankfurt am Main 2017

[15]Data for Frankfurt am Main from data "Census 2011" https://ergebnisse.zensus2011.de/#StaticContent:064120000000,BEG_4_4_6,m,table

It is noteworthy that the proportion of respondents with an academic educational background in groups using several car sharing systems at the same time is even higher than among users of only one system.

Regarding the employment condition of the Frankfurt respondents, a large majority of car sharing users (87.7%) are gainfully employed. 74.0% of car sharing users state that they are in an employment relationship (non-users also 74%). The proportion of self-employed is 13.7%. Only 3.3% of respondents are in training, the majority of whom are university graduates. 9.1% of respondents 74.0% say that they are currently neither employed nor in training.

While in earlier studies (Hülsmann et al., 2018; Nehrke & Loose, 2018) the proportion of students among car sharing users was overrepresented in comparison with the total population, this study demonstrates the opposite. According to the Statistical Yearbook of the City of Frankfurt am Main 2018, more than 66000 students were enrolled in the study area; this would constitute about 8.9% of all residents in relation to the population (assumption place of study=place of residence). The proportion of users who are undergoing a university education, however, is only 2.5% in the survey.

The monthly net household income available to car sharing users is above average. 39.6% of all car sharing users surveyed have 3001 euros or more net income at their disposal (66.6%), another 27% have more than 5000 euros. Only 12.3 % of all respondents have less than 2000 euros at their disposal. On average, the net household income of employees in Germany in 2017 was 3,224 euros.[16] Car sharing seems (to date) to be less popular among people with lower household incomes.

When comparing the individual alternatives, with free-floating car sharing the high number of households with an income of over 5000 euros (66.7%) stands out. In the previous study, too, there was an upward trend in the household income of this group. The very high net income in this study is very unusual and once again indicates that the group recruited here is unlikely to be representative of the target group of free-floating customers.

Finally, looking at the registration time to a car sharing service, most of the users surveyed have only in the past 10 years registered with one or more car sharing services (73.6%). The proportion of customers who have been using car sharing vehicles for more than 20 years lies at 4.5%.

To sum up, Frankfurt car sharing users are employed, mostly in dependent employment relationships. They generally have an academic background and earn above-average wages. They live mainly in households with 2 or more persons. The proportion of households with children lies between 25% and 32%.

[16] https://de.statista.com/statistik/daten/studie/5742/umfrage/nettoeinkommen-und-verfuegbares-nettoeinkommen/ - Accessed January 20th, 2020

The results obtained confirm the excess of men in car sharing found in several other studies. The gender ratio is balanced only among users of exclusively station-based services (Giesel & Nobis, 2016; Hülsmann et al., 2018). The balance in the proportion of men and women found in the first STARS study could be related to the concentration on a certain urban area, since the data otherwise available from other studies, as well as from this study, always refer to entire cities.

4.2 Differences and trends in car ownership

4.2.1 Cross sectional perspective: car ownership levels of users and non-users

Earlier STARS research (Bergstad et al., 2018) already showed differences in car ownership between car sharing users and non-users. New insights have been gained through the analysis of the differences in car ownership evaluated for each case study presented in par. 2.3 of this report. in particular, differences in car ownership within the Italian case study were evaluated by comparing the not oversampled car sharing members group (free-floating only) with the control group (as defined in section 2.1.2). Since the latter is composed of non-members having the same profile of car sharing members (in terms of gender distribution, age, household dimension, number of children, number of licensed driver within the household and income), differences in car ownership with the not oversampled members sample are more likely to be in relation with the car sharing subscription only. As already explained, the use of this approach does not guarantee the exploitation of the causality effect of car sharing membership; there might be others underlying factors that were not taken into consideration, above all differences in lifestyles, personal norms, values and attitudes concerning the fact of owning a car.

On the contrary, in the Frankfurt and in the Belgian case study respondents enrolled to different car sharing variants were separately analysed; therefore different user groups, which are composed of respondents registered for the same car sharing variant, were compared with non-users.

Italy

Starting with the Italian case study, information about car ownership within car sharing members and the control group of the city of Milan is summarised in Table 12. The table reports also CS members' information about the number of cars at disposal/owned within the respondent's household at the time of the STARS survey (2019), at the time of the first registration to a car sharing service and one year before. Non-members information is related to the number of cars owned at the time of the survey and the number of cars owned in 2013 (starting year of operations of the first car sharing organisation among the current existing services). This year was selected in order to have a

comparable time frame to carry out the analysis of changes in car ownership between members and non-members that will be presented in 0.

In the first six rows of the table, the number of respondents of each group (172) is divided according to the number of cars owned (from zero to more than three[17]). Then the total number of cars, calculated by multiply the number of observations of each category by the correspondent number of cars, is reported. Finally, the average number of household cars was evaluated together with the car stocks (cars/1000 people) and are reported in the last two rows.

	Car sharing members not oversampled			Control group	
	# of HH cars in May 2019	# of HH cars at registration	# of HH cars 1 year before registration	# of HH cars in May 2019	# of HH cars in 2013
Household cars					
0	19	28	26	8	12
1	102	91	96	95	94
2	47	44	43	58	57
3	2	7	5	9	8
More than 3	2	2	2	2	1
Respondents	172	172	172	172	172
Total n. of cars	210	208	205	246	236
Cars/HH	1.22	1.21	1.19	1.43	1.37
Cars/1000 people	473	468	462	564	541

Table 12: Differences in car ownership between car sharing members and non-members in Milan

The number of cars owned by car sharing members on average (1.22) is lower compared to non-members (1.43) and this difference is statistically significant[18].

It is finally worth mentioning that car ownership levels of the entire population of Milan (507 cars/1000 inhabitants in 2018[19]) are lower than those of the control group. It is therefore confirmed the importance of considering a control group rather than a general population to correctly assess the impacts of car sharing.

Similar information is presented for the city of Turin in Table 13 below.

[17] In the evaluation of average value, more than 3 was considered as 4
[18] Wilkoxon signed rank test, W=16970, p-value<0.01
[19] http://www.aci.it/laci/studi-e-ricerche/dati-e-statistiche/annuario-statistico.html - Accessed October 8th, 2019

	Car sharing members not oversampled			Control group	
	A – Number of HH cars in May 2019	B – Number of HH cars at registration	C - Number of HH cars 1 year before registration	# of HH cars in May 2019	# of HH cars in 2015
Household cars					
0	7	10	9	5	9
1	43	39	39	39	37
2	18	20	21	23	20
3	2	1	2	4	5
More than 3	2	2	1	1	1
Respondents	72	72	72	72	72
Total n. of cars	93	90	91	101	96
Cars/HH	1.29	1.25	1.26	1.40	1.33
Cars/1000 people	489	474	479	577	549

Table 13: Differences in car ownership between car sharing members and non-members in Turin

In this case the period under analysis for non-members starts from 2015, since two of the three car sharing organisations currently operating in Turin started in that year. Once again, the number of cars owned by car sharing members on average (1.29) is lower compared to non-members (1.40), however this difference is not statistically significant[20].

Contrarily to what was observed in Milan, the control group car stock is lower compared to the one of the whole Turin population (653 cars/1000 inhabitants in 2018[21]). Car ownership levels of both users and not users are much higher in Turin than in Milan, and the latter are in turn higher than those of other EU cities of comparable size.

Differences in the average number of household cars between the all members (both oversampled and not) and non-members were also evaluated, but are not reported here for the sake of brevity. However, in all comparisons carried out within this study, car sharing members' households have always less car than non-members' households, on average. Please refer to Appendix 7 for more information about statistical test results.

[20] Wilkoxon signed rank test W=2802, p-value>0.05

[21] http://www.aci.it/laci/studi-e-ricerche/dati-e-statistiche/annuario-statistico.html - Accessed October 8th, 2019

Belgium

Concerning the Belgian case study, data from the panel survey with almost 1000 car sharing non-members in the Flanders region and results from the full online survey among both members and non-members of car sharing in Flanders were firstly compared.

The results of both Belgian surveys are quite similar regarding car sharing non-members. Non-users from the panel survey own on average 1.5 cars at the whole household level, while non-user respondents from the online survey own on average 1.3 cars. For both surveys, almost one-tenth of the respondents do not own a car, almost half has one car and approximately a third possesses two cars. Among the respondents of the full online survey using car sharing, the average number of cars within the household is 0.44. Also the distribution of cars among the respondents is strikingly different than among the group of non-users. Almost two thirds have no private car available, three-tenths has one car and eight percent owns two cars. The general trend, car sharing users own fewer cars than non-users, is definitely confirmed by the Belgian data. At this point, it is important to recall that the majority of interviewees used roundtrip services in the Belgian case study, whereas virtually all car sharing users subscribed to free-floating services in the Italian case study. This is mainly explaining the different results in the two countries.

	Panel survey [Flanders region]	Full online survey [Flanders region]	
Household cars	**Non-car sharing users [N=985]**	**Car sharing users [N=52]**	**Non-car sharing users [N=83]**
0	7.2%	63.5%	10.8%
1	47.3%	28.8%	54.2%
2	37.0%	7.7%	32.5%
3	6.1%	0.0%	1.2%
4	1.6%	0.0%	0.0%
5	0.6%	0.0%	0.0%
5 or more	0.2%	0.0%	1.2%
Cars/HH	1.50[22]	0.44	1.30[23]
Cars/1000 people	596	176	543

Table 14: Current number of cars in household (including company cars) – panel survey and full online survey

[22] For the calculation of the average number of cars, '5 or more' was coded as '6'.

[23] For the calculation of the average number of cars, '5 or more' was coded as '6'.

To further clarify this point and to avoid exclusively comparing different car sharing forms in different countries, where local conditions might affect the outcomes, differences among members of different types of car sharing were investigated within the Belgian case study.

The comparison of the results from internal surveys shows that car ownership among users of free-floating car sharing schemes is more than five times higher than among users of roundtrip station-based operators. Within the latter group more than eight out of ten has no own car, 14% has one car and only 1.6% owns two cars or more. One-third of the free-floating car sharing users owns no private car, four out of ten have one car available, and almost a fourth owns two or more cars. Strikingly, the average number of cars within the Brussels households is 0.6, which is less than among free-floating users. This finding suggests that users of free-floating car sharing do not necessarily see the service as a replacement for their own car, but rather as a supplement.

Moreover, it is worth mentioning that these data are gathered in the Brussels Capital Region: the characteristics of the city make it hard to compare them with the results from the first two surveys, which gathered data within the Flanders region. This also explains the lower number of cars among station-based car sharers in Brussels than among car sharers from the full online survey (0.19 versus 0.44).

	Internal surveys of car sharing operators [Brussels Capital Region]		Survey among households of Brussels Capital Region[24]
Household cars	**Roundtrip station-based [N=2035]**	**Free-floating with operational area [N=819]**	**Household budget research [N=1880]**
0	84.0%	33.6%	45.0%
1	14.0%	40.7%	46.0%
2	1.0%	20.6%	9.0%[25]
3	0.2%	3.8%	/
More than 3	0.4%	1.3%	/
Average	0.19[26]	0.99[27]	0.60

Table 15: Current number of cars in household (including company cars) – surveys car sharing

[24] Ermans, T. (2019)

[25] For the general survey among inhabitants of the Brussels Capital Region, we only have data on three categories: 0, 1 and 2 or more.

[26] For the calculation of the average number of cars, 'more than 3' was coded as '4'.

[27] For the calculation of the average number of cars, 'more than 3' was coded as '4'.

Frankfurt

Results from the Frankfurt case study, where beyond roundtrip station-based and free-floating user groups also additional ones were considered, partially confirm what has been found in Belgium. Figure 3 below shows the number of household cars owned by Frankfurt respondents, grouped according to their car sharing membership at the time of the survey.

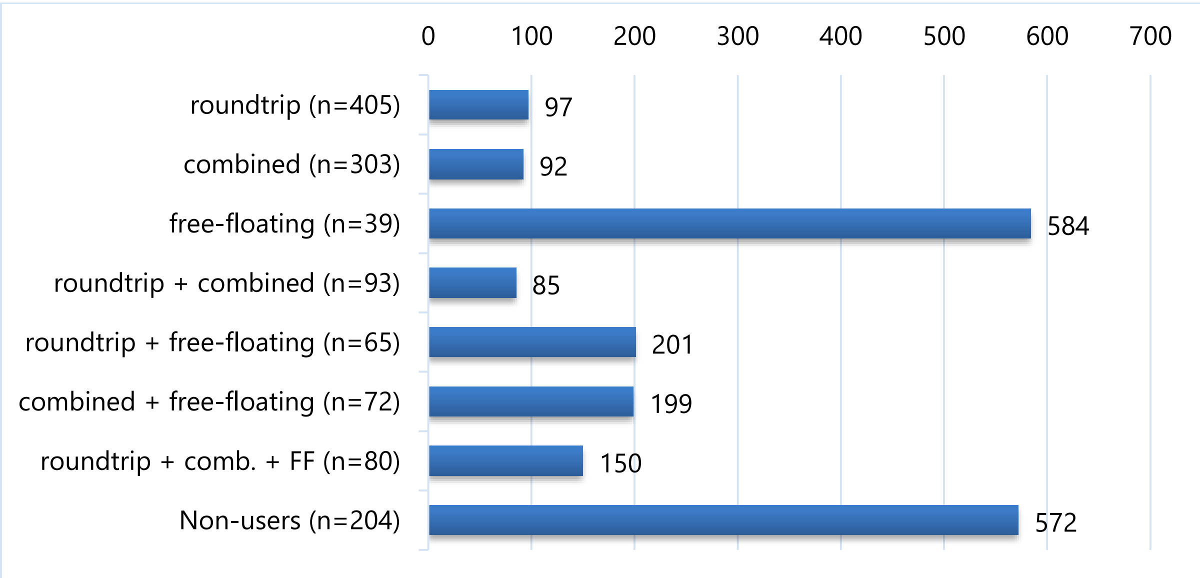

Figure 3: Private cars per 1000 people in selected user groups of the Frankfurt case study

Users of station-based and combined car sharing models indicate very low rates of car ownership, only 97 or 92 cars per 1,000 people. Customers who are registered at the same time for both roundtrip and combined models have only 85 cars per 1,000 people. These values lie well below the target of 150 passenger cars per 1,000 people as recommended by the German Environmental Agency for environmentally vehicle and climate-friendly urban transport in the future.[28]

By contrast, the users of free-floating car sharing show an above-average car ownership of 584 cars per 1,000 people. The level of car ownership is thus on par with that of non-users (572 passenger cars per 1,000 people in households surveyed). This result is somehow similar to what has been found in the Italian case study and consistent with previous findings in Germany (Bergstad et al., 2018).

It is noteworthy that car ownership level of free-floating car sharing members is significantly lower if they are still using station-based and/or combined models at the same time. This effect was also observed in the previous study (Bergstad et al., 2018).

[28]German Environmental Agency (Publ.): Tomorrow's Cities. Environmentally friendly mobility, low noise, green spaces, compact housing and mixed-use districts. Dessau-Roßlau, March 2017

4.2.2 Longitudinal perspective: changes in car ownership over time

In this section, the information about car ownership levels in three time points (time of the survey, time of first CS registration and one year before) and their differences are analysed. See section 2 for an explanation on the rationale behind the choice of such time points.

Again the Italian case study is firstly presented, followed by the Belgian and the German one. Comparing changes in the total number of cars among Milan car sharing members in the three periods (Table 12 above), it can be noted that the number of cars has increased by 1.0% between the time when the service was subscribed and when the survey was administered (May 2019) and by 2.4% since one year before. However, these increases are smaller than those of the control group (+4.2%). On the contrary, in Turin the trend was slightly decreasing before the registration (91 total cars one year before and 90 at the first registration) and moderately increasing between the first registration and the time of the survey (Table 13 above). The same happened to the number of cars within non-members households, which increased from 96 to 101. Also in this case the car ownership growth rate is higher among non-members (5.2%) compared to car sharing members (3.3%).

Differences in car ownership over time among Belgian respondents of the full online survey were also evaluated. Car sharing members were not divided into different user groups here due to the low number of answers collected within this survey version. Therefore the results refer to the general sample of car sharing members.

The data of car sharing users presented in the following Table 16 shows a clear decrease in car ownership over time. The average number of cars per household is 0.9 at 12 months before the first registration with a car sharing operator (moment C). At the time of registration with a car sharing scheme (moment B), this number drops to 0.6. This indicator further decreases until the moment of research (moment A).

	A – Number of HH cars in October 2019 [N=52]	B - Number of HH cars at registration [N=52]	C – Number of HH cars 1 year before registration [N=52]
0	63.5%	51.9%	21.2%
1	28.8%	36.5%	67.3%
2	7.7%	11.5%	11.5%
3	0.0%	0.0%	0.0%
4 or more	0.0%	0.0%	0.0%
Average	**0.44**	**0.60**	**0.90**

Table 16: Evolution of the number of cars in car sharing members households – Belgian full online survey

It is interesting to pay attention to the evolution of car free households and the ones with one car available. The first category increases over time from 21% at moment C to almost two-thirds of the households at moment A. On the contrary, the number of households with one car drops from almost 67% to almost one third of the households. In both situations the biggest change takes place between moment C and B, so in the months before registering with a car sharing organisation.

In the Table 17 below, one can deduce how many cars were scrapped or added at what moment of the process. As stated above, the biggest changes took place between moment B and C. Between 12 months before the registration and the first steps into car sharing, 31% of the respondents got rid of one or two cars. However between the registration with the car sharing scheme and the moment of research, an additional 14% of the respondents got rid of one or more cars. Between moment C and A almost half of the surveyed car sharers got rid of one or two cars. There is a clear relation between becoming a car sharing user and a changing number of cars in the household. It is, however, hard to state people own fewer cars due to car sharing. It can also be the other way around: people that decided to own less cars for whatever reason use car sharing as a replacement.

	A-B	A-C	B-C
-2	2.0%	3.9%	2.0%
-1	11.7%	41.2%	29.4%
0	86.3%	51.0%	64.7%
+1	0.0%	3.9%	3.9%

Table 17: Differences in household car ownership levels – Belgian full online survey

In addition, results from internal surveys of car sharing operators (Table 18), where car sharing members were asked if they "*disposed of a car in their family by joining a car sharing organisation*", indicate that almost half of the roundtrip station-based car sharers in Brussels got rid of a car after joining the scheme. Among members of free-floating operators this is almost one out of six (16%).

	Roundtrip station-based [N=291]	Free-floating with operational area [N=762]
No	51.2%	83.3%
Yes	48.8%	16.7%

Table 18: Disposal of cars after joining car sharing organisation – surveys car sharing operators

Concerning the changes in car ownership occurred directly before and during car sharing membership, 1048 out of 1100 respondents of the Frankfurt case study answered completely the questions. Contrarily to the Belgian case study, here a comparison of the evolution of car sharing

membership among user groups of different services has also been carried out. Very different results can be observed among the individual groups presented in Figure 4 below.

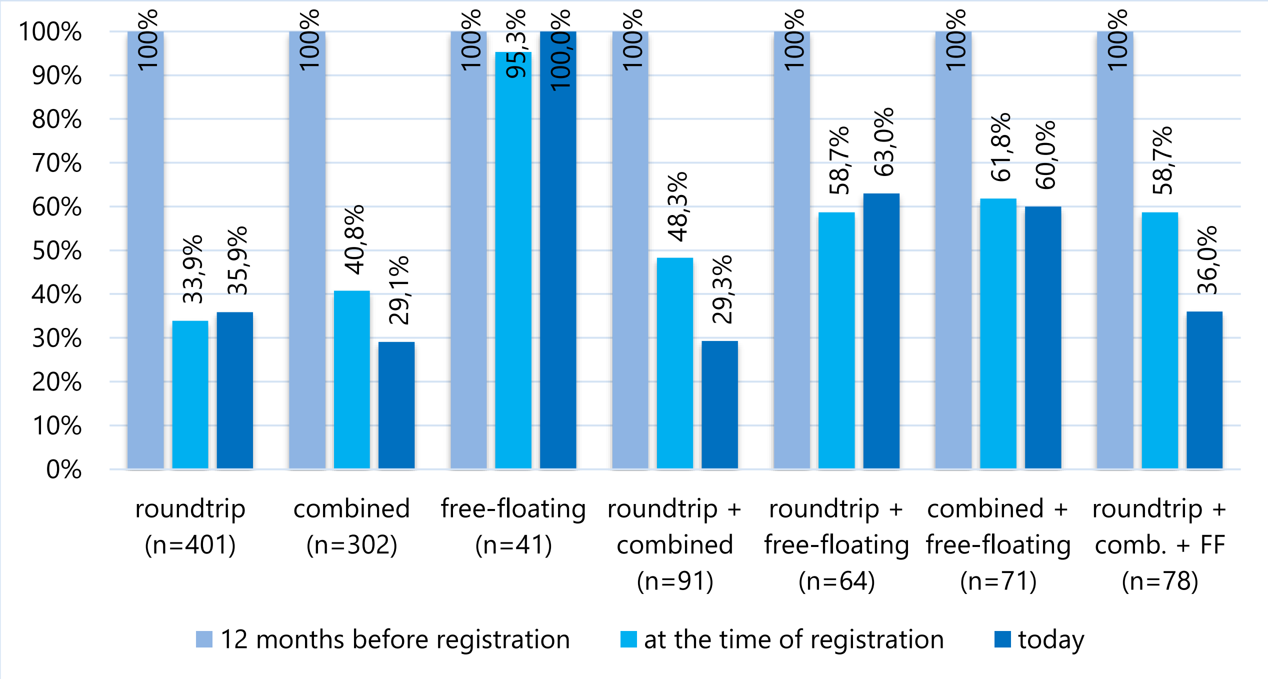

Figure 4: Changes in the number of private cars of different user groups

In the case of users of roundtrip car sharing, the number of cars decreased already by 66% in the run-up to the registration with car sharing, and by 59% in the case of users of the combined offer.

The situation is different for users who were registered only for free-floating: here the number of cars fell by only 5% in the same period. However, it should be noted here that the target group recruited for the survey does not represent the entire free-floating car sharing target group (see section 2.3.2).

For those groups that use free-floating in parallel with another car sharing service, however, the number of vehicles fell significantly by around 40%. This phenomenon was also observed in the previous bcs study. Apparently, the parallel use of free-floating with other car sharing alternatives increases the willingness to dispose of private cars.

From the time of registering with car sharing to the time of the survey, the number of vehicles trends differently in the user groups. In the case of users of the combined model (including parallel use of other car sharing alternatives), the number of vehicles fell still further after registration. At the time of the survey, the number of vehicles in this group fell by 71% compared to the 12 months prior to registration. In the case of users of roundtrip car sharing, car ownership stagnated at a lower level during membership.

At the time of the survey, customers who only use free-floating offerings had the same number of cars as they did before registering with car sharing. Cars that had been disposed of in the meantime were purchased again after registration.

Additionally, changes in the number of cars owned by users of different car sharing groups were analysed by differentiating between Frankfurt inner-city and the city as a whole, thanks to the inner-city level information collected in the previous STARS study (Bergstad et al., 2018).

Car ownership trends of different user groups belonging to Frankfurt inner-city areas (labelled with F. city c.) and the city of Frankfurt as a whole (labelled with Frankfurt) are presented in Figure 5 below.

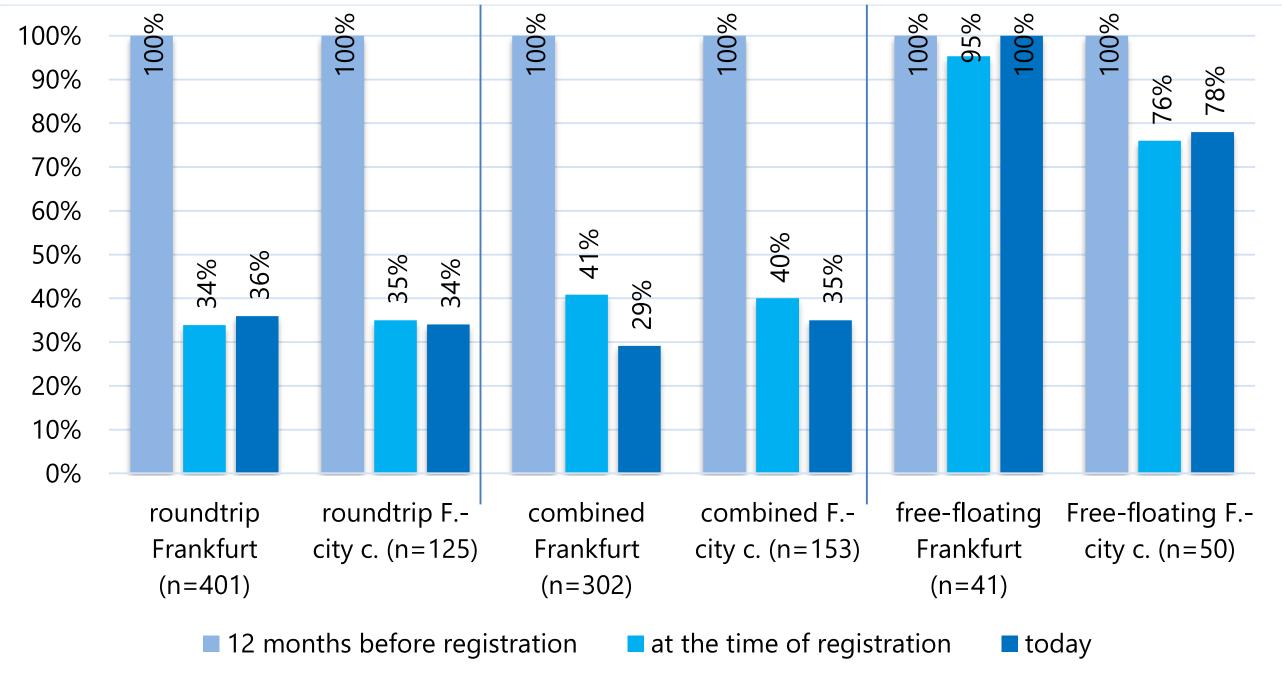

Figure 5: Changes in car ownership of different car sharing user groups sampled in the inner-city residential areas and in the city as a whole

It is notable how little the results for roundtrip and combined models differ between individual inner-city residential areas and the city as a whole. The greatest difference is that in the city as a whole, an even higher proportion of car sharing users have decided to dispose of a car after registering.

It would have been expected that comparatively fewer vehicles would be done away with in the city as a whole than in the residential areas close to the city centre. For the parking pressure is often higher in inner-city areas, public transport is denser and infrastructures and everyday destinations are usually closer to home. This assumption proves to be not applicable to Frankfurt.

By contrast, the difference between the inner city and the city as a whole is very pronounced among users who are only registered for free-floating. In relation to the city as a whole, the current study found no change in the ownership rate. In the previous study in residential areas close to the city

centre, however, there was a clearly discernible reduction in car ownership to 78 % at the time of the survey.

4.2.3 Respondents' self-assessment of the influence of car sharing in car ownership-related decisions

In addition to the questions about car ownership levels in the past and present, through which the actual disposal of auto before or during car sharing membership has derived, it is relevant whether car sharing has possibly contributed to the avoidance of new vehicle purchases. This was evaluated in slightly different way among the case studies.

In the Italian case study, the respondents were asked to indicate how likely they would buy a car if the car sharing operator typically used shut down the service in the city (Q37a), by using a Likert scale (1 – Strongly disagree, 5 – Strongly agree). Similarly, respondents of the Frankfurt case study were asked to state how many cars would be available in the households of today's users if there were no car sharing in the future. On the contrary, considering the car sharing operators internal survey whose data were analysed in the Belgian case study, customers were asked how likely it is they would have bought a(n) (additional) car if they had not started car sharing.

Since these questions are of a hypothetical nature, they must be classified methodically different compared to the questions of the actual change in the number of vehicles owned in the past. It is possible here that, with regard to the hypothetical question, the respondents overestimate or underestimate the importance of car sharing for their mobility.

For this analysis, all respondents classified as car sharing members within the Italian case study were considered. Results reported in Table 19 below show that the majority of users would not buy an additional private car in case of car sharing shut down, while very few think they would buy one (about 14% in Milan and 15% in Turin).

	Car sharing members - Milan [N=485]	Car sharing members – Turin [N=181]
1 – Strongly disagree	239 (49.3%)	97 (53.6%)
2	82 (16.9%)	24 (13.3%)
3	96 (19.8%)	33 (18.2%)
4	47 (9.7%)	19 (10.5%)
5 – Strongly agree	21 (4.3%)	8 (4.4%)

Table 19: Respondents likelihood of buying a car in case of car sharing shut down - answers from the Italian case study

Concerning the Italian case study, we recall that car sharing (and in particular free-floating car sharing) is adopted by individuals living in households with lower car ownership levels compared to their peers, i.e. individuals with the same socioeconomic characterisation. On the other hand, car sharing members did not decrease the number of cars they own after subscribing to the service, therefore it is not possible to estimate the number of cars substituted by each shared car as done in other researches (Schreier et al., 2018b). This seems a deceiving result in absolute terms, however it is important to frame it in the car ownership trends of the whole population and to observe that the growth rate of cars owned by car sharing members is smaller than that of non-members. Thus, car sharing might have a higher impact on postponing the purchase of additional cars (Melis et al., 2019).

This link between car sharing and car ownership is confirmed by the information collected through the STARS survey (Q25a, Q31a, Q33a, Q36a in Appendix 1), where respondents were asked to assess the likeliness of changes in car ownership at different time points and to which extent car sharing is influencing or influenced their choices. Figure 6 shows the related results for both Turin and Milan.

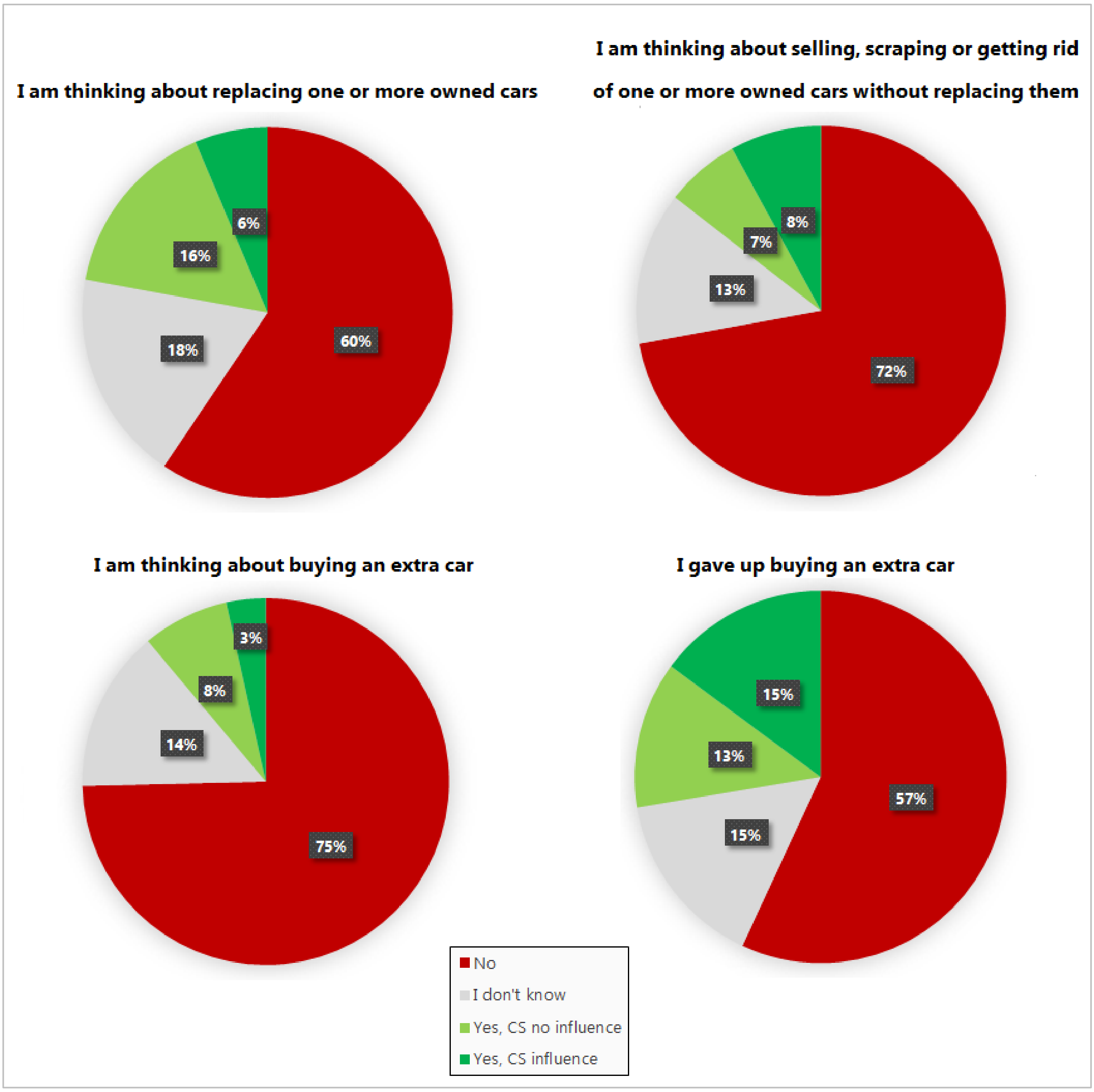

Figure 6: Car ownership changes perspectives of CS members within the Italian case study

When observing the four pie charts of Figure 6, car sharing seems to have the strongest positive effect in giving up buying an extra car: 28% of CS members agreed with this statement and in particular 15% reported that the car sharing had (at least in part) influence on the decision. On the contrary, very few respondents were thinking about buying an extra car (11%), but also to scrap a car without replacing it; in this case the majority of negative answers comes from respondents having one car at their disposal within the household.

Results concerning car ownership changes in Frankfurt, where as usual car sharing members are classified according to the user group they belong to, are presented in Figure 7 below.

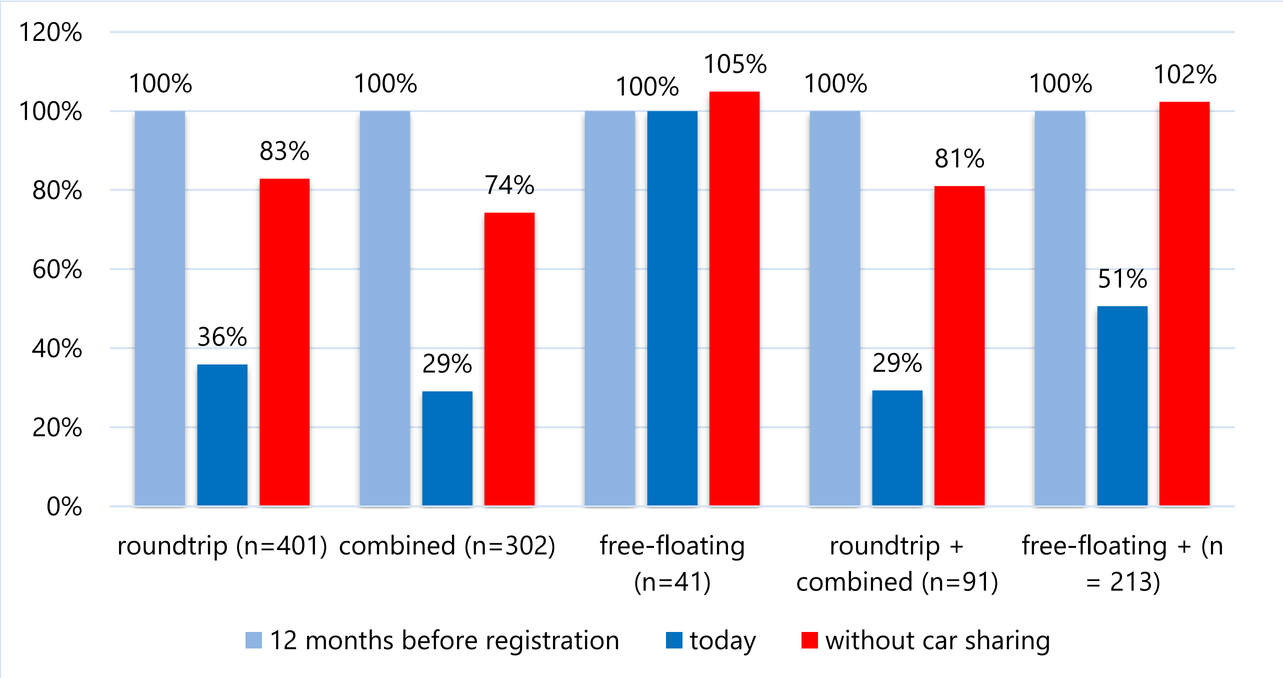

Figure 7: Trend in car ownership without car sharing in Frankfurt user groups (excl. "does not know")

Among users of the station-based or combined models, the number of cars would increase significantly if car sharing were no longer available. This is not surprising given that a large proportion of the car stock has already been disposed of in these groups. Nevertheless, respondents in these groups believe that their car inventory will remain below the level prior to registration. Here, a certain habituation of life without one's own vehicle seems to have transpired.

This is clearly different for the user groups "roundtrip + free-floating" and "combined + free-floating". Here, ownership of a vehicle without car sharing would be significantly higher than 12 months prior to registration.

Among those respondents using only free-floating car sharing, vehicle ownership would hardly change without car sharing; this comes as no surprise due to the very high availability of private vehicles in this group.

Finally, results from the Belgian car sharing operators' internal survey are summarised in Table 20 below. 44% of the roundtrip car sharers indicates they considered or were (quite) certain to buy an extra car, among free-floating car sharing users this is 58% of the respondents. More than half of the roundtrip users did not intend to purchase a(n) (extra) car, compared to 27% of the free-floating customers. Before joining car sharing, the group of roundtrip users had less intention to buy (an)

extra car(s) than free-floating users, but it is hard to explain this difference through the different car sharing schemes. It is possible that other dependent variables are at stake here.

	Roundtrip station-based [N=1841]	Free-floating with operational area [N=578]
Yes // We had certainly purchased a(n extra) car	9.7%	21.8%
Probably // We had probably purchased a(n extra) car	10.3%	36.3%
We had considered purchasing a(n extra) car	24.0%	/
Probably not	/	14.9%
No // We wouldn't have purchased a(n extra) car	56.0%	27.0%

Table 20: Probability of purchasing extra car if no car sharing member – Belgian car sharing operators surveys

4.2.4 Respondents' self-assessment of the substitution effect between private cars and car sharing in Frankfurt

Most car sharing users in Frankfurt agree with the statement "Car sharing is a full-fledged substitute for one's own car." Only among users who are registered exclusively with free-floating providers does rejection predominate. Conversely, users of free-floating see car sharing more as an additional option to their own auto – a thesis strongly denied by users of other alternatives but also by parallel users.

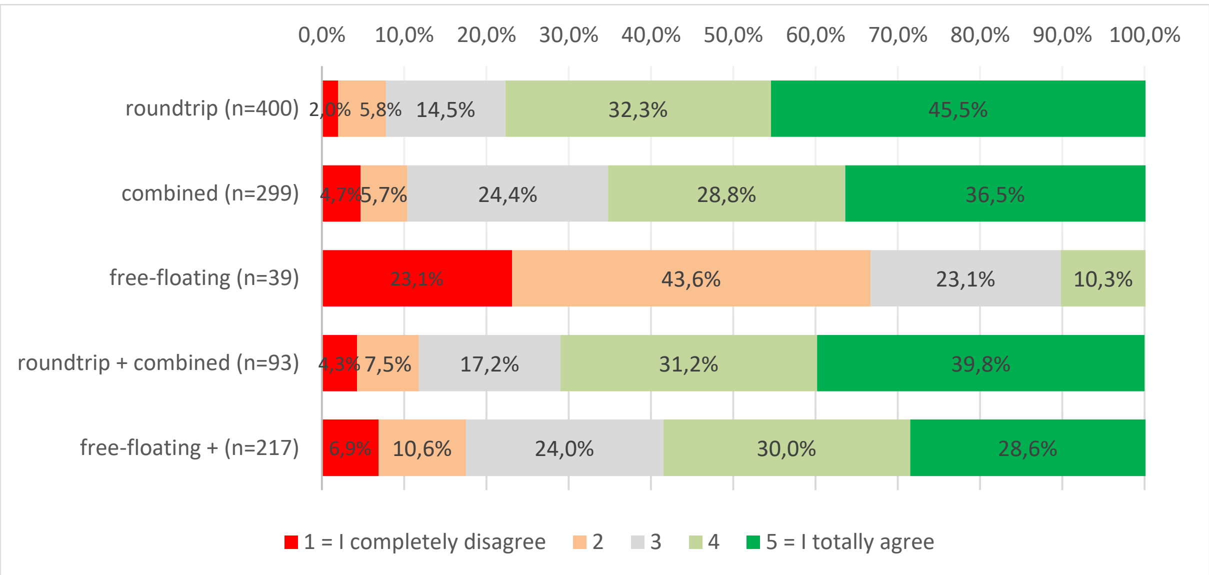

Figure 8: Agreement with the statement "Car sharing is a full-fledged substitute for one's own vehicle" in different user groups

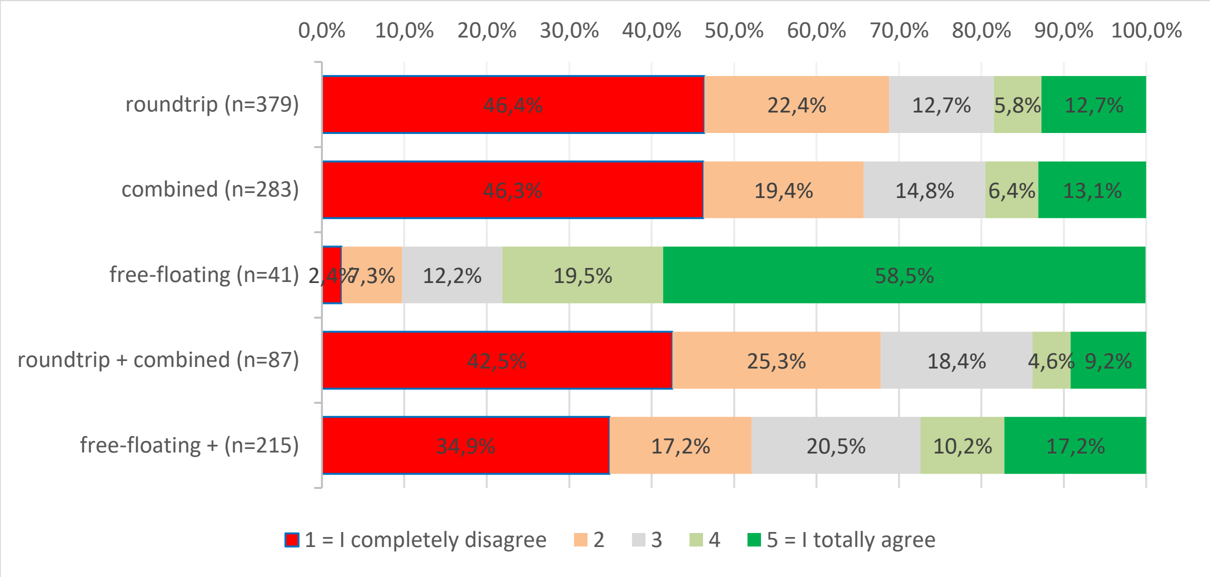

Figure 9: Agreement with the statement "Car sharing is rather an additional option to one's own car" in different user groups

These results coincide with those of the previous study in inner-city residential areas. The results show that the significance of car sharing as a car substitute varies according to the alternatives. Many users attest that roundtrip and combined systems function as car substitutes. But free-floating car sharing has little significance as a vehicle substitute and must be combined with the other systems so that the car sharing offer as a whole is regarded as a car substitute.

The Frankfurt case study provides strong evidence that roundtrip and combined car sharing alternatives might have an impact on car ownership, since in households where station-based or combined car sharing alternatives are used, the number of cars sharply decreases shortly before and during car sharing participation. In addition, a majority of customers consider these car sharing models to be a full-fledged substitute for their own car.

Furthermore, in the hypothetical situation that car sharing would no longer exist, the users of roundtrip and combined car sharing systems assume a sharp increase in the number of their vehicles.

With regard to free-floating car sharing, it can be determined that also in the Frankfurt study it does not in itself have a reducing effect on the number of vehicles and is also not regarded by the users as a full-fledged substitute for a private car. This effect only occurs in combination with the roundtrip and combined systems.

This result marks a deviation from the previous study (Bergstad et al., 2018), in that in the inner-city residential areas a slight impact on car ownership was also noticeable in the customer group that only uses free-floating car sharing. This may have to do both with the different spatial layout of the survey area in the present study and with the unusual layout of the target group recruited here. Both

studies show in context, however, that free-floating car sharing alone has no or hardly any effect on the private vehicle ownership of users.

This has already been established in the study for the city of Frankfurt (Hülsmann et al., 2018). There it was already pointed out that the willingness of free-floating users to dispose of vehicles increases if they use other car sharing alternatives at the same time.

4.2.5 Substitution rate between private cars and car sharing vehicles in Frankfurt

The substitution rate between private cards and car sharing vehicles was computed for the Frankfurt case study only, since this computation cannot be done for Turin or Milan as mentioned above.

The basis for calculating the quota of how many cars are replaced by a car sharing auto is the number of cars actually disposed of (and not reacquired) by users within the 12 month-period prior to registration for car sharing up to the survey date. Since not all users of a model participate in a survey, the cars that have been disposed of are extrapolated to the total number of registered customers and then divided by the number of car sharing vehicles under the offer. However, it must be noted that the users surveyed are not representative of the whole customers' population. People who make more intensive use of the models offered are more inclined to take part in surveys on these models. For this reason, answers to the question regarding the frequency of a model's use last year are compared with the backend data of the providers and a weighting factor is calculated. For both roundtrip and combined models, the substitution rate is 1:10.0 to 1:14.9. This means that for every car sharing vehicle there are, depending on the provider, 10-15 vehicles that have actually been disposed of.

The substitution rate shows that the car sharing offer covers the car use requests of households far more efficiently than would have been possible through private car ownership. If one converts the quota into parking lot lengths, the result is that every car sharing vehicle is able to free (longitudinally parking) vehicles between 50 and 75 meters from the edge of the road.

The hypothetical number of cars that the car sharing customers would have bought if there was no more car sharing was not included in the replacement rate. There are methodological reasons for this: on the one hand, the underlying question is hypothetical and does not impose a real car abolition. On the other hand, the car that was actually abolished and the vehicle that would be purchased if there were no longer any car sharing, may be the same vehicle. Adding up totals on both questions would therefore inadmissibly increase the replacement rate.

4.3 PT season ticket ownership and bike sharing membership

Car ownership changes are by far the most important impact that is expected by car sharing and it has been therefore extensively analysed in section 4.2. However, it is also important to have a look at the impacts in the levels of use of other modes, which is primarily influenced by the possession of transit passes or the participation in bike sharing programs.

The analysis of public transport season ticket ownership led to slightly different results between the two Italian cities. The differences in PT season ticket ownership for car sharing members, members not oversampled, non-members and the control group are reported in Figure 10 below. In both cities car sharing members seem to own more season tickets, 70% of car sharing members against 48% of the non-members in Milan and 62% compared to 38% in Turin (first and fourth column for both cities of Figure 10); these values might imply a higher use frequency of public transport, therefore it will be analysed in the following 4.4.1 . In general, less respondents in Turin have a season ticket than in Milan, which might due to the differences in the PT offer.

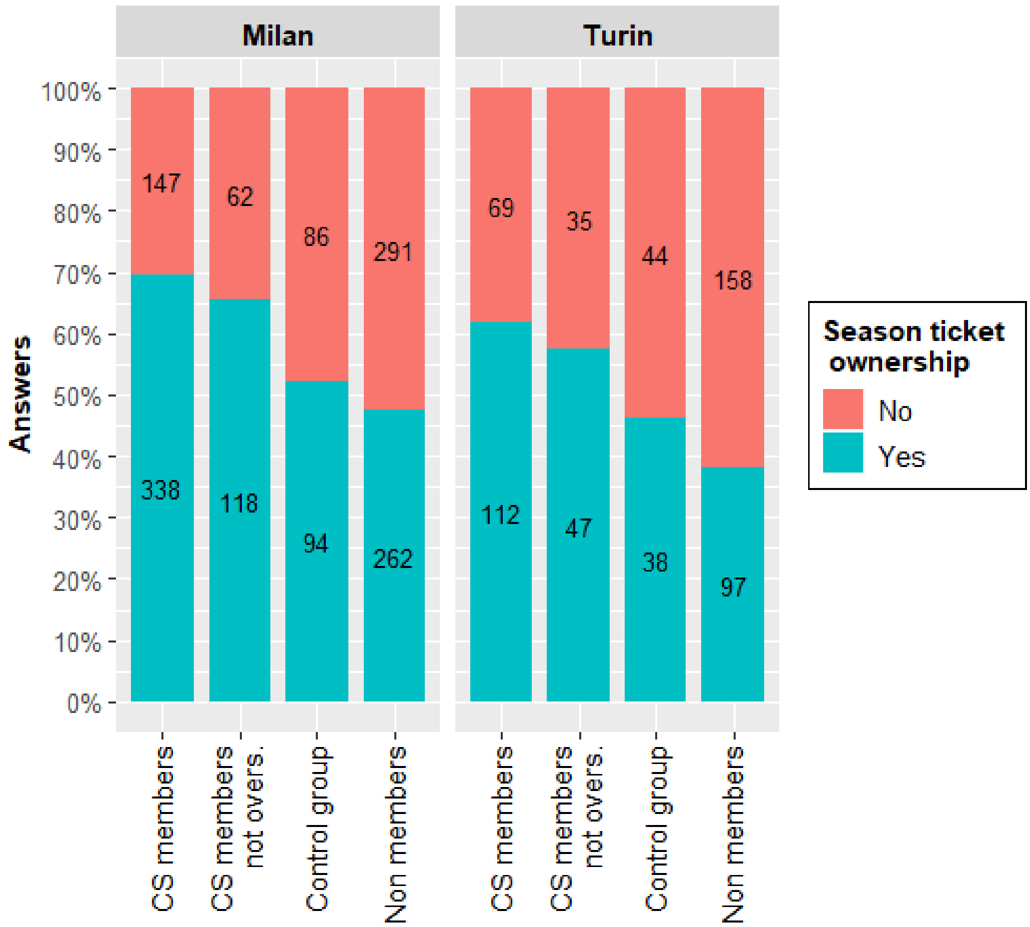

Figure 10: Differences in public transport season ticket ownership between car sharing members and non-members of the Italian case study

When comparing the not oversampled members and the control group (second and third column for both cities of Figure 10), these differences are less noticeable, however, but still significant[29].

In Turin, 58% of not oversampled members owns a PT season ticket while 47% of non-members within the control group does. The difference in this case is not significant[30], meaning that the observed differences are due to the sample variability. Once again, this result might be related to the PT use frequency, that will be analysed in subsection 4.4.1.

A similar analysis was carried out within the Belgian case study, whose results are shown in Figure 11 below. Here the comparison was made between respondents of the full online survey (both car sharing users and non-users) and respondents of the Flanders panel (non-users only, reported in the right column).

Figure 11: Differences in public transport season ticket ownership between car sharing members and non-members of the Belgian case study

According to the results of the full online survey, there is no big difference between car sharing users and non-users, concerning the rate of season tickets for public transport. The panel survey among almost 1000 car sharing non-users confirms this finding. However, results from section 4.4.1 show

29 $\chi^2=6.1$, p-value<0.05

30 $\chi^2=1.6$, p-value>0.05

car sharing members use public transport (bus/tram, metro and train) more often than non-car sharing users.

In addition to the ownership of season tickets for public transport, respondents were also asked if they have a subscription to a bike sharing scheme.

Outcomes from the analysis carried out on the bike sharing membership in Milan and Turin are shown in Figure 12 below.

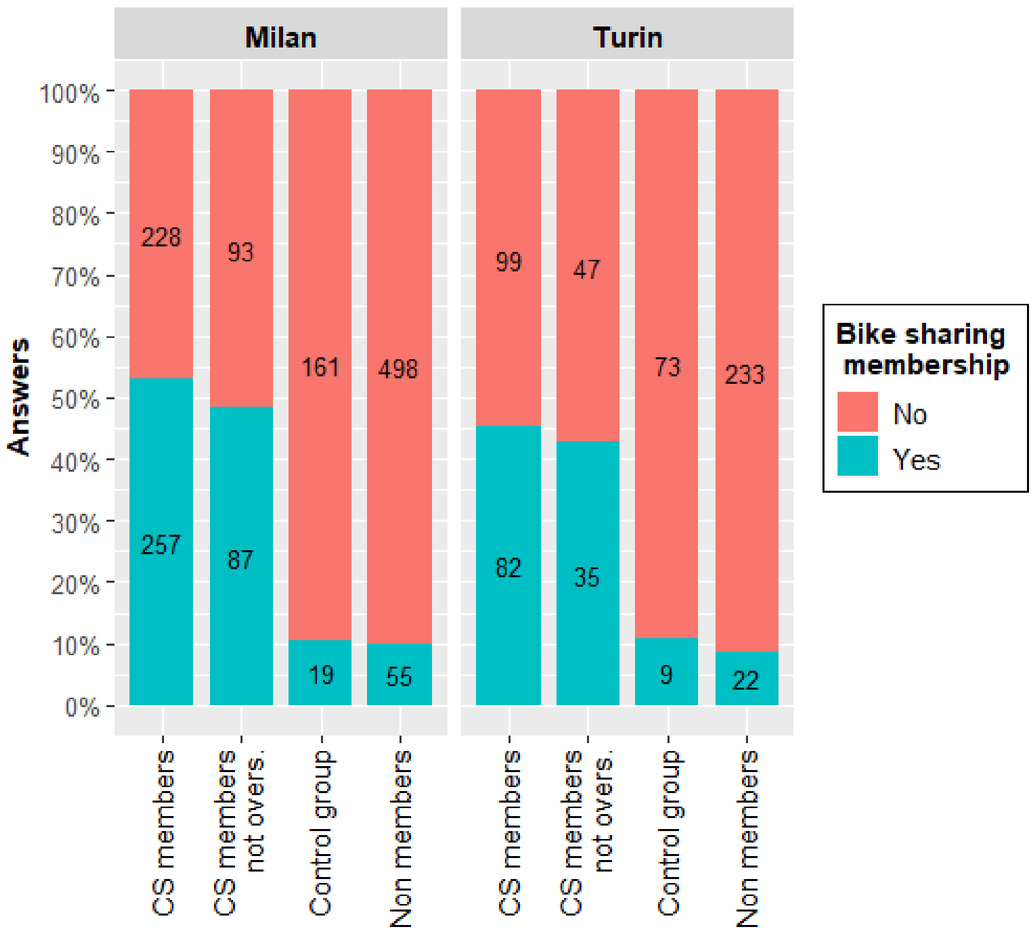

Figure 12: Differences in bike sharing membership between car sharing members and non-members of the Italian case study

In both cities, much higher bike sharing membership is reported among car sharing members, proving that this group is more open to share all transport modes, not only cars. Differences in bike sharing membership between not oversampled members and the control group are significant in Milan and Turin[31].

[31] Milan χ^2=61.8, p-value<0.01; Turin χ^2=21, p-value<0.01

Results coming from Belgian case study are shown in Figure 13. According to the full survey results, the subscription rate to bike sharing schemes tends to be much higher among car sharing users than non-users (44.9% versus 11.8%).

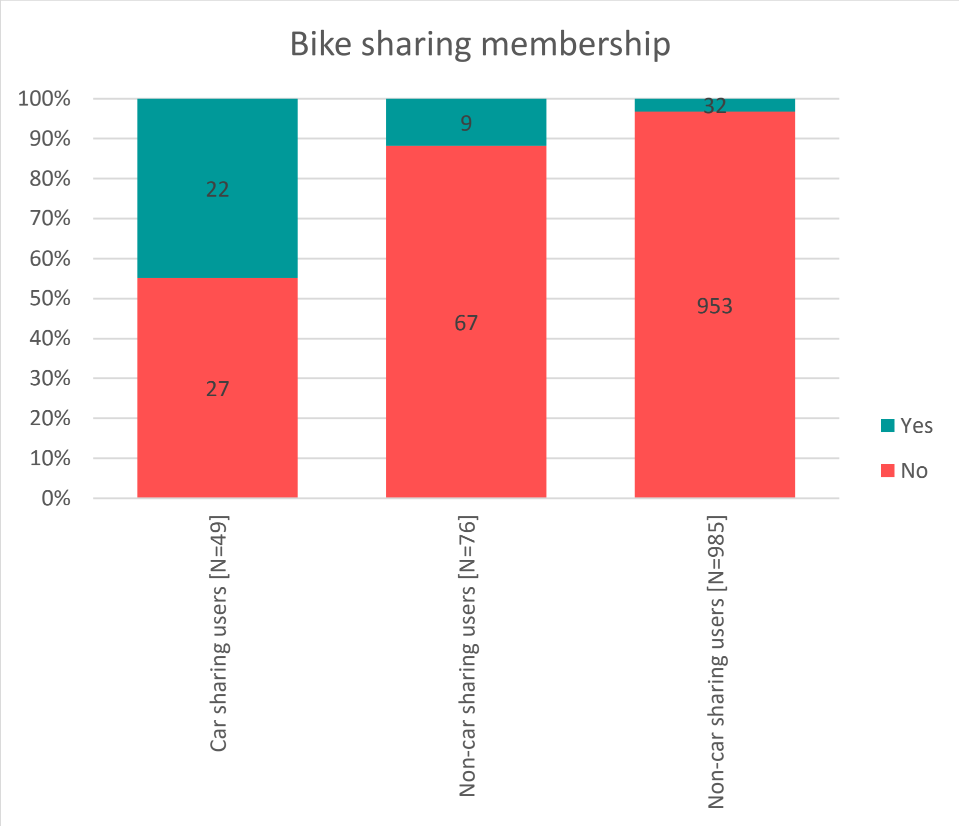

Figure 13: Differences in bike sharing membership between car sharing members and non-members of the Belgian case study

The analyses of the Belgian panel study results show that the registration to a bike sharing service is significantly higher among the group of respondents younger than 34 years old. It is also interesting to notice that the rate of respondents already using bike sharing is significantly higher among people indicating that it is (very) likely they will become a car sharing member in the future[32]. Not surprisingly, the number of registrations to bike sharing schemes and public transport season tickets is the highest among respondents without cars in their household[33]. Additionally, respondents driving a car less frequently tend to have more season tickets than people that drive a car every day[34].

[32] Among respondents indicating it is (very) likely they will become a car sharing member 13.8% has a subscription to a bike sharing scheme. Among respondents indicating it is (very) unlikely only 2.2% has a subscription.

[33] 58.8% of respondents without a car have a season ticket for public transport, versus 26.7% of respondents with one car and 17.9% of people with two cars. 10.3% of respondents without a car have a season ticket for public transport, versus 2.2% of people with one car.

[34] Among respondents driving a car daily 10.2% has a season ticket for public transport, among respondents driving a car less than weekly this is 37.8%.

The STARS travel survey version used in the whole city of Frankfurt contained some more specific questions about the type of public transport season tickets owned and the change in its ownership since participating to car sharing (see the Q6 variation in Appendix 2). The different kind of PT tickets owned by user groups at the time of the survey and before the car sharing registration are presented in Figure 14 below. The interviewed users already had an above-average number of season tickets before registering for car sharing – on average, 55.7% of the respondents were owners of monthly passes, job tickets, annual passes or severely disabled passes. Even among users who are only registered for free-floating, 39% already had a season ticket before registering (see the seventh column of Figure 14). According to the study "Mobility in Germany 2017"[35], 34 % of people living in metropolises (such as Frankfurt) are equipped with a public transport season ticket.

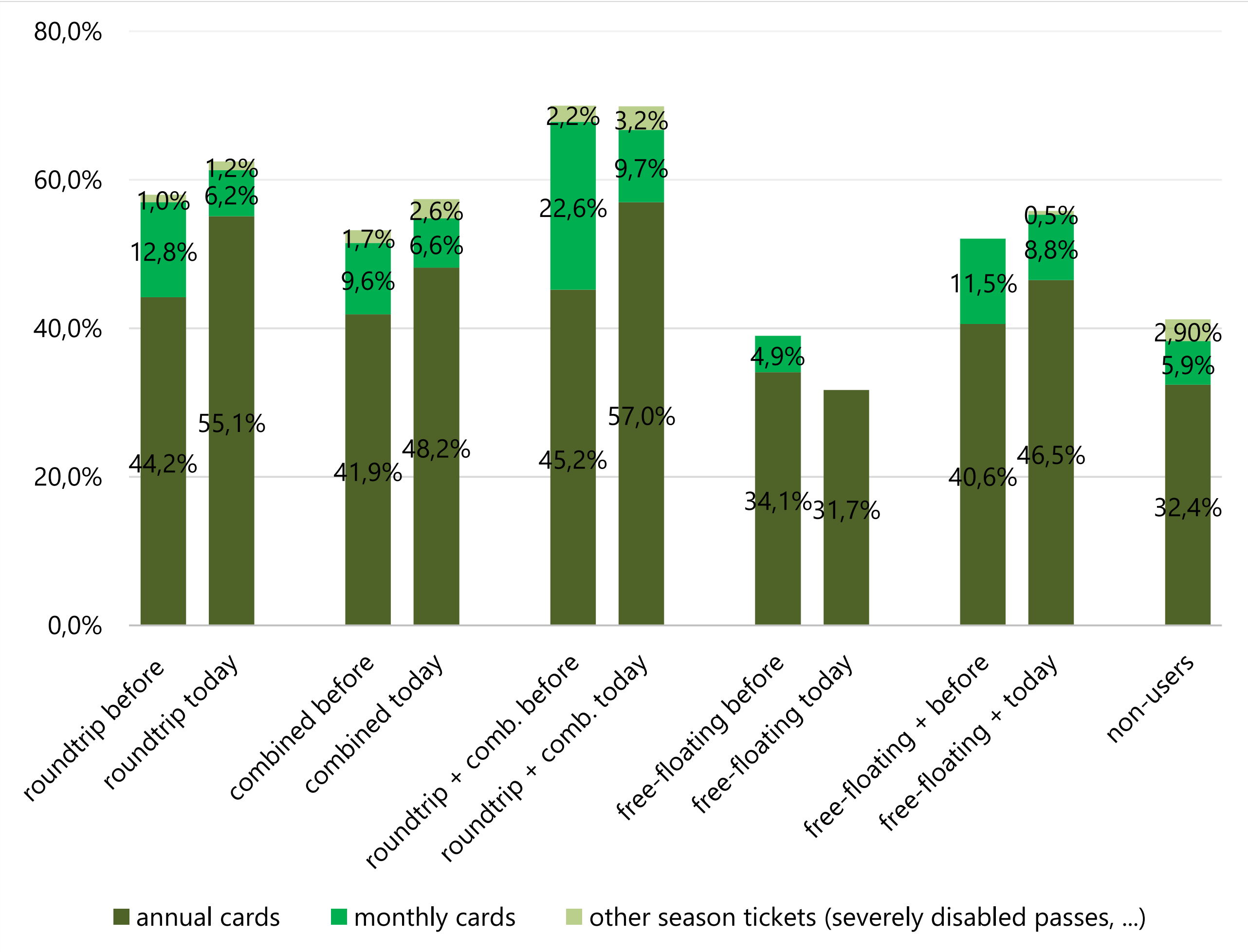

Figure 14: Changes in the possession of travel cards before registering with car sharing to date

In most of the surveyed groups, the proportion of season ticket holders has continued to rise since they took part in car sharing. On average across all groups, 59.1% of those surveyed were time card holders at the time of the survey. The exception is the group " Free-floating", were the proportion of

[35]MiD 2017, p. 43

people with a monthly or annual pass fell significantly to only 31.7% (see the eight column of Figure 14).

The group "roundtrip + combined," in which 70% own a season ticket, is the front-runner in terms of monthly and annual season tickets.

It is further notable that the number of public transport annual passes has increased in almost all groups (on average by 8 percentage points) since registering for car sharing. The exception here is also the "Free-floating" group.

The claim made occasionally in the media that car sharing (in general) cannibalises public transport can be refuted by the present study. Roundtrip and combined services strengthen and complement many more buses and trains. This also applies to user groups registered parallel to free-floating.

4.4 Differences in general mobility habits

4.4.1 Use frequency of different travel means for car sharing users and not users

The use frequency of different transport means of the full sample of car sharing members, of the not oversampled sample of car sharing members, of the control group and the non-members sample are reported in Figure 15 (Milan) and Figure 16 (Turin).

It is worth stressing that the observed differences between car sharing members and non-members (first and fourth row of each transport mode) might be biased since in the former group contains oversampled observation. Not oversampled members and the control group share similar socioeconomic characteristics instead (as described in 2.1.2), thus the observed differences are not related to those attributes and might be ascribed to the car sharing membership.

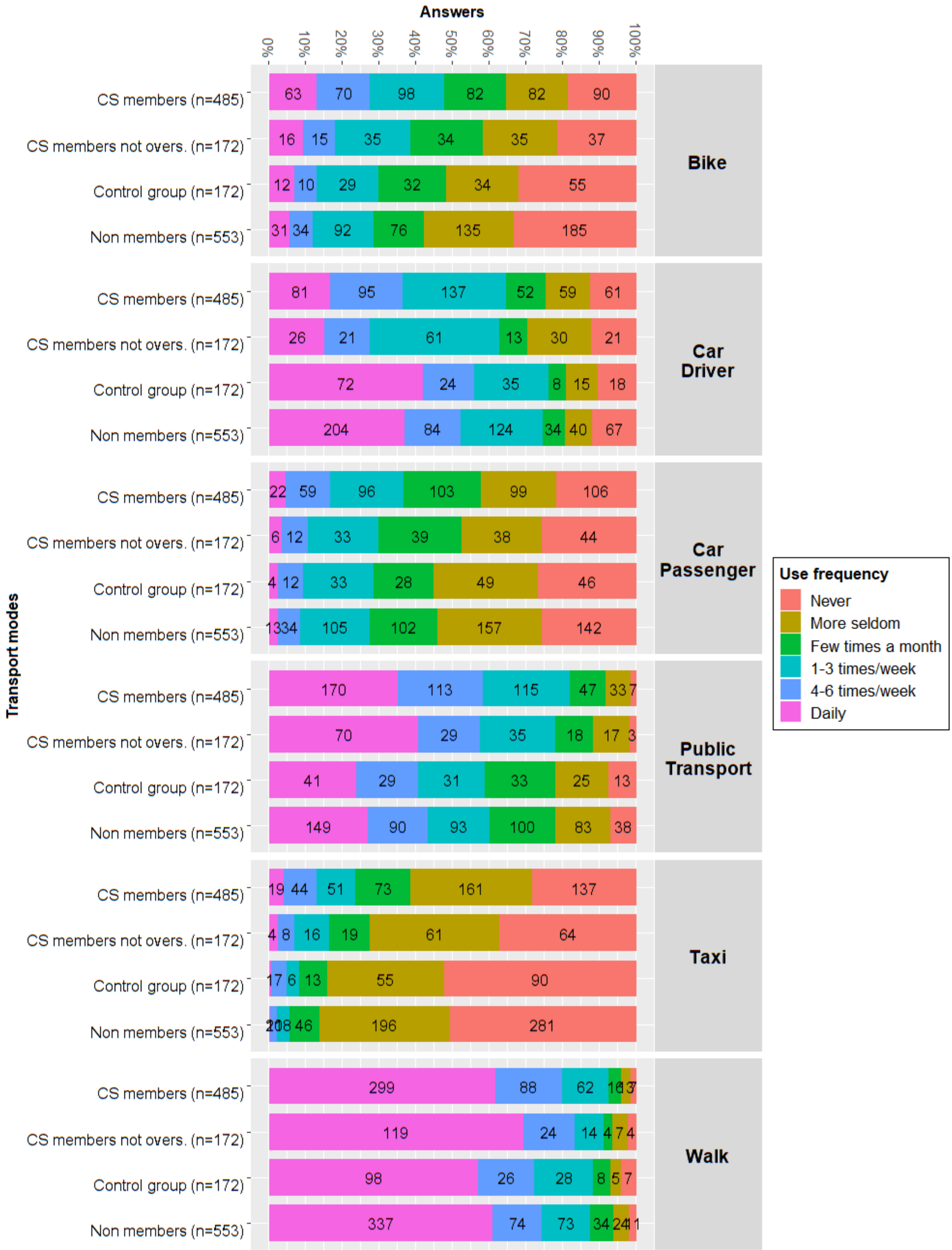

Figure 15: Use frequency of different travel modes – car sharing members and non-members of Milan

Car sharing members of Milan more frequently use active modes and public transport than non-members, however these differences are not statistically significant for walk and bike use[36]. On the contrary, significant differences were found between the two groups in the use of public transport: there are more car sharing members that use public transport on a daily basis[37] and less that use it few times a month or never, compared to non-members of the control group.

Concerning the use of the car as driver, less car sharing members drive a car every day but more use it sporadically (1-3 times a week) compared to non-members of the control group[38].

Taxi use frequencies seem quite low compared to other modes, but significant differences still exist between CS members and non-members[39]; in particular, more CS members use taxis from one up to three days a week, and few members that never use it.

Compared to the above results from Milan, modal use frequencies of Turin's CS members are quite similar to the ones of the control group, as showed in Figure 16 below; statistical tests confirm that differences are not significant indeed. This might be due to several reasons: firstly, the limited number of respondents collected within the city of Turin. Secondly, in Turin there are less car sharing services, which additionally have been operating for fewer years compared to those operating in the city of Milan; therefore car sharing still might be not seen as a mobility alternative to some use of the private car, and consequently mobility habits of the car sharing members might not be changed yet.

Finally, the two cities are different in terms of transport policies (Melis et al., 2019) and the offer of transport modes as a whole (beyond car sharing). Recently (February 2019), the city of Milan introduced a new limited traffic zone, the Area B, along with the existing Area C; these actions aim to reduce the number of relatively more polluting cars that enter into the city. It has been estimated that the number of accesses of polluting cars decreased by 13% during the first six months of activity of this measure[40]. Besides these push measures, the public transport system offers plenty of solutions; it is composed of four underground lines, 12 metropolitan train lines, several tram lines and buses, which guarantee high accessibility to the city. Furthermore, in Milan many sharing mobility and micro-mobility services are available, such as scooter sharing and bike sharing (Ciuffini et al., 2019). It is quite insightful to compare the results of the two Italian cities since it can be concluded that car sharing alone is not sufficient to trigger changes in mobility behaviour; it needs to be integrated into a transport system that can substitute the need of a private car in several ways.

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[36] χ^2 test, p-value>0.05
[37] Daily use χ^2=11.2, p-value<0.01
[38] Daily use χ^2=30.2, p-value<0.01, 1-3 times/week χ^2=9.8, p-value<0.01, more seldom χ^2=5.8, p-value<0.05
[39] 1-3 times/week χ^2=4.8, p-value<0.05, never χ^2=7.9, p-value<0.01
[40] https://www.comune.milano.it/-/area-b.-in-sei-mesi-diminuito-del-13-il-transito-delle-auto-inquinanti - Accessed November 25th, 2019

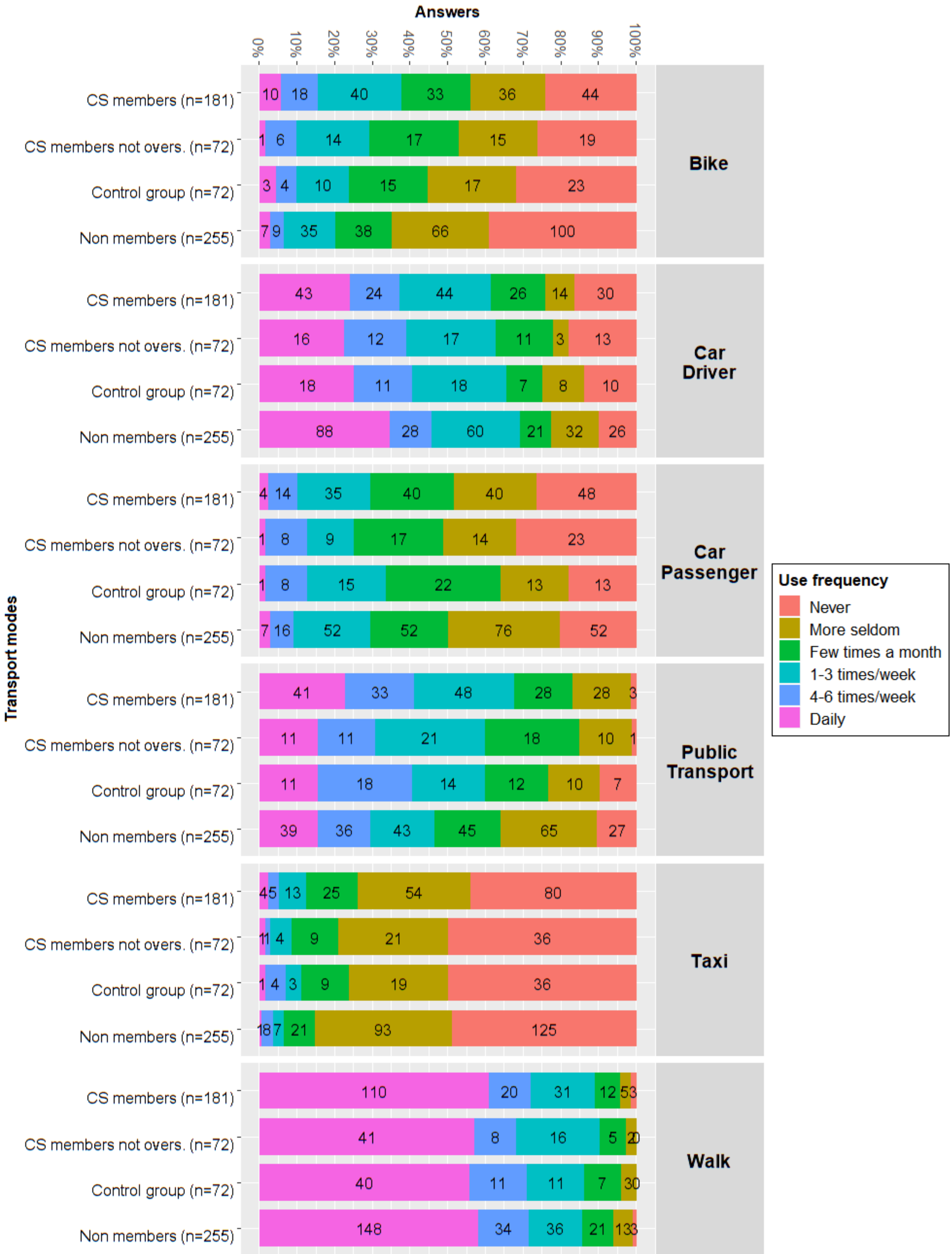

Figure 16: Use frequency of different travel modes – car sharing members and non-members of Turin

In addition to the use frequency of different transport means, respondents enrolled in a car sharing service were asked to indicate how many times in a month they use shared cars, and also the frequency in different periods of the year.

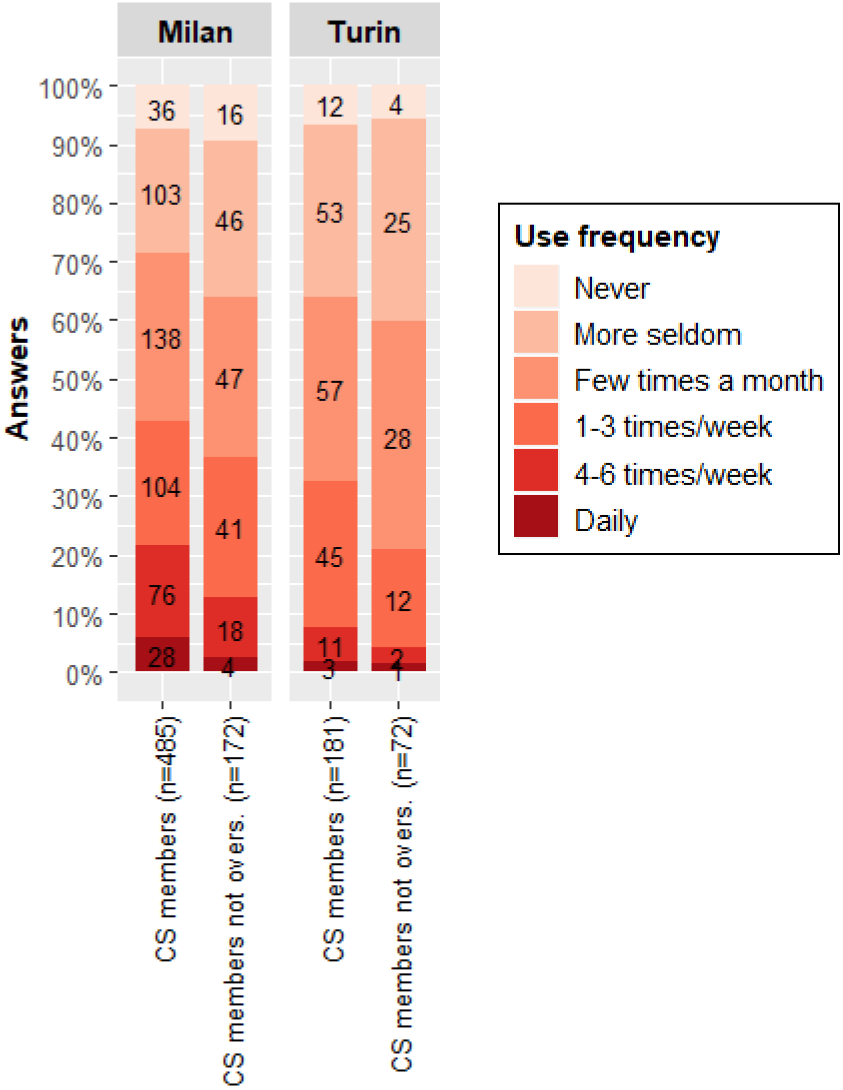

Figure 17: Car sharing use frequency among CS members of the Italian case study

The majority of members stated of using car sharing few times a month in both Milan and Turin city, as showed in Figure 17. Observed differences between CS members and not oversampled CS members in both cities are due to statistical fluctuations within the samples[41]. In general, members of Milan use the service more frequently (there are more observations in daily frequency and 4-6 times/week) than Turin members, also on a seasonal basis.

[41] Milan $\chi^2=8.2$, p-value>0.05, Turin $\chi^2=4.1$, p-value>0.05

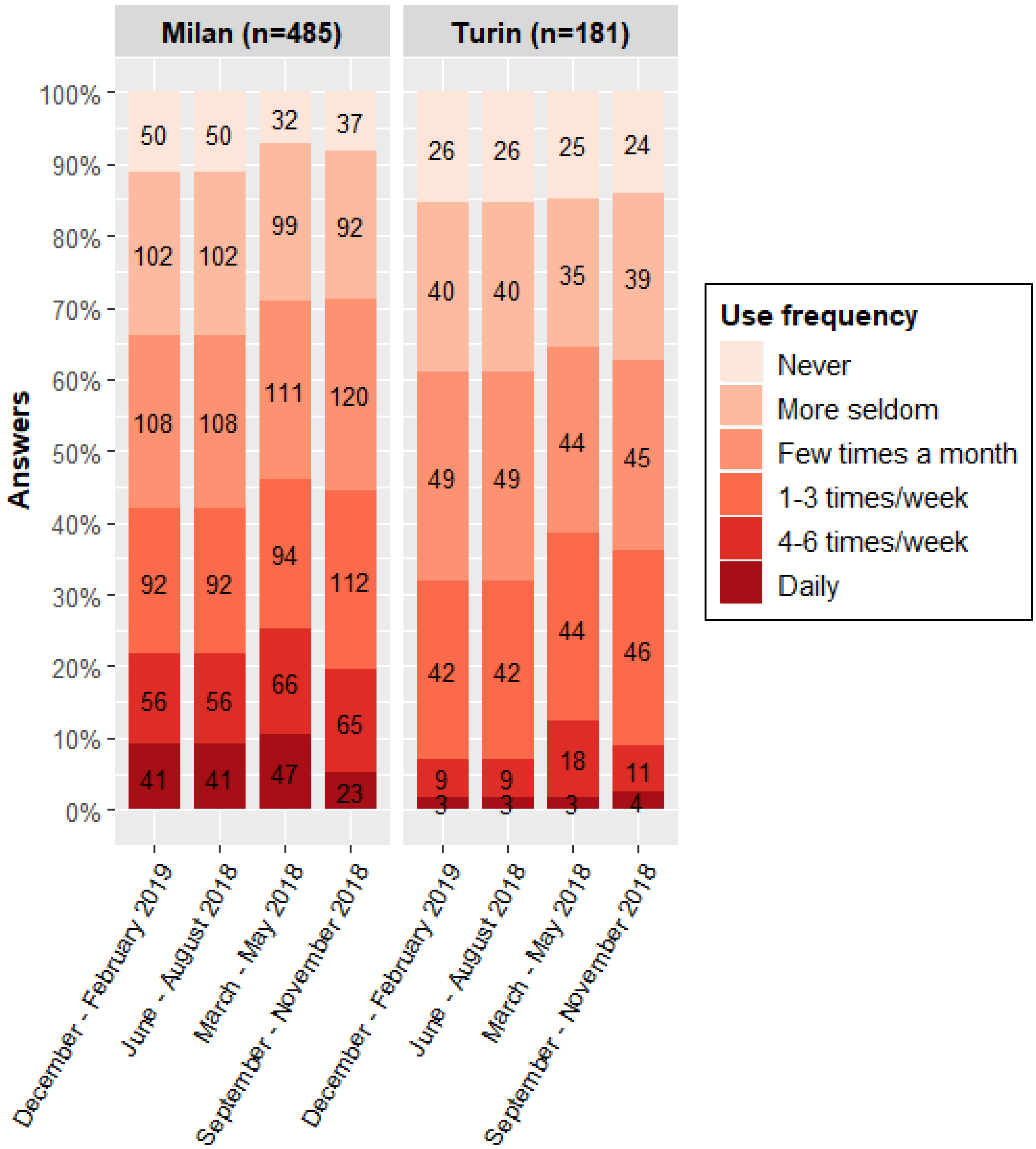

Figure 18: Seasonal car sharing use frequency in Milan and Turin

A similar comparison was carried out on mobility patterns of car sharing users and non-users of the Belgian case study. The results presented in the following Table 21 are based on the answers collected through the full online survey (65 users and 110 non-users).

Modes		Never	More seldom	Few times a month	1-3 times / week	4-6 days / week	Daily	Average
Bike	**CS**	1.8%	0.0%	3.5%	7.0%	12.3%	75.4%	**5.54**
	N-CS	12.9%	10.9%	8.9%	13.9%	18.8%	34.7%	**4.19**
Shared bike	**CS**	66.7%	11.1%	16.7%	5.6%	0.0%	0.0%	**1.61**
	N-CS	81.8%	11.1%	6.1%	1.0%	0.0%	0.0%	**1.26**
Walk	**CS**	1.8%	8.8%	15.8%	15.8%	12.3%	45.6%	**4.65**
	N-CS	4.0%	5.0%	10.9%	24.8%	20.8%	34.7%	**4.57**
Car driver	**CS**	48.1%	15.4%	21.2%	9.6%	5.8%	0.0%	**2.10**
	N-CS	12.9%	9.9%	14.9%	27.7%	8.9%	25.7%	**3.87**
Car sharing	**CS**	10.7%	25.0%	53.6%	10.7%	0.0%	0.0%	**2.64**
	N-CS	/	/	/	/	/	/	**/**
Car passenger	**CS**	18.5%	42.6%	38.9%	0.0%	0.0%	0.0%	**2.20**
	N-CS	18.2%	26.3%	26.3%	25.3%	3.0%	1.0%	**2.72**
Taxi	**CS**	85.2%	14.8%	0.0%	0.0%	0.0%	0.0%	**1.15**
	N-CS	85.0%	15.0%	0.0%	0.0%	0.0%	0.0%	**1.15**
Bus/tram	**CS**	19.3%	33.3%	29.8%	12.3%	5.3%	0.0%	**2.51**
	N-CS	37.0%	30.0%	19.0%	6.0%	3.0%	5.0%	**2.23**
Metro	**CS**	55.6%	27.8%	7.4%	3.7%	3.7%	1.9%	**1.78**
	N-CS	61.0%	28.0%	7.0%	2.0%	1.0%	1.0%	**1.57**
Train	**CS**	1.8%	23.2%	37.5%	21.4%	14.3%	1.8%	**3.29**
	N-CS	22.8%	29.7%	18.8%	14.9%	8.9%	5.0%	**2.72**

Table 21: Use frequency of different travel means – full online survey [car sharers N = 65 // non-car sharers N = 110]

Three quarters of the car sharers uses a bike every day, among non-car sharers this is true for almost one third (34.7%) of the respondents. More in general, on an ordinal frequency scale from 1 to 6[42], car sharers score a 5.5 for the use of bikes, non-car sharers end up with 4.2. The difference in use of shared bikes is not big, however the analysis in paragraph 4.3 shows far more car sharers have a subscription to a bike sharing scheme than non-car shares. The frequency of doing trips by foot is a bit higher among car sharing users, but the difference is negligible.

Furthermore, car sharing members use a private car less frequently than non-car sharers, as expected given the lower car ownership rates that were analysed in section 4.2. Only 15% drives a private car

[42] With 1 = never and 6 = daily use.

1 to 3 times a week or more, among non-users this number raises to 62%. Even considering the frequency of use of shared cars by car sharing, in general they use a car less frequently than non-car sharers. The frequency of using a taxi is almost exactly the same in both groups. Being a car passenger is a bit more frequent among non-car sharing members, but the difference is not huge. This confirms non-car sharing members do trips by car more often, both as a driver and as a passenger.

Car sharers are the most frequent users of bus, tram, metro and train. If we take a look at the number of respondents that never or more seldom uses the different travel means, we see this percentage is higher among non-users[43]. The difference is the biggest for trips by train. Almost one out of four non-car sharing users never uses a train, whereas only 2% of the car sharing practitioners never uses a train.

In conclusion, car sharing members more often choose for active modes of transportation (especially bike) and also do more trips with public transport than non-car sharers.

4.4.2 Use frequency of different travel means among different car sharing user groups

Differently from the Italian and Belgian case studies, within the German case study the use frequency of different travel means was evaluated only for car sharing members, thus no comparison with non-members is presented here. However, a more detailed descriptive analysis on use of travel means has been carried out by comparing different car sharing user groups.

A general overview of the mobility behaviour of car sharing users is presented in Table 22 below. The dominant means of transport for trips nearby the place of residence are the bicycle, bus and train. In view of the large number of car-free households, privately owned cars play no role. Car sharing is also rarely used. Only 8% of respondents use a car sharing vehicle at least once a week, only 0.4% on a daily basis. It is notable that in everyday use car sharing plays merely a subordinate role.

[43] 67% of non-car sharing users never or more seldom uses bus or tram, whereas 53% of car sharing members never or more seldom uses bus or tram. 89% of non-car sharing users never or more seldom uses a metro, whereas 84% of car sharing members never or more seldom uses a metro. 53% of non-car sharing users never or more seldom uses a train, whereas 25% of car sharing members never or more seldom uses a train.

All users [N = 1059]	(almost) never	Less than monthly	1-3 days /month	1-3 days /week	(almost) daily
Car driver	76.9%	3.2%	5.1%	10.1%	4.7%
Car passenger	67.9%	15.1%	11.2%	4.9%	0.8%
Car sharing	11.0%	42.9%	38.1%	7.6%	0.4%
Bike (in everyday life)	18.6%	7.6%	10.0%	16.7%	47.1%
Bike (leisure time)	15.2%	10.8%	16.6%	22.8%	34.7%
Public transport	1.8%	6.2%	24.6%	24.8%	42.5%
Taxi	52.8%	34.5%	10.9%	1.8%	0.1%
Walking	2.6%	2.5%	7.2%	16.8%	70.9%

Table 22: Use of transport means by Frankfurt car sharing users

When it comes to analyse differences in mobility habits among user groups, the use frequencies are separately analysed for each transport mode.

The car sharing members use frequency of private car is presented in Figure 19 below.

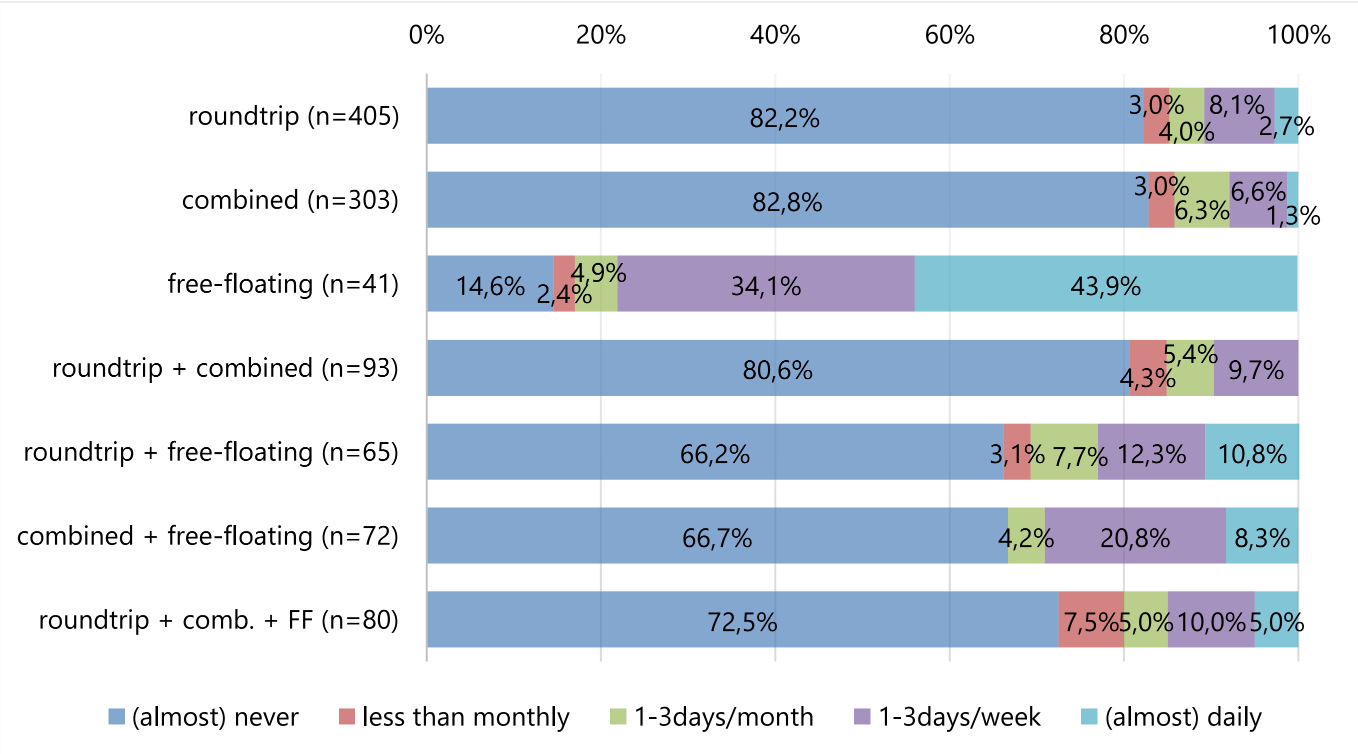

Figure 19: Frequency of private car use as driver by Frankfurt car sharing users

As expected, the individual car sharing user groups differ in terms of the use of a private car or company car, as a driver. More than 80% of users of the roundtrip and combined systems use their

own car (almost) never or less than monthly. This can be explained by the high number of car-free households in these groups. A further 8% drive a private car less frequently than once a week.

By contrast, 43.9% of users registered exclusively for free-floating services drive a private car themselves (almost) daily. Another 34.1% drive their own car at least once a week. In this group, as well, car use reflects the number of cars – in this case, the high car ownership rate and the low number of car-free households.

On the other hand, users who along with free-floating are also registered for roundtrip and/or combined systems show a use of transport means similar to the users of the roundtrip or combined systems. The proportion of respondents who do not at all use their own car is somewhat lower for "free-floating +", while the frequent use of a vehicle as a driver is somewhat higher. This also corresponds to the above analysed car ownership rates.

At a glance, a direct context can thus be established between the frequent use of a private car and the number of cars in the individual user groups.

Regarding the use of bicycles in everyday life reported in Figure 20, the differences between users of roundtrip and/or combined systems on the one hand and of the free-floating alternative on the other are not as striking as in the case of vehicle use, but they are quite clear.

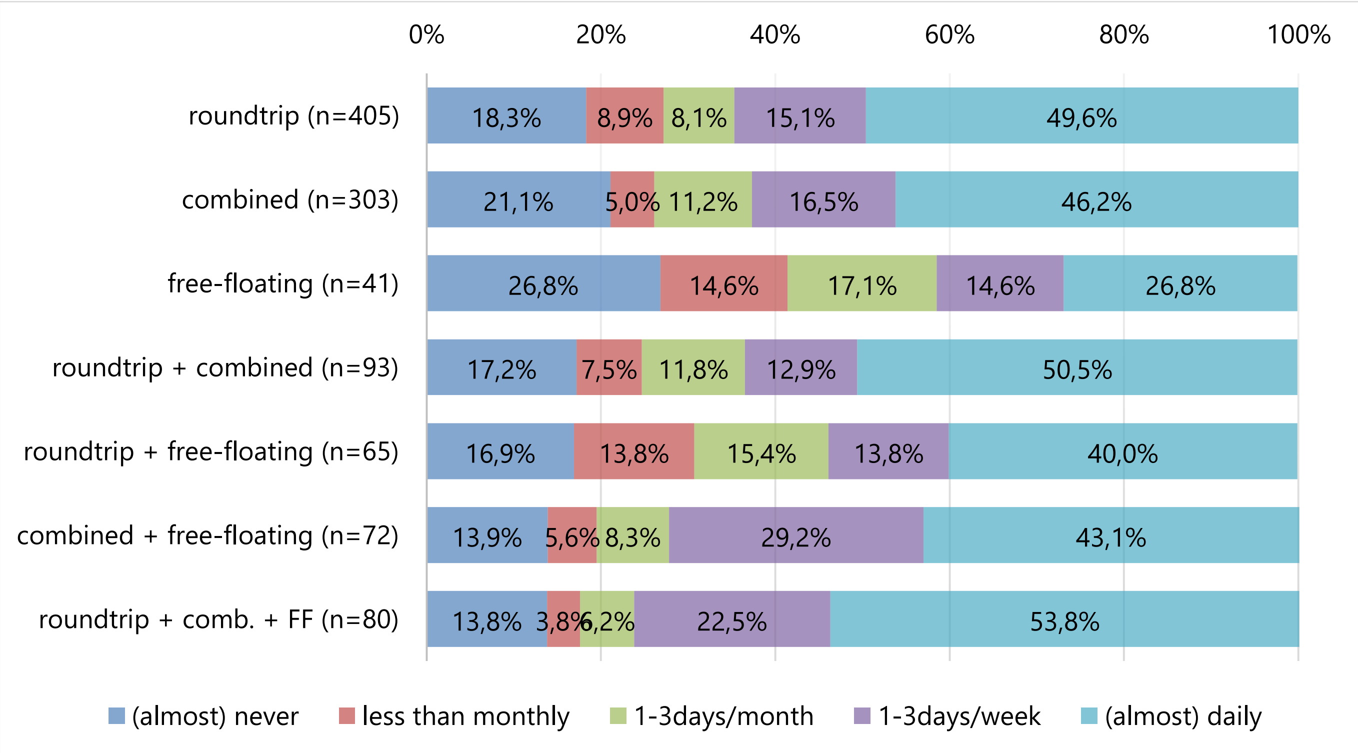

Figure 20: Frequency of bicycle use in the everyday lives of Frankfurt car sharing users

Almost half of all respondents in the "roundtrip" group use bicycles for everyday purposes on a daily basis. In the "combined" group, only slightly fewer people cycle daily.

In the case of users who are only registered for a free-floating model, only slightly more than a quarter ride their bicycles every day. This group also includes the majority of users who rarely use a bicycle for everyday purposes. Across the groups, however, the differences in non-use are not so divergent.

In the group "roundtrip + combined + free-floating", the proportion of daily bicycle users is the highest. More than three-quarters of the respondents in this group use their bicycles at least once a week. The differences in the use of bicycles for purposes of leisure are smaller between the groups studied.

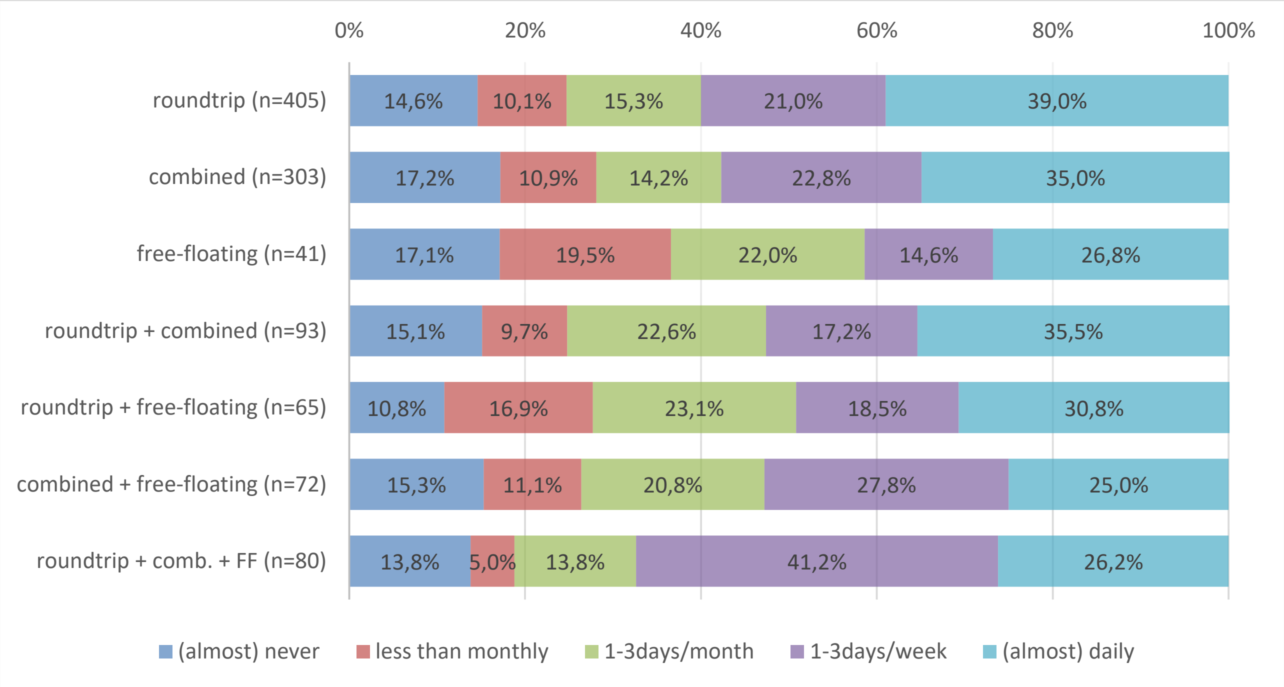

Figure 21: Frequency of bicycle use for purposes of leisure of Frankfurt car sharing users

Overall, car sharing customers across all groups use bicycles with greater frequency than average, both in everyday life and for purposes of leisure. According to "Mobility in Germany 2017,"[44] 38% of people in major cities (such as Frankfurt) use their bicycles at least once a week. That percentage lies in this study between 53.8% and 76.3%. The only exception in the present survey is the group of respondents who are only registered for free-floating.

In comparison to the previous study in residential areas close to the city centre, in this study the proportion of those who use their bicycles daily is significantly higher in all comparable groups.

[44]Page 94

The high frequency of bicycle use, especially in the user groups the majority of which no longer own their own vehicles, shows how important a well-developed bicycle infrastructure is in order to support multimodal transport behaviour.

The use frequency of public transport of different car sharing users groups is presented in Figure 22 below.

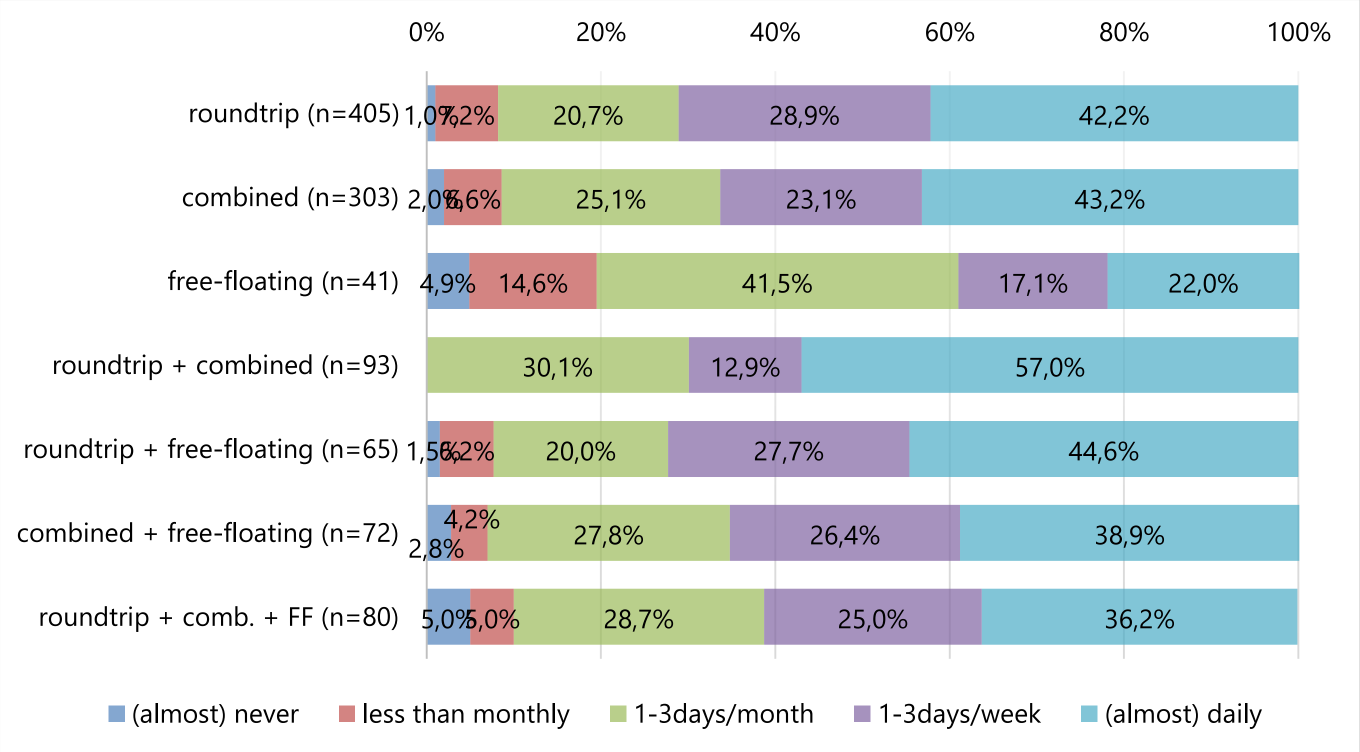

Figure 22: Frequency of public transport use by Frankfurt car sharing users

Buses and trains are intensively used by car sharing users across all groups. The proportion of almost daily users in the groups lies between 36.2% and 57%. Between 60% and 70% of respondents in all groups travel with public transport at least once a week. The group of those who use free-floating car sharing exclusively represents an exception. Here, only 22% travel by bus or train every day. Even in this group, however, more than 80% of those surveyed travel by bus or train at least once a month, just under 40% at least once a week.

The present study thus shows that the high affinity of car sharing users for public transport, as already established in the previous study, is not limited to residential areas close to the city centre. For the survey area of the entire city of Frankfurt, the shares of daily bus and train use in comparable groups are in some cases even significantly higher than the inner city values of the previous study.

Finally the use frequencies of car sharing by different user groups are presented in Figure 23.

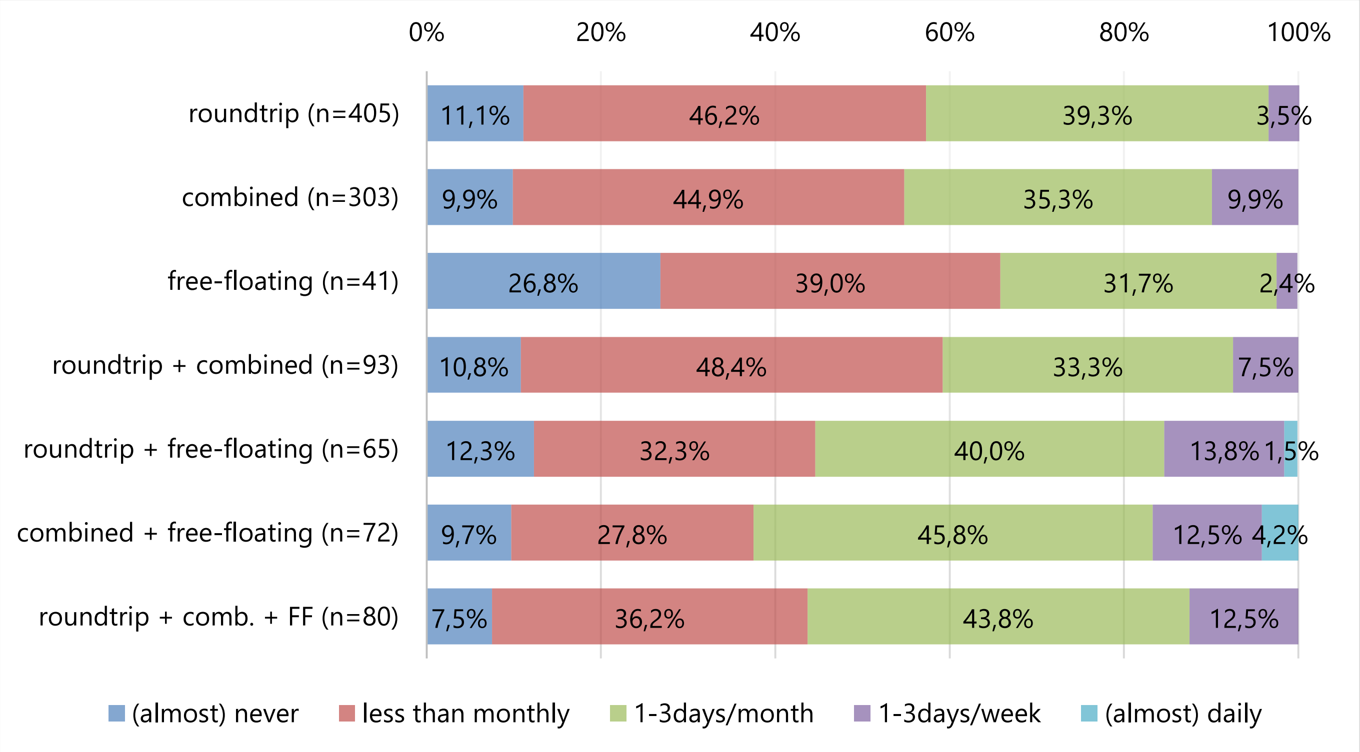

Figure 23: Frequency of car sharing use by Frankfurt users

Car sharing vehicles are apparently only seldom needed by users. Most users sit one to three days a month or less than monthly in a car sharing vehicle. Only a few customers book a shared car at least once a week or even more often.

Only those customers who subscribed several car sharing systems will be able to use car sharing vehicles somewhat more frequently. In these groups, the proportion of those who sit 1 to 3 times a week in a car sharing auto increases to 13.8%. It seems that users with more memberships in different car sharing systems also tend to make more intensive use of the offerings.

4.4.3 Changes in mobility behaviours after subscribing to car sharing

The introduction of car sharing might change how other means of transport are used. Additional mobility options are competing with previously used means of transport for users' daily trips. If this circumstance leads to one means of transport replacing another, this shift can also bring about changes in overall mobility behaviour. With car sharing, such change takes place above all when car sharing replaces the private car in the household.

In the framework of this study, all car sharing users were asked to what extent their use of different means of transport has changed since taking part in car sharing. This does not expressly mean an analysis of changes in the modal split, but merely a self-assessment by users.

Changes in mobility behaviours stated by free-floating car sharing members of Milan and Turin are reported in Figure 24.

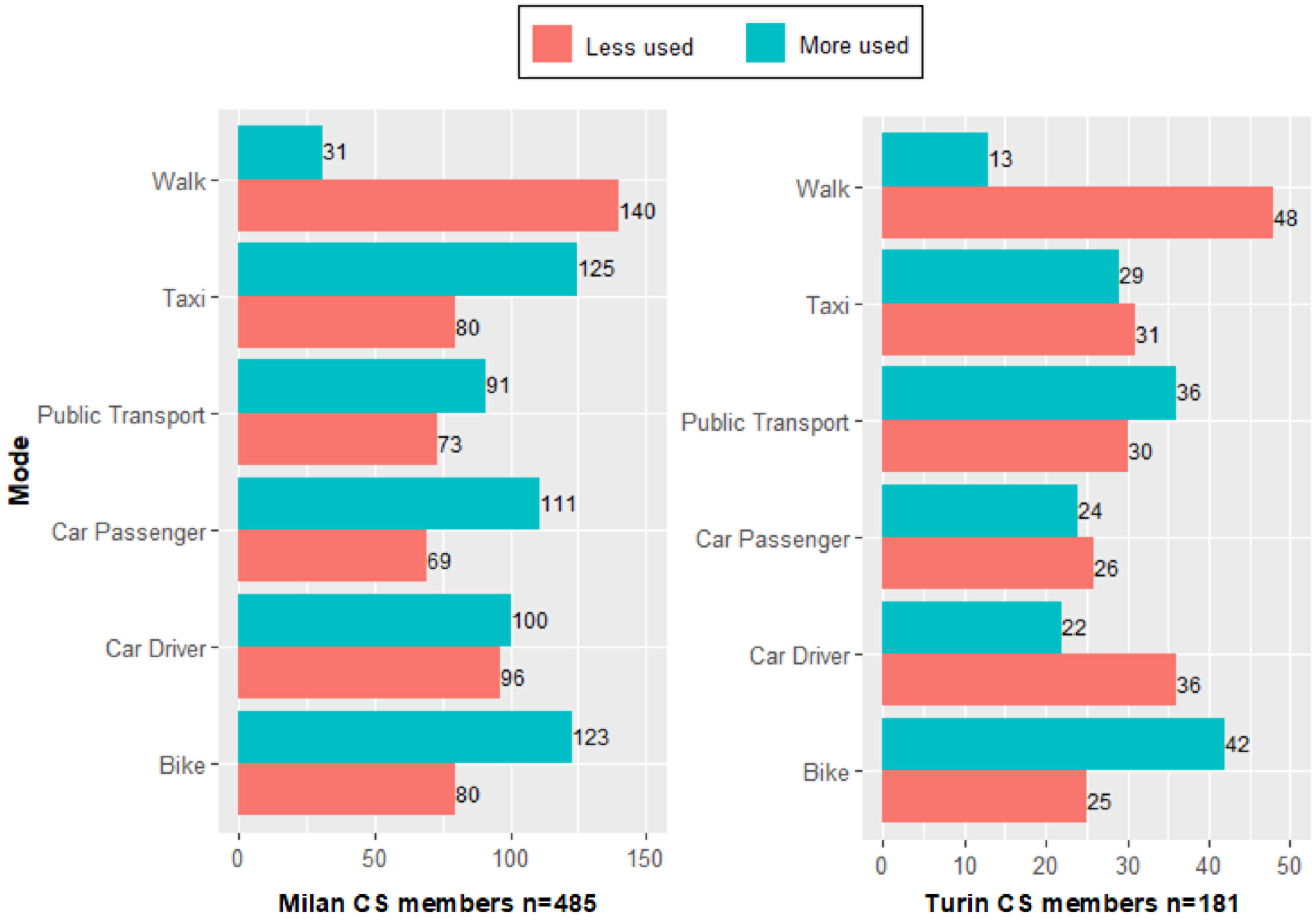

Figure 24: Changes in travel habits after joining car sharing within the Italian case study

In both cities, car sharing members are using more public transport and bike than before their subscription (in the sense that the difference between respondents who use more and the ones who use less these transport modes is still positive). On the contrary, members on average walk less.

Changes in the use of taxi and private car are different for Milan and Turin members. In Milan there are more car sharing members that are using taxi more frequently than in the past, while in Turin there is almost a balance; however slightly few members use more the taxi than before. The use of cars, as driver or passenger, seems a bit reduced among car sharing members of Turin: more respondents stated using less the car than before, especially when it comes to drive a car.

On the contrary, the majority of members uses the car as a passenger more frequently than in the past in Milan. This is also the case of driving a car, even if to a lesser extent. Matching this information with the previous analysis of the use frequency, it is worth noting that car sharers still use cars not so frequently albeit they stated to have increased its usage. Here it is not clear if respondents might have perceived a higher use of car due to their use of shared cars, which has been enabled after the car sharing subscription or, in the case of the use as passenger, the use of car pooling solutions.

Changes in mobility behaviour among car sharing members after their subscription to a car sharing platform were also analysed in the Belgian case study; the results are here presented through Table 23.

Members of car sharing schemes indicate to do more active trips (by bike – shared or private - and on foot) than before they started sharing cars. Interestingly, more than half of the respondents did not use a shared bike before their subscription with car sharing. Apparently a shared car does not come alone. Concerning the use of cars and taxis, the respondents of this research seem to have lowered their car use after becoming a car sharer. Only the use of taxis increased, which is a logic effect of not having access to their own car (or to a shared car) at all times and all places. At last, also the use of public transport modes increased after becoming a car sharing member in Flanders. The most considerable growth can be found among the number of trips per train. These results reflect earlier STARS research stating that car sharing members do more active trips and trips with public transport after their subscription to a car sharing scheme (Bergstad et al., 2018).

	I didn't use this mode of transport before registration	More frequently than before registration	As many as before registration	Less frequently than before registration
Bike	1.8%	30.4%	60.7%	7.1%
Shared bike	53.7%	11.1%	31.5%	3.7%
By foot	0.0%	17.9%	78.6%	3.6%
Car driver	7.1%	10.7%	25.0%	57.1%
Car passenger	5.5%	18.2%	47.3%	29.1%
Taxi	49.1%	7.3%	43.6%	0.0%
Bus/tram	7.1%	25.0%	57.1%	10.7%
Metro	27.3%	12.7%	58.2%	1.8%
Train	1.8%	37.5%	53.6%	7.1%

Table 23: Change in mobility behaviour – full online survey in Belgium, only car sharing users [N = 56]

Relying on data coming from internal surveys of car sharing operators, differences between members belonging to different car sharing categories were also analysed (see Table 24). Among members of roundtrip station-based systems in the Brussels Capital Region, the number of people that started to do more trips by bike is higher than the group doing fewer trips by bike. Among members of free-floating platforms, these groups are equal, even with slightly more respondents doing fewer trips by bike. This way, the impact of free-floating car sharing schemes on bike is negligible. The balance for trips by foot is more positive. For both categories of car sharing, the number of members doing trips

by foot increased. Among users of station-based car sharing schemes the use of a car (in all forms) dropped clearly, while the use of cars decreased less spectacularly among users of free-floating systems. It seems that a big part of trips done by private car are now done with a shared car.

At last there are some remarkable differences concerning the use of public transport. For all modes (tram, bus, metro and train), the frequency of use by members of free-floating schemes dropped after registration. Among roundtrip station-based car sharers the use of bus, tram and metro increased, the use of trains is more or less stable.

Unlike in the Italian case study, only data on the changes in mobility behaviour after subscribing to a car sharing platform were available. Therefore it is not possible to know the current use of transport means and derive strong conclusions, however from the analysed data it seems that the impact on users of the two car sharing systems is not the same. Members of roundtrip station-based schemes tend to do more trips by bike and with busses, trams or metros after they became a car sharing member. The members of free-floating schemes, on the other hand, do not use these modes more than before or in some cases even less than before.

		(Much) Less often	Unchanged	(Much) More often
Bike	**RTSB**	8.3%	75.1%	16.6%
	FFOA	9.5%	81.3%	9.2%
Walk	**RTSB**	4.0%	71.5%	24.5%
	FFOA	8.0%	78.2%	13.8%
Car sharing & taxi	**RTSB**	45.0%	42.9%	12.0%
	FFOA	21.9%	61.3%	16.8%
Motorbike / scooter	**RTSB**	12.6%	85.1%	2.3%
	FFOA	4.5%	93.0%	2.5%
Bus / tram / metro	**RTSB**	8.1%	66.7%	25.2%
	FFOA	28.7%	60.6%	10.7%
Train	**RTSB**	18.8%	64.1%	17.2%
	FFOA	9.3%	87.0%	3.6%

Table 24: Change in mobility behaviour – internal surveys car sharing operators

[N roundtrip station-based = 2085 // N free-floating operational area = 652]

Similarly to the analyses carried out within the Belgian case study, differences between members belonging to different car sharing categories were also analysed in Frankfurt. However, since here

car sharing members are divided in many more user groups, the results are separately presented for each transport mode.

According to the results presented in Figure 25 below, the use of private car, providing it is still present, has declined significantly since participating in car sharing. More than three-quarters of respondents of the roundtrip and combined models no longer use their own vehicle at all. In the other groups, the use of their own vehicle has also fallen sharply. This can be explained by the high proportion of car-free households in these groups. Against the background of the high car ownership and of the very low car sharing usage, it is noteworthy that even users who are only registered for the free-floating system have stated to just under one third that they use their own vehicle less than before.

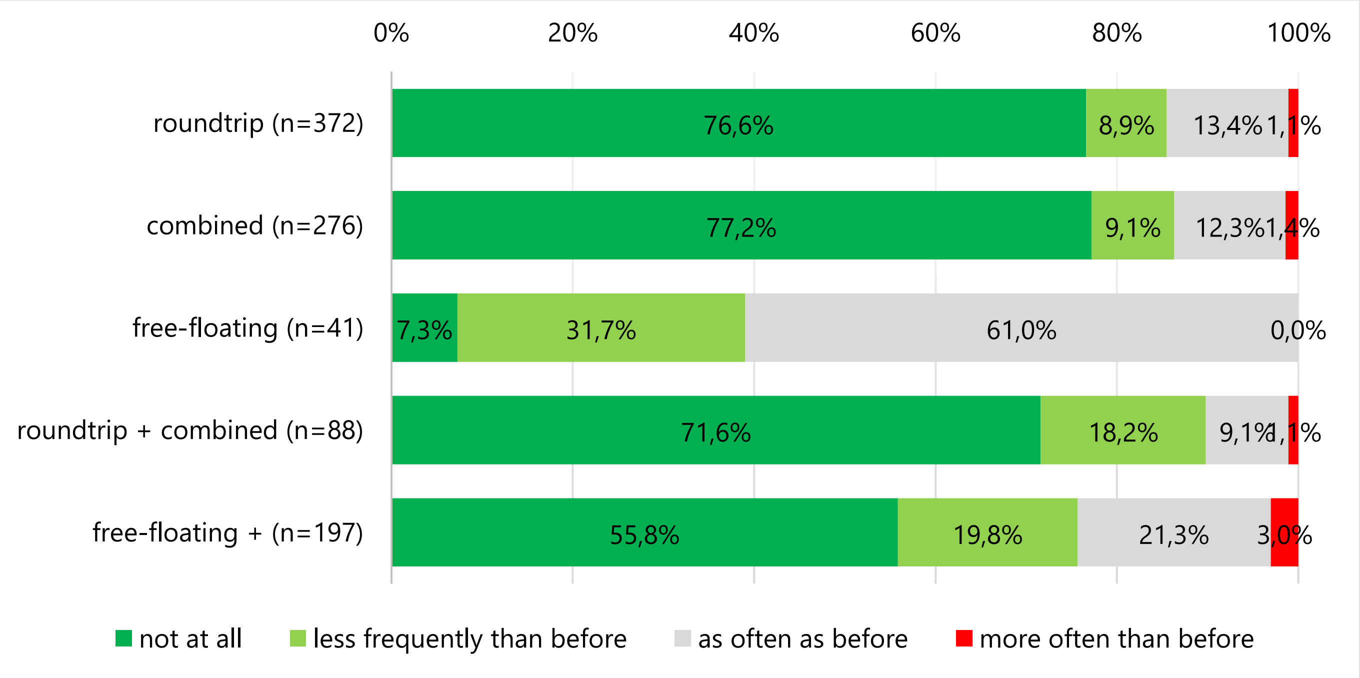

Figure 25: Change in use of private car since participating in car sharing (without "I cannot say")

Since participating in car sharing, a good third of respondents in almost all groups travel more frequently by public transport than in the past (Figure 26). Figure 26 shows that the proportion of those who use buses and trains less frequently than before is no higher than 15 % in any group. Free-floating car sharing users constitute one exception, where the group of those who use public transport less often is just as large as the group reporting more frequent use.

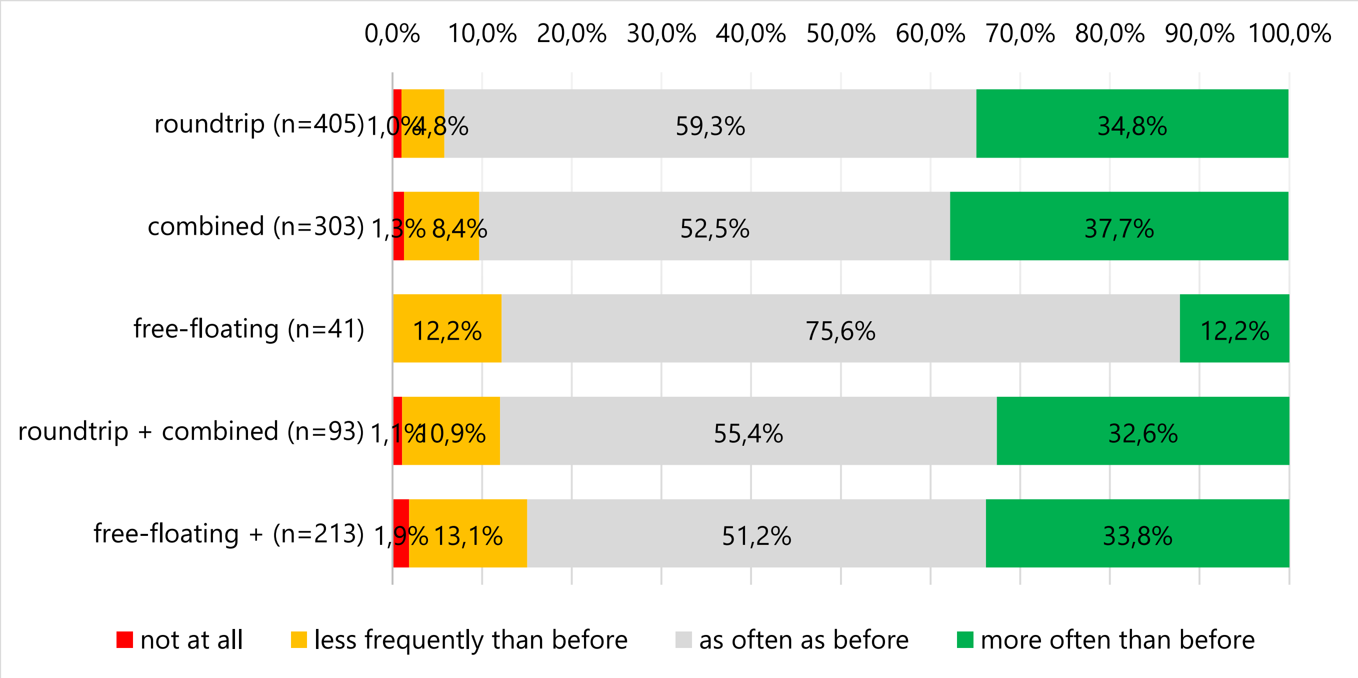

Figure 26: Change in the use of public transportation since participating in car sharing (without "I cannot say")

In the "roundtrip" group, for each user travelling less frequently with public transport since registering for car sharing, there are seven users who travel with public transport more frequently. The proportion of customers travelling by public transport less frequently than before rises slightly, the more varied the car sharing service is available to the customer.

More than half of all respondents use buses and trains just as often as before. In view of the already very high proportion of time ticket holders in these groups, even more frequent use of buses and trains is no longer possible for many.

Concerning non-usage patterns of public transport in Frankfurt, only between 4.3 % and 8.8 % of the respondents stated that they had not used public transport at all before registering for car sharing. The only exception is the group of free-floating users, where 22% stated that they had not used local public transport at all before registering with car sharing.

Since registering with car sharing, the proportion of those who do not use local public transport has again almost halved in all groups (from an average of 8.3 % to 4.5 %). After registering with car sharing, an encouraging 10 % of free floaters made their first acquaintance with local public transport.

How intensively buses and trains are used can be deduced from the question of what type of tickets are usually used.

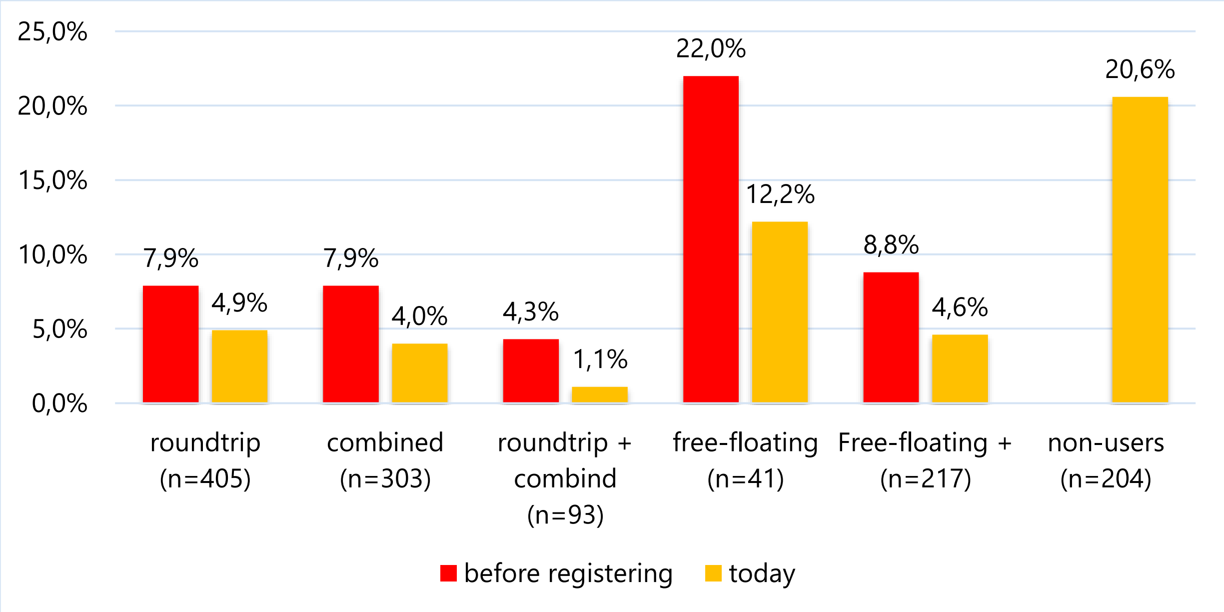

Figure 27: Non-use of public transport at their place of residence

Finally, Figure 28 below shows that since participating in car sharing, around a quarter of the respondents in all groups have travelled by bicycle more frequently than before. A clear majority of users cycle just as often as before, and very few use this mode of transport less frequently. However, the proportion of those who have not used bicycles since registering to car sharing, at 10 % on average, is significantly higher than for buses and trains. Once again, only the group of respondents who exclusively use the free-floating system shows greater discrepancies in use.

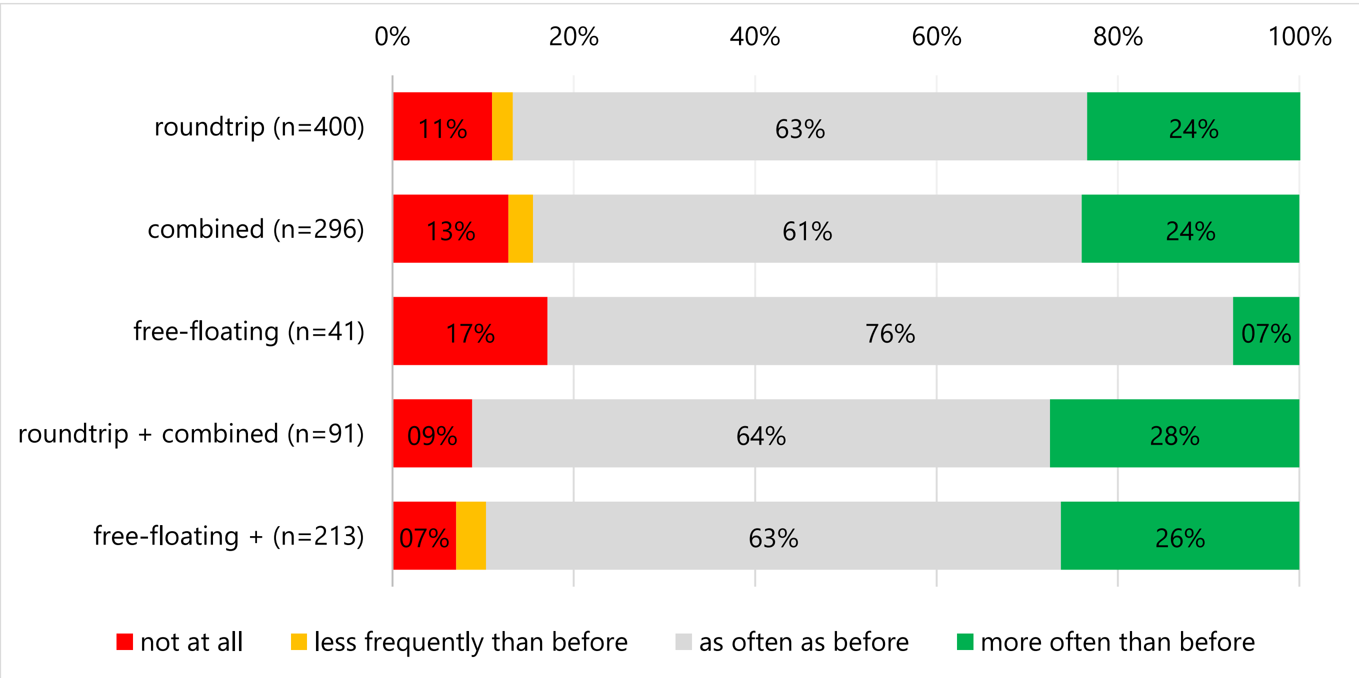

Figure 28: Change in the use of bicycles after registering with car sharing (without "I cannot say")

From the point of view of cities and towns that want to use car sharing to reduce the use of motorized private vehicles and strengthen the environmental alliance/ network/ eco-modes, station-based and combined car sharing systems are powerful tools.

4.5 Non-users attitudes on car sharing

Respondents belonging to the non-members group were asked to indicate how likely they would become a car sharing member in the future (Q2b in Appendix 1). Answers from the Italian and Belgian case study are summarised in Table 25. The observed situation in the two countries is a bit different: in Milan and Turin about 20% of respondents is likely to become a car sharing member (24.6% and 19.2% respectively), while in the Flanders region almost 10 percent of the respondents stated they are likely to become a car sharing members. About 40-45% of Milan and Turin respondents stated they will not become a customer while in Flanders this percentage rise up to 78%. Finally, 34.5% of Italian respondents and 13% of Flanders respondents have no clue about future registrations to this kind of services.

Differences between the two areas might be due to the different spatial context (region level vs city level). Thus, digging a little deeper into Flanders region's numbers, it is interesting to notice a significant difference in answers depending on geographical characteristics. In non-urban areas 5% of the respondents is likely to become a member, against 12% in urban areas, which is still low compared to the results in the two Italian cities. Another explanation can be linked to a different perception of the service itself, due to the different offer of car sharing services in the two countries. In particular, free-floating car sharing services offered by big industrial groups have a large visibility in Turin and Milan, that might attract more the attention of non-users.

	Certainly not	Rather not	No clue	Rather yes	Certainly yes
Milan (n = 553)	115 (20.8%)	111 (20.1%)	191 (34.5%)	102 (18.4%)	34 (6.2%)
Turin (n =255)	63 (24.7%)	55 (21.6%)	88 (34.5%)	38 (14.9%)	11 (4.3%)
Flanders region (Panel survey, n=985)	432 (43.9%)	336 (34.1%)	129 (13.1%)	79 (8.0%)	9 (0.9%)

Table 25: Likelihood of becoming a car sharing member

In addition, respondents belonging to the non-members group were asked to rate several features that would entice them in using a car sharing service (Q27b in Appendix 1). The most important and

the least important aspects are described in the following, whereas the full table is reported in Appendix 8.

The two most important aspects raised by respondents from the Italian case study are the assistance in case of breakdowns or damages of the shared cars (64.7% of non-members in both Milan and Turin) and the possibility of free parking in any parking space without limitations (54.3% in Milan and 67.1% in Turin). The latter is also one of the most important argument for Flanders' respondents. However, in a lot of European cities there are already favourable parking regulations for shared cars, thus these answers from non-members might be related to the lack of knowledge about car sharing already granted advantages. Our results therefore can give an indication to car sharing operators on which aspects should be better advertised in a marketing campaign. Similarly, another important aspect for current Italian non-members is the 24/7 telephone assistance of the service provider (53% both in Milan and in Turin), which is also already provided.

On the contrary, half of all respondents living in Flanders indicated the availability of cars whenever the user needs one is the most important reason that could entice them to start sharing. Again, such availability is probably more perceived by non-users when they can see a lot of shared cars around them as it happens in Milan and Turin, although strictly speaking the availability should be assessed in a different way. In any case, building on a widespread and dense offer of shared cars will definitely be one of the biggest challenges of the car sharing sector in the coming years.

Three other important features related to the car sharing offer were encountered among Italian respondents' answers: a larger number of available cars (59.8% in Milan, 60.4% in Turin), a larger extension of the operating area and/or diffusion of the stations (54.7% in Milan, 55.3% in Turin) and a denser network of car sharing stations (or charging stations in case of electric car sharing) would entice non-members to join the service (52.6% in Milan, 50.3% in Turin).

Finally, economical aspects were raised as important incentives to join car sharing, such as discount for short and long renting periods, by 56.4% of non-members in Milan and 51.4% in Turin.

Concerning the least important reasons to become a car sharing member, Italian and Flanders respondents share similar thoughts. The availability of cars equipped with child seats is not considered so important: 50.8% of Milan respondents in does consider it a plus, percentage that rises to 52.6% in Turin and 60.6% in Flanders. Another feature not important for non-members is the possibility of transporting animals (53.4% in Milan, 48.6% in Turin and 65.3% in Flanders) or bicycles (about 58% in both Milan and Turin). These might be very specific needs for a small percentage of the population.

Finally, another less important element that is in common between the two case studies is the design and look of the car (60% in Milan, 60% in Turin and 58% in Flanders). Therefore, people do not expect a shared car to have the latest and most beautiful look, which is to some extent the case for private cars.

4.6 Insights on the optimal mix of car sharing variants to maximise person-level benefits

Results from this chapter have extensively shown that different forms of car sharing have different impacts in terms of car ownership levels, use of different travel means and mobility habits in general. One of the key objectives of the STARS project is to understand how such forms can be jointly exploited to maximise the positive benefits of car sharing systems in urban areas. Based on the results presented so far, the following pages try to give some indications on this point.

4.6.1 Reducing car ownership levels

According to the Frankfurt case study results, free-floating services might be linked to a reduction of car ownership levels of its subscribers of up to 5% (Figure 4, section 4.2.2 and Figure 7, section 4.2.3). Such figures are somewhat lower than older results from other countries that were reported in STARS Deliverable 4.1 (Figure 13), since early adopters probably made mobility choices which are farther away than the average population. Coming back to Frankfurt, assuming that there are about 50,000 subscribers of free-floating services in the city out of 625,000 inhabitants aged 18 or more[45] (e.g. 1 out of 12.5 adults), this would mean an overall aggregate impact of free-floating services on the car stock of the city of about 0.4%. On the contrary, there is a dramatic reduction of car ownership for roundtrip subscribers (up to 65%), of which a large proportion (about 52%) was explicitly stated being connected with the availability of a roundtrip car sharing system (Figure 4, section 4.2.2 and Figure 7, section 4.2.3). However, only about 3,700 people are actual roundtrip car sharing subscribers in Frankfurt (e.g. 1 out of 169 adults); therefore, the aggregate impact on the car stock of the city is barely more than 0.3%. The customer-numbers are just a very rough estimate, but the trade-off between the two services (impact per customer versus market penetration) is rather clear.

Results from the city of Brussels are quite different concerning free-floating members, however as mentioned above we relied on data gathered outside the consortium so it is hard to find an explanation. The effect of mainly roundtrip services in Flanders is again roughly halving car ownership. Concerning the Italian case study, we only have free-floating services that are much more diffused in the population, since in Milan one out of three dweller aged 18 or more is a subscriber. At the same time, there was a growth rather than a reduction in car ownership of about 2% from one

[45] https://www.citypopulation.de/en/germany/hessen/hessen/06412000__frankfurt_am_main/

year before subscribing the service to the time of the survey, against a 4% increase of the control group over a comparable time period. It can therefore be said that the net effect is a reduction of 2% in car ownership rates due to car sharing. At the aggregate level, this comes to a limitation of the overall increase of car ownership of a little more than 0.6%. Free-floating services in Milan are less effective in reducing car ownership than free-floating services in Frankfurt, but this could be counterbalanced by a larger impact in terms of market penetration.

The above quantitative results are rough estimates, whose approximation error is probably of the same order of magnitude of these small percentages. As already mentioned, survey respondents tend to use car sharing more than the average, and it is possible that the impact on car ownership is overestimated as well. If such overestimation is affecting in a different way the customers of different forms of car sharing, then the results of the comparison would be biased. However, it seems unquestionable that there is a clear trade-off between the market penetration of a service and its impact in terms of car ownership changes for its customers, such that the aggregate impacts at the level of the overall urban area could be of the same order of magnitude. It is worth mentioning that these results have been obtained both with a longitudinal analysis of car ownership changes when subscribing a service and with a comparison of users versus a control group made by a matched sample of non-users with the same socioeconomic characteristics. In that way, our results are hopefully more reliable than the more naïve approaches based on the direct comparison of users versus non-users, prone to sample selectivity biases.

Given the above framework, the key question for policy-makers is to understand which can be the "optimal mix" in the supply of different systems in order to maximise their benefits in terms of car ownership reduction. Clearly, the ideal situation would be a complete complementarity of the different car sharing schemes, which would happen if these are more appealing to quite different market segments both in terms of individuals and of mobility patterns and therefore there is no competition among them. In such a case, the above estimated aggregated impacts would sum up and the policy indication would be to promote both as much as possible, keeping in mind that a massive number of customers needs to be reached for free-floating to have an appreciable effect, whereas more targeted and "in-depth" actions are appropriate for station-based services, since they can radically change the mobility styles of their customers. On the contrary, in case of substitution and competition across different forms of car sharing, in order to define the most effective policy it would become critical on the one hand to have more precise estimations of the above aggregate impacts, on the other to assess the market increase potential of both services in the urban area under analysis, in terms of number of customers (this analysis in terms of modal shares will later be shown for the Italian case study).

Experimental activities within the STARS project have collected a great deal of empirical evidence that seems indeed to point to a complementary role of different car sharing variants. The analysis of combined car sharing services carried out in Frankfurt shows that their impacts on car ownership are similar to those of station-based services, yet they are more successful in terms of number of customers (although not as much as free-floating services). Additionally, the socioeconomic profiles of users of different services somewhat differ. Albeit it was mentioned that surveying modalities in the Frankfurt case study for customers of different services are making hard to do comparisons, we can rely on STARS Deliverable 4.1 (§1.3.5, §5.4.2) where the socioeconomic profiles of different users had already been extensively analysed in different cities across Europe. There are higher proportions of males and well-off individuals among free-floating customers, which are also two typical characteristics of heavy private car users, while roundtrip based services have older users. Students are another and distinct segment typically using free-floating services.

To sum up, empirical evidence seems to point to a complementary role of different car sharing forms, where the contribution of each kind of service is relatively small but noticeable in reducing car ownership at the aggregate level and probably such contributions are of the same order of magnitude and additive. Thus, a varied offer of car sharing services rather than focusing on just one is probably the best way to maximise impacts on car ownership.

4.6.2 Reducing the use of cars

Beyond car ownership reduction which rests the key objective when promoting car sharing, results from the different case studies can also offer insights on how car sharing can have a positive impact in decreasing the frequency of use of private cars. The logical steps are the same as above and results seem consistent with previous findings.

The Frankfurt case study shows a drastic reduction in the frequency of use of private cars among roundtrip and combined car sharing customers, compared to free-floating ones (1.2 versus 11 days per month according to Figure 19), only marginally eroded by the more frequent use of car sharing by roundtrip customers (1.2 versus 0.8 days per month according to Figure 23). Repeating the analysis of the previous subsection, roughly speaking, the observed order of magnitude of difference in the frequency of use of cars between the two systems should be counterbalanced by the order of magnitude in market penetration levels.

The Italian case study is offering additional insights, given the availability of modal frequency data of both a control group and of longitudinal observations (increase or decrease in the use of cars after joining a car sharing service). On the positive side, car driving frequency of car sharing subscribers in Milan is almost half than that of the control group and car sharing subscribers are more frequently passengers in private cars after starting to use the service (ride sharing beyond car sharing); on the

other hand, the number of car sharing subscribers having decreased the driving frequency of their cars is almost equal to the number of those who acted on the opposite.

A different result was found for Turin, with no statistically significant difference between car sharing subscribers and control group in the frequency of driving but with a reported reduction of car driving after joining to car sharing, while the frequency of being passenger in a car did not change.

As already noted, this is probably due to the different role played by both car and public transport in the two cities in satisfying the mobility needs of individuals. Public transport performances are better in Milan (e.g. a larger underground network) and restrictions to private cars stronger (congestion charge area in the centre). As a result, private car trips might be substituted by car sharing trips more often in Turin, but both users and non-users have a comparable level of use of cars. On the other hand, car sharing subscribers in Milan already minimised the use of cars compared to the control group and therefore they did not reduce any further their car use after joining a car sharing service.

The recommendation stemming from the previous subheading on the complementarity of different services to design the optimal mix of services can therefore be completed by pointing at the synergic role between car sharing and public transport in reducing the use of private cars, which was on the other hand the first point of the STARS policy brief developed in D 7.4.

5 Trip level analysis: mobility scenarios in Turin and Milan

5.1 Definition of mobility scenarios to assess the car sharing potential

As discussed in section 2.1.3, impacts of car sharing will be studied at the individual trip level through the definition of a set of mobility scenarios for the Italian case study, where a representative set of trips was available in the dataset. This set of scenarios was presented in section 3.3.1, where the methodological steps that were taken to come to the later presented results are spelt out.

5.1.1 Business as usual scenario

The Business as Usual (BAU) scenario represents the actual market equilibrium among different travel means. The resulting modal split for the city of Milan and Turin is reported in the below Table 26 and Table 27, respectively.

Travel mode	Current daily trips (%)	
Walk	245941	(11.5%)
Bike	109179	(5.1%)
Car	974248	(45.6%)
Car sharing	17094	(0.7%)
PT	790935	(37.0%)
TOT	**2137397**	**(100.0%)**

Table 26: Modal split of the BAU scenario in Milan

Travel mode	Current daily trips (%)	
Walk	192856	(15.1%)
Bike	27735	(2.2%)
Car	684452	(53.7%)
Car sharing	4500	(0.4%)
PT	364532	(28.6%)
TOT	**1274075**	**(100.0%)**

Table 27: Modal split of the BAU scenario in Turin

5.1.2 All switch scenario

The all switch scenario maximises the travel demand served by car sharing. The diverted daily trips from different travel means of the current scenario to car sharing and the resulting all switch scenario modal split of the city of Milan are reported in the below Table 28.

Travel mode	Diverted trips to CS	(%)	Daily trips in the "all switch" scenario (%)	
Walk	9485	(5.2%)	236456	(11.1%)
Bike	8202	(4.5%)	100977	(4.7%)
Car	89595	(48.7%)	884653	(41.4%)
Car sharing	-	-	201205	(9.4%)
PT	76829	(41.7%)	714106	(33.4%)
TOT	**184111**	**(100.0%)**	**2137397**	**(100.0%)**

Table 28: Potential trips switching to car sharing and modal split of the "All switch" scenario - Milan

Observing the switch percentages from different travel modes towards car sharing, trips performed with private cars have the highest value (48.7%), followed by public transport trips (41.7%), walk (5.2%) and bike trips (4.5%). These results confirm that trips carried out within an urban area by both car and public transport, have characteristics that can be met by car sharing services. On the contrary, switches from non-motorised modes are lower, since probably trips characteristics such as distance, time and cost, are different (see Figure 36 and Figure 37 in Appendix 5). It is worth recalling that these predictions are obtained from a model calibrated on data coming from the city of Turin, therefore spatial transferability issues of models might affect the outcomes of the Milan case study. (Ortúzar & Willumsen, 2011).

Results coming out from the application of switch models show that, globally, car sharing has the potential to attract 184111 additional trips out of 2137397, which represent the 8.6% of the current daily travel demand estimated from Milan respondents. Considering that, on average, 17094 daily trips in 2018 were performed with shared cars in Milan, the car sharing demand predicted through the application of switch models is 10 times higher in terms of trips and sums up to 201205 trips.

The same approach was used for the data collected in the city of Turin. Results of the application of switch models on the Turin car sharing non-members trips are reported in Table 29.

Travel mode	Diverted trips to CS (%)		Daily trips in the "all switch" scenario (%)	
Walk	11266	(9.7%)	181590	(14.3%)
Bike	2157	(1.9%)	25578	(2.0%)
Car	69442	(59.6%)	615010	(48.3%)
Car sharing	-	-	120924	(9.5%)
PT	33559	(28.8%)	330973	(26.0%)
TOT	**116424**	**(100.0%)**	**1274075**	**(100.0%)**

Table 29: Potential trips switching to car sharing and modal split of the "All switch" scenario – Turin

Similarly to the findings in Milan, car and public transport trips have higher percentages (59.6% and 28.8% respectively) of switch to car sharing compared to non-motorised modes. In this case the number of private car trips diverted to car sharing is higher compared to the public transport one (it is more than two times the number of trips switching from PT), and very high compared to the other modes.

Comparing the number of the all switch scenario with those of the current scenario described in 5.1.1, the car sharing potential growth in Turin is even more relevant than in Milan (almost 26 times the number of current trips). However the percentage of car sharing trips in the modal split is similar to the one predicted for Milan.

The all switch scenario thus represents the ideal scenario under the current conditions for car sharing operators, because it maximises the switching trips from all transport modes and consequently the usage of the fleet (hopefully increasing the turnover rate of each car) and the profitability of car sharing organisations; on the other hand, this strong increase might be challenging for the operators in terms of fleet management.

Although the all switch scenario might represent the best case for car sharing business, it might not represent the scenario where the car sharing would maximise the overall benefits for transport systems. Comparing the current situation with the all switch scenario in both cities (Table 26 with Table 28 for Milan and Table 27 with Table 29 for Turin), even if most of the potential car sharing daily trips switched from private cars, there are also many diverted trips from non-motorised modes and public transport. As a consequence, all switch scenario might not represent the best situation overall in terms of CO_2 and pollutants emissions (and therefore their monetisation), especially considering how emissions have been evaluated in this study (see par. 3.4.1).

5.1.3 Rupture scenario

The rupture scenario seeks the maximisation of the benefits of car sharing in terms of reduction of the external costs due to the emissions of pollutants and greenhouse gases of the transport sector. For the sake of brevity, only the rupture scenario situation in terms of diverted daily trips to car sharing and the modal split is reported in this paragraph. The cost matrices that allowed to identify the rupture scenario are reported in Appendix 10.

The daily trips modal split of the city of Milan resulting from the rupture scenario, which would occur in case of an increase of both car sharing price and parking cost by 5% and 100% respectively, is reported in Table 30.

Travel mode	Diverted trips to CS	(%)	Daily trips in the "Rupture" scenario	(%)
Walk	8321	(4.5%)	237620	(11.1%)
Bike	7735	(4.2%)	101444	(4.7%)
Car	97474	(52.7%)	876774	(41.0%)
Car sharing	-	-	202150	(9.5%)
PT	71526	(38.7%)	719409	(33.7%)
TOT	**185056**	**(100.0%)**	**2137397**	**(100.0%)**

Table 30: Potential trips switching to car sharing and modal split of the "Rupture" scenario - Milan

The total number of trips diverted to car sharing is slightly higher compared to the all switch scenario: despite switches from walk, bike and public transport are lower in the rupture scenario, trips diverted from private cars rose from 48.7% to 52.7% of the total.

The daily trips modal split of the city of Turin resulting from the rupture scenario, which would occur in case of an increase of parking cost by 100% and no change in car sharing cost, is reported in Table 31.

Travel mode	Diverted trips to CS	(%)	Daily trips in the "Rupture" scenario	(%)
Walk	11266	(9.5%)	181590	(14.3%)
Bike	2157	(1.8%)	25578	(2.0%)
Car	71048	(60.2%)	613404	(48.1%)
Car sharing	-	-	122530	(9.6%)
PT	33559	(28.4%)	330973	(26.0%)
TOT	**118030**	**(100.0%)**	**1274075**	**(100.0%)**

Table 31: Potential trips switching to car sharing and modal split of the "Rupture" scenario - Turin

Since car sharing price for the customer is now unchanged, the total number of daily trips switching towards car sharing is higher than the one forecasted in the all switch scenario (see Table 29). In this case the maximisation of the benefits (costs minimisation) is only due to increased number of diverted private car trips, which are more pollutant (so more costly) than car sharing fleets (see Table 8 and Table 9 in par.3.4.1).

The impacts deriving from the rupture scenario and their comparison with the business as usual scenario (GAP analysis) will be presented in the following chapter 6.

5.1.4 All electric scenario

The "all electric" scenario presents the same modal shares of the rupture scenario presented in the previous section, but assuming that a fully electrified fleets is used. As a result, the same modal splits presented in the previous section would be reached and they are therefore not reported here.

5.1.5 No car sharing scenario

The "no car sharing" scenario studies how the travel demand that is currently served by car sharing services would redistribute, if car sharing ceased its operations. Its quantification is based on a specific question that was asked to car sharing users. The results are reported for the city of Milan and Turin in Table 32 and Table 33 respectively.

If car sharing had not been available…	Strongly disagree (1-2)	Neutral (3)	Strongly agree (4-5)
I would have not performed that trip	276 (58.5%)	79 (16.7%)	117 (24.8%)
I would have used a different travel mode	88 (18.6%)	86 (18.2%)	298 (63.1%)
I would have changed my travel schedule	253 (53.6%)	95 (20.1%)	124 (26.3%)
I would have changed trip destination	302 (64.0%)	79 (16.7%)	91 (19.3%)
I would have used car sharing in combination with another transport mode	208 (44.1%)	135 (28.6%)	129 (27.3%)

Table 32: Alternatives to car sharing for the last trip - Milan (n = 472)

If car sharing had not been available…	Strongly disagree (1-2)	Neutral (3)	Strongly agree (4-5)
I would have not performed that trip	112 (64.4%)	31 (17.8%)	31 (17.8%)
I would have used a different travel mode	17 (9.8%)	29 (16.7%)	128 (73.6%)
I would have changed my travel schedule	85 (48.9%)	35 (20.1%)	54 (31.0%)
I would have changed trip destination	120 (69.0%)	30 (17.2%)	24 (13.8%)
I would have used car sharing in combination with another transport mode	87 (50.0%)	49 (28.2%)	38 (21.8%)

Table 33: Alternatives to car sharing for the last trip – Turin (n = 174)

The majority of respondents from both cities stated that if car sharing had not been available they would have used a different travel mode (the statement has the majority of positive rates). Those respondents were also asked to rate – in a scale from 1 (very unlikely) to 5 (very likely) – which travel modes they would have used instead of car sharing. Since all travel modes alternatives were evaluated, only the one with the maximum score was considered as the real alternative to CS; if more than one alternative got the same top score, the score was split among the alternatives according to the number of maximum values. In this way, a single answer was assigned to each respondent, therefore obtaining 298 answers in Milan and 128 in Turin. The percentages of switch from car sharing to the other modes thus evaluated for both cities are summarised in Table 34.

Travel mode	Observations (%)			
	Milan (n = 298)		Turin (n = 128)	
Walk	20	(6.8%)	10	(7.9%)
Bike	21	(7.2%)	12	(9.2%)
Car as a driver	64	(21.5%)	43	(33.2%)
Car as passenger	18	(5.9%)	3	(2.1%)
Taxi	36	(12.0%)	7	(5.5%)
PT	139	(46.6%	54	(42.1%)
TOT	**298**	**(100.0%)**	**128**	**(100.0%)**

Table 34: Declared alternative modes to substitute the absence of car sharing for the recorded trip – Italian case study

Although the substitution effect of car sharing trips with private car is quite high, it is interesting to observe that the majority of respondents of both cities would have used public transport if car sharing had not been available. It is, however, important to remind that in this study only single trips rather than trip-chain were analysed: the previous results indeed might be biased by the fact that the respondents are moving back from one place previously reached in some way. The travel mode used in the previous trip would influence the alternative travel means available in the investigated trip and therefore the mode choice (e.g. a respondents move from home to work by public transport, and decide to go back home with car sharing for a certain reason; in absence of car sharing that person cannot use its private car, even if she owns one, simply because that car is not available in her workplace).

In addition, when comparing the two cities, more people living in Turin would use a private car and fewer people would use public transport services than in Milan; once again this might be related to different characteristics of the transport systems in the two cities (as recalled in 3.2 and in 4.4.1) and how these differences impact on the final decision of its usage.

The difference in the use of taxi is also quite remarkable between the two cities (12% of Milan respondents would take a taxi if car sharing had not been available against 5.5% in Turin). The corresponding differences in the use of car as passenger is similar but smaller.

Appling the percentage breakdowns observed in the above Table 34 to the daily trips of the current scenario (BAU scenario described in 3.3.1) of the respective city, it was possible to derive the potential modal split in absence of car sharing. Table 35 reports the situation with no car sharing in Milan whereas Table 36 shows the projected split in Turin.

Travel mode	Diverted trips from car sharing (%)		Daily trips in the "no car sharing" scenario (%)	
Walk	1165	(6.8%)	247106	(11.6%)
Bike	1223	(7.2%)	110402	(5.2%)
Car	4677	(27.4%)	978925	(45.8%)
Taxi	2055	(12.0%)	2055	(0.1%)
PT	7974	(46.6%)	798909	(37.4%)
TOT	**17094**	**(100.0%)**	**2137397**	**(100.0%)**

Table 35: Modal split of the "No car sharing scenario" in Milan

Travel mode	Diverted trips from car sharing (%)		Daily trips in the "no car sharing" scenario (%)	
Walk	357	(7.9%)	193213	(15.2%)
Bike	413	(9.2%)	28148	(2.2%)
Car	1591	(35.3%)	686043	(53.8%)
Taxi	246	(5.5%)	246	(0.0%)
PT	1893	(42.1%)	366425	(28.8%)
TOT	**4500**	**(100.0%)**	**1274075**	(100.0%)

Table 36: Modal split of the "No car sharing scenario" in Turin

Among the other travel modes, we notice that a very small proportion of trips are assigned to taxi, whereas such mode was not present at all in the previous scenarios. This is due to the methodological difference in deriving the present "no car sharing" scenario compared to the previous ones. More in details, there were no observed trips by taxi in the SP survey that was used to calibrate the switching models that originated the previous scenarios, nor observed trips by taxi in the STARS survey (see in Figure 2). On the other hand, the third to last row of Table 34 shows that some respondents stated that they would use taxi if car sharing were not available. However we believe that such discrepancy across scenarios is negligible, since the number of trips by taxi that appears in the "no car sharing"

scenario is of the same order of magnitude than the approximation errors in our methodology. To sum up, we can disregard the contribution of taxis in meeting the travel demand in all scenarios.

5.2 Insights on the optimal mix of different car sharing variants to maximise trip-level benefits compared to the “no car sharing” scenario

Results from section 4.6 have shown that implementing a variety of car sharing services in urban areas can maximise the aggregate impacts in terms of car ownership and car use reduction, due to the complementarity of different services. Unfortunately, it is not possible to fully replicate such analysis at the trip level since, as discussed in chapter 2, the complete questionnaire that included trip-level questions was administered only to a tiny number of individuals in the Belgian case study, while very limited information on the last trip performed was available from the Frankfurt case study.

Within the latter, it is nevertheless possible to get some insights on the “no car sharing” scenario, by differentiating across car sharing forms. Table 37 below shows the results to the question “What would have you done if no car sharing had been available for this trip”. There is a markedly distinct pattern of responses related to free-floating services, where only 2.3% of trips had not been performed. A first interpretation of this finding is related to the fact that there seems not to exist a viable alternative for a sizable proportion of trips performed through roundtrip services. On the other hand, it seems that the implementation of a free-floating car sharing system is marginally contributing to an overall increase of the travel demand, which is surely a desirable effect. Roundtrip and combined car sharing forms might instead contribute to inducing travel demand, while the joint subscription of different services shows an intermediate situation among the two. Consistently with the analytical framework that is carried out in this section, such interpretation considers a short term perspective where car ownership levels are not affected by the lack of availability of car sharing. Indeed, the wording of the question assumed that car sharing was not available for this specific trip, rather than in general. If the latter evenience would occur, it is likely that very low car ownership levels that were observed by roundtrip subscribers would substantially raise in the long run, and they would behave more similarly to free-floating subscribers.

If car sharing had not been available for this trip... (Yes answers only)	Round. (n=406)	Comb. (n=308)	Free-floating (n=43)	Round. + comb. (n=91)	Round. + free-floating (n=63)	Comb. + free-floating (n=74)	Round. + comb. + free-floating (n=78)
I would have not performed that trip	80 (19.7%)	53 (17.2%)	1 (2.3%)	12 (13.2%)	4 (6.3%)	9 (12.2%)	10 (12.8%)
I would have used a different travel mode	199 (49%)	163 (52.9%)	36 (83.7%)	56 (61.5%)	46 (73.0%)	48 (64.9%)	51 (65.4%)
I would have changed my travel schedule	62 (15.3%)	56 (18.2%)	2 (4.7%)	11 (12.1%)	7 (11.1%)	10 (13.5%)	13 (16.7%)
I would have changed trip destination	20 (4.9%)	6 (1.9%)	0 (0.0%)	5 (5.5%)	1 (1.6%)	2 (2.7%)	2 (2.6%)
Other	45 (11.1%)	30 (9.7%)	4 (9.3%)	7 (7.7%)	5 (7.9%)	5 (6.8%)	2 (2.6%)

Table 37: Alternatives to car sharing for the last trip – Frankfurt

As already done in section 5.1.5, modal diversion patterns can be studied by looking at the answers to the question "Which transport mode would you have used instead?", that was posed only to those that answered "I would have used a different travel mode". Results are reported in Table 38.

	Round. (n=197)	Comb. (n=162)	Free-floating (n=36)	Round. + comb. (n=55)	Round. + free-floating (n=46)	Comb. + free-floating (n=47)	Round. + comb. + free-floating (n=49)
Walk	2 (1.0%)	1 (0.6%)	0 (0.0%)	0 (0.0%)	1 (2.2%)	2 (4.3%)	0 (0.0%)
Bike	10 (5.1%)	7 (4.3%)	3 (8.3%)	2 (3.6%)	1 (2.2%)	3 (6.4%)	4 (8.2%)
Car as a driver	19 (9.6%)	18 (11.1%)	11 (30.6%)	3 (5.5%)	2 (4.3%)	3 (6.4%)	3 (6.1%)
Car as passenger	9 (4.6%)	12 (7.4%)	0 (0.0%)	5 (9.1%)	1 (2.2%)	1 (2.1%)	3 (6.1%)
Taxi	18 (9.1%)	18 (11.1%)	11 (30.6%)	6 (10.9%)	11 (23.9%)	5 (10.6%)	8 (16.3%)
Public transport	139 (70.6%)	106 (65.4%)	11 (30.6%)	39 (70.9%)	30 (65.2%)	33 (70.2%)	31 (63.3%)

Table 38: Declared alternative modes to substitute the absence of car sharing for the recorded trip – Frankfurt, only for those that declared "I would have used a different mode" in Table 37

Here free-floating members' answers are almost equally split among car driver, taxi and public transport, whereas public transport is predominantly chosen by customers of other car sharing services. This is in line with the lower availability of private cars of the latter group. Finally, active means are clearly not competing with any form of car sharing, with the partial exception of bikes versus free-floating services.

Putting together the results of the two above tables is useful to understand the overall impact of different car sharing forms in terms of change in the number of car trips (including car sharing and private car). Car sharing can be considered to increase such number when respondents stated that they would not have made the trip under analysis if car sharing had not existed (one more new trip), or that they would have made it by public transport or through active means (one more diverted trip). On the other hand, the number of car trips can be considered unchanged whenever car sharing would have been substituted by private cars. Concerning the answers reporting a likely change in either the destination or the time of the trip, from a survey it is not possible to understand these changes had been coupled with a modal diversion as well. We can therefore define an optimistic scenario where a modal diversion would have taken place from the private car (if at all), and a pessimistic one where the substituted mode is either public transport or an active one.

The following table shows the relative frequencies of the different situations for the two above scenarios.

	Fraction of trips diverted from private cars	**Fraction of additional car trips (newly induced or diverted from public transport, bike and walk)**
	Optimistic – Pessimistic assumption	Optimistic – Pessimistic assumption
Roundtrip (n=361)	35% - 13%	64% - 87%
Combined (n=278)	40% - 17%	60% - 82%
Free-floating (n=394)	62% - 56%	38% - 44%
Comb. + Round. (n=84)	36% - 17%	63% - 82%
Round. + free-floating (n=58)	38% - 24%	62% - 76%
Comb. + free-floating (n=69)	30% - 13%	68% - 86%
Round. + comb. + free-floating (n=76)	38% - 18%	59% - 79%

Table 39: Estimation of the fractions of trips diverted from private cars and additional car trips under optimistic or pessimistic assumptions

It can be seen that free-floating contributed in increasing the number of car trips in about 38% to 44% of cases, whereas such figures increase to the 59% to 87% of cases for the other car sharing forms. This is due to the fact that the larger substitution rate of free-floating services versus environmentally benign modes, which is a negative effect, is more than counterbalanced by a much small number of induced car sharing trips.

Coming to the optimal mix of different car sharing services, it becomes apparent that from the trip-level viewpoint the design should be targeted at avoiding stimulating the demand for trips that could be avoided or diverting trips from public transport and active means. Decision-makers can more directly play a role in the latter aspect, which according to the above results becomes critical especially in the presence of free-floating services. Such remark is not therefore changing the indications coming out from the person-level analysis of section 4.6.

6 Impacts of the rupture scenario and gap analysis with the business as usual scenario

As already mentioned in the methodological section, the following impacts exclusively refer to the trip-level mobility scenarios of free-floating services for the Italian case study, thus not considering the long-term benefits e.g. in terms of parking demand due to changes in car ownership levels that are due to car sharing systems.

6.1 Impact on greenhouse emissions

Free-floating car sharing impacts on greenhouse emissions were evaluated for both rupture scenario (see Table 30 in par. 5.1.3) and business as usual scenario (Table 26 in par. 5.1.1), therefore only the difference between the two scenarios is reported in this section.

Table 40 below shows the case of the city of Milan.

Mode	Delta = Rupture – BAU scenario			
	Delta daily trips	Delta daily trip lengths [km]	Delta CO_2 emissions [t]	Delta CO_2 costs [€]
Walk	-8321	-34391	-	-
Bike	-7735	-18792	-	-
Car	-97474	-848487	-130.16	-13016
Car sharing	185056	1528587	137.04	13704
Public transport	-71526	-745580	-	-
Total	**0**	**-118663**	**+6.88**	**+688**
Variation from BAU [%]	**-**	**-0.4%**	**+0.2%**	**+0.2%**

Table 40: free-floating car sharing impact on CO_2 emission in Milan

The first column reports the transport modes, while the second and third columns report the difference between rupture and BAU scenarios in terms of daily trips and daily trips distances respectively. It is worth noting that the total number of trips is unchanged (the delta is null since switch models used to create the rupture scenario assume an overall travel demand invariance, as explained in par. 5.1) while the total trip length is not; in this case the difference is negative, meaning that more kilometres were ridden in the business as usual scenario. An explanation to this value can be done by considering trips diverted from public transport: the path connecting origin and destination might be, in many cases, longer than the one chosen when driving a shared car.

This motivation is also supported by the values reported in the fourth column, in fact the total reduction of the kilometres travelled does not correspond to a reduction of the overall CO_2 emissions. As explained in par. 3.4.1, the reduction of trips performed by public transport (and consequently their distances) does not produce positive effects in terms of CO_2 and pollutants emissions, since public transport offer is supposed invariant as well.

As anticipated, values in the fourth column show an increase in the total amount of CO_2 emissions (the total is positive), which can be quantified in about 7 tons every day. Given the approximation of the analytical methods used, it can therefore be said that no statistically significant difference was found between the two scenarios. In fact, the estimated daily CO_2 production in BAU scenario is about 3400 tons (Table 66 in Appendix 11), therefore the increase foreseen in the rupture scenario is about 0.2% (as reported in the last row of Table 40). In any case, the reduction of CO_2 emissions produced by the trip diversion from private car to car sharing is not completely eroded by the increase of CO_2 emissions produced by car sharing trips which were previously performed by walk, bike and public transport. The estimated daily cost for the society in the rupture scenario, obtained by multiplying the amount of CO_2 emissions by the respective cost coefficient (European Commission, 2019) reported in par. 3.4.2, is 688€ higher than the cost of the current scenario, or 0.2% due to the proportionality of the cost coefficient.

Similarly to what has been done for the city of Milan, the gap analysis between rupture (Table 31) and BAU (Table 27) scenarios evaluated for the city of Turin is reported in Table 41 below.

Mode	Delta = Rupture – BAU scenario			
	Delta daily trips	Delta daily trip lengths [km]	Delta CO_2 emissions [t]	Delta CO_2 costs [€]
Walk	-11266	-25758	-	-
Bike	-2157	-7789	-	-
Car	-71048	-474980	-71.77	-7177
Car sharing	118030	911251	82.08	8208
Public transport	-33559	-425982	-	-
Total	**0**	**-23259**	**10.31**	**1031**
Variation from BAU [%]	**-**	**-0.1%**	**+0.5%**	**+0.5%**

Table 41: free-floating car sharing impact on CO_2 emission in Turin

Once again the difference of daily trips in unchanged while total distances are negative, meaning that the sum of trips length was bigger in the business as usual scenario. Results in Turin, are similar to Milan: the use of car sharing predicted by switch models will increase the estimated daily amount

of CO_2 emissions, which is about 1985 tons per day in the BAU (Table 71 in Appendix 11), by an overall negligible amount of about 10 tons (+0.51% as reported in the last row of Table 41).

In both cities, the predicted increasing use of car sharing as a mobility alternative to the current transport modes would produce negligible effects in terms of CO_2 emissions. However, it is worth stressing that the rupture scenario has been defined (see par. 5.1.3) as the scenario that maximises the overall benefits of car sharing, reducing transport systems externalities and therefore the cost for the society. The externalities evaluation takes into account different kinds of emissions and their respective costs, therefore the scenario which maximises the benefits related to the reduction of a specific pollutant (or greenhouse gas) might not represent the best in the overall balance. Concerning CO_2 emissions for example, Figure 42 (which refers to the city of Milan) and Figure 54 (which refers to the city of Turin) reported in Appendix 9 show many scenarios (marked in green) where car sharing has a more positive effects in terms of reduction of greenhouse gas emissions and therefore a saving for the society. In addition, also during the evaluation of the "no car sharing" scenario (see Table 70 and Table 75 in Appendix 11) lower levels of CO_2 emissions were estimated in both cities compared to the BAU scenario. However, those scenarios were producing less positive effects in terms of emissions of other pollutants, which were globally producing an increase in the costs for society (+122€ and +10€ every day for the city of Milan and Turin, respectively).

6.2 Impact on the emissions of pollutants

The same method applied to evaluate the impact of car sharing on CO_2 emissions in the rupture scenario, in the BAU scenario and their difference (gap analysis) was used to evaluate the impacts on the emissions of the main pollutants resulting from the combustion, namely NMVOC, NO_X, NH_3 and $PM_{2.5}$ (as described in par. 3.4.1).

The case of the city of Milan is presented in the following Table 42 and Table 43.

The first three columns of both tables report the same information of Table 40 for the sake of clarity. In the four last columns of Table 42 the differences (in kilograms) in the emissions of each pollutant between the rupture and the current scenario (BAU) are reported. The four last columns of Table 43 report those differences in economic terms (€); the economic evaluation was carried out by considering the differences in emission quantities of Table 42 multiplied by the respective cost coefficients reported in par. 3.4.2. The variation of each pollutant compared to the BAU scenario is reported (in percentage) in the last row of both tables, while the absolute values of each pollutant emission and its monetisation can be retrieved in Table 68 of Appendix 11.

Mode	Delta daily trips	Delta daily trip lengths [km]	Delta NMVOC emissions [kg]	Delta NO_x emissions [kg]	Delta NH_3 emissions [kg]	Delta $PM_{2.5}$ emissions [kg]
	Delta = Rupture – BAU scenario					
Walk	-8321	-34391	-	-	-	-
Bike	-7735	-18792	-	-	-	-
Car	-97474	-848487	-184.0	-405.6	-16.9	-8.1
Car sharing	185056	1528587	63.4	69.3	14.5	2.1
Public transport	-71526	-745580	-	-	-	-
Total	**0**	**-118663**	**-120.6**	**-336.3**	**-2.4**	**-6**
Variation from BAU [%]	**-**	**-0.4%**	**-2.5%**	**-3.1%**	**-0.5%**	**-2.8%**

Table 42: Car sharing impact on pollutants emission in Milan

Mode	Delta daily trips	Delta daily trip lengths [km]	Delta NMVOC costs [€]	Delta NO_x costs [€]	Delta NH_3 costs [€]	Delta $PM_{2.5}$ costs [€]	**Total costs [€]**
	Delta = Rupture – BAU scenario						
Walk	-8321	-34391	-	-	-	-	-
Bike	-7735	-18792	-	-	-	-	-
Car	-97474	-848487	-202	-10481	-365	-1071	**-12119**
Car sharing	185056	1528587	70	1938	314	283	**2605**
Public transport	-71526	-745580	-	-	-	-	**-**
Total	**0**	**-118663**	**-132**	**-8543**	**-51**	**-788**	**-9514**
Variation from BAU [%]	**-**	**-0.4%**	**-2.5%**	**-3.1%**	**-0.5%**	**-2.8%**	**-1.4%**

Table 43: Economic evaluation of car sharing impact on pollutants emission in Milan

As already remarked, walk, bike and public transport rows are empty, since the reduction in the use of these modes (the number and the length of these trips) and the consequent theoretical reduction in terms of emissions (valid only for PT trips) cannot be quantified (see par. 3.4.1).

Differently from the above presented results about the impact of car sharing on CO_2 emissions, the rupture scenario's emissions are lower than the emissions of the BAU scenario for every pollutant taken into account in this study (the row "Total" of Table 42 has negative values only), although for a negligible amount. In fact, the variation in the quantity of each pollutant ranges between 0.4%-3.1% compared to the estimated emission of the BAU scenario. This means that the increase in the

emissions due to the increased use of shared cars (see the row related to the mode "car sharing") is less than the reduction of current emissions generated by private cars (row "car"), even considering those trips diverted to car sharing that are currently made with more sustainable modes. This is mainly due to the difference in pollutants' emissions of car sharing cars, that use more efficient engines compared to the private cars (see Table 8 and Table 9 in par. 3.4.1). The reduction in the pollutants' emissions generate a positive effect in terms of cost internalisation, thus the costs reported in the last row of Table 43 becomes savings for the city of Milan.

The car sharing rupture scenario in the city of Milan would therefore generate an increase of CO_2 emissions along with a reduction of all main pollutants, that can be evaluated in economic terms as a saving for the city of Milan of about 8827€ every day (which is obtained by summing up the savings produced by the reduction of pollutants' emissions and the cost deriving from the increase in CO_2 emissions).

The same approach was used to evaluate the gap between the rupture and the BAU scenario in the city of Turin. The difference in the pollutants' production is quantified in kilograms in Table 44, while the economic evaluation is presented in the following Table 45.

	Delta = Rupture – BAU scenario					
Mode	Delta daily trips	Delta daily trip lengths [km]	Delta NMVOC emissions [kg]	Delta NO_x emissions [kg]	Delta NH_3 emissions [kg]	Delta $PM_{2.5}$ emissions [kg]
Walk	-11266	-25758	-	-	-	-
Bike	-2157	-7789	-	-	-	-
Car	-71048	-474980	-84.3	-207.3	-8.91	-4.3
Car sharing	118030	911251	38.8	42.4	8.90	1.3
Public transport	-33559	-425982	-	-	-	-
Total	**0**	**-23259**	**-45.4**	**-164.9**	**-0.01**	**-3**
Variation from BAU [%]	**-**	**-0.1%**	**-2.1%**	**-2.8%**	**-0%**	**-2.5%**

Table 44: Car sharing impact on pollutants emission in Turin

	Delta = Rupture – BAU scenario						
Mode	Delta daily trips	Delta daily trip lengths [km]	Delta NMVOC costs [€]	Delta NO_x costs [€]	Delta NH_3 costs [€]	Delta $PM_{2.5}$ costs [€]	**Total costs [€]**
Walk	-11266	-25758	-	-	-	-	-
Bike	-2157	-7789	-	-	-	-	-
Car	-71048	-474980	-93	-5303	-192	-567	-6155
Car sharing	118030	911251	43	1114	192	168	1517
Public transport	-33559	-425982	-	-	-	-	-
Total	**0**	**-23259**	**-50**	**-4189**	**0**	**-399**	**-4638**
Variation from BAU [%]	**-**	**-0.1%**	**-2.1%**	**-2.8%**	**-0%**	**-2.5%**	**-1.3%**

Table 45: Economic evaluation of car sharing impact on pollutants emission in Turin

Similarly to what has been found in the city of Milan, in the city of Turin the emissions of every considered pollutant are lower in the rupture scenario than in the BAU scenario. Differences here are lower in absolute terms, since the estimated overall number of daily trips within the city and of those switching to car sharing is lower as well. The car sharing rupture scenario in the city of Turin would therefore generate an increase of CO_2 emissions along with a reduction of all main pollutants, which are however negligible compared to the amount currently produced (variations range between 0% and 2.8% of the BAU emissions, as showed in the last row of Table 41, Table 44 and Table 45).

Anyway, this can be evaluated in economic terms as a saving for the city of about 3607€ every day, which is obtained by summing up the savings produced by the reduction of pollutants' emissions and the cost deriving from the increase in CO_2 emissions (see also Table 73 in Appendix 11).

Finally, it is worth observing that car sharing impacts on emissions of both, greenhouse gas and air pollutants, would be even more positive if current fleets would be substituted with electric ones. Given the assumptions of the analytical methods used, electric vehicles would not produce exhaust emissions, therefore the increasing use of car sharing deriving by the switch from other modes would not correspond to an increase in the emissions (all "car sharing" rows in tables of section 6.1 and 6.2 would be null). Daily economic savings for the society deriving from the reduction of both CO_2 and air pollutants emissions associated with the use of full-electric fleets of car sharing vehicles are summarised in Table 46 below. For more information about absolute values of each pollutant and total costs, please refer to Table 69 and Table 74 in Appendix 11).

City	Scenarios	Delta CO_2 cost [€]	Delta Pollutants cost [€]	Delta total costs [€]
Milan	Rupture scenario	+688	-9514	**-8827**
	All electric rupture scenario	-13704	-12119	**-25823**
	All electric scenario variation from BAU [%]	-3.9%	-3.9%	**-3.9%**
Turin	Rupture scenario	+1031	-4638	**-3607**
	All electric rupture scenario	-7177	-6155	**-13332**
	All electric scenario variation from BAU [%]	-3.5%	-3.5%	**-3.5%**

Table 46: Daily economic savings for the cities of Milan and Turin deriving from the use of full electric car sharing fleets

As anticipated, the use of full-electric fleets will reduce the emissions of greenhouse gas and air pollutants compared to the rupture scenario; the daily savings for the city of Milan are quantified in about 26000€ while for the city of Turin in about 13000€. The savings produced by electric fleets are still neglect table compared to the overall costs deriving from current mobility scenarios (the variation is 3.9% in Milan and 3.5% in Turin).

6.3 Impact on public spaces

Changes in car ownership have the strongest impact in the use of public space, with specific reference to parking demand, and they were already evaluated for the Italian case study in par. 4.2. Here the focus is rather on a trip level analysis, in order to understand how the using car sharing rather than private cars for the set of diverted trips will impact on the spatial patterns of parking demand.

Daily parking events measurement was therefore used to quantify car sharing impacts on public spaces: the two cities were divided in zones according to the zoning presented in par. 3.4.3 in order to observe where registered parking events occurred and so where the impact is a positive, negative or neutral. Neutral impacts were not analysed in detail (so they are not presented here) since they always occur when private cars have been parked in garages, thus not producing a tangible impact on public spaces (refers to par. 3.4.3 for more information). Therefore positive and negative impacts were evaluated for each zone, by distinguishing on-street parking events and parking events in-dedicated parking slots.

Tables reporting positive and negative impacts on both on-street and on–surface dedicated parking areas are not reported here for the sake of brevity. Please refer to Appendix 12 for the full tables,

while here the same kind of information will be presented through maps elaborated using a GIS software.

The graphic representation of the zoning and of the parking events impacts of car sharing in Milan is reported in Figure 29 below. For each zone, identified through a thick red line, up to four bars are displayed: the red bars represent the negative impact on street while the green ones the positive impact on street; orange and light green bars represent negative and positive impacts on dedicated parking areas, respectively.

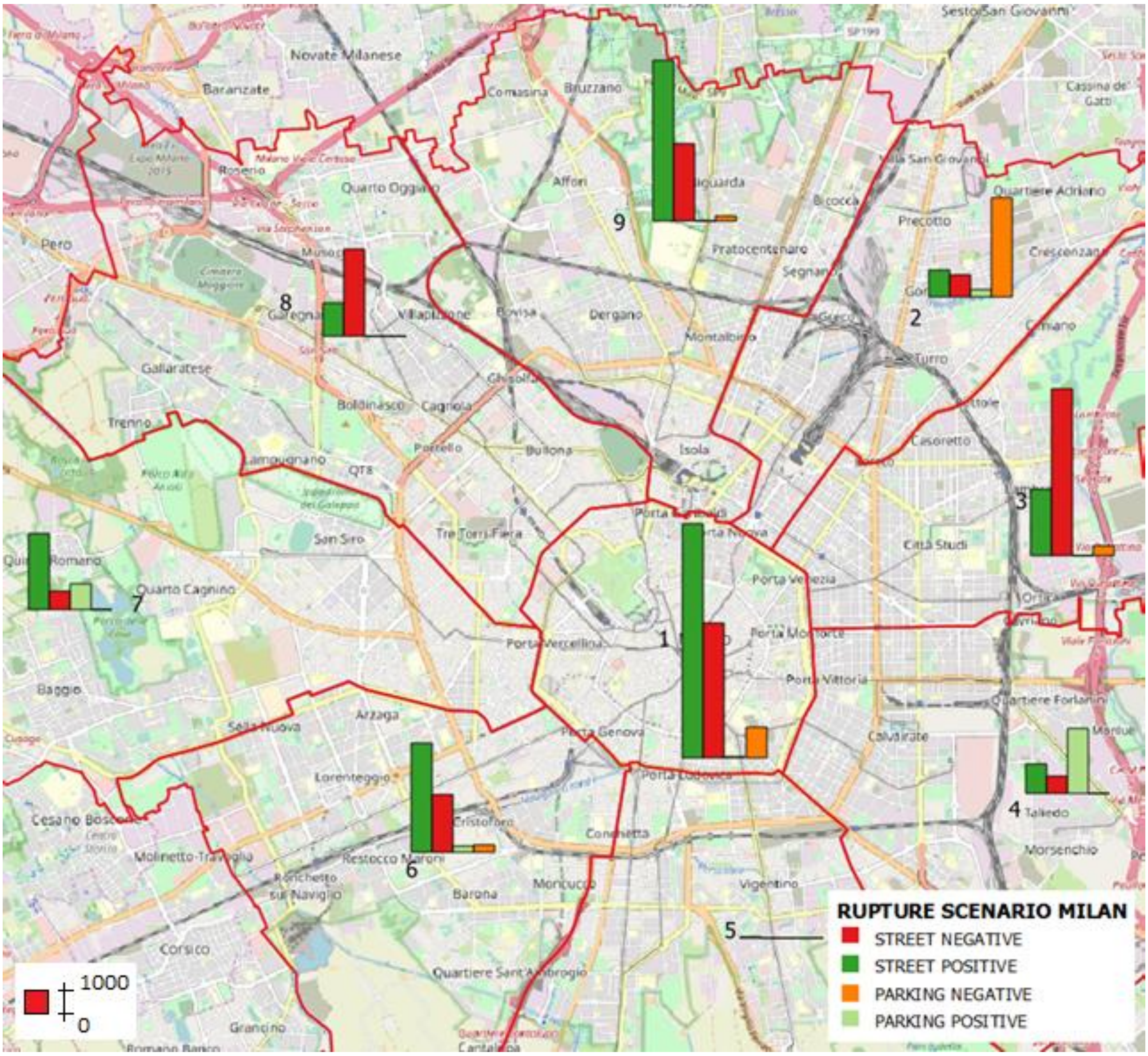

Figure 29: Daily parking events evaluation in the city of Milan (Rupture–BAU scenario)

Negative and positive impacts for both kinds of public space are separately presented in the maps before being algebraically summated, since they might have a different meaning. On the one hand, a positive impact given by one less parking event represents one less vehicle that is actively looking

for a parking spot in the area. On the other, a negative impact could represent longer occupancy times of already occupied parking spots. It is therefore clear that the two are not always compensating each other on a practical viewpoint.

Observing the central area of Figure 29 , which coincides with the Milan city centre (zone 1), it can be noted that there are positive and negative impacts of parking events on street, however the green bar is higher than the red one (so an higher absolute value). Concerning parking events in dedicated parking, only negative impacts were estimated. Therefore considering the algebraic sum of the contributes car sharing might produce a positive impact on daily central areas parking events in the rupture scenario. On the contrary, higher negative impacts on both street and dedicated parking events might be encountered in more peripheral areas, for example in zones closer to the upper right corner (zones 2, 3 and 8).

Clearly the results presented here give an initial and partial evaluation of the impacts on public spaces due on one hand to the limited number of trips recorded through the survey and, on the other hand, to the kind of trip and the type of parking used for that trip.

Beyond the above introduced maps, the difference between positive and negative impacts on daily parking events was computed according to the type of parking (on street and in dedicated parking areas). The results are summarised in the following Table 47.

Zone	Street	Parking
1	5187	-1489
2	300	-4790
3	-5194	-566
4	590	3396
5	56	42
6	2685	-46
7	2962	1372
8	-2774	-8
9	4290	-257
Total	8102	-2346

Table 47: CS impacts on daily parking events in street and in dedicated on-surface parking spaces of Milan

Information reported in Table 47 shows that some zones have a positive balance in terms of daily parking events in both street and parking areas (e.g. zone 4 and zone 7); in others the balance is negative (e.g. zone 3) or mixed (e.g. zone 1). However looking at the overall balance of the city (row

"Total") car sharing might produce a positive effect on street spaces, quantifiable in 8160 daily parking events. On the other hand, CS might produce negative effects on dedicated parking spaces, quantifiable in 2346 daily parking events. The total balance of public surfaces is still positive (8160-2346).

Similarly, the graphic representation of the zoning and of the daily parking events impacts of car sharing in Turin is reported in Figure 30 below, where each zone is delimited with a thick red line. Absolute values are reported in Table 77, Appendix 10.

It is interesting to observe that the city centre area (zone 1), where is located one of the two major railway stations of the city, car sharing might produce a positive effect on street parking events. This is related to the fact that in many of those car trips respondents reported to park in that area on the street.

In line with results obtained for the city of Milan, higher on-street negative impacts were encountered in peripheral areas, especially in the south-west area of the city (zones 2 and 3).

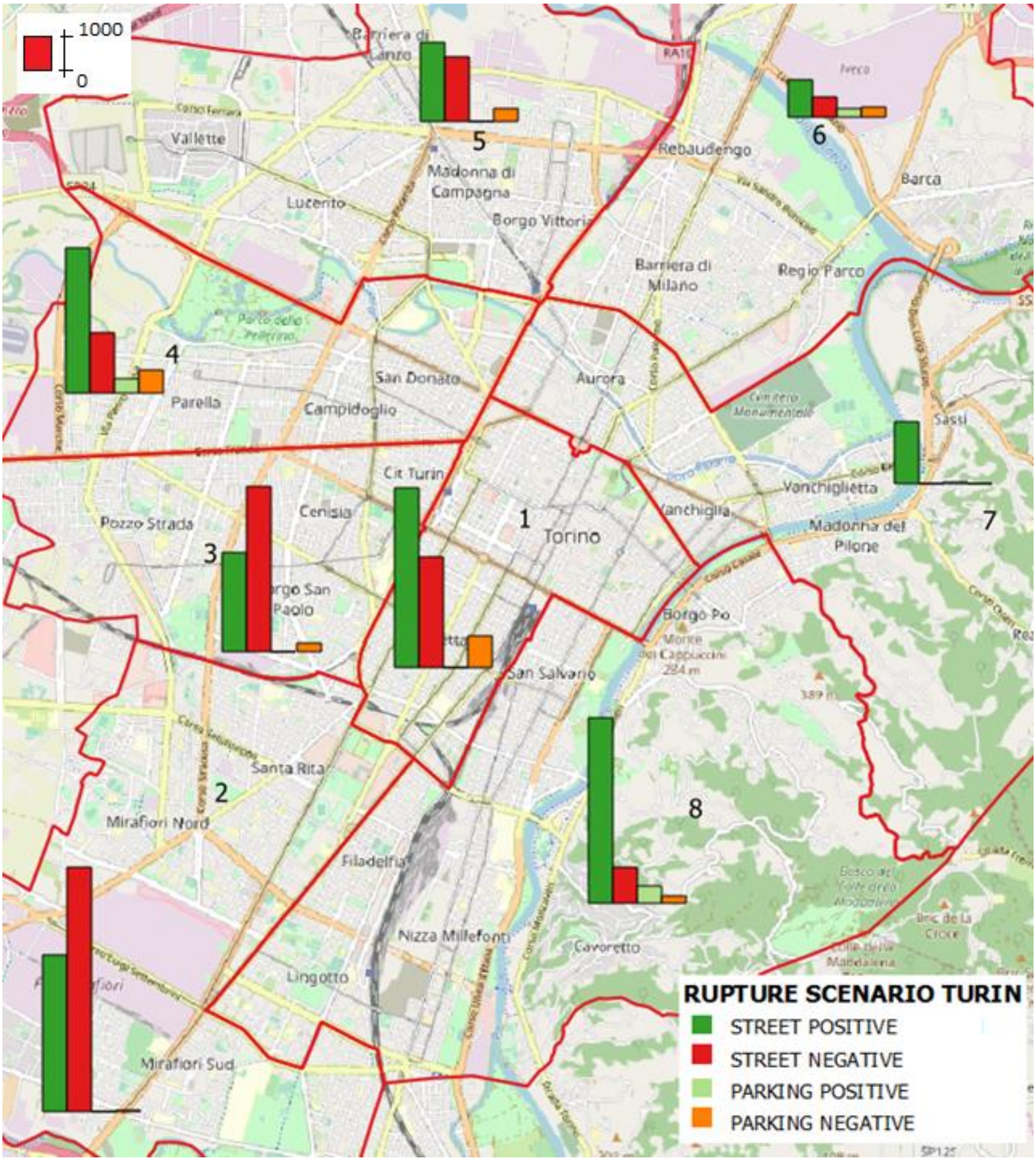

Figure 30: Parking events evaluation in the city of Turin (Rupture–BAU scenario)

Finally, information reported in Table 48 shows that in the overall balance of the city (row "Total"), car sharing might produce a positive effect on street spaces, quantifiable in 7246 daily parking events. On the other hand, CS might produce negative effects on dedicated parking spaces, quantifiable in 1679 daily parking events. The total balance of public surfaces is still positive (7246-1679).

Zone	Street	Parking
1	2058	-974
2	-2629	-52
3	-1988	-273
4	2552	-283
5	424	-403
6	483	-42
7	1888	52
8	4458	296
Total	7246	-1679

Table 48: CS impacts on parking events in streets and in dedicated on-surface parking spaces of Turin

It is worth stressing that results obtained for the two cities of the Italian case study are based only on the last trip performed by respondents, so areas with no impact might derive to the combination of few trips staring/ending there and the low switching probability towards car sharing of those trips. Therefore it is not possible to state that car sharing has no impact in those zones or that it might be used less than in other areas of the city, on the basis of the outcomes presented in this section. In other words, car sharing scenarios results are not fully reliable at the more disaggregated zonal level, whereas the more aggregated figures that were presented here can represent a useful indication for policy makers.

7 Enlarging the view beyond the STARS case studies: feedback from uptake cities

As already mentioned in section 2.4 ICLEI formed a small group of the Uptake city to collect recommendations about the project results from the city representatives interested in implementing car sharing in their cities. Two workshops were organised to communicate results and progress made in the project but also for the Uptake cities to be critical and ask questions directly to presenters. After each workshop, a questionnaire was sent to the Uptake cities representatives to collect feedback. We have collected five anonymous responses from the Uptake cities (results are reported in Appendix 3).

The feedback received was generally positive and constructive. Overall, only the satisfaction of presented information was a bit lower that the maximum score. One of the reasons could be that the first webinar was also the introduction to the project and main overview of the results available at the time of the webinar.

The same procedure was repeated after the second webinar, however the questions had been slightly different. Again, we have collected five anonymous responses (see Appendix 3).

Similarly, overall satisfaction was high, and the amount of presented information seems to be received slightly better.

To summarise the overall feedback received from the Uptake cities, this project helped them to understand what kind of mobility options are available in terms of shared economy approach. We have in general received more detailed feedback about possible implementation from advanced cities, i.e. cities that already have one or more car sharing services or have already implemented a SUMP. From cities that are not as advanced, we have received a general feedback that they have understood more about positive and negative impacts of different car sharing variants, as well as what conditions they still have to achieve in order to introduce the optimal car sharing services in their city. For example, the city of Varna stated in the final document that based on the experience from the STARS project, they are considering implementing a bike sharing scheme that might grow into car sharing scheme, providing a good feedback from the users. Moreover, in Varna they now recognise the possible implications of car sharing to overall urban mobility and they state that it must be included in the SUMP they are developing. As the need for the future, Uptake cities generally agree that specific help in further knowledge exchange and training activities would be beneficial in deciding whether to implement car sharing and what type of service to consider, according to their local specific context.

Conclusions

Person level analyses carried out on data gathered through the STARS mobility survey show that car sharing members of different European countries have some similar characteristics. Some findings are in line with previous STARS results and characteristics already reported in the literature, such as the average age of car sharing members, the higher proportion of males among customers, a higher education level compared to the general population and higher incomes.

Car sharing users are more inclined to be multimodal, usually they own public transport season tickets, use PT more frequently and are more willing to share bikes (there is a high percentage of car sharers within the Italian and the Belgian case studies having also a bike sharing membership). In addition, CS members live in household where other people are registered to a car sharing service (about 40% of respondents of both cities, while this percentage falls to 10% in non-members households), confirming the importance of subjective norms in the attitudes towards car sharing (Bergstad et al., 2018).

Outcomes from the Italian case study however showed that car sharers' travel behaviour might be related to the variety and the reliability of alternative transport options. In fact, car sharers of the two cities behave differently: in Turin the differences encountered among car sharers and the non-members' control group were not significant. Therefore we can conclude that car sharing alone is not sufficient to trigger changes in mobility behaviour, it needs to be integrated into a broad transport system that can substitute the need for a private car in several ways. City administrations need to carefully look at this aspect.

Outcomes from Belgian and Frankfurt case studies, which had a deeper look at differences among users of different forms of car sharing, showed that users of roundtrip station-based car sharing on average use public transport solutions (bus, tram, metro and train) more frequently after their subscription with car sharing. In Frankfurt users of combined services have very similar behaviour to roundtrip user group. Among free-floating car sharers, on the other hand, more respondents are using these public modes less often than before their subscription.

Interestingly the variant-specific differences, which were already identified for Frankfurt inner-city residential areas in (Bergstad et al., 2018), can also be found in the city as a whole. This might mean that dense bus and train services provided in the inner-city and the short travelled distances there are not as decisive as expected.

Concerning car ownership levels, results from all case studies showed that car sharing is adopted by individuals living in households with a lower number of private cars compared to non-members and, as showed in the Italian case study, also compared to non-members with the same socioeconomic

characterisation (control group). The use of a control group, rather than the simple comparison of members versus non-members, allows us to link more directly the low car ownership level with the car sharing membership.

Nevertheless, differences in car ownership were encountered when considering users registered for different car sharing variants. In the Brussels Capital Region, roundtrip station-based car sharing users own five times fewer cars than free-floating ones. Together with the results of the Frankfurt case study and to the previous STARS Deliverable 4.2 (Nehrke et al., 2018), this findings suggest that users of free-floating car sharing do not necessarily see the service as a replacement for their own car, but rather as a supplement.

Asking a longitudinal question about car ownership (car ownership levels in three different time points) allowed the STARS consortium to understand when changing in car ownership occurred (if any): in both Belgian and Frankfurt case studies the number of owned cars dropped some months before car sharing users subscribe to a service. It is not possible to conclude that the car sharing membership is the unique trigger to scrap a private car, or the enrolment to a car sharing service is a consequence of an occasional need of a car. However, even if car sharing is not the leading cause of car ownership reduction, it is undoubtedly one of the solutions making possible to live with fewer cars for citizens.

Differently from the other case studies, in Italy, where free-floating services represent over 90% of the car sharing market, car sharing members interviewed did not decrease the number of owned cars after subscribing to the service but slightly increase it. It is however important to frame it in the car ownership trends of the whole population and to observe that the growth rate of cars owned by car sharing members is smaller than that of non-members. A positive impact on car ownership level was therefore registered also in this case study. Thus, car sharing might have a higher impact on postponing the purchase of additional cars. This assumption is also supported by the hypothetical control question "how many cars would be in your household if there were no car sharing", that revealed the prevention in the purchase of new cars to a considerable extent.

Even if in many analyses carried out in this document, free-floating car sharing has fewer positive social impacts for each subscriber than other forms of car sharing, it is very important to remark that free-floating services on the other hand attract much wider and new target groups compared to station-based and peer-to-peer car sharing services, the latter being still a niche phenomenon. Free-floating organisations also bring a slightly different offer of car sharing to cities, which is tailored for other types of journeys (e.g. one-way trips) and therefore not in competition with roundtrip services. Since the number of people using shared cars is still quite small, free-floating operators can be an

important way to enlarge the emerging market of shared mobility more rapidly. In this perspective, free-floating car sharing can be considered as a possible entry point to the car sharing world.

In addition, we showed that there is a clear trade-off between the market penetration of a service and its impacts, especially in terms of car ownership changes for its customers. Thus, the aggregate impacts of free floating at the level of the overall urban area could be of the same order of magnitude of more effective car sharing services, which are more positively impacting but on a very small segment of the city population.

In order to maximise positive impacts (i.e. lower private car ownership and higher use of bicycle and public transport), the Frankfurt case study and the German case study reported in STARS Deliverable 4.1 (Bergstad et al., 2018) showed that members of combined car sharing systems and people using both station-based and free-floating systems have a far better impact on car ownership and in their mobility behaviours than respondents who only use a free-floating service. Thus, free-floating car sharing users should be seduced to broaden their view and start using station-based services after that they become familiar with the concept. Gradually this should impact their mobility habits in a positive way. In order to achieve this goal, policy-makers can ask free-floating car sharing operators either to diversify their offer and integrate station-based cars into their existing services or to cooperate with station-based or peer-to-peer operators.

The trip level analysis carried out on data gathered in Italy (where extensive information about the last trip performed by respondents was collected) allowed to determine the maximum potential travel demand that can be attracted by free-floating car sharing. According to the models' results, the potential car sharing demand might increase from about 1% of the daily travel demand currently served in Milan and Turin, up to about 10% estimated in the rupture scenario.

The rupture scenario, defined as the scenario that will maximise the car sharing benefits for both the industrial and the transport sectors, will increase the portion of travel demand satisfied by car sharing based on both socioeconomic and trip characteristics of the current non-users. On one hand, this would produce the increase of car sharing operators’ revenues and therefore benefits for the industrial sector. On the other hand, the rupture scenario would lead to a reduction of greenhouse gas and air pollution produced by the transport sector in the cities. This reduction implies therefore a benefit in terms of transport costs for society. However, it is worth stressing that these reductions are quite small compared to the quantities of emissions currently produced, clearly due to the phenomenon scale (even with the predicted growth, car sharing always remain a niche market) and to the fact that free-floating car sharing would attract trips also from public transport and active modes. The reduction in emissions is almost always below 3% for the considered pollutants, which

corresponds to a saving of 1.4-1.6% in terms of related social costs. In case of fully electric car sharing fleets, the latter saving could reach 3.5%.

Finally, this study gives a preliminary evaluations of the impacts on parking events occurring in dedicated parking spaces and along the city streets. The method used allowed to distinguish dedicated parking areas from on-street parking, showing for the latter positive impacts due to the switch for specific trips to car sharing. It is worth stressing that impacts evaluated are not directly quantifiable in parking lots saved, but represent a parking unit in time. In general, more positive effects were observed in central area of the city, probably due to the fact that many car trips substituted by car sharing finish there. Therefore the problem of public spaces occupation seems moved in peripheral areas, were private cars might remain parked for more time due to the car sharing usage. On the base of these results, it is hard to derive strong conclusions about the impacts on parking spaces.

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Appendix 1: Travel survey questions list

Notation guidelines

- Questions are numbered only to understand the maximum length of the survey.
- Questions with "**a"** (e.g. Q5a) are addressed to users, while questions with "**b**" (e.g. Q5b) are asked to non-users.
- **START_TRIP**: the variables are indicated with this notation.
- **RED_CAUSE_B:** all variables with "**_B**" in the CAR OWNERSHIP section are referred to the situation before the car sharing subscription (only in case of user).
- **RED_CAUSE_A:** all variables with "**_A**" in the CAR OWNERSHIP section are referred to the situation after the car sharing subscription (only in case of user).
- **1:** variable codes are indicated with this notation.

CAR SHARING AND TRAVEL BEHAVIOUR

In this section information about car sharing subscription and usage frequency of different transport means will be asked.

Q1 **CS_USER** Are you currently a member of a car sharing service?

- **1** = Yes
- **0** = No

IF CS_USER = 1

Q2a **CITY** In which of the following two cities do you use car sharing more often?

Dropdown menu

1 = Milan

2 = Turin

Q3a **MEMBER** Which car sharing operator are you a member? When did you subscribe? If you are registered to more than one service, please report them in chronological order from the least recent to the most recent.

1. **SERV_CS1** Dropdown menu (CS services available) **YR_CS1** (Years: 2001 -> 2019);
2. **SERV_CS2** Open answer **YR_CS2** Year;
3. **SERV_CS3** Open answer **YR_CS3** Year;
4. **SERV_CS4** Open answer **YR_CS4** Year;
5. **SERV_CS5** Open answer **YR_CS5** Year;

Q4a **CS_ACTIVE_USER** Have you used car sharing at least once?

1 = Yes
0 = No

ELSE IF CS_USER = 0

Q2b **POT_CS_USER** To what extent are you likely to become a member of a car sharing service?

1 (Extremely unlikely) - **5** (Extremely likely)

END IF

Q5 **SEASON_TICKET_PT** Do you own a season ticket for public transport in the town where you live?

1 = Yes
0 = No

Q6 **SEASON_TICKET_BS** Are you registered to a bike sharing service?

a. **1** = Yes
b. **0** = No

Q7 **MODEFREQU / MODEFREQNU** How often did you use the following travel modes in the last month? Possible answers: **6** = Daily, **5** = 4-6 days/week, **4** = 1-3 times/week, **3** = few times a month, **2** = More seldom, **1** = Never.

- **FREQ_BIKE** Bicycle
- **FREQ_BS** Bike sharing
- **FREQ_CAR_D** Car as driver
- IF CS_USER = 1 **FREQ_CS** Car sharing as driver
- **FREQ_CAR_P** Car as passenger
- **FREQ_TAXI** Taxi
- **FREQ_BUS** Urban and suburban bus, tram
- **FREQ_METRO** Metro
- **FREQ_TRAIN** Train
- **FREQ_WALK** Walking

IF CS_USER = 1

Q8a **MODEFREQUBEF** Considering the following travel modes did you use them more often, equally often or less often in the past, before starting to use car sharing? Possible answers: **1** = more often than today, **2** = as often as today, **3** = less often than today, **4** = not used before

- **BEF_BIKE** Bicycle
- **BEF_BS** Bike sharing

- **BEF_CAR_D** Car as driver
- **BEF_CAR_P** Car as passenger
- **BEF_TAXI** Taxi
- **BEF_BUS** Urban and suburban bus, tram
- **BEF_METRO** Metro
- **BEF_TRAIN** Train
- **BEF_WALK** Walking

Q9a **FREQCSSEASON** IF FREQ_CS <> 1 How often did you use car sharing in each period of the last 12 months? Possible answers: **6** = Daily, **5** = 4-6 days/week, **4** = 1-3 times/week, **3** = few times a month, **2** = More seldom, **1** = Never.

- **SPRING** March 2018 – May 2018
- **SUMMER** June 2018 – August 2018
- **AUTUMN** September 2018 – November 2018
- **WINTER** December 2018 – February 2019

END IF

TRIP INFORMATION

IF CS_USER = 1 **AND** CS_ACTIVE_USER=1

In this section information about the last trip performed using car sharing as a driver will be asked. Additionally we will ask you which alternative transport mode you would have used if car sharing had not been available.

Please now focus on the last trip performed driving a car sharing vehicle.

Q10a IF the interviewed is a member of more than one car sharing service **SERV_USED** Which car sharing service did you use? **Dropdown menu** (List of the services operating within the city)

Otherwise **SERV_USED** = **SERV_CS1**

Q11a **DAY_U** In which day of the week did you perform the trip?

a. **1** = Monday;
b. **2** = Tuesday;
c. **3** = Wednesday;
d. **4** = Thursday;
e. **5** = Friday;
f. **6** = Saturday;
g. **7** = Sunday;

Q12a **START_TRIP_U** What time did you leave? **hh:mm**

Q13a **ORIGIN_U** Where did you start from? Please write the **specific address/coordinates on a map**.

Q14a **PURP_O_U** Why were you there?

a. **1** = Home (house where you usually live);
b. **2** = Work (in the usual place of work where you work);
c. **3** = Education (school or university where you study);
d. **4** = Business (work not in the usual place e.g. in a client's office, for a meeting etc.);
e. **5** = Personal business (e.g. hairdressers, launderettes, dry-cleaners, betting shops, solicitors, banks, estate agents, libraries, churches; or for medical consultations or treatment);
f. **6** = Taking away or picking up people (for example, taking a child to school);
g. **7 =** Grocery shopping;
h. **8** =Visiting a shopping centre
i. **9** = Eating and/or drinking (unless the main purpose was to meet friends/relatives);
j. **10 =** Visiting friends, relatives (both at someone's home or at a pub, restaurant, etc.;
k. **11 =** Taking a stroll in the city centre
l. **12** = Taking an excursion in nice weather or holidays;
m. **13** = Other discretionary and recreational activities (all types of entertainment or sport, clubs, and voluntary work, non-vocational evening classes, political meetings, etc.).

Q15a **DEST_U** Where did you go? Please write the **specific address/coordinates on a map** .

Q16a **PURP_ D_U** Why did you go there?

a. **1** = Home (house where you usually live);
b. **2** = Work (in the usual place of work where you work);
c. **3** = Education (school or university where you study);
d. **4** = Business (work not in the usual place e.g. in a client's office, for a meeting etc.);
e. **5** = Personal business (e.g. hairdressers, launderettes, dry-cleaners, betting shops, solicitors, banks, estate agents, libraries, churches; or for medical consultations or treatment);
f. **6** = Taking away or picking up people (for example, taking a child to school);
g. **7 =** Grocery shopping;
h. **8** =Visiting a shopping centre
i. **9** = Eating and/or drinking (unless the main purpose was to meet friends/relatives);

j. **10 =** Visiting friends, relatives (both at someone's home or at a pub, restaurant, etc.;
k. **11 =** Taking a stroll in the city centre
l. **12** = Taking an excursion in nice weather or holidays;
m. **13** = Other discretionary and recreational activities (all types of entertainment or sport, clubs, and voluntary work, non-vocational evening classes, political meetings, etc.).

Q17a **END_TRIP_U** What time did you arrive? **hh:mm**

Q18a **ALT_TRIPS_U** To what extent do you agree with the following statement?

1 (Strongly disagree) - **5** (Strongly agree)

If car sharing had not been available for that trip…

- **ALT_TRIP1** I would have not performed that trip;
- **ALT_TRIP2** I would have used a different travel mode;
- **ALT_TRIP3** I would have changed my travel schedule;
- **ALT_TRIP4** I would have changed trip destination;
- **ALT_TRIP5** I would have used car sharing in combination with another mode.

IF ALT_TRIP2 = 3 **OR** 4 OR 5

Q19a **ALT_MODE_U** Which of the following travel mode(s) would you have used if car sharing had not been available?

1 (Very unlikely) - **5** (very likely)

a. **WALK** Walking
b. **BIKE** Bicycle;
c. **BS** Bike sharing;
d. **CAR_D** Car as driver;
e. **CAR_P** Car as passenger;
f. **TAXI** Taxi;
g. **BUS** Urban or suburban bus, tram;
h. **METRO** Metro;
i. **TRAIN** Train.

END IF

IF ALT_TRIP4 = 3 **OR** 4 OR 5

Q20a **ALT_DEST_U** You declared that if car sharing had not been available you would have changed trip destination. Would the new trip destination has been closer or farther compared to the current trip destination?

- **1** = Closer;

- **2** = Farther;
- **3** = More or less at the same distance.

END IF

IF ALT_TRIP5 = 3 **OR** 4 **OR** 5

Q21a **ALT_MODE_U2** Which of the following travel mode(s) would you have used in combination with car sharing if car sharing had not been available at the origin/destination of your trip?

1 (Very unlikely) - **5** (very likely)

a. **WALK** Walking
b. **BIKE** Bicycle;
c. **BS** Bike sharing;
d. **BUS** Urban or suburban bus, tram;
e. **METRO** Metro;
f. **TRAIN** Train.

END IF

IF CS_USER = 0 **OR** (CS_USER=1 **AND** CS_ACTIVE_USER=0)

In this section information about the last trip performed within your city using car (as driver or as passenger), public transport, bike or walking will be asked. Additionally, we will ask you which alternative transport mode you would have used if the selected transport mode had not been available. Now please focus on your last trip.

Q8b **MODE_USED** Which travel mode did you use most of the time?

a. **WALK** Walking
b. **BIKE** Bicycle;
c. **BS** Bike sharing;
d. **CAR_D** Car as driver;
e. **CAR_P** Car as passenger;
f. **TAXI** Taxi;
g. **BUS** Urban or suburban bus, tram;
h. **METRO** Metro;
i. **TRAIN** Train.

Q9b **DAY_NU** In which day of the week did you perform the trip?

a. **1** = Monday;
b. **2** = Tuesday;
c. **3** = Wednesday;
d. **4** = Thursday;
e. **5** = Friday;
f. **6** = Saturday;
g. **7** = Sunday;

Q10b **START_TRIP_NU** What time did you leave? **hh:mm**

Q11b **ORIGIN_NU** Where did you start from? Please write the **specific address/coordinates on a map**.

Q12b **PURP_O_NU** Why were you there?

a. **1** = Home (house where you usually live);
b. **2** = Work (in the usual place of work where you work);
c. **3** = Education (school or university where you study);
d. **4** = Business (work not in the usual place e.g. in a client's office, for a meeting etc.);
e. **5** = Personal business (e.g. hairdressers, launderettes, dry-cleaners, betting shops, solicitors, banks, estate agents, libraries, churches; or for medical consultations or treatment);
f. **6** = Taking away or picking up people (for example, taking a child to school);
g. **7 =** Grocery shopping;
h. **8** =Visiting a shopping centre
i. **9** = Eating and/or drinking (unless the main purpose was to meet friends/relatives);
j. **10 =** Visiting friends, relatives (both at someone's home or at a pub, restaurant, etc.;
k. **11 =** Taking a stroll in the city centre
l. **12** = Taking an excursion in nice weather or holidays;
m. **13** = Other discretionary and recreational activities (all types of entertainment or sport, clubs, and voluntary work, non-vocational evening classes, political meetings, etc.).

Q13b **DEST_NU** Where did you go? Please write the **specific address/coordinates on a map** .

Q14b **PURP_ D_NU** Why did you go there?

a. **1** = Home (house where you usually live);
b. **2** = Work (in the usual place of work where you work);
c. **3** = Education (school or university where you study);
d. **4** = Business (work not in the usual place e.g. in a client's office, for a meeting etc.);
e. **5** = Personal business (e.g. hairdressers, launderettes, dry-cleaners, betting shops, solicitors, banks, estate agents, libraries, churches; or for medical consultations or treatment);
f. **6** = Taking away or picking up people (for example, taking a child to school);

g. **7 =** Grocery shopping;
h. **8** =Visiting a shopping centre
i. **9** = Eating and/or drinking (unless the main purpose was to meet friends/relatives);
j. **10 =** Visiting friends, relatives (both at someone's home or at a pub, restaurant, etc.;
k. **11 =** Taking a stroll in the city centre
l. **12** = Taking an excursion in nice weather or holidays;
m. **13** = Other discretionary and recreational activities (all types of entertainment or sport, clubs, and voluntary work, non-vocational evening classes, political meetings, etc.).

Q15b **END_TRIP_NU** What time did you arrive? **hh:mm**

Q16b **ALT_TRIPS_NU** To what extent do you agree with the following statements?

1 (Strongly disagree) - **5** (Strongly agree)

If the used travel means (**{MODE_USED}**) had not been available for that trip...

- **ALT_TRIP1** I would have not performed that trip;
- **ALT_TRIP2** I would have used a different travel mode;
- **ALT_TRIP3** I would have changed my travel schedule;
- **ALT_TRIP4** I would have changed trip destination;
- **ALT_TRIP5** I would have used car sharing in combination with another transport mode (IF CS_USER=1 **AND** CS_ACTIVE_USER=0).

IF ALT_TRIP2 = 3 **OR** 4 **OR** 5

Q17b **ALT_MODE_NU** Which of the following travel means would you have used if **{MODE_USED}** had not been available?

1 (Very unlikely) - **5** (very likely)

a. **WALK** Walking
b. **BIKE** Bicycle;
c. **BS** Bike sharing;
d. **CS** Car sharing (IF CS_USER=1 **AND** CS_ACTIVE_USER=0)
e. **CAR_D** Car as driver;
f. **CAR_P** Car as passenger;
g. **TAXI** Taxi;
h. **BUS** Urban or suburban bus, tram;
i. **METRO** Metro;
j. **TRAIN** Train.

ELSE IF ALT_TRIP4 = 3 **OR** 4 **OR** 5

Q18b **ALT_DEST_NU** You declared that if the used mode **{MODE_USED}** had not been available you would have changed trip destination. Would the new trip destination has been closer or farther compared to the current trip destination?

- **1** = Closer;
- **2** = Farther;
- **3** = More or less at the same distance.

END IF

IF ALT_TRIP5 = 3 **OR** 4 **OR** 5

Q19b **ALT_MODE_U2** Which of the following travel mode(s) would you have used in combination with car sharing if car sharing had not been available at the origin/destination of your trip?

1 (Very unlikely) - **5** (very likely)

a. **WALK** Walking
b. **BIKE** Bicycle;
c. **BS** Bike sharing;
d. **BUS** Urban or suburban bus, tram;
e. **METRO** Metro;
f. **TRAIN** Train.

END IF

END IF

CAR OWNERSHIP

In this section information about changing in car ownership at the household level will be asked. Please consider as household the household unit or the people with whom you have emotional bond that are currently living with you, excluding guests or those who now live elsewhere for study or work.

Q22 **HH_CAR** How many cars do you currently have available in your household? Please include commercial vehicles, those made available by the employer (company cars), those temporarily lent or under repair. Do not include cars that are permanently out of order.

- **0** = 0
- **1** = 1
- **2** = 2

- **3** = 3
- **4** = 4 or more

IF CS_USER = 1

Q23a **HH_CAR_PREV_U** How many cars were available in your household when you registered with **{SERV_CS1}** in **{YR_CS1}**?

- **0** = 0
- **1** = 1
- **2** = 2
- **3** = 3
- **4** = 4 or more

Q24a **HH_CAR_PREV_Y_U** How many cars were available in your household 12 months before registering with **{SERV_CS1}** in **{YR_CS1}**?

- **0** = 0
- **1** = 1
- **2** = 2
- **3** = 3
- **4** = 4 or more

IF HH_CAR = HH_CAR_PREV= HH_CAR_PREV_Y

CASE 1: The number of cars is unchanged

Q25a **CASE1** To what extent do you agree with the following statements?
1 (Strongly disagree) - **5** (Strongly agree)

1. IF HH_CAR <>0, **SUB** I am thinking about replacing one or more owned cars
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
2. IF HH_CAR <>0, **SUB_CS** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
3. IF HH_CAR <>0, **SELL** I am thinking about selling, scraping or getting rid of one or more owned cars without replacing them
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
4. IF HH_CAR <>0, **SELL_CS** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
5. **PURCH** I am thinking about buying a (Se HH_CAR <>0 "an extra") car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**

6. **PURCH_CS** This decision is due, at least in part, to car sharing membership
    - **1** = Yes
    - **0** = No
7. **AVOID** I gave up buying a (Se HH_CAR <>0 "an extra") car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
8. **AVOID_CS** This decision is due, at least in part, to car sharing membership
    - **1** = Yes
    - **0** = No

END IF

IF HH_CAR_PREV_Y - HH_CAR_PREV > 0,

CASE 2: Cars sold before the registration

For the following questions consider the time when you sold the latest car before registering to {SERV_CS1} in {YR_CS1}.

Q25a **RED_CAUSE_B** Is the reduction in the number of cars in your household deriving from a voluntary scrapping?

- **1** = Yes
- **0** = No (The car-scrapping was caused by an accident, for car ownership transfer to another relative from the transfer of the vehicle to another family, changes in the composition of the household, failed renew of the driving licence, disability to drive)

IF RED_CAUSE =1 **AND** IF HH_CAR_PREV_Y- HH_CAR_PREV=1,

One car sold before the registration

Q26a **RED_WHEN_B** When this car was sold?

1. Several months before the registration with **{SERV_CS1}** in **{YR_CS1}.**
2. Few weeks or just before the registration with **{SERV_CS1}** in **{YR_CS1}.**

Q27a **RED_INFL_CS_B** To what extent did the registration to a car sharing service affect your choice to sell this car? **[1** (No influence) - **5** (Strong Influence)**]**

Q28a **PARK_SPACE_PAST_B(WP)** You got rid of one car before the registration with **{SERV_CS1}** in **{YR_CS1}**. Where the car sold was usually parked from 9:00am to 17:00pm on weekdays?

1. Paying park near home (guarded or not)

2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

Q29a **PARK_SPACE_PAST_B(OP)** You got rid of one car before the registration with **{SERV_CS1}** in **{YR_CS1}**. Where the sold car was usually parked in other times?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

ELSE IF RED_CAUSE =1 **AND** IF HH_CAR_PREV_Y- HH_CAR_PREV>1,

Many cars sold before the registration

Q26a **RED_WHEN_B2** When the latest car was sold before the registration with **{SERV_CS1}** in **{YR_CS1}**?

1. Several months before this registration
2. Few weeks or just before this registration

Q27a **RED_INFL_CS_B2** To what extent did the registration to a car sharing service affect your choice to sell this car? **[1** (No influence) - **5** (Strong Influence)**]**

Q28a **PARK_SPACE_PAST_B2(WP)** You got rid of many cars before the registration with **{SERV_CS1}** in **{YR_CS1}**. Where sold cars were usually parked from 9:00am to 17:00pm on weekdays?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

Q29a **PARK_SPACE_PAST_B2(OP)** You got rid of many cars before the registration with **{SERV_CS1}** in **{YR_CS1}**. Where sold cars were usually parked in other times?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

END IF

Q30a **RED_ALT_B** Which one among the following means of transport started being mostly used for those trips that were formerly made with the no longer available car?

- **BIKE** Private bycicle
- **BS** Bycicle of a bike sharing service
- **CAR_D** Car driver of another available car in the household
- **CAR_P** Car passenger of another available car in the household
- **CS** Car sharing
- **TAXI** Taxi
- **BUS** Urban and suburban buses, tram
- **METRO** Underground
- **TRAIN** Train
- **WALK** Walk
- **NONE** No one, We no longer perform such trips

ELSE IF HH_CAR_PREV_Y - HH_CAR_PREV < 0,

CASE 3: Cars bought before the registration

For the following questions consider the time when you bought the latest car before registering to {SERV_CS1} in {YR_CS1}.

IF HH_CAR_PREV_Y-HH_CAR_PREV = -1,

One car bought before the registration

Q25a **PURCH_WHEN_B** When this car was bought?

1. Several months before the registration with **{SERV_CS1}** in **{YR_CS1}**
2. Few weeks or just before the registration with **{SERV_CS1}** in **{YR_CS1}**

Q26a **PURCH_INFL_CS_B** To what extent did the registration to a car sharing service affect your choice to buy this car? E.g. the use of a specific car model through car sharing has encouraged me to buy it; using car sharing a lot I understood the importance of having the car owned **[1** (No influence) - **5** (Strong Influence)**]**

ELSE IF HH_CAR_PREV_Y-HH_CAR_PREV < 1,

Many cars bought before the registration

Q25a **PURCH_WHEN_B2** When the latest car was bought before joining **{SERV_CS1}** in **{YR_CS1}**?

1. Several months before this registration
2. Few weeks or just before this registration

Q26a **PURCH_INFL_CS_B2** To what extent did the registration to a car sharing service affect your choice to buy this car? E.g. the use of a specific car model through car sharing has encouraged me to buy it; using car sharing a lot I understood the importance of having the car owned **[1** (No influence) - **5** (Strong Influence)**]**

END IF

END IF

IF HH_CAR_PREV - HH_CAR > 0,

CASE 4: Cars sold after the registration

At the time you registered to a car sharing service there was/were {HH_CAR_PREV} car(s) in your household, while now there is/are {HH_CAR} car(s). For the following questions consider this time period.

Q31a **RED_CAUSE_A** Is the reduction in the number of cars in your household deriving from a voluntary scrapping?

- **1** = Yes
- **0** = No (The car-scrapping was caused by an accident, for car ownership transfer to another relative from the transfer of the vehicle to another family, changes in the composition of the household, failed renew of the driving licence, disability to drive)

IF RED_CAUSE =1 **AND** IF HH_CAR_PREV-HH_CAR = 1,

One car sold after the registration

Q32a **RED_WHEN_A** When this car was sold?

1. Within few weeks after the registration with **{SERV_CS1}** in **{YR_CS1}**
2. Several months or years after registration with **{SERV_CS1}** in **{YR_CS1}**

Q33a **RED_INFL_CS_A** To what extent did the registration to a car sharing service affect your choice to sell this car? **[1** (No influence) - **5** (Strong Influence)**]**

Q34a **PARK_SPACE_PAST_A(WP)** You got rid of one car after the registration with **{SERV_CS1}** in **{YR_CS1}**. Where the car sold was usually parked from 9:00am to 17:00pm on weekdays?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

Q35a **PARK_SPACE_PAST_A(OP)** You got rid of one car after the registration with **{SERV_CS1}** in **{YR_CS1}**. Where the sold car was usually parked in other times?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

ELSE IF RED_CAUSE =1 **AND** IF HH_CAR_PREV-HH_CAR > 1,

Many cars sold after the registration

Q32a **RED_WHEN_A** When the latest car was sold after joining **{SERV_CS1}** in **{YR_CS1}**?

1. Within few weeks after this registration
2. Several months or years after this registration

Q33a **RED_INFL_CS_A** To what extent did the registration to a car sharing service affect your choice to sell this car? **[1** (No influence) - **5** (Strong Influence)**]**

Q34a **PARK_SPACE_PAST_A2(WP)** You got rid of many cars after the registration with **{SERV_CS1}** in **{YR_CS1}**. Where sold cars were usually parked from 9:00am to 17:00pm on weekdays?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

Q35a **PARK_SPACE_PAST_B2(OP)** You got rid of many cars after the registration with **{SERV_CS1}** in **{YR_CS1}**. Where sold cars were usually parked in other times?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

END IF

Q36a **CASE4** To what extent do you agree with the following statements?
1 (Strongly disagree) - **5** (Strongly agree)

1. IF RED_CAUSE =0 **OR** IF HH_CAR <>0, **SUB_A** I am thinking about replacing one or more owned cars
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
2. IF RED_CAUSE =0 **OR** IF HH_CAR <>0, **SUB_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
3. IF HH_CAR <>0 **SELL_CS_A** I am thinking about selling, scraping or getting rid of one or more owned cars without replacing them
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
4. IF HH_CAR <>0 **SELL_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
5. **PURCH_A** I am thinking about buying an extra car

[1 (Strongly disagree) - 5 (Strongly agree)]

6. **PURCH_CS_A** This decision is due, at least in part, to car sharing membership
    - **1** = Yes
    - **0** = No
7. **AVOID_A** I gave up buying an extra car

    [1 (Strongly disagree) - 5 (Strongly agree)]
8. **AVOID_CS_A** This decision is due, at least in part, to car sharing membership
    - **1** = Yes
    - **0** = No

Q37a **RED_ALT_A** Which one among the following means of transport is now mainly used for those trips that were formerly made with the no longer available car(s)?

- **BIKE** Private bycicle
- **BS** Bycicle of a bike sharing service
- **CAR_D** Car driver of another available car in the household
- **CAR_P** Car passenger of another available car in the household
- **CS** Car sharing
- **TAXI** Taxi
- **BUS** Urban and suburban buses, tram
- **METRO** Underground
- **TRAIN** Train
- **WALK** Walk
- **NONE** No one, We no longer perform such trips

IF HH_CAR_PREV - HH_CAR = 0 AND HH_CAR_PREV != HH_CAR_PREVY

CASE 5: The number of cars after the registration is unchanged

Q31a **CASE5** To what extent do you agree with the following statements?

1 (Strongly disagree) - **5** (Strongly agree)

1. IF HH_CAR <>0, **SUB_A** I am thinking about replacing one or more owned cars

    [1 (Strongly disagree) - 5 (Strongly agree)]
2. IF HH_CAR <>0, **SUB_CS_A** This decision is due, at least in part, to car sharing membership
    - **1** = Yes
    - **0** = No
3. IF HH_CAR <>0, **SELL_A** I am thinking about selling, scraping or getting rid of one or more owned cars without replacing them

[1 (Strongly disagree) - 5 (Strongly agree)]

4. IF HH_CAR <>0, **SELL_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
5. **PURCH_A** I am thinking about buying an extra car

   [1 (Strongly disagree) - 5 (Strongly agree)]
6. **PURCH_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
7. **AVOID_A** I gave up buying an extra car

   [1 (Strongly disagree) - 5 (Strongly agree)]
8. **AVOID_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No

ELSE IF HH_CAR_PREV - HH_CAR < 0,

CASE 6: Cars bought after the registration

At the time you registered to a car sharing service there was/were {HH_CAR_PREV} car(s) in your household, while now there is/are {HH_CAR} car(s). For the following questions consider this time period.

IF HH_CAR_PREV-HH_CAR = -1,

One car bought after the registration

Q31a **PURCH_WHEN_A** When this car was bought?

1. Within few weeks after the registration with **{SERV_CS1}** in **{YR_CS1}**
2. Several months or years after the registration with **{SERV_CS1}** in **{YR_CS1}**

Q32a **PURCH_INFL_CS_A** To what extent did the registration to a car sharing service affect your choice to buy this car? E.g. the use of a specific car model through car sharing has encouraged me to buy it; using car sharing a lot I understood the importance of having the car owned

[1 (No influence) - 5 (Strong Influence)]

ELSE IF HH_CAR_PREV-HH_CAR < 1,

Many cars bought after the registration

Q31a **PURCH_WHEN_A2** When the first car was bought after joining **{SERV_CS1}** in **{YR_CS1}**?
1. Within few weeks after this registration
2. Several months or years after this registration

Q32a **PURCH_INFL_CS_A2** To what extent did the registration to a car sharing service affect your choice to buy this car? E.g. the use of a specific car model through car sharing has encouraged me to buy it; using car sharing a lot I understood the importance of having the car owned
[**1** (No influence) - **5** (Strong Influence)]

END IF

Q33a **CASE6** To what extent do you agree with the following statements?
1 (Strongly disagree) - **5** (Strongly agree)?

1. **SUB_A** I am thinking about replacing one or more owned cars
   [**1** (Strongly disagree) - **5** (Strongly agree)]
2. **SUB_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
3. **SELL_A** I am thinking about selling, scraping or getting rid of one or more owned cars without replacing them
   [**1** (Strongly disagree) - **5** (Strongly agree)]
4. **SELL_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
5. **PURCH_A** We are thinking to buy an extra car
   [**1** (Strongly disagree) - **5** (Strongly agree)]
6. **PURCH_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No
7. **AVOID_A** I gave up buying an extra car
   [**1** (Strongly disagree) - **5** (Strongly agree)]
8. **AVOID_CS_A** This decision is due, at least in part, to car sharing membership
   - **1** = Yes
   - **0** = No

END IF

Q38a **CS_ALT** To what extent do you agree with the following statements?

[1 (Strongly disagree) - **5** (Strongly agree)**]**

If the car sharing operator that you normally use shut down the service in the city ...

1. I would buy a car
2. I would use more often another car sharing service
3. I would completely stop using car sharing

IF **CS_ALT - 1. > 3:**

Q39a SP_PARK_SPACE_WP Think about the car you declared you would buy in case the car sharing operator that you normally use shut down the service. Where this car would be parked from 9:00am to 17:00pm on weekdays?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

Q340a SP _PARK_SPACE_OP Where this car would be parked in other times?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

END IF

--- USER PART END ---

IF CS_USER = 0

In this section information about changing in car ownership of your household will be asked.

IF HH_CAR=0

Q23b HH_CAR_OWNED Has your current household ever had at least an available car? Include the commercial vehicles, the ones available to the employer, those temporarily lent or under repair

- **1** = Yes
- **0** = No

IF HH_CAR_OWNED = 1

#A car (or more than one) has been sold

Q24b **CAR_CHANGE_WHEN** When was the last time you bought, changed, sold, scrapped or replaced a car? **Dropdown menu YYYY (1=1990 -> 30=2019)**

Q25b **HH_CAR_PREV_NU** Before that, how many available cars did you have?

- **0** = 0
- **1** = 1
- **2** = 2
- **3** = 3
- **4** = 4 or more

Q26b **CASE_NU** To what extent do you agree with the following statements??

1. **PURCH** I am thinking about buying a car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
2. **PURCH_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No
3. **AVOID** I gave up buying a car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
4. **AVOID_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No

Q27b **RED_ALT_NU** Which one among the following means of transport is now mainly used for those trips that were formerly made with the no longer available car(s)?

- **BIKE** Private bycicle
- **BS** Bycicle of a bike sharing service
- **CS** Car sharing
- **TAXI** Taxi
- **BUS** Urban and suburban buses, tram
- **METRO** Underground
- **TRAIN** Train
- **WALK** Walk
- **NONE** No one, We no longer perform such trips

ELSE IF HH_CAR_OWNED = 0

Q24b **CASE_NU_N** To what extent do you agree with the following statements?

1. **PURCH** We are thinking to buy a car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
2. **PURCH_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No
3. **AVOID** I gave up buying a car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
4. **AVOID_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No

END IF

ELSE IF HH_CAR<>0

Q23b **CAR_CHANGE_WHEN2** When was the last time you bought, changed, sold, scrapped or replaced a car? **Dropdown menu YYYY (1=2019 -> 30=1990, 31=Before 1990)**

Q24b **HH_CAR_PREV_NU2** Before that, how many cars did you have available?

- **0** = 0
- **1** = 1
- **2** = 2
- **3** = 3
- **4** = 4 or more

Q25b **CASE_NU2** To what extent do you agree with the following statements?

1. **SUB** I am thinking about replacing one or more owned cars
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
2. **SUB_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No
3. **SELL_CS** I am thinking about selling, scraping or getting rid of one or more owned cars without replacing them
   [1 (Strongly disagree) - **5** (Strongly agree)**]**

4. **SELL_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No
5. **PURCH** We are thinking to buy a car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
6. **PURCH_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No
7. **AVOID** I gave up buying a car
   [1 (Strongly disagree) - **5** (Strongly agree)**]**
8. **AVOID_CS** This decision is due, at least in part, to the fact that I intend to enrol to a car sharing service
   - **1** = Yes
   - **0** = No

IF HH_CAR – HH_CAR_PREV <0,

CASE 7: Cars have been sold

Q26b **RED_ALT7** Which one among the following means of transport is now mainly used for those trips that were formerly made with the no longer available car(s)?

- **BIKE** Private bycicle
- **BS** Bycicle of a bike sharing service
- **CAR_D** Car driver of another available car in the household
- **CAR_P** Car passenger of another available car in the household
- **CS** Car sharing
- **TAXI** Taxi
- **BUS** Urban and suburban buses, tram
- **METRO** Underground
- **TRAIN** Train
- **WALK** Walk
- **NONE** No one, We no longer perform such trips

END IF

END IF

Q27b **OFFER_IMPR** To what extent the following car sharing features would entice you in using the service?

[1 (absolutely not important) - **5** (very important)**]**

1. Possibility of booking a parking space at destination to avoid looking for parking

2. Possibility of free parking in any parking space without limitations
3. Increased availability of cars
4. Availability of different car models
5. Availability of cars whenever I want
6. Greater extension of the operating area and/or diffusion of the stations (charging stations in case of electric car sharing)
7. More stations (charging stations in case of electric car sharing) within the area currently served
8. Increased availability of reserved parking spaces near interchange points (train station, metro stations, bus terminal)
9. Possibility of parking inside guarded areas or in underground car parks
10. Increased visibility of parking areas and parking areas dedicated in public spaces
11. Better connection with public transport stops
12. Possibility of booking a car hours or days in advance
13. Greater simplicity in booking procedures
14. Service provider's telephone assistance 24/7
15. Useful and timely information on new offers and changes in terms of use
16. Discount for longer renting periods (e.g. more than a couple of hours or a day)
17. Discount for shorter renting periods (e.g. less than 1-2 hour)
18. Ease of use of the car
19. Car equipped with child seats
20. Possibility of transporting animals
21. Possibility of transporting bicycles
22. Design and car-look
23. Vehicles with upgraded technical and technological equipment, e.g. air conditioning, navigation, Bluetooth etc.
24. Internal and external car conditions and cleanliness
25. Assistance in case of breakdowns or damages

END IF

------------------------------------ NON-USER PART END --

IF HH_CAR<>0

IF HH_CAR = 1 **One car is currently available in your household.**

IF HH_CAR = 2 **Please consider the two cars currently available in your household as "Car 1" and "Car 2".**

IF HH_CAR = 3 **Please consider the three cars currently available in your household as "Car 1", "Car 2" and "Car 3".**

IF HH_CAR = 4 **Please consider the three cars currently available in your household as "Car 1", "Car 2", "Car 3" and "Car 4".**

FOR n FROM 1 TO HH_CAR:

Q41 **PARK_SPACE_WP_n** Where the car(n) is usually parked from 9:00am to 17:00pm on weekdays?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

Q42 **PARK_SPACE_OP_n** Where the car is usually parked in other times?

1. Paying park near home (guarded or not)
2. Paying park near workplace/ school/ university
3. Garage or private space near home
4. Garage or private space near workplace/ school/ university
5. Roadside near home
6. Roadside near workplace/ school/ university
7. Free parking near home
8. Free parking near workplace/ school/ university

END IF

SOCIODEMOGRAPHIC CHARACTERIZATION

Q43 **GENDER** What is your gender?

1. Male
2. Female
3. Other

Q44 **AGE** When you were born? **Dropdown menu YYYY (1900 -> 2001)**

Q45 **REGION_LIVE** In which city do you currently live?

Dropdown menu with the regions of the country

IF REGIONLIVE = 1

Q46 **CITY_LIVE_L** In which city do you live?

Dropdown menu with all the cities in that region

Q47 **ZIP_CODE_L** Please select the usual residence ZIP code

Dropdown menu with all the ZIP codes of that region

ELSE IF REGIONLIVE = 2

Q46 **CITY_LIVE_P** In which city do you live?

Dropdown menu with all the cities in that region

Q47 **ZIP_CODE_P** Please select the usual residence ZIP code

Dropdown menu with all the ZIP codes of that region

ELSE IF REGIONLIVE = 3

Q46 **CITY_LIVE_O** In which city do you live? **Open answer**

Q47 **ZIP_CODE_O** Please insert the usual residence ZIP code **Open answer**

END IF

Q48 **EDUCATION** What is the highest education level you have? Select the answer that you think best suits you. If you have not yet completed your education, please mark the degree you will reach next.

1. No studies
2. Primary school
3. Middle school
4. High school
5. University degree (Bachelor, Master of Science, Doctorate)

Q49 **EMPL** What is your current job or employment situation?

1. Entrepreneur, freelancer
2. Officer, manager
3. Employee, trade employee
4. Worker
5. Teacher
6. Salesperson
7. Artisan, retailer
8. Student
9. Housewife
10. Retired
11. Waiting for first employment, never worked
12. Unemployed
13. Other **Open answer**

We ask you now to consider the household unit or the people with whom you have emotional bond that are currently living with you, excluding guests or those who now live elsewhere for study or work.

Q50 **HH_SIZE** How many people, including yourself, live in your household?

1. 1
2. 2
3. 3
4. 4
5. 5 or more

IF HH_SIZE > 1

Q51 **HH_EMPL** How many people in your household, including yourself, currently work?

0. 0
1. 1
2. 2
3. 3
4. 4
5. 5 or more

MUST BE <= HH_SIZE

Q52 **HH_DRIV_LICENCE** How many drivers / licensees, including yourself, are there in your household?

1. 1
2. 2
3. 3
4. 4
5. 5 or more

MUST BE <= HH_SIZE

Q53 **HH_CS** How many of people have at least one car sharing subscription, including yourself, in your household?

0. 0
1. 1
2. 2
3. 3
4. 4
5. 5 or more

MUST BE <= HH_DRIV_LICENCE

Q54 **HH_CHILD** Do you have children living in your household?

0. No
1. 1
2. 2
3. 3
4. 4

5. 5 or more

MUST BE <= HH_SIZE

IF HH_CHILD <> 0

Q55 **HH_U18** How many of them are underage?

0. 0
1. 1
2. 2
3. 3
4. 4
5. 5 or more

MUST BE <= HH_CHILD

END IF

END IF

Q56 **HH_INCOME** Considering the income of all members or people with whom you have emotional bond currently living with you, excluding guests or those who now live elsewhere for study or work, in which of the following ranges does the average net monthly income of your household fall?

1. Up to 500€
2. 501€ - 1000€
3. 1001€ - 1500€
4. 1501€ - 2000€
5. 2001€ - 2500€
6. 2501€ - 3000€
7. 3001€ - 4000€
8. 4001€ - 5000€
9. 5001€ - 6000€
10. 6001€ - 10.000 €
11. More than 10.001 €

Appendix 2: Local variants of the travel survey

STARS Travel survey questions	Flanders panel survey	Internal survey from car sharing operators within the Capital Region of Brussels	Frankfurt users and non-users survey
Q1	Same	Same	Same
Q2a	Missing	Missing	Missing
Q2b	Same	Missing	Missing
Q3a	Same	Missing	Same
Q4a	Missing	Missing	Missing
Q5	Same	Missing	Missing
Q6	Same	Missing	Different: "What kind of ticket do you usually use?" + "What kind of ticket did you usually use before your first registration?" Answers: A) single fare or multi-trip tickets B) 1 day tickets (24-hour tickets) C) weekly ticket (multi-day tickets) D) monthly pass E) annual pass (abo tickets, jobtickets) F) other tickets (also severely-disabled-cards, ...) Additionally:

			(v19) Did you use public transport at your place of residence before you first registered for car sharing? (v20) What kind of ticket did you usually use before your first registration?
Q7	Same	Missing	Same
Q8a	Missing	Same	Same
Q9a	Missing	Missing	Different: If you think back in the past twelve months: how often do you use a car from the following car sharing-services?
Q10a	Missing	Missing	Missing
Q11a	Missing	Missing	Missing
Q12a	Missing	Missing	Missing
Q13a	Missing	Missing	Missing
Q14a	Missing	Missing	Missing
Q15a	Missing	Missing	Missing
Q16a	Missing	Missing	Different answers: A) way to work/job training/university B) visiting relatives/ friends in another town C) Taking a stroll in the city centre

			D) Going out for dinner E) Taking an excursion in nice weather F) Shopping for groceries G) Visiting a shopping centre H) Weekend activities I) Taking away and picking up people J) Other purpose
Q17a	Missing	Missing	Missing
Q18a	Missing	Missing	Different: one choice instead of Likert scale
Q19a	Missing	Missing	Different: one choice instead of Likert scale
Q20a	Missing	Missing	Same
Q21a	Missing	Missing	Missing
Q8b	Missing	Missing	Same
Q9b	Missing	Missing	Missing
Q10b	Missing	Missing	Missing
Q11b	Missing	Missing	Missing
Q12b	Missing	Missing	Missing
Q13b	Missing	Missing	Missing
Q14b	Missing	Missing	Different answers: A) way to work/job training/university B) visiting relatives/ friends in another town C) Taking a stroll in the city centre

			D) Going out for dinner E) Taking an excursion in nice weather F) Shopping for groceries G) Visiting a shopping centre H) Weekend activities I) Taking away and picking up people J) Other purpose
Q15b	Missing	Missing	Missing
Q16b	Missing	Missing	Different: one choice instead of Likert scale
Q17b	Missing	Missing	Different: one choice instead of Likert scale
Q18b	Missing	Missing	Same
Q19b	Missing	Missing	Missing
Q22	Same	Same	Same
Q23a	Missing	Missing	Same
Q24a	Missing	Missing	Same
Q25a	Missing	Other wording: “How likely do you consider the chance that you would have purchased an (additional) car if you had not subscribed to a car sharing organisation? A) Yes - we had certainly purchased a(n extra) car B) Probably - we had probably purchased a(n extra) car C) Probably not -	Missing

		we had considered purchasing a(n extra) car D) No - We wouldn't have purchased a(n extra) car"	
Q26a	Missing	Missing	Missing
Q27a	Missing	Missing	Missing
Q28a	Missing	Missing	Same
Q29a	Missing	Missing	Same
Q30a	Missing	Missing	Missing
Q31a	Missing	Missing	Missing
Q32a	Missing	Missing	Missing
Q33a	Missing	Missing	Missing
Q34a	Missing	Missing	Same
Q35a	Missing	Missing	Same
Q36a	Missing	Missing	Missing
Q37a	Missing	Missing	Missing
Q38a	Missing	Missing	Missing
Q39a	Missing	Missing	Missing
Q40a	Missing	Missing	Missing
Q23b	Missing	Missing	Missing
Q24b	Missing	Missing	Other answers: A) I plan to own a car in the next 12 months B) I will get a company car in the next 12 months, which I can also use privately C) I would like to buy my own car, but

			postponed the purchase until later. D) I would buy my own car if my circumstances require it. E) I have not had my own car for some time and I do not plan to buy one.
Q25b	Missing	Missing	Missing
Q26b	Missing	Missing	Missing
Q27b	Missing	Missing	Missing
Q41	Missing	Missing	Missing
Q42	Missing	Missing	Different: Where is your car usually parked when you are at home?
Q43	Same	Same	Same
Q44	Other answer possibilities: A) 18-34 B) 35-54 C) 55+	Other answer possibilities: A) younger than 19 years B) 19-25 years C) 26-39 years D) 40-49 years E) 50-64 years F) 65 years or older	Same
Q45	Same	Missing	Missing (only Frankfurt citizens)
Q46	Missing	Missing	Missing (only Frankfurt citizens)
Q47	Missing	Missing	Same
Q48	Same	Missing	Same
Q49	Same	Missing	Different answers: A) Employed B) Self-employed

			C) Trainee D) School education E) University education F) Unemployed/retired
Q50	Same	Same	Same
Q51	Same	Missing	Missing
Q52	Same	Missing	Same
Q53	Missing	Missing	Missing
Q54	Same	Same	Missing
Q55	Missing	Same	
Q56	Same	Missing	Different ranges: A) <1000€ B) 1000-2000€ C) 2000-3000€ D) 3000-4000€ E) 4000-5000€ F) >5000€ G) I do not want to answer

Table 49: Differences between STARS travel survey and other survey exploited within the Belgian case study

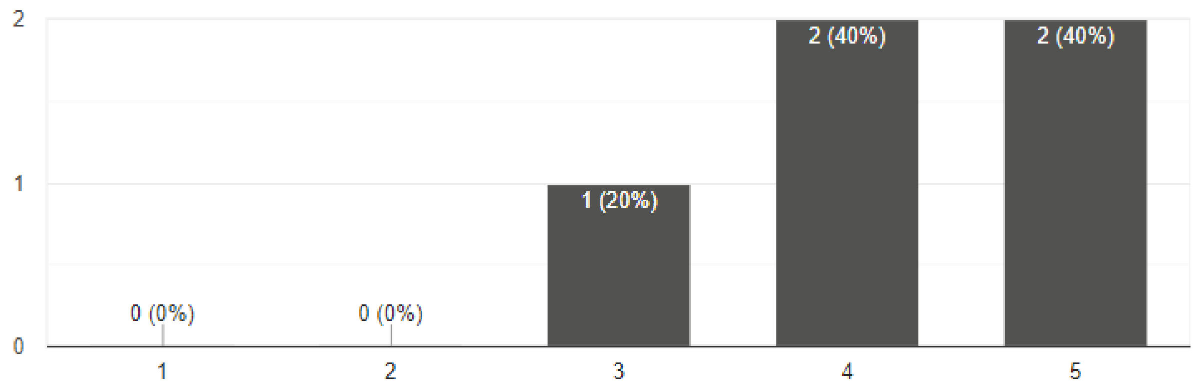
Appendix 3: Uptake cities questionnaires and aggregated answers

Questionnaire sent to the Uptake cities after the first webinar

1. How familiar are you personally with the car sharing topic in general?
2. How useful overall did you find the 1st webinar in terms of gaining new knowledge about car sharing?
3. How did you find the amount of presented information?
4. What is the most interesting information you have learned during the Webinar 1?
5. Did you find some information or discussion useful to implement a new policy or measure related to car sharing in your city?
6. What would be most interesting for you to hear more about in our 2nd webinar?

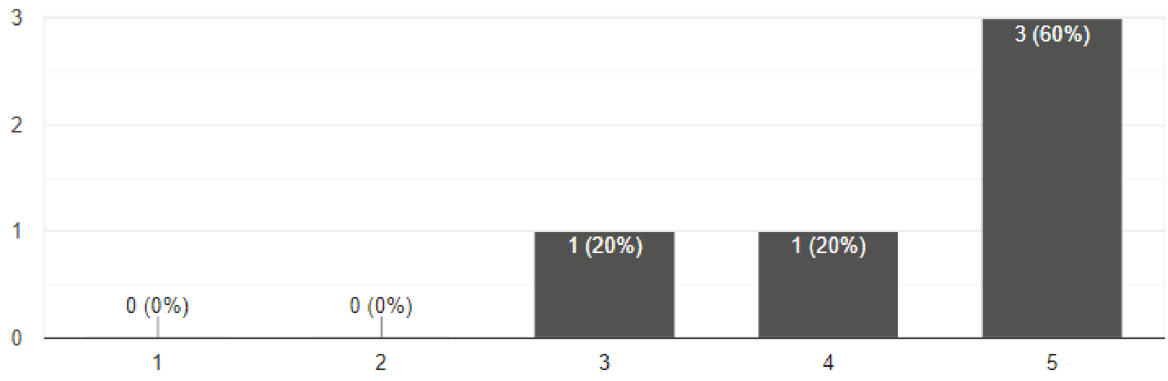
1. How familiar are you personally with the car sharing topic in general

5 responses



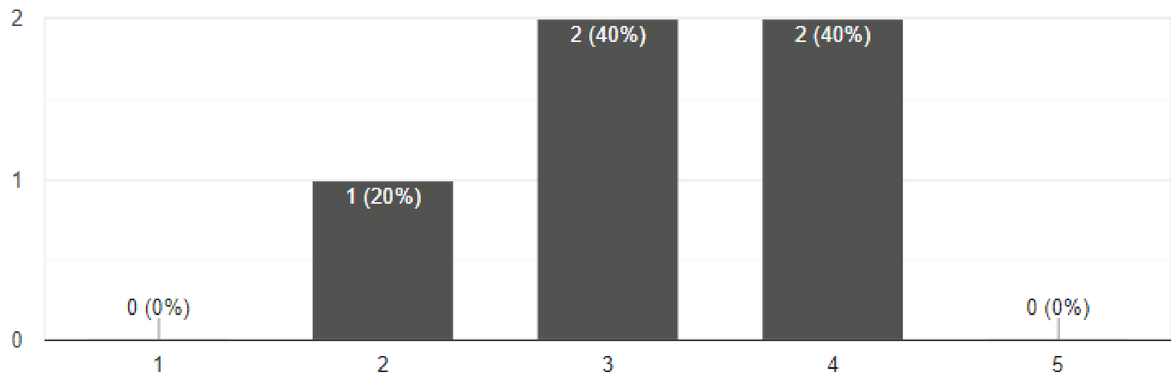
2. How useful overall did you find the 1st webinar in terms of gaining new knowledge about car sharing

5 responses



3. How did you find the amount of presented information?

5 responses



4. What is the most interesting information you have learned during the Webinar 1?

3 responses

All the presentation was very interesting.
The last presentation brought something new
car sharing management schemes models

5. Did you find some information or discussion useful to implement a new policy or measure related to car sharing in your city?

4 responses

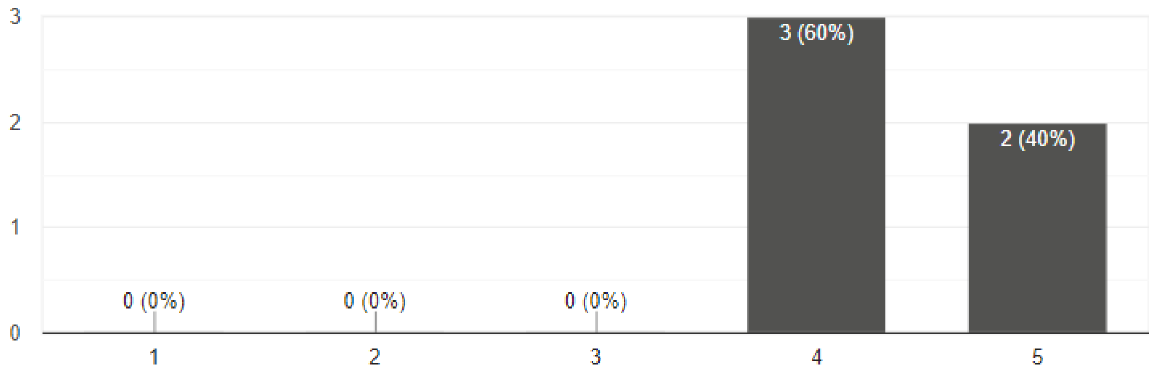
I found a lot of excellent ideas but in my country (Bulgaria) the legal frame is not allowing to apply them at present.
Not really, I saw most of the informations and presentations on earlier seminars and conferences. In a very dynamic market, showing data from before 5-10 years is useless, unless the goal is to show historic evolution, I understood that this was not the case.
Yes
Yes.

Questionnaire sent to the Uptake cities after the second webinar

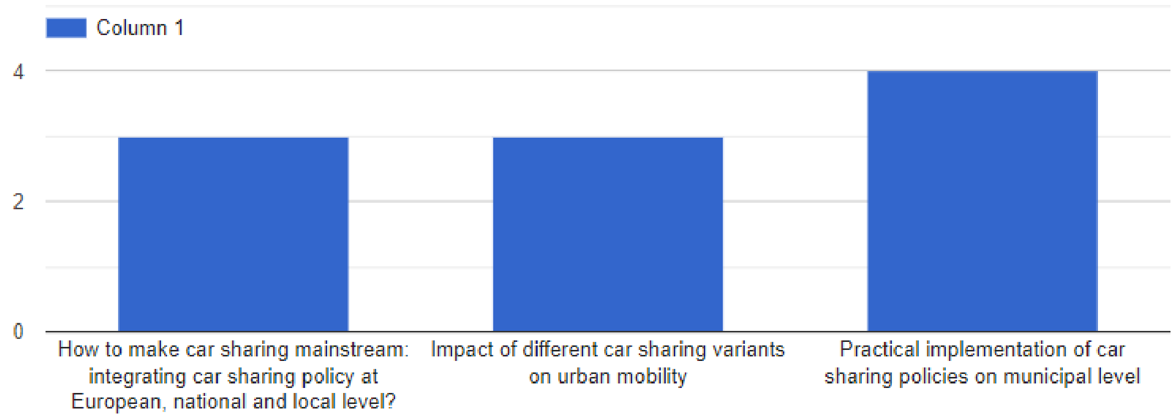
1. How useful do you find the selected topics in the 2nd webinar?
2. What was the most interesting topic in the 2nd webinar for you as a city representative?
3. How did you find the amount of presented information?
4. What is the most interesting information you have learned during the Webinar 2?
5. What additional information would you need to replicate/ choose the right car sharing system in your city?
6. How would you advise us to approach other cities with STARS results before and after the project will end?

1. How useful do you find the selected topics in the 2nd webinar?

5 responses

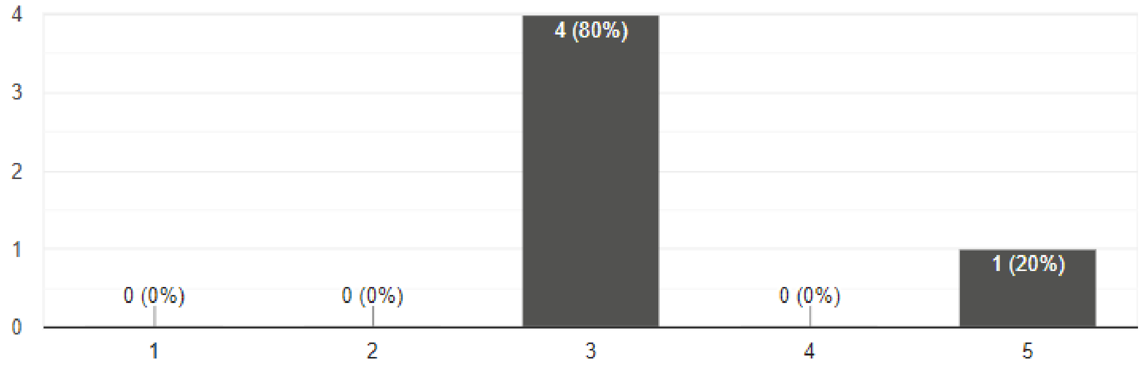


2. What was the most interesting topic in the 2nd webinar for you as a city representative?



3. How did you find the amount of presented information?

5 responses



4. What is the most interesting information you have learned during the Webinar 2?

3 responses

cars shared with driver, neighbors sharing cars.
Mainly the practical issues
All issues were interesting for me.

5. What additional information would you need to replicate/ choose the right car sharing system in your city?

3 responses

private cars sharing
ELTIS proposes enough information for us
How to change the national legislation in order to allow car-sharing in Bulgaria. It is still considered by illegal competition to PT.

6. How would you advice us to approach other cities with STARS results before and after the project will end?

3 responses

sharing good practices, workshops.
By organizing workshops together with the corresponding municipalities
By face-to-face seminars and demonstrations (why not a "moving" seminar, circulating from city to city all over EU).

6. What would be most interesting for you to hear more about in our 2nd webinar?

5 responses

How to persuade the state authority that the car sharing is not a competitor of the public transport but a contribution to sustainable urban mobility.
Influence of free floating carsharing on urban mobility. The new CS markets seem to "jump over" the earlier stages of CS evolution based on round trip operators. The large scale implementations of free floating schemes does not leave any place for RT operators starting from scratch.
Car sharing and mobility points
more examples of good practice from the perspective of municipalities
Presenting of car sharing management schemes models from various cities from Europe

Appendix 4: Matching results

Socioeconomic variables (covariates) used to estimate the car sharing membership propensity score are listed in Table 50 below.

Variable	Description	Type	Level
Age	Age	Metric	Individual
Gender	Gender *(M: male, F: female)*	Categorical	Individual
HHsize	Number of household members	Metric	Household
HHchild	Number of children	Metric	Household
HHdrivLic	Number of driving licences	Metric	Household
HHincome	Monthly gross income [k€]	Metric	Household

Table 50: List of variables used in the propensity score matching

The results of the matching procedure are summarised in the following figures. The comparison between the "Treated" group (car sharing members not oversampled) and the "Control" group (the whole non-members sample) characteristics of Milan respondents is reported in Figure 31. Mean values, standard deviations are evaluated for metric variables while proportions of each category are showed for the categorical variable (gender). Then mean differences (Mean Diff.) as well as the median, mean, and maximum value of differences in empirical quantile functions for each covariate are evaluated by the "*matchIt*" function (eQQ Med, eQQ Mean, and eQQ Max, respectively).

```
### Matching procedure
matchit(formula = CSuser ~ Age + Gender + HHsize + HHdrivLic + HHchild + HHincome,
    data = MIdataset, method = "nearest", ratio = 1)

Summary of balance for all data:
             Means Treated Means Control SD Control Mean Diff eQQ Med eQQ Mean eQQ Max
distance            0.3148        0.2230     0.1175    0.0918  0.0983   0.0930  0.1483
Age                43.0833       51.7233    14.9520   -8.6400  9.0000   8.6056 14.0000
GenderMale          0.6389        0.4575     0.4986    0.1814  0.0000   0.1833  1.0000
GenderFemale        0.3611        0.5425     0.4986   -0.1814  0.0000   0.1778  1.0000
HHsize              2.5889        2.6890     1.1054   -0.1001  0.0000   0.1389  1.0000
HHdrivLic           1.9778        2.0398     0.8609   -0.0620  0.0000   0.0722  1.0000
HHchild             0.5444        0.6854     0.8652   -0.1409  0.0000   0.1611  1.0000
HHincome            3.5028        3.2825     2.8869    0.2202  0.0000   0.3917  7.0000
```

Figure 31: Car sharing members and control group before the matching procedure - Milan

Once the control group is extracted from the whole non-users sample, the same comparative information are reported by the function together with the percent balance improvement and the

new sample size (Figure 32), which is in this case the same of the treated group according to our set up.

Summary of balance for matched data:

	Means Treated	Means Control	SD Control	Mean Diff	eQQ Med	eQQ Mean	eQQ Max
distance	0.3148	0.3023	0.1250	0.0125	8e-04	0.0131	0.0502
Age	43.0833	44.1889	14.1976	-1.1056	1e+00	1.5944	7.0000
GenderMale	0.6389	0.6389	0.4817	0.0000	0e+00	0.0000	0.0000
GenderFemale	0.3611	0.3611	0.4817	0.0000	0e+00	0.0000	0.0000
HHsize	2.5889	2.5833	1.0876	0.0056	0e+00	0.0944	1.0000
HHdrivLic	1.9778	1.9944	0.8423	-0.0167	0e+00	0.0278	1.0000
HHchild	0.5444	0.5056	0.7437	0.0389	0e+00	0.0722	1.0000
HHincome	3.5028	3.3472	3.0932	0.1556	0e+00	0.5111	7.0000

Percent Balance Improvement:

	Mean Diff.	eQQ Med	eQQ Mean	eQQ Max
distance	86.3555	99.2247	85.9565	66.1481
Age	87.2042	88.8889	81.4719	50.0000
GenderMale	100.0000	0.0000	100.0000	100.0000
GenderFemale	100.0000	0.0000	100.0000	100.0000
HHsize	94.4489	0.0000	32.0000	0.0000
HHdrivLic	73.1205	0.0000	61.5385	0.0000
HHchild	72.4013	0.0000	55.1724	0.0000
HHincome	29.3661	0.0000	-30.4965	0.0000

Sample sizes:

	Control	Treated
All	553	180
Matched	180	180
Unmatched	373	0
Discarded	0	0

Figure 32: Car sharing members and control group after the matching procedure – Milan

The outcomes of the matching algorithm applied to the Turin samples are reported in Figure 33 below.

```
### Matching procedure
matchit(formula = CSuser ~ Age + Gender + HHsize + HHdrivLic + HHchild + HHincome,
    data = TOdataset, method = "nearest", ratio = 1)

Summary of balance for all data:
             Means Treated Means Control SD Control Mean Diff eQQ Med eQQ Mean eQQ Max
distance            0.3380        0.2129     0.1371    0.1252  0.1406   0.1255  0.1901
Age                40.1951       52.0235    14.9173  -11.8284 13.0000  11.8171 18.0000
GenderMale          0.5244        0.4510     0.4986    0.0734  0.0000   0.0732  1.0000
GenderFemale        0.4756        0.5490     0.4986   -0.0734  0.0000   0.0732  1.0000
HHsize              2.6707        2.5529     1.0850    0.1178  0.0000   0.1463  1.0000
HHdrivLic           2.1951        1.9333     0.7834    0.2618  0.0000   0.2805  1.0000
HHchild             0.4878        0.6392     0.8847   -0.1514  0.0000   0.1585  1.0000
HHincome            3.2774        2.8167     2.5913    0.4608  0.0000   0.5945  9.5000


Summary of balance for matched data:
             Means Treated Means Control SD Control Mean Diff eQQ Med eQQ Mean eQQ Max
distance            0.3380        0.3353     0.1537    0.0027  0.0022   0.0045  0.0442
Age                40.1951       40.0366    14.5809    0.1585  1.0000   1.5732  5.0000
GenderMale          0.5244        0.5122     0.5029    0.0122  0.0000   0.0122  1.0000
GenderFemale        0.4756        0.4878     0.5029   -0.0122  0.0000   0.0122  1.0000
HHsize              2.6707        2.6098     1.1838    0.0610  0.0000   0.1341  1.0000
HHdrivLic           2.1951        2.0000     0.8607    0.1951  0.0000   0.1951  1.0000
HHchild             0.4878        0.4878     0.8202    0.0000  0.0000   0.0488  1.0000
HHincome            3.2774        3.0457     2.7544    0.2317  0.2500   0.6829  9.5000

Percent Balance Improvement:
             Mean Diff. eQQ Med eQQ Mean eQQ Max
distance        97.8532 98.4673  96.4153 76.7453
Age             98.6597 92.3077  86.6873 72.2222
GenderMale      83.3876  0.0000  83.3333  0.0000
GenderFemale    83.3876  0.0000  83.3333  0.0000
HHdrivLic       25.4658  0.0000  30.4348  0.0000
HHsize          48.2339  0.0000   8.3333  0.0000
HHchild        100.0000  0.0000  69.2308  0.0000
HHincome        49.7133    -Inf -14.8718  0.0000

Sample sizes:
          Control Treated
All           255      82
Matched        82      82
Unmatched     173       0
Discarded       0       0
```

Figure 33: Car sharing members and control group before and after the matching procedure - Turin

Appendix 5: SP experiments details and estimation results of binomial logit

As reported in section 3.2, the switch models used in this study were calibrated on data coming from a previous work (Ceccato & Diana, 2018) where stated-preference (SP) experiments were used to investigate the characteristics of one randomly selected trip among those reported in travel diary of each respondents and related mode switching attitudes. In particular, respondents were asked to state their willingness to switch to car sharing from the base mode, which represented the currently used mode, to car sharing under a certain condition obtained as a combination of trip cost and duration. The cost value was selected among three possible values defined through functions, which are represented in Figure 34: same cost of base mode and of car sharing (base), the base cost increased by the 30% (Chigh) and the base cost decreased by the 30% (Clow).

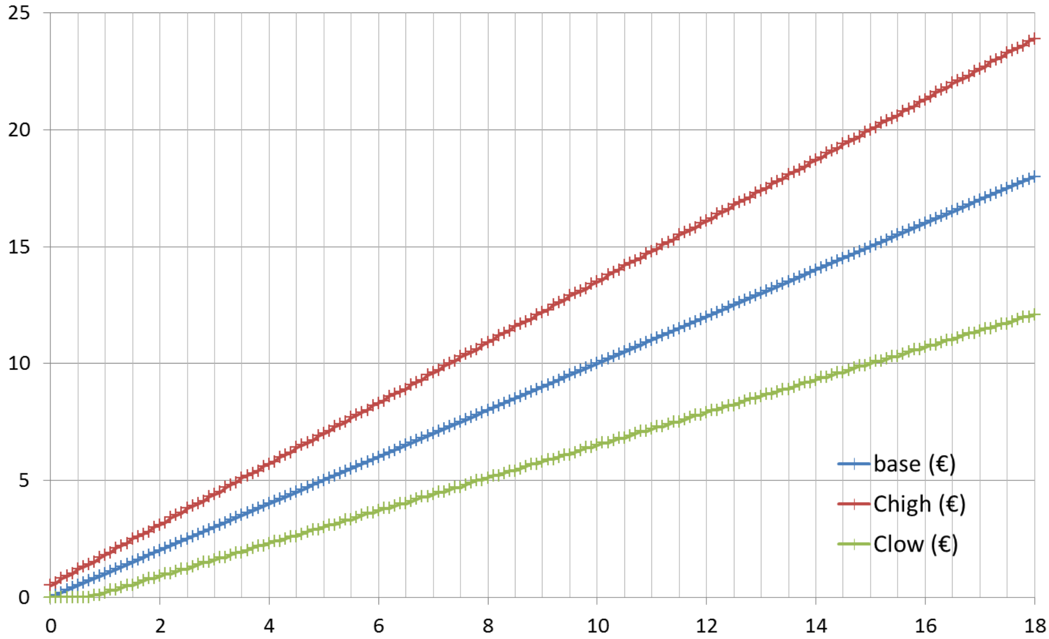


Figure 34: Trip cost functions used in the SP experiments

Concerning the duration value, it was selected among three possible values defined by the functions plotted in Figure 35: same trip duration of base mode and of car sharing (base), the base duration increased (Thigh) and the base duration decreased (Tlow).

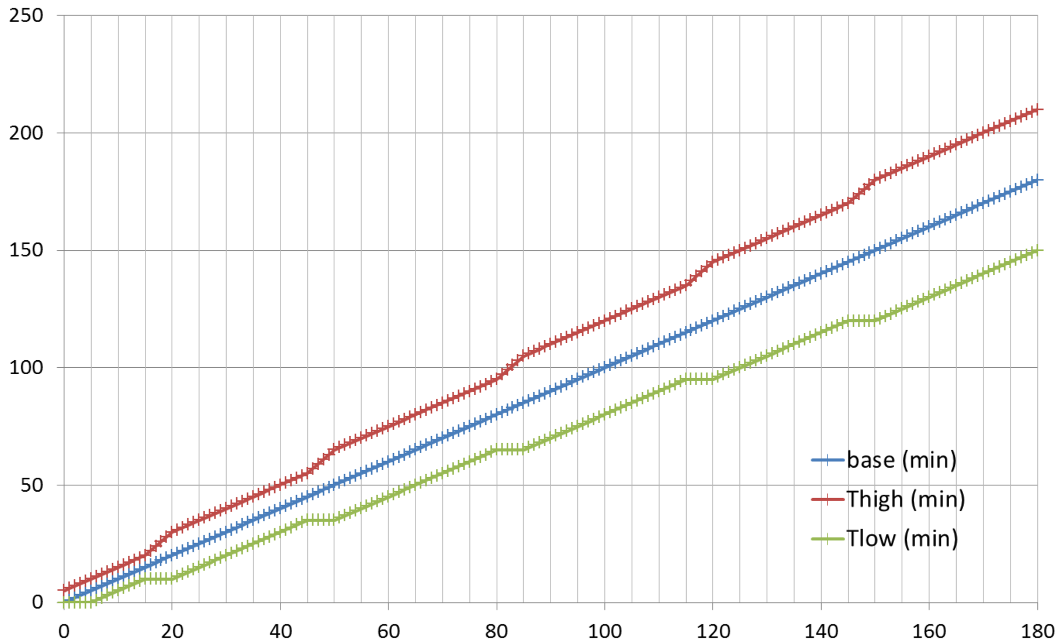


Figure 35: Trip duration functions used in the SP experiments

SP experiments results grouped by main transport modes used in the investigated trip - namely walk, bike, car and public transport - are presented in the following Figure 36, Figure 37, Figure 38 and Figure 39 respectively. In every figure the x-axle reports the time difference between car sharing and the reported used mode, while the y-axle reports the difference in terms of cost.

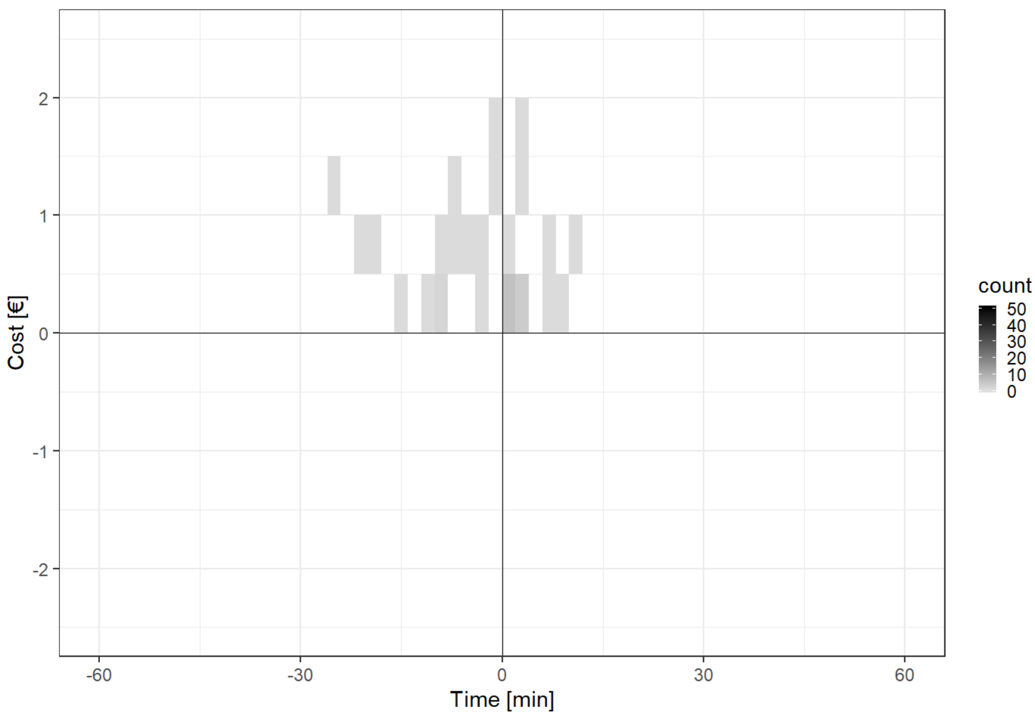


Figure 36: Positive switch from walking to car sharing coming from SP experiments

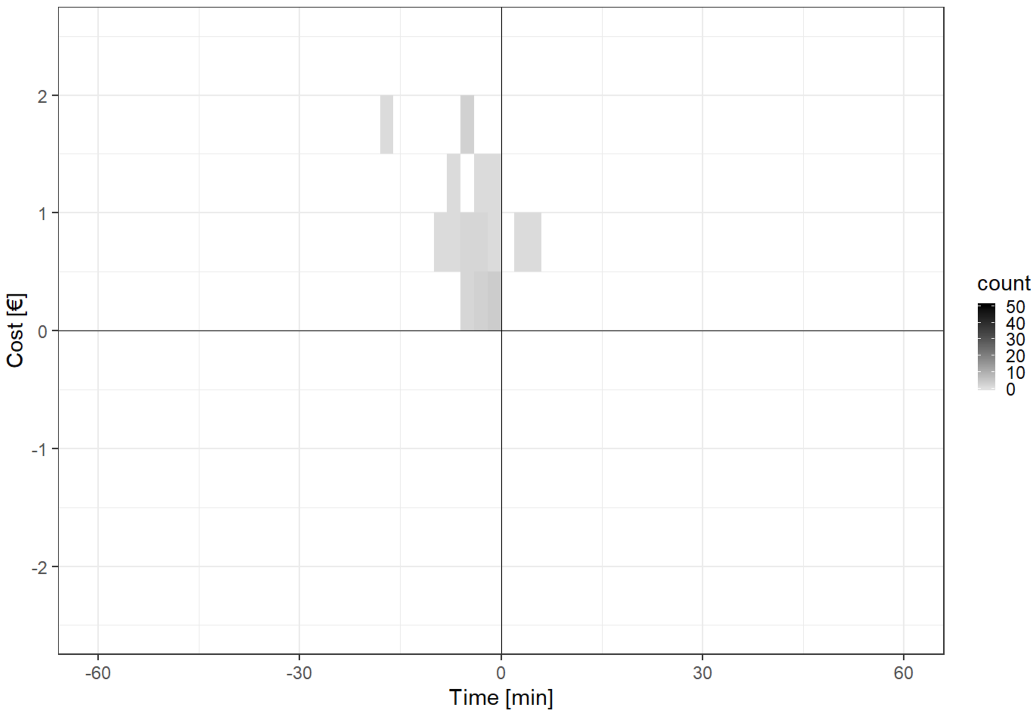


Figure 37: Positive switch from bike to car sharing coming from SP experiments

According to both Figure 36 and Figure 37 many respondents would switch from their current mode (walk or bike) towards car sharing if they could save time for the specific trip investigated. However there are also cases where respondents would change travel mean even if this solution would increase both the travel time and the cost. External elements not captured through SP experiments might influence these choices. Finally, as expected, there are no observations for negative difference between car sharing and non-motorised modes costs; the difference is always positive, since walk and bike trip have no cost from the respondents' point of view.

Switching intention from car towards car sharing resulting in the SP experiments are reported in Figure 38 below. Observations in left-down quadrant represent the situation where car sharing is perceived cheaper and time-saver compared to the private car, which were expectable. Some respondents would use car sharing instead of their private cars. Interestingly, some of them would use car sharing even if they spend more money and time. Here external conditions (such as the possibility to access to restricted areas, socioeconomic characteristics of the respondents, etc.) might have a stronger influence compared to cost and time.

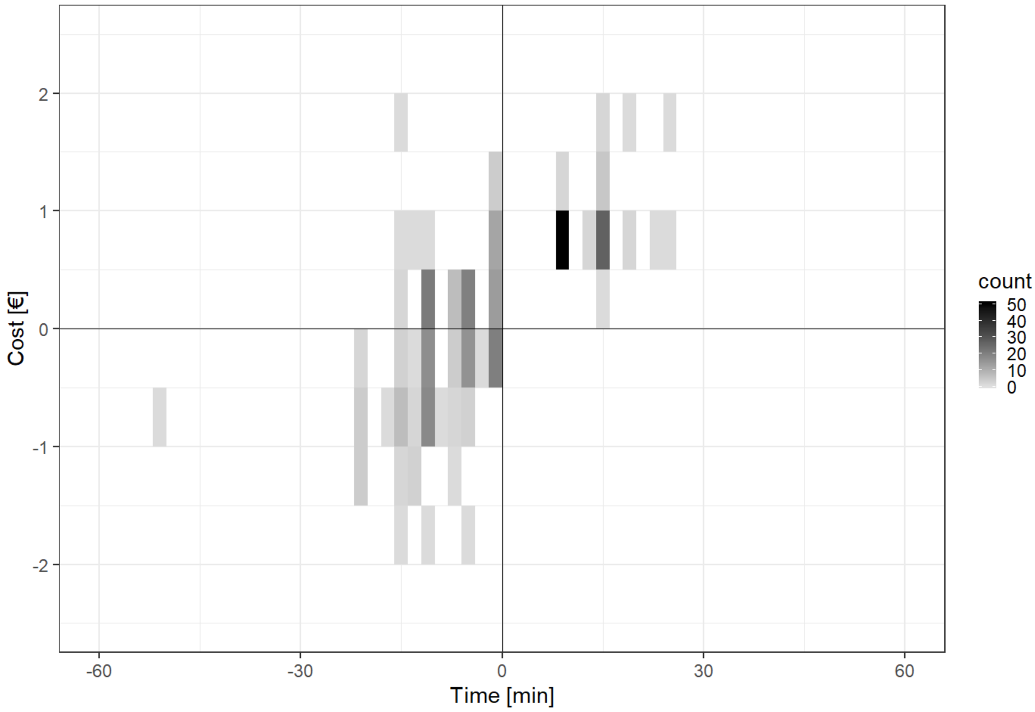


Figure 38: Positive switch from car to car sharing coming from SP experiments

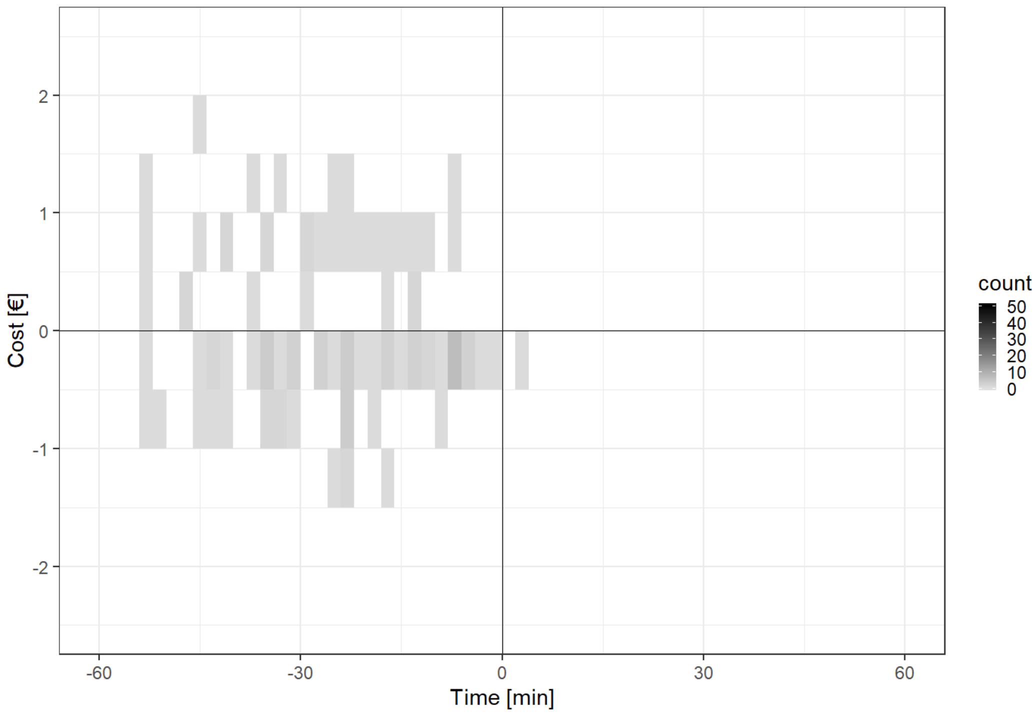


Figure 39: Positive switch from public transport to car sharing coming from SP experiments

Concerning the switching intention from public transport, Figure 39 shows that almost all respondents would use (for the investigated trip) car sharing instead of transit only if the former allowed them to save time independently from the cost.

Since the dependent variable of the problem was the "yes" or "no" answer given by respondents during SP experiments, switch models used in this study are based on discrete choice model. Among discrete choice models based on Random Utility Maximisation (Bierlaire, 1998), binomial logit models were applied. Those models were calibrated through a stepwise selection of the explanatory variables presented in Table 7 (par. 3.2). In particular a forward selection was used, therefore the model started with no variables and at in each step the addition of variable is tested using a chosen model fit criterion. The variable was added if produced the most statistically significant improvement of the calibration (fit). Adjusted R^2, Akaike and Bayesian information criterion were taken into account.

The significant explanatory variables retained through this procedure, for each switch model, are reported in the following tables.

Binomial logit estimation for switching intention from walk trips to car sharing

Name	Value	Std err	t-test	p-value	
B_AGE	-0.538	0.129	-4.160	3.15E-05	***
B_BASE_DUR	-0.059	0.023	-2.610	0.009	**
B_CS_COST	-0.859	0.501	-1.720	0.086	†
B_CS_WALK_DUR	-0.071	0.027	-2.680	0.007	**
B_HH_CAR	-1.240	0.401	-3.090	0.002	**
B_HH_CHILDREN_U	0.597	0.330	1.810	0.070	†
B_HH_WORKERS	0.754	0.281	2.690	0.007	**
Significance codes: *** p< 0.001; ** p< 0.01; * p< 0.05; † p<0.10					

Table 51: Walk to car sharing switching model - significant coefficients

Statistics	
Sample size:	347
Init log likelihood:	-240.52
Final log likelihood:	-74.61
Likelihood ratio test for the init. model:	331.83
Rho-square for the init. model:	0.69
Rho-square-bar for the init. model:	0.66
Akaike Information Criterion:	165.21
Bayesian Information Criterion:	196.01

Table 52: Walk to car sharing switching model - statistics

Binomial logit estimation for switching intention from bike trips to car sharing

Name	Value	Std err	t-test	p-value	
B_AGE	-0.042	0.014	-3.080	0.002	**
B_BASE_DIST	0.000	0.000	-1.680	0.094	†
B_BASE_WALK_DIST	-0.002	0.001	-1.710	0.087	†
B_CS_COST	-0.785	0.458	-1.720	0.086	†
B_D_NH	-1.600	1.000	-1.600	0.104	
B_F_CAR	0.108	0.039	2.790	0.005	**
B_F_PT	-0.055	0.032	-1.720	0.085	†
B_HH_CAR	-1.710	0.735	-2.330	0.020	*
B_HH_SIZE	0.954	0.416	2.290	0.022	*
B_HH_WORKERS	-1.380	0.607	-2.280	0.023	*
B_INCOME_AVG	0.769	0.428	1.800	0.072	†
B_PT_SEASON_TICKET	1.860	1.220	1.530	0.102	
Significance codes: *** p< 0.001; ** p< 0.01; * p< 0.05; † p<0.10					

Table 53: Bike to car sharing switching model - significant coefficients

Statistics	
Sample size:	12
Init log likelihood:	-54.76
Final log likelihood:	-39.00
Likelihood ratio test for the init. model:	31.51
Rho-square for the init. model:	0.29
Rho-square-bar for the init. model:	0.07
Akaike Information Criterion:	102.00
Bayesian Information Criterion:	130.44

Table 54: Bike to car sharing switching model - statistics

Binomial logit estimation for switching intention from car trips to car sharing

Name	Value	Std err	t-test	p-value	
B_AGE	-0.014	0.003	-4.290	0.000	***
B_BASE_COST	-0.318	0.094	-3.360	0.001	***
B_CARPERLICENCE	-0.748	0.222	-3.370	0.001	***
B_CS_COST	-0.522	0.113	-4.630	0.000	***
B_D_MP	0.377	0.148	2.550	0.011	*
B_F_BIKE	0.038	0.014	2.640	0.008	**
B_HH_CHILDREN_U	0.220	0.099	2.220	0.027	*
B_INCOME_AVG	0.147	0.052	2.830	0.005	**
B_ZTL_TO_AP	-1.360	0.745	-1.830	0.068	†
Significance codes: *** p< 0.001; ** p< 0.01; * p< 0.05; † p<0.10					

Table 55: Car to car sharing switching model - significant coefficients

Statistics	
Sample size:	1329
Init log likelihood:	-921.19
Final log likelihood:	-743.06
Likelihood ratio test for the init. model:	356.26
Rho-square for the init. model:	0.19
Rho-square-bar for the init. model:	0.18
Akaike Information Criterion:	1504.12
Bayesian Information Criterion:	1550.85

Table 56: Car to car sharing switching model - statistics

Binomial logit estimation for switching intention from public transport trips to car sharing

Name	Value	Std err	t-test	p-value	
B_AGE	-0.477	0.101	-4.71	0.000	***
B_BASE_COST	-0.401	0.197	-2.04	0.041	*
B_BASE_DIST	0.000	0.000	-2.00	0.046	*
B_BASE_WAIT	-0.032	0.018	-1.75	0.080	†
B_BIKE_SHARING	1.550	0.668	2.32	0.020	*
B_CARPERLICENCE	-0.853	0.404	-2.11	0.035	*
B_CS_COST	-0.387	0.170	-2.27	0.023	*
B_D_WAH	-0.925	0.432	-2.14	0.033	*
B_F_CAR	0.064	0.013	4.79	0.000	***
B_GENDER	-0.672	0.266	-2.53	0.011	*
B_NO_WORK_DAY	0.767	0.425	1.80	0.071	†
Significance codes: *** p< 0.001; ** p< 0.01; * p< 0.05; † p<0.10					

Table 57: PT to car sharing switching model - significant coefficients

Statistics	
Sample size:	538
Init log likelihood:	-372.91
Final log likelihood:	-214.15
Likelihood ratio test for the init. model:	317.53
Rho-square for the init. model:	0.43
Rho-square-bar for the init. model:	0.40
Akaike Information Criterion:	450.30
Bayesian Information Criterion:	497.46

Table 58: PT to car sharing switching model - statistics

Appendix 6: Demographic characteristics of the samples within the Italian case study

The main characteristics at household and individual level of the sample of the Italian case study are reported in Table 59 and Table 60 below. The former refers to the Milan sample whereas the latter to the Turin sample. Both tables report information of the general population (columns 2 and 3), of the respondents not members of a car sharing service (columns 4 and 5) and of the respondents who reported being car sharing members (last two columns).

	Entire sample		Non-users		Car sharing users	
	N	%	N	%	N	%
Totals	1038		553		485	
Household characteristics						
Household members	Avg 2.7	Sd 1.1	Avg 2.7	Sd 1.1	Avg 2.7	Sd 1.2
1	176	17.0%	89	16.1%	87	17.9%
2	299	28.8%	161	29.1%	138	28.4%
3	283	27.3%	158	28.6%	125	25.8%
4	233	22.4%	123	22.2%	110	22.7%
More than 4	47	4.5%	22	4.0%	25	5.1%
Licensed drivers	Avg 2	Sd 0.8	Avg 1.9	Sd 0.8	Avg 2.0	Sd 0.8
1	278	26.8%	141	25.5%	137	28.2%
2	547	52.7%	297	53.7%	250	51.5%
3	149	14.3%	72	13.0%	77	15.9%
4	58	5.6%	38	6.9%	20	4.1%
More than 4	6	0.6%	5	0.9%	1	0.2%
Household cars	Avg1.3	Sd0.7	Avg1.4	Sd0.7	Avg 1.2	Sd 0.7
0	77	7.4%	24	4.3%	53	10.9%
1	602	58.0%	309	55.9%	293	60.4%
2	308	29.7%	188	34.0%	120	24.7%
3	41	4.0%	29	5.2%	12	2.5%
More than 3	10	1.0%	3	0.5%	7	1.4%
Household car sharing members						
0	489	47.1%	489	88.4%	0	0.0%
1	334	32.2%	44	8.0%	290	59.8%
2	172	16.6%	15	2.7%	157	32.4%
3	34	3.3%	3	0.5%	31	6.4%
More than 3	9	0.9%	2	0.4%	7	1.4%
Household income [€/month]						
Less than 500	42	4.0%	15	2.7%	27	5.6%
500 - 1000	37	3.6%	19	3.4%	18	3.7%
1000 - 1500	93	9.0%	58	10.5%	35	7.2%

1500 - 2000	162	15.6%	90	16.3%	72	14.8%
2000 - 2500	133	12.8%	71	12.8%	62	12.8%
2500 - 3000	164	15.8%	86	15.6%	78	16.1%
3000 - 4000	183	17.6%	112	20.2%	71	14.6%
4000 - 5000	105	10.1%	50	9.0%	55	11.3%
5000 - 6000	40	3.8%	12	2.2%	28	5.8%
6000 - 10.000	38	3.7%	16	2.9%	22	4.5%
More than 10.000	41	4.0%	24	4.3%	17	3.5%
Individual characteristics						
Type of interview						
CAWI	383	36.9%	4	50.3%	105	21.6%
CATI	350	33.7%	5	49.7%	75	15.5%
CAWI (oversampling)	305	29.4%	0	0.0%	305	62.9%
Gender						
Male	535	51.5%	253	45.8%	282	58.1%
Female	503	48.5%	300	54.2%	203	41.9%
Age	Avg 46.9	Sd 14.8	Avg 51.7	Sd 15	Avg 41.4	Sd 12.5
18-24	70	6.7%	28	5.1%	42	8.7%
25-34	169	16.3%	55	10.0%	114	23.5%
35-44	273	26.3%	109	19.7%	164	33.8%
45-54	201	19.4%	114	20.65	87	17.9%
55-64	136	13.1%	88	15.9%	48	9.9%
Over 64	189	18.2%	159	28.7%	30	6.2%
Education level						
Not medium school graduate	6	0.6%	6	1.1%	0	0.0%
Medium school graduate	70	6.7%	46	8.3%	24	5.0%
High school graduate	483	46.5%	266	48.1%	217	44.7%
Degree or Ph.D.	479	46.2%	235	42.5%	244	50.3%
Occupational status						
Entrepreneur, manager	221	21.3%	82	14.8%	139	28.7%
Employee	577	55.6%	289	52.4%	288	59.4%
Student	44	4.2%	15	2.7%	29	6.0%
Retired	172	16.6%	149	26.9%	23	4.7%
Unemployed	24	2.3%	18	3.2%	6	1.2%
PT season ticket						
Yes	600	57.8%	262	47.4%	338	69.7%
No	438	42.2%	291	52.6%	147	30.3%
BS subscription						
Yes	312	30.1%	55	10.0%	257	53.0%
No	726	69.9%	498	90.0%	228	47.0%
Car sharing time membership					Avg 2.9	sd3.2

Less than 1 year	17	1.6%	0	0.0%	17	3.5%
From 1 up to 2 years	95	9.2%	0	0.0%	95	19.6%
From 2 up to 3 years	106	10.2%	0	0.0%	106	21.9%
From 3 up to 4 years	81	7.8%	0	0.0%	81	16.7%
From 4 up to 5 years	74	7.1%	0	0.0%	74	15.3%
From 5 up to 6 years	52	5.0%	0	0.0%	52	10.7%
More than 6 years	60	5.8%	0	0.0%	60	12.4%
Not member	553	53.3%	553	100.0%	0	0.0%

Table 59: Key demographic characteristics of the Milan respondents

	Entire sample		Non-users		Car sharing users	
	N	%	N	%	N	%
Totals	436		255		181	
Household characteristics						
Household members	Avg 2.6	Sd 1.1	Avg 2.6	Sd 1.1	Avg 1.4	Sd 0.6
1	80	18.4%	48	18.8%	32	17.7%
2	140	32.1%	83	32.6%	57	31.5%
3	110	25.2%	64	25.1%	46	25.4%
4	93	21.3%	55	21.6%	38	21.0%
More than 4	13	3.0%	5	2.0%	8	4.4%
Licensed drivers	Avg 2	Sd 0.8	Avg 1.9	Sd 0.8	Avg 2.1	Sd 0.9
1	117	26.8%	73	28.6%	44	24.3%
2	234	53.7%	139	54.5%	95	52.5%
3	55	12.6%	31	12.2%	24	13.3%
4	28	6.4%	11	4.3%	17	9.4%
More than 4	2	0.5%	1	0.4%	1	0.5%
Household cars	Avg1.4	Sd0.7	Avg1.4	Sd0.7	avg1.3	sd0.7
0	39	8.9%	21	8.2%	18	9.9%
1	227	52.1%	121	47.4%	106	58.6%
2	147	33.7%	96	37.6%	51	28.2%
3	19	4.4%	16	6.3%	3	1.7%
More than 3	4	0.9%	1	0.4%	3	1.7%
Household car sharing members						
0	230	52.8%	230	90.2%	0	0.0%
1	133	30.5%	20	7.8%	113	62.4%
2	64	14.7%	3	1.2%	61	33.7%
3	7	1.6%	1	0.4%	6	3.3%
More than 3	2	0.5%	1	0.4%	1	0.5%
Household income [€/month]						
Less than 500	13	3.0%	8	3.1%	5	2.8%
500 - 1000	29	6.6%	19	7.4%	10	5.5%

1000 - 1500	64	14.7%	40	15.7%	24	13.3%
1500 - 2000	76	17.4%	39	15.3%	37	20.4%
2000 - 2500	68	15.6%	38	14.9%	30	16.6%
2500 - 3000	70	16.1%	43	16.9%	27	14.9%
3000 - 4000	54	12.4%	34	13.3%	20	11.1%
4000 - 5000	24	5.5%	12	4.7%	12	6.6%
5000 - 6000	15	3.4%	10	3.9%	5	2.8%
6000 - 10.000	6	1.4%	4	1.6%	2	1.1%
More than 10.000	17	3.9%	8	3.1%	9	5.0%
Individual characteristics						
Type of interview						
CAWI	180	41.3%	140	54.9%	40	22.1%
CATI	157	36.0%	115	45.1%	42	23.2%
CAWI (oversampling)	99	22.7%	0	0.0%	99	54.7%
Gender						
Male	211	48.4%	115	45.1%	96	53.0%
Female	225	51.6%	140	54.9%	85	47.0%
Age	Avg 46.1	Sd 15.3	Avg 52	Sd 14.9	Avg 37.8	Sd 11.4
18-24	40	9.2%	14	5.5%	26	14.4%
25-34	87	20.0%	25	9.8%	62	34.2%
35-44	78	17.9%	37	14.5%	41	22.7%
45-54	94	21.6%	56	22.0%	38	21.0%
55-64	55	12.6%	45	17.6%	10	5.5%
Over 64	82	18.8%	78	30.6%	4	2.2%
Education level						
Not medium school graduate	1	0.2%	1	0.4%	0	0.0%
Medium school graduate	45	10.3%	30	11.8%	15	8.3%
High school graduate	207	47.5%	136	53.3%	71	39.2%
Degree or Ph.D.	183	42.0%	88	34.5%	95	52.5%
Occupational status						
Entrepreneur, manager	76	17.4%	40	15.7%	36	19.9%
Employee	238	54.6%	127	49.8%	111	61.3%
Student	31	7.1%	12	4.7%	19	10.5%
Retired	71	16.3%	65	25.5%	6	3.3%
Unemployed	20	4.6%	11	4.3%	9	5.0%
PT season ticket						
Yes	209	47.9%	97	38.0%	112	61.9%
No	227	52.1%	158	62.0%	69	38.1%
BS subscription						
Yes	104	23.8%	22	8.6%	82	45.3%
No	332	76.1%	223	91.4%	99	54.7%

Car sharing time membership					Avg 2.9	sd3.2
Less than 1 year	9	2.1%	0	0.0%	9	5,0%
From 1 up to 2 years	54	12.4%	0	0.0%	54	29,8%
From 2 up to 3 years	49	11.2%	0	0.0%	49	27,1%
From 3 up to 4 years	25	5.7%	0	0.0%	25	13,8%
From 4 up to 5 years	19	4.4%	0	0.0%	19	10,5%
More than 5 years	25	5.7%	0	0.0%	25	13.8%
Not member	255	58.5%	255	100.0%	0	0.5%

Table 60: Key demographic characteristics of the Turin respondents

Appendix 7: Test performed in person level analyses of the Italian case study

Differences in average values

Shapiro-Wilk normality test was firstly used to check if data is normally distributed. In case of normally distributed data T-test was conducted, while in case of not normally distributed data (Shapiro-Wilk p-value<0.05) Wilcoxon was used.

Full samples (CS members and non-members)

Milan

CSuser	n_interviewees	mean_HHcar	std_dev
0	553	1.42	0.684
1	485	1.23	0.730

```
Shapiro-Wilk normality test
      data:  MI_users$HHcar
      W = 0.7911, p-value < 2.2e-16
      data:  MI_Non-users$HHcar
      W = 0.794, p-value < 2.2e-16

Wilcoxon rank sum test with continuity correction
      data:  MI_users$HHcar and MI_Nusers$HHcar
      W = 114460, p-value = 3.848e-06
      alternative hypothesis: true location shift is not equal to 0
```

Turin

CSuser	n_interviewees	mean_HHcar	std_dev
0	255	1.43	0.749
1	181	1.27	0.728

```
Shapiro-Wilk normality test
      data:  TO_users$HHcar
      W = 0.79149, p-value = 8.568e-15
      data:  TO_Nusers$HHcar
      W = 0.84664, p-value = 3.478e-15

Wilcoxon rank sum test with continuity correction
      data:  TO_users$HHcar and TO_Nusers$HHcar
      W = 20020, p-value = 0.009194
      alternative hypothesis: true location shift is not equal to 0
```

Samples without car sharing members oversampling

Milan

CSuser	n_interviewees	mean_HHcar	std_dev
0	553	1.42	0.684
1	172	1.22	0.698

```
Welch Two Sample t-test
```

```
data:  HHcar by CSuser
t = 3.281, df = 299.18, p-value = 0.001157
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.07823862 0.31275997
sample estimates:
mean in group 0 mean in group 1
       1.417722        1.222222
```

Turin

```
CSuser n_interviewees mean_HHcar std_dev
0                255        1.43    0.749
1                 72        1.30    0.781

Wilcoxon rank sum test with continuity correction
      data:  TOusersHHcar$HHcar and TONOusersHHcar$HHcar
      W = 9285.5, p-value = 0.09479
      alternative hypothesis: true location shift is not equal to 0
```

Not oversampled members and control group

Milan

```
CSuser n_interviewees mean_HHcar std_dev
0                  180        1.4     0.698
1                  180        1.22    0.698

Welch Two Sample t-test
      data:  HHcar by CSuser
      t = 2.417, df = 358, p-value = 0.01615
      alternative hypothesis: true difference in means is not equal to 0
      95 percent confidence interval:
       0.03312773 0.32242782
      sample estimates:
      mean in group 0 mean in group 1
             1.400000        1.222222
```

Turin

```
CSuser n_interviewees mean_HHcar std_dev
0                 82        1.4     0.878
1                 82        1.29    0.781

Wilcoxon rank sum test with continuity correction
      data:  TOus$HHcar and TOControl$HHcar
      W = 2831.5, p-value = 0.05944
      alternative hypothesis: true location shift is not equal to 0
```

Pearson's Chi-squared test was firstly used to look for statistical significance in use frequency difference of each transport mode between groups (not oversampled members and control group non-members). Whether H0 hypothesis has been rejected (p-value <0.05), therefore there is at least

one significant difference, the two sample test for equality proportions has been applied for each use frequency.

Use frequency of transport means

Milan

```
Pearson's Chi-squared test
data:  Biketable
X-squared = 9.3886, df = 5, p-value = 0.09453

Pearson's Chi-squared test
data:  CarDrivertable
X-squared = 35.255, df = 5, p-value = 1.338e-06

      2-sample test for equality of proportions without continuity correction

      Frequency = Never
      data:  c(CarDtable[freq, 1], CarDtable[freq, 2]) out of c(sum(CarDtable[,
      1]), sum(CarDtable[, 2]))
      X-squared = 0.26028, df = 1, p-value = 0.6099
      alternative hypothesis: two.sided
      95 percent confidence interval:
       -0.04954017  0.08442389
      sample estimates:
         prop 1    prop 2
      0.1220930 0.1046512

      Frequency = More seldom
      data:  c(CarDtable[freq, 1], CarDtable[freq, 2]) out of c(sum(CarDtable[,
      1]), sum(CarDtable[, 2]))
      X-squared = 5.7525, df = 1, p-value = 0.01647
      alternative hypothesis: two.sided
      95 percent confidence interval:
       0.0165417 0.1578769
      sample estimates:
         prop 1    prop 2
      0.1744186 0.0872093

      Frequency = Few times a month
      data:  c(CarDtable[freq, 1], CarDtable[freq, 2]) out of c(sum(CarDtable[,
      1]), sum(CarDtable[, 2]))
      X-squared = 1.2679, df = 1, p-value = 0.2602
      alternative hypothesis: two.sided
      95 percent confidence interval:
       -0.02143699  0.07957653
      sample estimates:
          prop 1     prop 2
      0.07558140 0.04651163

      Frequency = 1-3 times/week
      data:  c(CarDtable[freq, 1], CarDtable[freq, 2]) out of c(sum(CarDtable[,
      1]), sum(CarDtable[, 2]))
      X-squared = 9.7675, df = 1, p-value = 0.001776
      alternative hypothesis: two.sided
      95 percent confidence interval:
       0.05771974 0.24460584
      sample estimates:
         prop 1    prop 2
      0.3546512 0.2034884

      Frequency = 4-6 times/week
      data:  c(CarDtable[freq, 1], CarDtable[freq, 2]) out of c(sum(CarDtable[,
      1]), sum(CarDtable[, 2]))
      X-squared = 0.2301, df = 1, p-value = 0.6314
      alternative hypothesis: two.sided
```

```
        95 percent confidence interval:
         -0.08868400  0.05380028
        sample estimates:
           prop 1    prop 2
        0.1220930 0.1395349

        Frequency = Daily
        data:  c(CarDtable[freq, 1], CarDtable[freq, 2]) out of c(sum(CarDtable[,
        1]), sum(CarDtable[, 2]))
        X-squared = 30.193, df = 1, p-value = 3.91e-08
        alternative hypothesis: two.sided
        95 percent confidence interval:
         -0.3585533 -0.1763304
        sample estimates:
           prop 1    prop 2
        0.1511628 0.4186047

Pearson's Chi-squared test
data:  CarPassengertable
X-squared = 3.6412, df = 5, p-value = 0.6021

Pearson's Chi-squared test
data:  PTtable
X-squared = 20.005, df = 5, p-value = 0.001247

        2-sample test for equality of proportions without continuity correction

        Frequency = Never
        data:  c(PTtable[freq, 1], PTtable[freq, 2]) out of c(sum(PTtable[, 1]), s
        um(PTtable[, 2]))
        X-squared = 6.5549, df = 1, p-value = 0.01046
        alternative hypothesis: two.sided
        95 percent confidence interval:
         -0.1022214 -0.0140577
        sample estimates:
            prop 1     prop 2
        0.01744186 0.07558140

        Frequency = More seldom
        data:  c(PTtable[freq, 1], PTtable[freq, 2]) out of c(sum(PTtable[, 1]), s
        um(PTtable[, 2]))
        X-squared = 1.7357, df = 1, p-value = 0.1877
        alternative hypothesis: two.sided
        95 percent confidence interval:
         -0.1155309  0.0225076
        sample estimates:
            prop 1     prop 2
        0.09883721 0.14534884

        Frequency = Few times a month
        data:  c(PTtable[freq, 1], PTtable[freq, 2]) out of c(sum(PTtable[, 1]), s
        um(PTtable[, 2]))
        X-squared = 5.1797, df = 1, p-value = 0.02285
        alternative hypothesis: two.sided
        95 percent confidence interval:
         -0.16174509 -0.01267352
        sample estimates:
           prop 1    prop 2
        0.1046512 0.1918605

        Frequency = 1-3 times/week
        data:  c(PTtable[freq, 1], PTtable[freq, 2]) out of c(sum(PTtable[, 1]), s
        um(PTtable[, 2]))
        X-squared = 0.29998, df = 1, p-value = 0.5839
        alternative hypothesis: two.sided
        95 percent confidence interval:
         -0.05992925  0.10644088
        sample estimates:
```

```
      prop 1    prop 2
0.2034884 0.1802326

Frequency = 4-6 times/week
data:  c(PTtable[freq, 1], PTtable[freq, 2]) out of c(sum(PTtable[, 1]), s
um(PTtable[, 2]))
X-squared = 0, df = 1, p-value = 1
alternative hypothesis: two.sided
95 percent confidence interval:
 -0.07912932  0.07912932
sample estimates:
   prop 1    prop 2
0.1686047 0.1686047

Frequency = Daily
data:  c(PTtable[freq, 1], PTtable[freq, 2]) out of c(sum(PTtable[, 1]), s
um(PTtable[, 2]))
X-squared = 11.186, df = 1, p-value = 0.0008242
alternative hypothesis: two.sided
95 percent confidence interval:
 0.07141916 0.26579014
sample estimates:
   prop 1    prop 2
0.4069767 0.2383721
```

```
Pearson's Chi-squared test
data:  Taxitable
X-squared = 12.237, df = 5, p-value = 0.03168

      2-sample test for equality of proportions without continuity correction

      Frequency = Never
      data:  c(Taxitable[freq, 1], Taxitable[freq, 2]) out of c(sum(Taxitable[,
      1]), sum(Taxitable[, 2]))
      X-squared = 7.9475, df = 1, p-value = 0.004815
      alternative hypothesis: two.sided
      95 percent confidence interval:
       -0.25503561 -0.04728997
      sample estimates:
         prop 1    prop 2
      0.3720930 0.5232558

      Frequency = More seldom
      data:  c(Taxitable[freq, 1], Taxitable[freq, 2]) out of c(sum(Taxitable[,
      1]), sum(Taxitable[, 2]))
      X-squared = 0.46824, df = 1, p-value = 0.4938
      alternative hypothesis: two.sided
      95 percent confidence interval:
       -0.06496467  0.13473211
      sample estimates:
         prop 1    prop 2
      0.3546512 0.3197674

      Frequency = Few times a month
      data:  c(Taxitable[freq, 1], Taxitable[freq, 2]) out of c(sum(Taxitable[,
      1]), sum(Taxitable[, 2]))
      X-squared = 1.2404, df = 1, p-value = 0.2654
      alternative hypothesis: two.sided
      95 percent confidence interval:
       -0.02639481  0.09616225
      sample estimates:
         prop 1    prop 2
      0.1104651 0.0755814

      Frequency = 1-3 times/week
      data:  c(Taxitable[freq, 1], Taxitable[freq, 2]) out of c(sum(Taxitable[,
      1]), sum(Taxitable[, 2]))
      X-squared = 4.856, df = 1, p-value = 0.02755
```

```
alternative hypothesis: two.sided
95 percent confidence interval:
 0.006795199 0.109483870
sample estimates:
    prop 1     prop 2
0.09302326 0.03488372

Frequency = 4-6 times/week
data:  c(Taxitable[freq, 1], Taxitable[freq, 2]) out of c(sum(Taxitable[,
1]), sum(Taxitable[, 2]))
X-squared = 0.069706, df = 1, p-value = 0.7918
alternative hypothesis: two.sided
95 percent confidence interval:
 -0.03734193  0.04896984
sample estimates:
    prop 1     prop 2
0.04651163 0.04069767

Frequency = Daily
data:  c(Taxitable[freq, 1], Taxitable[freq, 2]) out of c(sum(Taxitable[,
1]), sum(Taxitable[, 2]))
X-squared = 1.8265, df = 1, p-value = 0.1765
alternative hypothesis: two.sided
95 percent confidence interval:
 -0.007785349  0.042669070
sample estimates:
     prop 1      prop 2
0.023255814 0.005813953
```

```
Pearson's Chi-squared test
data:  Walktable
X-squared = 9.2638, df = 5, p-value = 0.09899
```

Turin

```
Pearson's Chi-squared test
data:  Biketable
X-squared = 2.6976, df = 5, p-value = 0.7465

Pearson's Chi-squared test
data:  CarDtable
X-squared = 3.7426, df = 5, p-value = 0.587

Pearson's Chi-squared test
data:  CarPtable
X-squared = 4.9558, df = 5, p-value = 0.4213

Pearson's Chi-squared test
data:  PTtable
X-squared = 8.7897, df = 5, p-value = 0.1178

Pearson's Chi-squared test
data:  Taxitable
X-squared = 2.0429, df = 5, p-value = 0.843

Pearson's Chi-squared test
data:  Walktable
X-squared = 5.0191, df = 5, p-value = 0.4136
```

Ownership PT season ticket

Milan

```
Pearson's Chi-squared test with Yates' continuity correction
```

```
data:  PTownTable
X-squared = 6.0696, df = 1, p-value = 0.01375

	2-sample test for equality of proportions without continuity correction

	data:  c(PTownTable[freq, 1], PTownTable[freq, 2]) out of c(sum(PTownTable
	[, 1]), sum(PTownTable[, 2]))
	X-squared = 6.6089, df = 1, p-value = 0.01015
	alternative hypothesis: two.sided
	95 percent confidence interval:
	 -0.23404962 -0.03261705
	sample estimates:
	   prop 1    prop 2
	0.3444444 0.4777778
```

Turin

```
Pearson's Chi-squared test with Yates' continuity correction
data:  PTownTable
X-squared = 1.5631, df = 1, p-value = 0.2112
```

<u>Bike sharing membership</u>

Milan

```
Pearson's Chi-squared test with Yates' continuity correction
data:  BStable
X-squared = 60.022, df = 1, p-value = 9.379e-15

	2-sample test for equality of proportions without continuity correction

	data:  c(BStable[freq, 1], BStable[freq, 2]) out of c(sum(BStable[, 1]), s
	um(BStable[, 2]))
	X-squared = 61.827, df = 1, p-value = 3.749e-15
	alternative hypothesis: two.sided
	95 percent confidence interval:
	 -0.4634770 -0.2920786
	sample estimates:
	   prop 1    prop 2
	0.5166667 0.8944444
```

Turin

```
Pearson's Chi-squared test with Yates' continuity correction
data:  BStable
X-squared = 19.413, df = 1, p-value = 1.053e-05

	2-sample test for equality of proportions without continuity correction

	data:  c(BStable[freq, 1], BStable[freq, 2]) out of c(sum(BStable[, 1]), s
	um(BStable[, 2]))
	X-squared = 20.997, df = 1, p-value = 4.6e-06
	alternative hypothesis: two.sided
	95 percent confidence interval:
	 -0.4437158 -0.1904305
	sample estimates:
	   prop 1    prop 2
	0.5731707 0.8902439
```

Appendix 8: Important car sharing features for current non-members

Car sharing offer improvement: to what extent the following car sharing features would entice you in using the service? (Q27b)

Improvement	Scale	Milan (n=553)		Turin (n=255)		Flanders region (n=985)	
Possibility of booking a parking space at destination to avoid looking for parking	1	91	16.5%	54	21.2%	243	24.7%
	2	57	10.3%	16	6.3%	118	12.0%
	3	111	20.1%	54	21.2%	195	19.8%
	4	134	24.2%	57	22.4%	262	26.6%
	5	160	28.9%	74	29.0%	166	16.9%
Possibility of free parking in any parking space without limitations	1	62	11.2%	38	14.9%	240	24.4%
	2	39	7.0%	10	3.9%	115	11.7%
	3	96	17.4%	36	14.1%	178	18.1%
	4	118	21.3%	63	24.7%	211	21.4%
	5	238	43.0%	108	42.4%	241	24.5%
Increased availability of cars	1	86	15.6%	50	19.6%	248	25.2%
	2	73	13.2%	14	5.5%	112	11.4%
	3	149	26.9%	77	30.2%	190	19.3%
	4	130	23.5%	56	22.0%	259	26.3%
	5	115	20.8%	58	22.8%	176	17.9%
Availability of different car models	1	143	25.9%	75	29.4%	280	28.4%
	2	111	20.1%	42	16.5%	201	20.4%
	3	159	28.7%	79	31.0%	201	20.4%
	4	87	15.7%	37	14.5%	216	21.9%
	5	53	9.6%	22	8.6%	88	8.9%
Availability of cars whenever I want	1	64	11.6%	36	14.1%	235	23.9%
	2	45	8.1%	14	5.5%	82	8.3%
	3	113	20.4%	51	20.0%	174	17.7%
	4	145	26.2%	60	23.5%	248	25.2%
	5	186	33.6%	94	36.9%	244	24.8%
Greater extension of the operating area and/or diffusion of the stations (charging stations in case of electric car sharing)	1	65	11.8%	42	16.5%	251	25.5%
	2	52	9.4%	16	6.3%	143	14.5%
	3	133	24.1%	56	22.0%	226	22.9%
	4	144	26.0%	57	22.4%	243	24.7%
	5	159	28.7%	84	32.9%	122	12.4%
More stations (charging stations in case of electric car sharing) within the area currently served	1	60	10.8%	42	16.5%	253	25.7%
	2	60	10.8%	22	8.6%	140	14.2%
	3	142	25.7%	63	24.7%	225	22.8%
	4	151	27.3%	58	22.8%	240	24.4%
	5	140	25.3%	70	27.5%	126	12.8%
Increased availability of reserved parking spaces near	1	72	13.0%	45	17.6%	256	26.0%
	2	53	9.6%	16	6.3%	145	14.7%

interchange points (train station, metro stations, bus terminal)	3	134	24.2%	65	25.5%	215	21.8%
	4	146	26.4%	72	28.2%	226	22.9%
	5	148	26.8%	57	22.4%	143	14.5%
Possibility of parking inside guarded areas or in underground car parks	1	66	11.9%	50	19.6%	243	24.7%
	2	71	12.8%	19	7.4%	152	15.4%
	3	157	28.4%	63	24.7%	200	20.3%
	4	132	23.9%	55	21.6%	241	24.5%
	5	127	23.0%	68	26.7%	150	15.2%
Increased visibility of parking areas and parking areas dedicated in public spaces	1	63	11.4%	45	17.6%	247	25.1%
	2	64	11.6%	26	10.2%	154	15.6%
	3	171	30.9%	74	29.0%	208	21.1%
	4	155	28.0%	68	26.7%	250	25.4%
	5	100	18.1%	42	16.5%	126	12.8%
Better connection with public transport stops	1	63	11.4%	44	17.2%	264	26.8%
	2	70	12.7%	25	9.8%	148	15.0%
	3	139	25.1%	75	29.4%	220	22.3%
	4	144	26.0%	66	25.9%	225	22.8%
	5	137	24.8%	45	17.6%	128	13.0%
Possibility of booking a car hours or days in advance	1	64	11.6%	47	18.4%	272	27.6%
	2	65	11.8%	22	8.6%	133	13.5%
	3	127	23.0%	66	25.9%	195	19.8%
	4	155	28.0%	62	24.3%	222	22.5%
	5	142	25.7%	58	22.8%	164	16.6%
Greater simplicity in booking procedures	1	66	11.9%	39	15.3%	260	26.4%
	2	47	8.5%	15	5.9%	131	13.3%
	3	140	25.3%	75	29.4%	260	26.4%
	4	165	29.8%	64	25.1%	224	22.7%
	5	135	24.4%	62	24.3%	110	11.2%
Service provider's telephone assistance 24/7	1	61	11.0%	38	14.9%	266	27.0%
	2	57	10.3%	20	7.8%	131	13.3%
	3	142	25.7%	62	24.3%	218	22.1%
	4	153	27.7%	70	27.5%	232	23.6%
	5	140	25.3%	65	25.5%	137	13.9%
Useful and timely information on new offers and changes in terms of use	1	69	12.5%	46	18.0%	285	28.9%
	2	67	12.1%	24	9.4%	178	18.1%
	3	192	34.7%	82	32.2%	233	23.7%
	4	127	23.0%	64	25.1%	204	20.7%
	5	98	17.7%	39	15.3%	85	8.6%
Discount for longer renting periods (e.g. more than a couple of hours or a day)	1	69	12.5%	44	17.2%	277	28.1%
	2	49	8.9%	21	8.2%	142	14.4%
	3	123	22.2%	59	23.1%	225	22.8%
	4	144	26.0%	56	22.0%	213	21.6%
	5	168	30.4%	75	29.4%	129	13.1%
Discount for shorter renting periods (e.g. less than 1-2 hour)	1	64	11.6%	41	16.1%	295	29.9%
	2	43	7.8%	14	5.5%	172	17.5%
	3	139	25.1%	54	21.2%	228	23.1%

	4	138	24.9%	68	26.7%	188	19.1%
	5	169	30.6%	78	30.6%	103	10.5%
Ease of use of the car	1	62	11.2%	50	19.6%	245	24.9%
	2	62	11.2%	16	6.3%	104	10.6%
	3	155	28.0%	63	24.7%	170	17.3%
	4	136	24.6%	67	26.3%	284	28.8%
	5	138	24.9%	59	23.1%	182	18.5%
Car equipped with child seats	1	202	36.5%	107	42.0%	395	40.1%
	2	79	14.3%	27	10.6%	202	20.5%
	3	123	22.2%	62	24.3%	243	24.7%
	4	73	13.2%	32	12.6%	106	10.8%
	5	76	13.7%	27	10.6%	39	4.0%
Possibility of transporting animals	1	216	39.1%	102	40.0%	443	45.0%
	2	79	14.3%	22	8.6%	200	20.3%
	3	110	19.9%	59	23.1%	209	21.2%
	4	85	15.4%	41	16.1%	93	9.4%
	5	63	11.4%	31	12.2%	40	4.1%
Possibility of transporting bicycles	1	233	42.1%	107	42.0%	322	32.7%
	2	88	15.9%	41	16.1%	202	20.5%
	3	129	23.3%	60	23.5%	205	20.8%
	4	66	11.9%	29	11.4%	181	18.4%
	5	37	6.7%	18	7.1%	75	7.6%
Design and car-look	1	231	41.8%	107	42.0%	337	34.2%
	2	100	18.1%	46	18.0%	239	24.3%
	3	133	24.1%	60	23.5%	202	20.5%
	4	66	11.9%	27	10.6%	166	16.9%
	5	23	4.2%	15	5.9%	40	4.1%
Vehicles with upgraded technical and technological equipment, e.g. air conditioning, navigation, Bluetooth etc.	1	100	18.1%	54	21.2%	265	26.9%
	2	64	11.6%	23	9.0%	153	15.5%
	3	158	28.6%	71	27.8%	181	18.4%
	4	133	24.1%	67	26.3%	253	25.7%
	5	98	17.7%	40	15.7%	133	13.5%
Internal and external car conditions and cleanliness	1	65	11.8%	43	16.9%	249	25.3%
	2	44	8.0%	15	5.9%	113	11.5%
	3	143	25.9%	58	22.8%	179	18.2%
	4	144	26.0%	67	26.3%	251	25.5%
	5	157	28.4%	72	28.2%	192	19.5%
Assistance in case of breakdowns or damages	1	56	10.1%	35	13.7%	261	26.5%
	2	42	7.6%	13	5.1%	109	11.1%
	3	97	17.5%	42	16.5%	207	21.0%
	4	125	22.6%	67	26.3%	232	23.6%
	5	233	42.1%	98	38.4%	174	17.7%

Table 61: Features that would entice respondents to become car sharing member

Appendix 9: Additional material used in the evaluation of greenhouse and pollutants emissions

European emission standards and CO_2 emissions of vehicles composing car sharing fleets in Milan and Turin that were considered in the estimation of weighted averaged coefficients used in this study are reported in Table 62 below.

City	Number of cars[46]	Type of engine	Car models[47]	Directive	CO_2 exhaust emission [g/km][48]
Milan	727	Electric	-	-	0
Milan	2040	Conventional	FIAT 500 1.2	EURO 6	108
			SMART fortwo	EURO 6	94
			SMART forfour	EURO 6	130
			SMART fortwo Cabrio	EURO 6	120
			BMW Active Tourer	EURO 6	114
			BMW Serie 2 Cabrio	EURO 6	118
			BMW Serie 1	EURO 6	109
			MINI 3 Porte	EURO 6	107
			MINI Cabrio	EURO 6	123
			MINI 5 Porte	EURO 6	109
			MINI Clubman	EURO 6	123
Turin	187	Electric	-	-	0
Turin	721	Conventional	FIAT 500 1.2	EURO 6	108
			SMART fortwo	EURO 6	94
			SMART forfour	EURO 6	130
			SMART fortwo Cabrio	EURO 6	120

Table 62: Car sharing fleet composition in Milan and Turin

[46] From "3° Rapporto Nazionale sulla Sharing Mobility" (Ciuffini et al., 2019)
[47] From car sharing operators webistes – Accessed November 29th, 2019
[48] https://www.terraup.it/auto - Accessed November 29th, 2019

Private car fleet segmentation by EU emission standards and type of fuel in Milan and Turin.

City	EURO	Petrol	LNG	CNG	EV	Diesel	Hybrid		ND	Total
							petrol	diesel		
Milan	0	62407	2168	231	0	10821	0	0	109	75736
	1	13761	540	43	0	2103	0	0	3	16450
	2	38641	1343	108	0	6915	0	0	6	47013
	3	38957	1034	161	0	25871	0	3	1	66027
	4	110840	14546	2259	0	55529	661	0	0	183835
	5	64281	7705	1698	0	65831	3518	124	0	143157
	6	73158	5137	1142	0	70524	9711	115	0	159787
	NC[49]	0	0	0	635	0	0	0	0	635
	NA[50]	425	2	1	0	7	0	0	9	444
Total		**402470**	**32475**	**5643**	**635**	**237601**	**13890**	**242**	**128**	**693084**
Turin	0	38903	2717	102	0	7043	0	0	12	48777
	1	7908	729	21	0	1541	0	0	0	10199
	2	30255	2601	77	0	6177	0	0	0	39110
	3	35484	1938	308	0	24216	0	0	0	61946
	4	71053	17919	4889	0	47238	129	0	0	141228
	5	34012	10866	1945	0	46527	834	34	1	94219
	6	60716	17780	2252	0	95052	4484	36	0	180320
	NC	0	0	0	385	0	0	0	0	385
	NA	376	2	1	0	2	0	0	6	387
Total		**278707**	**54552**	**9595**	**385**	**227796**	**5447**	**70**	**19**	**576571**

Table 63: Private car fleet classification by EU emission standards and type of fuel [source: http://www.opv.aci.it/WEBDMCircolante/]

Average emission factors used in this document are reported in the below Table 64. These coefficients are obtained by averaging the factors reported in "*Table 3-17: Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i*" (Ntziachristos et al., 2018) per passenger cars categories (namely Small, Medium and Large-SUV-Executive).

49 Not Classified
50 Not Available

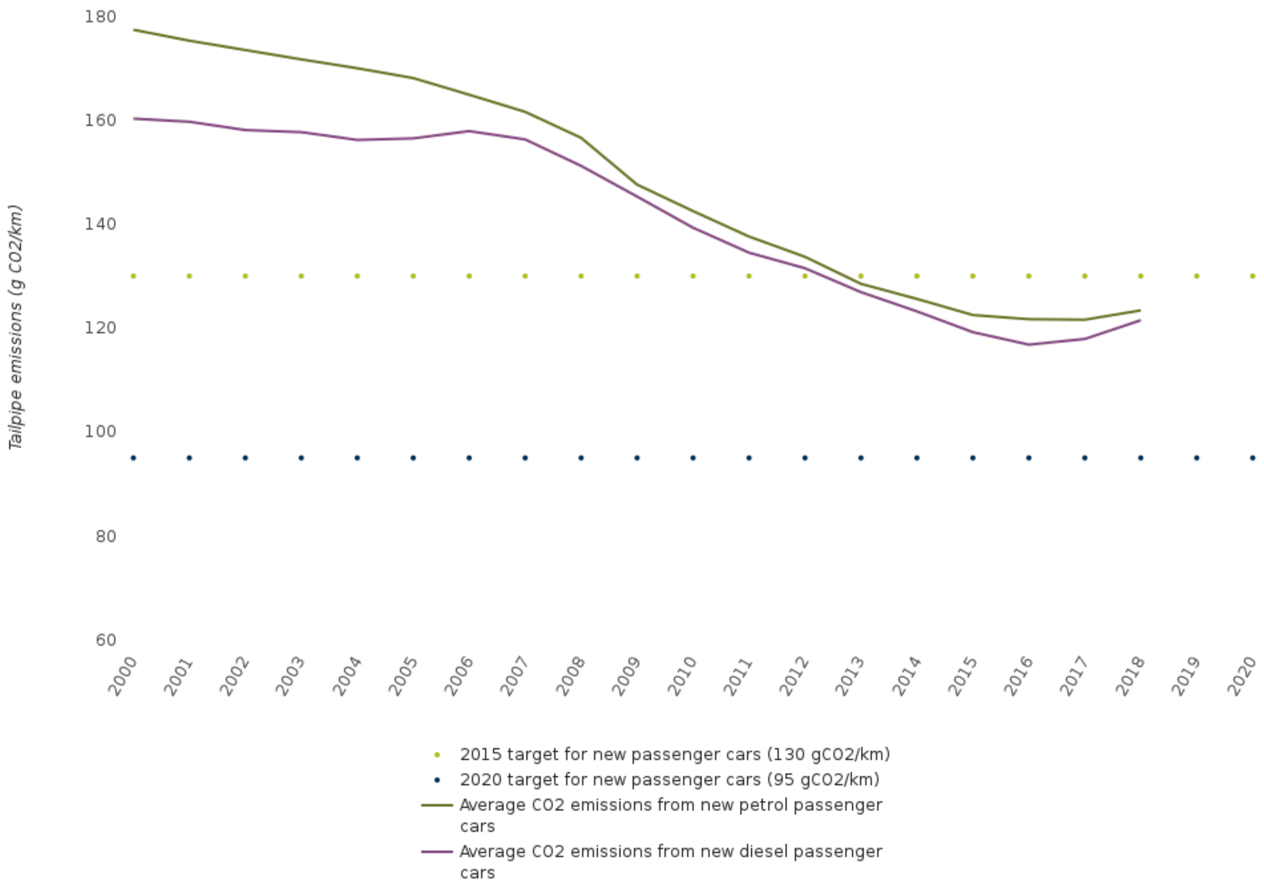
Stage	Directive	CO	NMVOC	NO_x	NH_3	$PM_{2,5}$
		g/km	g/km	g/km	g/km	g/km
Petrol						
Euro 0	ECE 15/04	13.300	1.680	2.543	0.002	0.002
Euro 1	91/441/EEC	4.070	0.476	0.459	0.092	0.002
Euro 2	94/12/EEC	2.043	0.218	0.242	0.104	0.002
Euro 3	98/69/EC I	1.797	0.099	0.093	0.034	0.001
Euro 4	98/69/EC II	0.613	0.054	0.059	0.034	0.001
Euro 5	EC 715/2007	0.613	0.054	0.059	0.012	0.001
Euro 6	2014.09	0.613	0.054	0.059	0.012	0.001
Diesel						
Euro 0	ECE 15/04	0.688	0.159	0.762	0.001	0.221
Euro 1	91/441/EEC	0.414	0.062	0.690	0.001	0.084
Euro 2	94/12/EEC	0.296	0.078	0.716	0.001	0.055
Euro 3	98/69/EC I	0.089	0.031	0.771	0.001	0.039
Euro 4	98/69/EC II	0.092	0.014	0.580	0.001	0.031
Euro 5	EC 715/2007	0.043	0.009	0.550	0.002	0.002
Euro 6	2014.09	0.046	0.009	0.350	0.002	0.002

Table 64: Exhaust emission factors for passenger cars

Car fleet registration	Turin	Milan
From 0 to 1 year	64395	46489
From 1 to 2 years	65674	44835
From 2 to 5 years	71691	100744
From 5 to 10 years	110481	159881
From 10 to 15 years	115982	143964
From 15 to 20 years	68601	81495
From 20 to 30 years	40711	55516
From 30 to 40 years	19072	34457
More than 40 years	19157	23610
Not defined	807	2093
Total	**576571**	**693084**

Table 65: Private cars composition in Milan and Turin in 2018 by year of registration[51]

[51] http://www.opv.aci.it/WEBDMCircolante/ - Accessed November 29th, 2019



Notes:
- g CO2/km: grammes of carbon dioxide per km.
- 2015 target for new passenger cars: 130 g CO2/km.
- 2020 target for new passenger cars: 95 g CO2/km.

Data sources: Monitoring of CO2 emissions from passenger cars – Regulation 443/2009 provided by European Environment Agency (EEA)

Figure 40: Average CO_2 emissions from new passenger cars

Appendix 10: Costs evaluation of different mobility scenarios

In order to evaluate the potential effects of an increase of both car sharing and parking costs on diverted trips to car sharing from different modes, the two costs were both varied in a range from 0% (all switch scenario) up to 100% of increase with 5% increasing steps.

As a result, a 21x21 matrix of possible scenarios was created. Travelled distances, the quantity of each pollutant analysed in this study, greenhouse gas and respective costs have been evaluated for each scenario. Then, to identify the maximum impact (or rupture) scenario, a cost evaluation of the related externalities was carried out by considering the coefficients reported in par. 3.4.2.

Costs related to each pollutant and greenhouse gas and their difference with the BAU scenario are reported from Figure 41 to Figure 50 for the city of Milan and from Figure 53 to Figure 62 for Turin. It can be noted that the minimum cost deriving from each pollutant/greenhouse gas not necessarily represents the minimum cost in the overall situation.

Finally, the monetary cost of greenhouse and pollutants emissions for the society was summed up for each scenario. The rupture scenario was identified as the scenario that minimises the costs for the society, therefore maximising the positive difference of the gap analysis (BAU – rupture) which are indicated in Figure 52 for the city of Milan and Figure 64 for Turin.

Car sharing cost increase [%]	Parking cost increase [%] 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	342153	341995	341837	341693	341570	341471	341393	341332	341283	341243	341207	341175	341145	341116	341087	341058	341029	341000	340970	340939	340908
5	341686	341543	341387	341232	341089	340968	340871	340794	340735	340688	340650	340616	340586	340558	340531	340505	340478	340451	340424	340397	340369
10	341374	341255	341115	340962	340808	340667	340547	340451	340376	340319	340273	340237	340205	340177	340151	340126	340102	340077	340053	340028	340003
15	341140	341046	340930	340792	340642	340490	340350	340231	340136	340063	340007	339963	339928	339898	339872	339848	339825	339802	339780	339757	339734
20	340953	340880	340789	340676	340541	340392	340242	340103	339985	339891	339819	339764	339721	339688	339660	339635	339613	339591	339571	339550	339530
25	340800	340744	340675	340586	340475	340343	340196	340046	339909	339792	339699	339627	339573	339532	339500	339473	339450	339429	339410	339391	339372
30	340677	340632	340579	340513	340427	340318	340188	340042	339894	339757	339641	339549	339478	339425	339385	339354	339328	339307	339287	339269	339252
35	340580	340542	340501	340451	340387	340303	340197	340068	339924	339777	339641	339525	339433	339363	339311	339271	339241	339217	339197	339179	339162
40	340507	340472	340438	340399	340352	340290	340208	340103	339976	339834	339688	339552	339437	339345	339276	339224	339186	339156	339133	339114	339097
45	340454	340420	340389	340358	340321	340276	340216	340136	340033	339907	339766	339621	339486	339370	339279	339210	339159	339121	339093	339071	339052
50	340416	340382	340352	340324	340295	340261	340217	340159	340081	339979	339855	339714	339570	339435	339320	339229	339160	339110	339073	339045	339023
55	340391	340354	340324	340297	340272	340245	340213	340171	340114	340037	339937	339814	339675	339531	339397	339282	339191	339122	339072	339035	339008
60	340376	340335	340302	340276	340252	340230	340205	340174	340133	340078	340002	339904	339782	339643	339500	339366	339251	339160	339091	339041	339005
65	340367	340322	340287	340258	340235	340214	340194	340170	340141	340101	340047	339973	339875	339755	339617	339474	339340	339225	339134	339066	339016
70	340364	340315	340275	340244	340220	340199	340181	340162	340140	340111	340073	340020	339947	339850	339731	339594	339452	339318	339203	339111	339043
75	340365	340312	340268	340233	340206	340185	340167	340150	340133	340112	340085	340047	339995	339923	339828	339709	339573	339431	339297	339182	339090
80	340369	340313	340264	340226	340195	340172	340153	340137	340122	340106	340086	340060	340023	339972	339901	339807	339689	339554	339412	339278	339163
85	340376	340317	340265	340221	340187	340161	340141	340124	340110	340097	340081	340062	340037	340001	339950	339880	339787	339671	339536	339395	339261
90	340385	340324	340268	340221	340182	340152	340130	340112	340098	340085	340073	340058	340040	340015	339980	339930	339861	339769	339653	339519	339378
95	340396	340334	340275	340224	340181	340147	340121	340102	340086	340074	340063	340051	340037	340020	339995	339961	339912	339844	339753	339638	339504
100	340408	340346	340286	340231	340183	340145	340116	340093	340076	340063	340052	340042	340031	340018	340001	339977	339944	339895	339828	339738	339623

Figure 41: CO_2 emissions cost [€] in Milan scenarios

Car sharing cost increase [%]	Parking cost increase [%] 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	-2472	-2314	-2156	-2012	-1889	-1790	-1712	-1651	-1602	-1562	-1526	-1494	-1464	-1435	-1406	-1377	-1348	-1319	-1289	-1258	-1227
5	-2005	-1862	-1706	-1551	-1408	-1287	-1190	-1113	-1054	-1007	-969	-935	-905	-877	-850	-824	-797	-770	-743	-716	-688
10	-1693	-1574	-1434	-1281	-1127	-986	-866	-770	-695	-638	-592	-556	-524	-496	-470	-445	-421	-396	-372	-347	-322
15	-1459	-1365	-1249	-1111	-961	-809	-669	-550	-455	-382	-325	-282	-247	-217	-191	-167	-144	-121	-99	-76	-53
20	-1272	-1199	-1108	-995	-860	-711	-561	-422	-304	-210	-138	-83	-40	-7	21	46	68	90	110	131	151
25	-1119	-1063	-994	-905	-794	-662	-515	-365	-228	-111	-18	54	108	149	181	208	231	252	271	290	309
30	-996	-951	-898	-832	-746	-637	-507	-361	-213	-76	40	132	203	256	296	327	353	374	394	412	429
35	-899	-861	-820	-770	-706	-622	-516	-387	-243	-96	40	156	248	318	370	410	440	464	484	502	519
40	-826	-791	-757	-718	-671	-609	-527	-422	-295	-153	-7	129	244	336	405	457	495	525	548	567	584
45	-773	-739	-708	-677	-640	-595	-535	-455	-352	-226	-85	60	195	311	402	471	522	560	588	610	629
50	-735	-701	-671	-643	-614	-580	-536	-478	-400	-298	-174	-33	111	246	361	452	521	571	608	636	658
55	-710	-673	-643	-616	-591	-564	-532	-490	-433	-356	-256	-133	6	150	284	399	490	559	609	646	673
60	-695	-654	-621	-595	-571	-549	-524	-493	-452	-397	-321	-223	-101	38	181	315	430	521	590	640	676
65	-686	-641	-606	-577	-554	-533	-513	-489	-460	-420	-366	-292	-194	-74	64	207	341	456	547	615	665
70	-683	-634	-594	-563	-539	-518	-500	-481	-459	-430	-392	-339	-266	-169	-50	87	229	363	478	570	638
75	-684	-631	-587	-552	-525	-504	-486	-469	-452	-431	-404	-366	-314	-242	-147	-28	108	250	384	499	591
80	-688	-632	-583	-545	-514	-491	-472	-456	-441	-425	-405	-379	-342	-291	-220	-126	-8	127	269	403	518
85	-695	-636	-584	-540	-506	-480	-460	-443	-429	-416	-400	-381	-356	-320	-269	-199	-106	10	145	286	420
90	-704	-643	-587	-540	-501	-471	-449	-431	-417	-404	-392	-377	-359	-334	-299	-249	-180	-88	28	162	303
95	-715	-653	-594	-543	-500	-466	-440	-421	-405	-393	-382	-370	-356	-339	-314	-280	-231	-163	-72	43	177
100	-727	-665	-605	-550	-502	-464	-435	-412	-395	-382	-371	-361	-350	-337	-320	-296	-263	-214	-147	-57	58

Figure 42: Delta CO_2 emissions cost [€] in Milan (BAU – Rupture scenarios)

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	5295	5290	5285	5281	5277	5274	5272	5270	5268	5267	5266	5265	5264	5263	5262	5261	5260	5259	5259	5258	5257
5	5303	5298	5294	5289	5284	5281	5278	5275	5273	5272	5271	5270	5269	5268	5267	5266	5265	5265	5264	5263	5262
10	5310	5306	5302	5297	5292	5288	5284	5281	5279	5277	5276	5275	5274	5273	5272	5271	5271	5270	5269	5268	5267
15	5316	5313	5310	5306	5301	5296	5292	5288	5285	5283	5281	5280	5279	5278	5277	5276	5276	5275	5274	5273	5273
20	5322	5320	5317	5313	5309	5304	5300	5296	5292	5289	5287	5285	5284	5283	5282	5281	5280	5280	5279	5278	5278
25	5327	5325	5323	5320	5317	5313	5308	5303	5299	5295	5293	5290	5289	5287	5286	5286	5285	5284	5284	5283	5282
30	5331	5330	5328	5326	5323	5320	5316	5311	5307	5303	5299	5296	5294	5292	5291	5290	5289	5289	5288	5287	5287
35	5335	5334	5333	5331	5329	5327	5323	5319	5315	5310	5306	5302	5300	5297	5296	5295	5294	5293	5292	5292	5291
40	5339	5338	5337	5336	5334	5332	5330	5327	5323	5318	5314	5309	5306	5303	5301	5299	5298	5297	5296	5296	5295
45	5343	5342	5341	5340	5339	5337	5335	5333	5330	5326	5321	5317	5313	5309	5306	5304	5303	5301	5300	5300	5299
50	5346	5345	5344	5343	5342	5341	5340	5338	5336	5333	5329	5324	5320	5316	5312	5309	5307	5306	5304	5304	5303
55	5349	5348	5347	5346	5346	5345	5344	5343	5341	5338	5335	5331	5327	5323	5319	5315	5312	5310	5308	5307	5306
60	5352	5351	5350	5349	5349	5348	5347	5346	5345	5343	5341	5338	5334	5330	5325	5321	5318	5315	5313	5311	5310
65	5355	5354	5353	5352	5351	5350	5350	5349	5348	5347	5345	5343	5340	5336	5332	5328	5323	5320	5317	5315	5313
70	5358	5356	5355	5354	5353	5353	5352	5352	5351	5350	5349	5347	5345	5342	5338	5334	5330	5325	5322	5319	5317
75	5360	5359	5357	5356	5355	5355	5354	5354	5353	5352	5352	5350	5349	5347	5344	5340	5336	5331	5327	5324	5321
80	5363	5361	5359	5358	5357	5356	5356	5355	5355	5354	5354	5353	5352	5350	5348	5345	5342	5337	5333	5329	5325
85	5365	5363	5361	5360	5359	5358	5357	5357	5357	5356	5356	5355	5354	5353	5352	5349	5346	5343	5339	5334	5330
90	5367	5365	5363	5362	5360	5360	5359	5358	5358	5357	5357	5357	5356	5355	5354	5353	5351	5348	5344	5340	5336
95	5369	5367	5365	5363	5362	5361	5360	5360	5359	5359	5358	5358	5358	5357	5356	5355	5354	5352	5349	5345	5341
100	5370	5369	5367	5365	5363	5362	5361	5361	5360	5360	5359	5359	5359	5358	5358	5357	5356	5355	5352	5350	5346

Figure 43: NMVOC emissions cost [€] in Milan scenarios

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	99	104	109	114	118	121	123	125	126	128	129	130	131	132	133	133	134	135	136	137	138
5	92	96	101	106	110	114	117	119	121	123	124	125	126	127	128	128	129	130	131	132	133
10	85	88	93	97	102	107	110	113	116	117	119	120	121	122	123	123	124	125	126	126	127
15	78	81	85	89	94	99	103	107	109	112	113	115	116	117	118	118	119	120	121	121	122
20	73	75	78	81	86	90	95	99	103	106	108	110	111	112	113	114	114	115	116	116	117
25	68	70	72	75	78	82	87	91	96	99	102	104	106	107	108	109	110	110	111	112	112
30	64	65	67	69	71	75	79	83	88	92	96	99	101	102	104	105	105	106	107	107	108
35	59	61	62	63	65	68	71	75	80	84	89	92	95	97	99	100	101	102	102	103	103
40	56	57	58	59	60	62	65	68	72	76	81	85	89	92	94	95	97	98	98	99	99
45	52	53	54	55	56	57	59	62	65	69	73	78	82	86	88	91	92	93	94	95	95
50	49	50	51	51	52	53	55	57	59	62	66	70	75	79	83	85	87	89	90	91	92
55	45	46	47	48	49	50	51	52	54	56	59	63	68	72	76	80	83	85	86	87	88
60	42	44	45	45	46	47	48	49	50	52	54	57	61	65	69	74	77	80	82	84	85
65	39	41	42	43	44	44	45	46	46	48	49	52	55	58	63	67	71	75	78	80	81
70	37	38	40	41	41	42	42	43	44	45	46	47	50	53	56	61	65	69	73	76	78
75	34	36	37	38	39	40	40	41	42	42	43	44	46	48	51	55	59	63	67	71	74
80	32	34	35	37	37	38	39	39	40	40	41	42	43	44	47	50	53	57	62	66	69
85	30	32	33	35	36	37	37	38	38	39	39	40	40	42	43	45	48	52	56	60	65
90	28	30	32	33	34	35	36	36	37	37	38	38	39	39	40	42	44	47	51	55	59
95	26	28	30	31	33	34	35	35	36	36	36	37	37	38	38	40	41	43	46	50	54
100	24	26	28	30	31	32	33	34	35	35	35	36	36	36	37	38	39	40	42	45	49

Figure 44: Delta NMVOC emissions cost [€] in Milan (BAU – Rupture scenarios)

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	267739	267459	267180	266925	266708	266533	266396	266288	266202	266130	266067	266010	265957	265905	265854	265803	265752	265700	265647	265593	265539
5	268318	268065	267790	267515	267263	267048	266876	266742	266637	266554	266486	266427	266374	266324	266276	266229	266182	266135	266087	266039	265989
10	268833	268621	268374	268103	267832	267582	267370	267201	267069	266967	266887	266821	266766	266716	266670	266626	266583	266540	266497	266453	266408
15	269279	269112	268907	268664	268397	268129	267882	267672	267504	267374	267275	267198	267135	267083	267036	266994	266953	266913	266874	266834	266794
20	269665	269537	269376	269176	268937	268674	268408	268163	267955	267789	267661	267564	267489	267429	267380	267336	267297	267259	267223	267186	267150
25	270004	269905	269783	269627	269431	269196	268936	268673	268430	268223	268058	267932	267837	267764	267707	267659	267619	267582	267547	267514	267481
30	270308	270229	270136	270018	269867	269675	269444	269187	268925	268683	268478	268314	268189	268096	268025	267970	267925	267887	267852	267820	267790
35	270586	270519	270446	270358	270244	270096	269908	269680	269426	269166	268926	268721	268558	268435	268342	268273	268220	268177	268141	268109	268079
40	270844	270783	270722	270654	270570	270460	270316	270131	269906	269654	269396	269156	268952	268790	268667	268576	268508	268457	268416	268382	268352
45	271085	271025	270971	270915	270851	270770	270664	270523	270341	270119	269869	269612	269374	269170	269009	268886	268796	268730	268679	268640	268608
50	271310	271249	271196	271147	271096	271035	270958	270855	270717	270537	270318	270070	269814	269576	269373	269212	269090	269001	268935	268886	268848
55	271520	271454	271400	271354	271310	271262	271205	271131	271030	270895	270718	270500	270254	270000	269762	269559	269398	269277	269188	269123	269075
60	271715	271643	271586	271539	271498	271458	271413	271359	271287	271189	271055	270881	270666	270421	270168	269931	269728	269567	269445	269357	269293
65	271896	271817	271754	271704	271663	271626	271590	271548	271496	271426	271330	271199	271027	270814	270570	270318	270081	269878	269717	269596	269507
70	272063	271977	271907	271852	271809	271772	271740	271706	271667	271617	271549	271455	271326	271156	270945	270703	270451	270214	270011	269850	269728
75	272219	272125	272048	271986	271939	271901	271869	271840	271809	271772	271723	271657	271565	271438	271270	271060	270820	270569	270332	270128	269966
80	272363	272263	272178	272110	272056	272015	271982	271954	271927	271898	271863	271816	271752	271661	271536	271369	271161	270922	270672	270435	270231
85	272498	272393	272301	272224	272164	272118	272082	272053	272028	272004	271977	271943	271898	271835	271745	271622	271457	271251	271013	270763	270526
90	272624	272516	272417	272333	272265	272212	272172	272141	272116	272094	272071	272046	272014	271970	271908	271820	271698	271535	271330	271093	270844
95	272741	272632	272528	272437	272361	272301	272256	272221	272194	272172	272152	272132	272107	272076	272033	271973	271886	271766	271604	271401	271165
100	272851	272742	272636	272538	272455	272387	272335	272296	272266	272242	272223	272205	272186	272163	272132	272091	272031	271946	271827	271667	271465

Figure 45: NO_x emissions cost [€] in Milan scenarios

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	6793	7073	7352	7607	7824	7999	8137	8244	8331	8402	8465	8522	8575	8627	8678	8729	8780	8832	8885	8939	8993
5	6215	6467	6742	7017	7270	7484	7656	7790	7895	7978	8047	8105	8158	8208	8256	8303	8350	8397	8445	8493	8543
10	5700	5911	6158	6429	6700	6950	7162	7332	7464	7565	7646	7711	7766	7816	7862	7906	7949	7992	8035	8079	8124
15	5253	5420	5625	5868	6135	6403	6650	6860	7028	7158	7257	7335	7397	7449	7496	7538	7579	7619	7658	7698	7738
20	4867	4995	5156	5356	5595	5858	6124	6369	6577	6743	6871	6968	7043	7103	7153	7196	7235	7273	7309	7346	7382
25	4528	4627	4749	4905	5101	5336	5596	5859	6102	6309	6474	6600	6696	6768	6826	6873	6913	6950	6985	7018	7051
30	4224	4303	4396	4514	4665	4857	5088	5346	5607	5849	6054	6218	6343	6436	6507	6563	6607	6646	6680	6712	6743
35	3946	4013	4086	4175	4288	4436	4624	4852	5106	5366	5606	5811	5974	6098	6190	6259	6312	6355	6391	6423	6453
40	3688	3749	3810	3878	3963	4072	4216	4401	4626	4879	5136	5376	5580	5742	5865	5956	6024	6075	6116	6150	6180
45	3447	3507	3562	3617	3681	3762	3868	4009	4191	4413	4663	4920	5159	5362	5523	5646	5736	5803	5853	5892	5924
50	3222	3284	3336	3385	3436	3497	3574	3677	3815	3995	4214	4463	4718	4956	5159	5320	5442	5531	5597	5646	5684
55	3012	3078	3132	3178	3222	3270	3327	3401	3502	3638	3814	4032	4278	4532	4770	4973	5134	5255	5344	5409	5457
60	2817	2889	2946	2993	3035	3075	3119	3173	3245	3343	3477	3651	3866	4111	4364	4602	4804	4966	5087	5175	5239
65	2636	2715	2778	2828	2870	2906	2943	2984	3036	3106	3202	3333	3505	3718	3962	4214	4451	4654	4815	4937	5025
70	2469	2555	2625	2680	2724	2760	2792	2826	2865	2915	2983	3077	3206	3376	3587	3829	4081	4318	4521	4683	4804
75	2313	2407	2484	2546	2594	2631	2663	2693	2724	2760	2809	2875	2967	3094	3263	3472	3713	3964	4200	4404	4566
80	2169	2269	2354	2422	2476	2517	2550	2578	2605	2634	2669	2716	2780	2871	2996	3163	3371	3610	3860	4097	4301
85	2034	2139	2231	2308	2368	2415	2450	2479	2504	2528	2555	2589	2634	2698	2787	2910	3075	3281	3519	3769	4006
90	1908	2017	2115	2199	2267	2320	2360	2391	2416	2438	2461	2486	2518	2562	2624	2712	2834	2997	3202	3439	3688
95	1791	1900	2004	2095	2171	2231	2276	2311	2338	2360	2380	2401	2425	2456	2499	2560	2646	2766	2928	3131	3367
100	1681	1790	1896	1994	2078	2145	2197	2237	2266	2290	2309	2327	2347	2369	2400	2442	2501	2586	2706	2865	3067

Figure 46: Delta NO_x emissions cost [€] in Milan (BAU – Rupture scenarios)

Car sharing cost increase [%]	Parking cost increase [%] 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	9748	9742	9736	9731	9726	9723	9720	9718	9716	9715	9713	9712	9711	9710	9709	9708	9707	9706	9705	9704	9703
5	9742	9736	9731	9725	9720	9716	9712	9709	9707	9706	9704	9703	9702	9701	9700	9699	9698	9697	9696	9695	9694
10	9739	9734	9729	9724	9718	9713	9709	9705	9703	9700	9699	9698	9696	9695	9694	9694	9693	9692	9691	9690	9689
15	9737	9734	9729	9724	9719	9713	9708	9704	9701	9698	9696	9694	9693	9692	9691	9690	9689	9689	9688	9687	9686
20	9736	9733	9730	9726	9721	9715	9710	9705	9701	9697	9695	9693	9691	9690	9689	9688	9687	9686	9686	9685	9684
25	9735	9733	9730	9727	9723	9718	9713	9708	9703	9698	9695	9693	9691	9689	9688	9687	9686	9685	9685	9684	9683
30	9735	9733	9731	9729	9726	9722	9717	9712	9706	9701	9697	9694	9691	9689	9688	9687	9686	9685	9684	9684	9683
35	9735	9733	9732	9730	9728	9725	9721	9716	9711	9706	9701	9696	9693	9691	9689	9687	9686	9685	9685	9684	9683
40	9735	9734	9732	9731	9729	9727	9724	9720	9716	9711	9705	9700	9696	9693	9690	9689	9687	9686	9685	9685	9684
45	9736	9734	9733	9732	9731	9729	9727	9724	9720	9716	9711	9706	9701	9696	9693	9691	9689	9687	9686	9686	9685
50	9737	9735	9734	9733	9732	9731	9729	9727	9724	9721	9716	9711	9706	9701	9697	9694	9691	9689	9688	9687	9686
55	9738	9736	9735	9734	9733	9732	9731	9730	9728	9725	9721	9717	9712	9707	9702	9698	9694	9692	9690	9689	9688
60	9739	9737	9736	9735	9734	9734	9733	9732	9730	9728	9725	9722	9717	9712	9707	9702	9698	9695	9692	9691	9689
65	9740	9738	9737	9736	9735	9734	9734	9733	9732	9730	9728	9726	9722	9718	9713	9708	9703	9699	9695	9693	9691
70	9741	9739	9738	9737	9736	9735	9735	9734	9733	9732	9731	9729	9726	9723	9718	9713	9708	9703	9699	9696	9693
75	9742	9741	9739	9738	9737	9736	9735	9735	9734	9733	9732	9731	9729	9727	9723	9719	9714	9709	9704	9700	9696
80	9744	9742	9740	9739	9737	9737	9736	9735	9735	9734	9733	9733	9731	9729	9727	9723	9719	9714	9709	9704	9700
85	9745	9743	9741	9739	9738	9737	9736	9736	9735	9735	9734	9734	9733	9731	9730	9727	9724	9719	9715	9709	9705
90	9746	9744	9742	9740	9739	9738	9737	9736	9736	9735	9735	9734	9734	9733	9731	9730	9727	9724	9720	9715	9710
95	9747	9745	9743	9741	9739	9738	9737	9737	9736	9736	9735	9735	9734	9734	9733	9732	9730	9727	9724	9720	9715
100	9748	9746	9744	9742	9740	9739	9738	9737	9736	9736	9736	9735	9735	9734	9734	9733	9732	9730	9727	9724	9720

Figure 47: NH_3 emissions cost [€] in Milan scenarios

Car sharing cost increase [%]	Parking cost increase [%] 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	-2	3	9	14	19	22	25	27	29	31	32	33	34	35	36	37	38	39	40	42	43
5	4	9	14	20	25	30	33	36	38	40	41	42	43	44	45	46	47	48	49	50	51
10	7	11	16	21	27	32	36	40	43	45	46	48	49	50	51	52	53	53	54	55	56
15	8	12	16	21	26	32	37	41	45	47	49	51	52	53	54	55	56	57	58	58	59
20	10	12	15	20	24	30	35	40	45	48	51	53	54	55	56	57	58	59	59	60	61
25	10	12	15	18	22	27	32	38	43	47	50	53	55	56	57	58	59	60	61	61	62
30	11	12	14	17	20	24	28	34	39	44	48	51	54	56	57	59	59	60	61	62	62
35	11	12	14	15	18	21	25	29	34	40	45	49	52	55	57	58	59	60	61	61	62
40	10	12	13	14	16	18	21	25	29	35	40	45	49	52	55	57	58	59	60	61	61
45	10	11	12	13	14	16	18	21	25	29	34	40	45	49	52	55	56	58	59	60	60
50	9	10	11	12	13	14	16	18	21	24	29	34	39	44	48	52	54	56	57	58	59
55	8	9	10	11	12	13	14	16	18	20	24	28	34	39	44	48	51	54	55	57	58
60	6	8	9	10	11	12	13	14	15	17	20	24	28	33	38	43	47	50	53	55	56
65	5	7	8	9	10	11	11	12	13	15	17	19	23	27	32	38	42	47	50	52	54
70	4	6	7	8	9	10	11	11	12	13	15	16	19	23	27	32	37	42	46	49	52
75	3	5	6	7	8	9	10	11	11	12	13	14	16	19	22	26	31	37	41	46	49
80	2	4	5	7	8	9	9	10	10	11	12	13	14	16	18	22	26	31	36	41	45
85	0	2	4	6	7	8	9	9	10	10	11	12	13	14	16	18	22	26	31	36	41
90	-1	1	3	5	6	8	8	9	10	10	10	11	12	13	14	16	18	21	26	30	36
95	-2	0	2	4	6	7	8	9	9	10	10	10	11	12	12	14	15	18	21	25	30
100	-3	-1	1	3	5	6	7	8	9	9	10	10	10	11	12	12	14	15	18	21	25

Figure 48: Delta NH_3 emissions cost [€] in Milan (BAU – Rupture scenarios)

Car sharing cost increase [%]	Parking cost increase [%] 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	27944	27917	27889	27864	27843	27826	27812	27802	27793	27786	27780	27775	27769	27764	27759	27754	27749	27744	27739	27734	27728
5	27994	27969	27942	27915	27890	27869	27852	27839	27829	27821	27814	27808	27803	27798	27794	27789	27784	27780	27775	27770	27765
10	28039	28018	27994	27967	27941	27916	27896	27879	27866	27856	27848	27842	27836	27831	27827	27823	27818	27814	27810	27806	27801
15	28078	28062	28042	28018	27992	27966	27941	27921	27904	27892	27882	27874	27868	27863	27859	27854	27850	27846	27843	27839	27835
20	28113	28100	28084	28065	28041	28015	27989	27965	27945	27929	27916	27907	27899	27893	27889	27884	27880	27877	27873	27870	27866
25	28143	28133	28121	28106	28087	28064	28038	28012	27988	27968	27952	27940	27930	27923	27918	27913	27909	27905	27902	27899	27895
30	28170	28162	28153	28142	28127	28108	28085	28060	28034	28011	27991	27975	27962	27953	27946	27941	27936	27933	27929	27926	27923
35	28195	28189	28181	28173	28162	28147	28129	28106	28081	28056	28032	28012	27996	27984	27975	27968	27963	27959	27955	27952	27949
40	28218	28212	28206	28200	28192	28181	28167	28148	28126	28102	28076	28053	28033	28017	28005	27996	27989	27984	27980	27977	27974
45	28240	28235	28229	28224	28217	28210	28199	28185	28167	28146	28121	28096	28073	28053	28037	28025	28016	28009	28004	28001	27997
50	28261	28255	28250	28245	28240	28234	28226	28216	28203	28185	28164	28139	28114	28091	28071	28055	28043	28035	28028	28023	28020
55	28280	28274	28269	28264	28260	28255	28249	28242	28232	28219	28202	28180	28156	28131	28108	28088	28072	28060	28052	28045	28041
60	28298	28291	28286	28281	28277	28273	28269	28263	28256	28247	28234	28217	28195	28171	28147	28123	28103	28088	28076	28067	28061
65	28315	28307	28301	28296	28292	28289	28285	28281	28276	28269	28260	28247	28230	28209	28185	28160	28137	28117	28101	28089	28081
70	28331	28322	28315	28310	28306	28302	28299	28296	28292	28287	28280	28271	28258	28242	28221	28197	28173	28149	28129	28114	28102
75	28345	28336	28328	28322	28318	28314	28311	28308	28305	28301	28297	28290	28281	28269	28252	28231	28208	28183	28160	28140	28124
80	28359	28349	28340	28334	28328	28324	28321	28318	28316	28313	28310	28305	28299	28290	28277	28261	28241	28217	28193	28169	28149
85	28371	28361	28352	28344	28338	28334	28330	28328	28325	28323	28320	28317	28312	28306	28297	28285	28269	28249	28226	28201	28178
90	28383	28372	28363	28354	28348	28343	28339	28336	28333	28331	28329	28326	28323	28319	28313	28304	28292	28276	28256	28233	28208
95	28394	28383	28373	28364	28357	28351	28346	28343	28340	28338	28336	28334	28332	28329	28325	28319	28310	28298	28282	28263	28239
100	28404	28394	28383	28374	28365	28359	28354	28350	28347	28345	28343	28341	28339	28337	28334	28330	28324	28316	28304	28288	28268

Figure 49: $PM_{2.5}$ emissions cost [€] in Milan scenarios

Car sharing cost increase [%]	Parking cost increase [%] 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	610	638	665	690	711	728	742	753	761	768	774	780	785	790	795	800	805	810	815	821	826
5	561	585	612	639	664	685	702	715	725	733	740	746	751	756	761	765	770	775	779	784	789
10	515	536	560	587	614	638	659	675	688	698	706	713	718	723	727	732	736	740	744	749	753
15	476	492	512	536	562	589	613	633	650	663	672	680	686	691	696	700	704	708	712	716	720
20	442	454	470	490	513	539	565	589	609	626	638	648	655	661	666	670	674	678	681	685	688
25	411	421	433	448	468	491	516	542	566	586	602	615	624	631	637	641	645	649	652	656	659
30	384	392	401	413	428	446	469	494	520	544	564	580	592	601	608	614	618	622	625	628	631
35	359	366	373	382	393	407	426	448	473	498	522	542	558	570	579	586	591	595	599	602	605
40	336	342	348	355	363	374	388	406	428	453	478	501	521	537	549	558	565	570	574	577	580
45	314	320	325	331	337	345	355	369	387	409	433	458	482	502	518	530	538	545	550	554	557
50	293	299	304	309	314	320	328	338	351	369	391	415	440	463	483	499	511	520	526	531	535
55	274	280	286	290	295	299	305	312	322	335	353	374	398	423	446	466	482	494	503	509	514
60	256	263	269	273	277	281	286	291	298	308	321	338	359	383	408	431	451	467	479	487	494
65	239	247	253	258	262	266	269	273	278	285	295	308	324	345	369	394	417	437	453	465	473
70	224	232	239	244	249	252	255	259	263	267	274	283	296	313	333	357	382	405	425	441	453
75	209	218	226	232	237	240	244	246	249	253	258	264	273	286	302	323	346	371	394	414	430
80	196	206	214	221	226	230	233	236	238	241	245	249	256	265	277	293	314	337	362	385	405
85	183	193	202	210	216	220	224	227	229	232	234	238	242	248	257	269	285	305	329	353	376
90	171	182	192	200	207	212	216	219	221	223	225	228	231	235	242	250	262	278	298	321	346
95	160	171	181	190	198	203	208	211	214	216	218	220	222	226	230	236	244	256	272	292	315
100	150	161	171	181	189	195	201	204	207	210	212	213	215	217	220	225	230	239	250	266	286

Figure 50: Delta $PM_{2.5}$ emissions cost [€] in Milan (BAU – Rupture scenarios)

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	652879	652402	651928	651493	651124	650827	650593	650410	650263	650140	650034	649937	649846	649758	649671	649585	649497	649409	649319	649228	649135
5	653042	652612	652144	651676	651247	650882	650589	650360	650182	650041	649924	649824	649734	649649	649568	649488	649408	649328	649247	649164	649080
10	653295	652935	652514	652053	651591	651167	650806	650517	650293	650119	649983	649872	649777	649693	649615	649540	649466	649393	649319	649245	649169
15	653551	653267	652918	652505	652051	651594	651173	650816	650530	650310	650140	650009	649903	649813	649735	649662	649593	649525	649458	649390	649322
20	653788	653570	653296	652955	652549	652101	651649	651232	650878	650595	650377	650212	650084	649983	649898	649825	649757	649693	649631	649570	649508
25	654008	653840	653632	653366	653033	652634	652191	651743	651329	650977	650697	650482	650320	650196	650098	650018	649949	649886	649827	649770	649714
30	654220	654086	653928	653727	653469	653142	652749	652312	651867	651456	651106	650827	650615	650455	650335	650241	650165	650099	650041	649987	649934
35	654431	654317	654192	654042	653849	653598	653277	652890	652456	652015	651605	651257	650980	650770	650612	650495	650404	650331	650270	650215	650165
40	654643	654539	654436	654320	654176	653990	653745	653429	653047	652618	652179	651771	651424	651148	650939	650784	650669	650581	650511	650453	650402
45	654857	654756	654663	654568	654459	654322	654141	653901	653591	653213	652788	652351	651945	651599	651324	651116	650962	650849	650764	650697	650642
50	655070	654965	654876	654793	654705	654603	654471	654295	654060	653755	653381	652959	652525	652119	651774	651499	651292	651140	651028	650945	650880
55	655279	655167	655075	654996	654921	654840	654743	654616	654445	654214	653913	653543	653124	652692	652287	651942	651668	651461	651310	651199	651118
60	655481	655358	655260	655180	655110	655042	654967	654874	654751	654584	654358	654061	653695	653278	652847	652443	652098	651824	651617	651467	651358
65	655673	655539	655432	655346	655276	655214	655152	655081	654993	654874	654710	654487	654194	653831	653418	652988	652585	652239	651965	651758	651608
70	655857	655710	655591	655497	655423	655362	655306	655249	655183	655098	654982	654822	654602	654313	653953	653541	653113	652710	652364	652089	651883
75	656031	655872	655741	655636	655555	655490	655436	655386	655333	655271	655188	655076	654919	654702	654416	654059	653650	653223	652820	652474	652198
80	656197	656027	655882	655766	655675	655604	655548	655500	655455	655406	655346	655267	655157	655002	654789	654506	654152	653745	653319	652916	652569
85	656355	656176	656019	655889	655787	655708	655647	655598	655555	655514	655468	655411	655334	655226	655074	654864	654584	654233	653828	653403	652999
90	656505	656321	656153	656010	655894	655804	655736	655683	655641	655603	655565	655522	655467	655392	655286	655137	654929	654652	654304	653900	653476
95	656647	656461	656285	656129	656000	655898	655821	655762	655716	655679	655645	655610	655568	655515	655442	655339	655192	654987	654712	654366	653965
100	656782	656597	656416	656249	656107	655992	655903	655836	655786	655746	655713	655682	655649	655610	655559	655488	655386	655241	655038	654766	654423

Figure 51: Total emissions costs [€] and identification of the Rupture scenario in Milan

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	5029	5505	5980	6414	6783	7081	7314	7498	7645	7767	7874	7970	8061	8149	8236	8323	8410	8498	8588	8680	8773
5	4865	5296	5764	6232	6661	7025	7319	7547	7725	7867	7983	8083	8174	8258	8339	8419	8499	8579	8661	8743	8827
10	4613	4972	5393	5854	6316	6740	7101	7390	7615	7788	7924	8035	8130	8214	8292	8367	8441	8514	8588	8663	8738
15	4356	4640	4990	5403	5857	6314	6734	7091	7377	7598	7767	7899	8005	8094	8173	8245	8314	8382	8449	8517	8585
20	4119	4337	4611	4952	5358	5806	6258	6675	7029	7312	7530	7695	7823	7924	8009	8083	8150	8214	8276	8338	8399
25	3899	4067	4275	4541	4875	5274	5716	6165	6579	6930	7211	7426	7588	7712	7809	7889	7958	8021	8080	8137	8193
30	3687	3821	3980	4180	4438	4765	5158	5596	6040	6452	6802	7080	7293	7452	7573	7667	7743	7808	7866	7921	7973
35	3476	3590	3715	3865	4058	4309	4630	5018	5451	5893	6302	6650	6927	7138	7295	7413	7503	7576	7638	7692	7742
40	3264	3368	3472	3588	3731	3917	4163	4478	4860	5290	5729	6136	6483	6759	6968	7123	7239	7327	7396	7454	7505
45	3050	3152	3244	3339	3448	3585	3766	4006	4316	4694	5119	5556	5962	6309	6583	6791	6945	7058	7144	7211	7266
50	2837	2942	3032	3115	3202	3305	3436	3612	3847	4152	4526	4948	5383	5788	6134	6408	6615	6768	6879	6963	7027
55	2628	2741	2832	2911	2987	3067	3164	3291	3462	3693	3994	4364	4783	5216	5620	5966	6240	6446	6598	6708	6790
60	2427	2549	2647	2727	2797	2865	2941	3033	3156	3323	3550	3847	4213	4629	5060	5464	5809	6084	6290	6441	6550
65	2234	2368	2476	2561	2631	2693	2756	2826	2915	3033	3197	3420	3713	4076	4490	4919	5323	5668	5943	6149	6299
70	2050	2197	2316	2410	2484	2546	2601	2658	2725	2810	2925	3086	3305	3595	3954	4366	4794	5197	5543	5818	6024
75	1876	2035	2167	2271	2353	2417	2471	2521	2574	2637	2719	2832	2989	3205	3491	3848	4257	4684	5087	5434	5709
80	1710	1880	2025	2142	2233	2303	2359	2407	2452	2502	2561	2641	2751	2905	3118	3402	3755	4162	4588	4991	5339
85	1552	1731	1888	2018	2121	2200	2261	2310	2352	2393	2439	2497	2574	2681	2833	3043	3324	3675	4080	4505	4908
90	1402	1587	1754	1898	2013	2103	2171	2224	2267	2304	2342	2386	2441	2516	2621	2770	2978	3256	3604	4007	4431
95	1260	1446	1623	1778	1907	2009	2087	2145	2191	2229	2263	2298	2339	2392	2465	2568	2716	2921	3195	3541	3942
100	1126	1310	1492	1658	1800	1915	2004	2071	2122	2161	2194	2225	2258	2297	2348	2420	2521	2666	2869	3141	3484

Figure 52: Total costs difference between BAU and Rupture scenario in Milan [€]

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	199524	199522	199519	199517	199514	199512	199509	199507	199504	199501	199498	199495	199492	199490	199486	199483	199480	199477	199474	199471	199467
5	199359	199357	199355	199353	199350	199348	199346	199343	199341	199338	199336	199333	199330	199328	199325	199322	199319	199316	199313	199310	199307
10	199204	199202	199200	199198	199196	199194	199192	199189	199187	199185	199182	199180	199178	199175	199173	199170	199167	199165	199162	199159	199157
15	199061	199059	199057	199055	199054	199052	199050	199047	199045	199043	199041	199039	199037	199034	199032	199030	199027	199025	199023	199020	199017
20	198931	198930	198928	198926	198924	198922	198921	198919	198917	198915	198913	198911	198909	198907	198905	198902	198900	198898	198896	198893	198891
25	198815	198813	198812	198810	198808	198807	198805	198803	198801	198800	198798	198796	198794	198792	198790	198788	198786	198784	198782	198780	198778
30	198711	198710	198709	198707	198705	198704	198702	198701	198699	198697	198696	198694	198692	198691	198689	198687	198685	198683	198681	198679	198677
35	198621	198619	198618	198617	198615	198614	198612	198611	198609	198608	198606	198605	198603	198601	198600	198598	198596	198595	198593	198591	198589
40	198542	198541	198539	198538	198537	198536	198534	198533	198531	198530	198529	198527	198526	198524	198523	198521	198519	198518	198516	198514	198513
45	198474	198473	198472	198470	198469	198468	198467	198465	198464	198463	198462	198460	198459	198457	198456	198455	198453	198452	198450	198449	198447
50	198416	198415	198413	198412	198411	198410	198409	198408	198407	198406	198404	198403	198402	198400	198399	198398	198396	198395	198394	198392	198391
55	198366	198365	198364	198363	198362	198361	198360	198359	198358	198357	198356	198355	198353	198352	198351	198350	198349	198347	198346	198345	198343
60	198325	198324	198323	198322	198321	198320	198319	198318	198317	198316	198315	198314	198313	198312	198311	198309	198308	198307	198306	198305	198303
65	198290	198289	198288	198287	198287	198286	198285	198284	198283	198282	198281	198280	198279	198278	198277	198276	198275	198274	198273	198272	198270
70	198261	198260	198260	198259	198258	198257	198256	198256	198255	198254	198253	198252	198251	198250	198249	198248	198247	198246	198245	198244	198243
75	198238	198237	198236	198235	198235	198234	198233	198232	198232	198231	198230	198229	198228	198228	198227	198226	198225	198224	198223	198222	198221
80	198218	198218	198217	198216	198216	198215	198214	198214	198213	198212	198212	198211	198210	198209	198208	198208	198207	198206	198205	198204	198203
85	198203	198202	198202	198201	198201	198200	198199	198199	198198	198197	198197	198196	198195	198195	198194	198193	198192	198192	198191	198190	198189
90	198191	198190	198190	198189	198189	198188	198188	198187	198186	198186	198185	198185	198184	198183	198183	198182	198181	198180	198180	198179	198178
95	198181	198181	198181	198180	198179	198179	198178	198178	198177	198177	198176	198176	198175	198174	198174	198173	198173	198172	198171	198170	198170
100	198174	198174	198173	198173	198173	198172	198172	198171	198171	198170	198170	198169	198168	198168	198167	198167	198166	198166	198165	198164	198164

Figure 53: CO_2 emissions cost [€] in Turin scenarios

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	-1088	-1086	-1083	-1081	-1078	-1076	-1073	-1071	-1068	-1065	-1062	-1059	-1056	-1053	-1050	-1047	-1044	-1041	-1038	-1034	-1031
5	-923	-921	-919	-917	-914	-912	-910	-907	-905	-902	-900	-897	-894	-892	-889	-886	-883	-880	-877	-874	-871
10	-768	-766	-764	-762	-760	-758	-756	-753	-751	-749	-746	-744	-742	-739	-737	-734	-731	-729	-726	-723	-721
15	-625	-623	-621	-619	-617	-615	-613	-611	-609	-607	-605	-603	-601	-598	-596	-594	-591	-589	-586	-584	-581
20	-495	-493	-492	-490	-488	-486	-485	-483	-481	-479	-477	-475	-473	-471	-469	-466	-464	-462	-460	-457	-455
25	-379	-377	-376	-374	-372	-371	-369	-367	-365	-364	-362	-360	-358	-356	-354	-352	-350	-348	-346	-344	-342
30	-275	-274	-272	-271	-269	-268	-266	-265	-263	-261	-260	-258	-256	-255	-253	-251	-249	-247	-245	-243	-241
35	-185	-183	-182	-181	-179	-178	-176	-175	-173	-172	-170	-169	-167	-165	-164	-162	-160	-159	-157	-155	-153
40	-106	-105	-103	-102	-101	-99	-98	-97	-95	-94	-93	-91	-90	-88	-87	-85	-83	-82	-80	-78	-77
45	-38	-37	-35	-34	-33	-32	-31	-29	-28	-27	-26	-24	-23	-21	-20	-19	-17	-16	-14	-12	-11
50	20	21	23	24	25	26	27	28	29	31	32	33	34	36	37	38	40	41	42	44	45
55	70	71	72	73	74	75	76	77	78	79	80	81	83	84	85	86	87	89	90	91	93
60	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	127	128	129	130	131	133
65	146	147	148	149	150	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	166
70	175	176	176	177	178	179	180	180	181	182	183	184	185	186	187	188	189	190	191	192	193
75	199	199	200	201	201	202	203	204	204	205	206	207	208	209	209	210	211	212	213	214	215
80	218	218	219	220	220	221	222	222	223	224	225	225	226	227	228	228	229	230	231	232	233
85	233	234	234	235	235	236	237	237	238	239	239	240	241	241	242	243	244	244	245	246	247
90	245	246	246	247	247	248	248	249	250	250	251	252	252	253	254	254	255	256	256	257	258
95	255	255	256	256	257	257	258	258	259	259	260	260	261	262	262	263	264	264	265	266	266
100	262	262	263	263	264	264	264	265	265	266	267	267	268	268	269	269	270	271	271	272	272

Figure 54: Delta CO_2 emissions cost [€] in Turin (BAU – Rupture scenarios)

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	2586	2586	2586	2586	2586	2586	2586	2586	2586	2586	2585	2585	2585	2585	2585	2585	2585	2585	2585	2585	2585
5	2590	2590	2590	2589	2589	2589	2589	2589	2589	2589	2589	2589	2589	2589	2589	2589	2589	2589	2589	2588	2588
10	2593	2593	2593	2593	2593	2593	2593	2592	2592	2592	2592	2592	2592	2592	2592	2592	2592	2592	2592	2592	2592
15	2596	2596	2596	2596	2596	2595	2595	2595	2595	2595	2595	2595	2595	2595	2595	2595	2595	2595	2595	2595	2595
20	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2597	2597	2597
25	2601	2601	2601	2601	2601	2601	2601	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
30	2603	2603	2603	2603	2603	2603	2603	2603	2603	2603	2603	2603	2602	2602	2602	2602	2602	2602	2602	2602	2602
35	2605	2605	2605	2605	2605	2605	2605	2605	2605	2605	2605	2605	2605	2604	2604	2604	2604	2604	2604	2604	2604
40	2607	2607	2607	2607	2607	2607	2607	2607	2607	2607	2607	2606	2606	2606	2606	2606	2606	2606	2606	2606	2606
45	2609	2609	2609	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608	2608
50	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610	2610
55	2612	2612	2612	2612	2612	2612	2612	2612	2611	2611	2611	2611	2611	2611	2611	2611	2611	2611	2611	2611	2611
60	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613	2613
65	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614
70	2616	2616	2616	2616	2616	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615
75	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617	2616	2616	2616	2616	2616	2616	2616	2616	2616
80	2618	2618	2618	2618	2618	2618	2618	2618	2618	2618	2618	2618	2618	2618	2618	2618	2617	2617	2617	2617	2617
85	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2618	2618	2618	2618	2618
90	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2619	2619	2619	2619	2619	2619	2619	2619
95	2621	2621	2621	2621	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620
100	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621	2621

Figure 55: NMVOC emissions cost [€] in Turin scenarios

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	50	50	50	50	50	50
5	45	45	45	45	45	45	45	45	45	46	46	46	46	46	46	46	46	46	46	46	46
10	42	42	42	42	42	42	42	42	42	42	42	42	42	43	43	43	43	43	43	43	43
15	39	39	39	39	39	39	39	39	39	39	39	39	40	40	40	40	40	40	40	40	40
20	36	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37
25	34	34	34	34	34	34	34	34	34	34	34	34	34	34	35	35	35	35	35	35	35
30	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	33
35	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
40	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	29
45	26	26	26	26	26	26	26	26	26	26	26	26	26	26	27	27	27	27	27	27	27
50	24	24	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
55	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	24
60	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
65	20	20	20	20	20	20	20	20	20	20	20	20	21	21	21	21	21	21	21	21	21
70	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
75	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
80	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
85	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
90	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
95	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
100	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14

Figure 56: Delta NMVOC emissions cost [€] in Turin (BAU – Rupture scenarios)

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	145579	145575	145571	145567	145563	145558	145554	145549	145545	145540	145536	145531	145526	145521	145516	145511	145505	145500	145495	145489	145483
5	145903	145899	145896	145892	145888	145884	145880	145876	145872	145868	145863	145859	145854	145850	145845	145841	145836	145831	145826	145821	145816
10	146196	146192	146189	146185	146182	146178	146175	146171	146167	146163	146159	146155	146151	146147	146143	146139	146134	146130	146125	146121	146116
15	146461	146458	146455	146452	146448	146445	146442	146438	146435	146431	146427	146424	146420	146416	146412	146408	146404	146400	146396	146392	146388
20	146702	146699	146696	146693	146690	146687	146684	146681	146678	146675	146671	146668	146664	146661	146657	146654	146650	146646	146642	146639	146635
25	146922	146919	146916	146914	146911	146908	146905	146902	146899	146896	146893	146890	146887	146884	146880	146877	146874	146870	146867	146863	146860
30	147122	147120	147117	147115	147112	147110	147107	147104	147102	147099	147096	147093	147090	147087	147084	147081	147078	147075	147072	147068	147065
35	147306	147304	147301	147299	147297	147294	147292	147289	147287	147284	147282	147279	147276	147273	147271	147268	147265	147262	147259	147256	147253
40	147474	147472	147470	147468	147466	147463	147461	147459	147456	147454	147452	147449	147447	147444	147442	147439	147436	147434	147431	147428	147425
45	147629	147627	147625	147623	147621	147619	147617	147614	147612	147610	147608	147606	147603	147601	147599	147596	147594	147591	147589	147586	147583
50	147771	147769	147767	147765	147763	147761	147760	147758	147756	147754	147752	147749	147747	147745	147743	147741	147738	147736	147734	147731	147729
55	147901	147900	147898	147896	147895	147893	147891	147889	147888	147886	147884	147882	147880	147878	147876	147874	147872	147870	147867	147865	147863
60	148022	148020	148019	148017	148016	148014	148013	148011	148009	148008	148006	148004	148002	148000	147999	147997	147995	147993	147991	147989	147987
65	148133	148132	148130	148129	148128	148126	148125	148123	148122	148120	148118	148117	148115	148113	148112	148110	148108	148106	148104	148102	148101
70	148236	148235	148233	148232	148231	148229	148228	148227	148225	148224	148222	148221	148219	148218	148216	148214	148213	148211	148209	148208	148206
75	148331	148330	148328	148327	148326	148325	148323	148322	148321	148320	148318	148317	148315	148314	148312	148311	148309	148308	148306	148305	148303
80	148418	148417	148416	148415	148414	148413	148412	148411	148409	148408	148407	148406	148404	148403	148402	148400	148399	148397	148396	148395	148393
85	148500	148499	148498	148497	148496	148495	148493	148492	148491	148490	148489	148488	148487	148485	148484	148483	148482	148480	148479	148478	148476
90	148575	148574	148573	148572	148571	148570	148569	148568	148567	148566	148565	148564	148563	148562	148560	148559	148558	148557	148556	148554	148553
95	148644	148643	148642	148642	148641	148640	148639	148638	148637	148636	148635	148634	148633	148632	148631	148630	148629	148628	148627	148626	148624
100	148708	148708	148707	148706	148705	148705	148704	148703	148702	148701	148700	148699	148698	148698	148697	148696	148695	148694	148693	148692	148690

Figure 57: NO_x emissions cost [€] in Turin scenarios

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	4092	4096	4100	4105	4109	4113	4118	4122	4127	4131	4136	4141	4146	4151	4156	4161	4166	4172	4177	4183	4188
5	3768	3772	3776	3780	3783	3787	3791	3796	3800	3804	3808	3813	3817	3822	3826	3831	3836	3841	3846	3851	3856
10	3476	3479	3483	3486	3490	3493	3497	3501	3504	3508	3512	3516	3520	3524	3529	3533	3537	3542	3546	3551	3556
15	3210	3214	3217	3220	3223	3227	3230	3233	3237	3240	3244	3248	3251	3255	3259	3263	3267	3271	3275	3279	3284
20	2969	2972	2975	2978	2981	2984	2987	2990	2994	2997	3000	3004	3007	3011	3014	3018	3021	3025	3029	3033	3037
25	2750	2752	2755	2758	2761	2763	2766	2769	2772	2775	2778	2781	2785	2788	2791	2794	2798	2801	2805	2808	2812
30	2549	2552	2554	2557	2559	2562	2564	2567	2570	2573	2575	2578	2581	2584	2587	2590	2594	2597	2600	2603	2607
35	2366	2368	2370	2373	2375	2377	2380	2382	2385	2387	2390	2393	2395	2398	2401	2404	2407	2410	2413	2416	2419
40	2197	2200	2202	2204	2206	2208	2210	2213	2215	2217	2220	2222	2225	2227	2230	2233	2235	2238	2241	2243	2246
45	2043	2045	2047	2049	2051	2053	2055	2057	2059	2061	2064	2066	2068	2071	2073	2075	2078	2080	2083	2085	2088
50	1901	1903	1904	1906	1908	1910	1912	1914	1916	1918	1920	1922	1924	1926	1929	1931	1933	1935	1938	1940	1943
55	1770	1772	1773	1775	1777	1778	1780	1782	1784	1786	1788	1790	1792	1794	1796	1798	1800	1802	1804	1806	1809
60	1650	1651	1653	1654	1656	1657	1659	1661	1662	1664	1666	1667	1669	1671	1673	1675	1677	1679	1681	1683	1685
65	1538	1540	1541	1542	1544	1545	1547	1548	1550	1552	1553	1555	1556	1558	1560	1562	1563	1565	1567	1569	1571
70	1436	1437	1438	1439	1441	1442	1444	1445	1446	1448	1449	1451	1452	1454	1456	1457	1459	1460	1462	1464	1466
75	1341	1342	1343	1344	1346	1347	1348	1349	1351	1352	1353	1355	1356	1358	1359	1361	1362	1364	1365	1367	1368
80	1253	1254	1255	1256	1257	1259	1260	1261	1262	1263	1265	1266	1267	1268	1270	1271	1273	1274	1275	1277	1278
85	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1183	1184	1185	1186	1187	1189	1190	1191	1193	1194	1195
90	1097	1098	1099	1100	1101	1102	1102	1103	1104	1106	1107	1108	1109	1110	1111	1112	1113	1115	1116	1117	1118
95	1027	1028	1029	1030	1031	1032	1033	1033	1034	1035	1036	1037	1038	1039	1040	1041	1043	1044	1045	1046	1047
100	963	964	965	965	966	967	968	969	969	970	971	972	973	974	975	976	977	978	979	980	981

Figure 58: Delta NO_x emissions cost [€] in Turin (BAU – Rupture scenarios)

Car sharing cost increase [%]	Parking cost increase [%]: 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	5473	5473	5473	5473	5473	5473	5473	5473	5473	5473	5472	5472	5472	5472	5472	5472	5472	5472	5472	5472	5471
5	5471	5471	5471	5471	5471	5471	5471	5471	5471	5471	5471	5470	5470	5470	5470	5470	5470	5470	5470	5470	5470
10	5469	5469	5469	5469	5469	5469	5469	5469	5469	5469	5469	5469	5469	5468	5468	5468	5468	5468	5468	5468	5468
15	5468	5468	5467	5467	5467	5467	5467	5467	5467	5467	5467	5467	5467	5467	5467	5467	5467	5466	5466	5466	5466
20	5466	5466	5466	5466	5466	5466	5466	5466	5466	5465	5465	5465	5465	5465	5465	5465	5465	5465	5465	5465	5465
25	5465	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5464	5463	5463	5463
30	5463	5463	5463	5463	5463	5463	5463	5463	5463	5463	5463	5463	5463	5463	5463	5462	5462	5462	5462	5462	5462
35	5462	5462	5462	5462	5462	5462	5462	5462	5462	5462	5462	5462	5462	5462	5462	5461	5461	5461	5461	5461	5461
40	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5461	5460	5460
45	5461	5461	5461	5461	5461	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460
50	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5459	5459	5459	5459
55	5460	5460	5460	5460	5460	5460	5460	5460	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
60	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
65	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
70	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
75	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
80	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
85	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
90	5460	5460	5460	5460	5460	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459	5459
95	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5459	5459	5459	5459	5459	5459	5459
100	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460	5460

Figure 59: NH_3 emissions cost [€] in Turin scenarios

Car sharing cost increase [%]	Parking cost increase [%]: 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	0	0	0	0
5	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
10	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
15	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5
20	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7
25	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8
30	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
35	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
40	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11
45	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12
50	11	11	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
55	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	13	13
60	12	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13
65	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13
70	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13
75	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13	13
80	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13
85	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13
90	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
95	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
100	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Figure 60: Delta NH_3 emissions cost [€] in Turin (BAU – Rupture scenarios)

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	15714	15714	15714	15713	15713	15712	15712	15711	15711	15710	15710	15709	15709	15708	15708	15707	15707	15706	15706	15705	15705
5	15744	15744	15744	15743	15743	15743	15742	15742	15741	15741	15740	15740	15740	15739	15739	15738	15738	15737	15737	15736	15736
10	15772	15771	15771	15771	15770	15770	15769	15769	15769	15768	15768	15767	15767	15767	15766	15766	15765	15765	15764	15764	15763
15	15796	15796	15796	15795	15795	15795	15794	15794	15794	15793	15793	15792	15792	15792	15791	15791	15790	15790	15790	15789	15789
20	15819	15818	15818	15818	15817	15817	15817	15816	15816	15816	15815	15815	15815	15814	15814	15814	15813	15813	15813	15812	15812
25	15839	15839	15838	15838	15838	15838	15837	15837	15837	15836	15836	15836	15835	15835	15835	15834	15834	15834	15833	15833	15833
30	15858	15857	15857	15857	15857	15856	15856	15856	15855	15855	15855	15855	15854	15854	15854	15853	15853	15853	15852	15852	15852
35	15875	15874	15874	15874	15874	15873	15873	15873	15873	15872	15872	15872	15872	15871	15871	15871	15871	15870	15870	15870	15869
40	15890	15890	15890	15890	15890	15889	15889	15889	15889	15888	15888	15888	15888	15887	15887	15887	15887	15886	15886	15886	15885
45	15905	15905	15904	15904	15904	15904	15904	15903	15903	15903	15903	15902	15902	15902	15902	15902	15901	15901	15901	15900	15900
50	15918	15918	15918	15918	15917	15917	15917	15917	15917	15916	15916	15916	15916	15916	15915	15915	15915	15915	15914	15914	15914
55	15930	15930	15930	15930	15930	15930	15929	15929	15929	15929	15929	15928	15928	15928	15928	15928	15927	15927	15927	15927	15927
60	15942	15942	15941	15941	15941	15941	15941	15941	15941	15940	15940	15940	15940	15940	15939	15939	15939	15939	15939	15938	15938
65	15952	15952	15952	15952	15952	15952	15951	15951	15951	15951	15951	15951	15950	15950	15950	15950	15950	15950	15949	15949	15949
70	15962	15962	15962	15962	15962	15961	15961	15961	15961	15961	15961	15961	15960	15960	15960	15960	15960	15960	15959	15959	15959
75	15971	15971	15971	15971	15971	15970	15970	15970	15970	15970	15970	15970	15970	15969	15969	15969	15969	15969	15969	15968	15968
80	15979	15979	15979	15979	15979	15979	15979	15979	15979	15978	15978	15978	15978	15978	15978	15978	15977	15977	15977	15977	15977
85	15987	15987	15987	15987	15987	15987	15987	15986	15986	15986	15986	15986	15986	15986	15986	15985	15985	15985	15985	15985	15985
90	15994	15994	15994	15994	15994	15994	15994	15994	15994	15993	15993	15993	15993	15993	15993	15993	15993	15993	15992	15992	15992
95	16001	16001	16001	16001	16001	16001	16001	16000	16000	16000	16000	16000	16000	16000	16000	16000	15999	15999	15999	15999	15999
100	16007	16007	16007	16007	16007	16007	16007	16007	16007	16006	16006	16006	16006	16006	16006	16006	16006	16006	16006	16005	16005

Figure 61: $PM_{2.5}$ emissions cost [€] in Turin scenarios

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	388	389	389	390	390	391	391	391	392	392	393	393	394	394	395	395	396	396	397	398	398
5	358	359	359	359	360	360	361	361	361	362	362	363	363	364	364	365	365	366	366	367	367
10	331	331	332	332	333	333	333	334	334	334	335	335	336	336	337	337	337	338	338	339	339
15	307	307	307	307	308	308	309	309	309	310	310	310	311	311	311	312	312	313	313	314	314
20	284	284	285	285	285	286	286	286	287	287	287	288	288	288	289	289	289	290	290	291	291
25	264	264	264	265	265	265	265	266	266	266	267	267	267	268	268	268	269	269	269	270	270
30	245	245	246	246	246	246	247	247	247	248	248	248	248	249	249	249	250	250	250	251	251
35	228	228	229	229	229	229	229	230	230	230	231	231	231	231	232	232	232	233	233	233	233
40	212	213	213	213	213	213	214	214	214	214	215	215	215	215	216	216	216	216	217	217	217
45	198	198	198	199	199	199	199	199	200	200	200	200	200	201	201	201	201	202	202	202	203
50	185	185	185	185	185	186	186	186	186	186	187	187	187	187	187	188	188	188	188	189	189
55	172	172	173	173	173	173	173	174	174	174	174	174	174	175	175	175	175	176	176	176	176
60	161	161	161	161	162	162	162	162	162	162	163	163	163	163	163	164	164	164	164	164	165
65	150	151	151	151	151	151	151	151	152	152	152	152	152	152	153	153	153	153	153	154	154
70	141	141	141	141	141	141	141	142	142	142	142	142	142	143	143	143	143	143	143	144	144
75	132	132	132	132	132	132	132	133	133	133	133	133	133	133	134	134	134	134	134	134	134
80	123	123	124	124	124	124	124	124	124	124	124	125	125	125	125	125	125	125	126	126	126
85	116	116	116	116	116	116	116	116	116	117	117	117	117	117	117	117	117	118	118	118	118
90	108	108	109	109	109	109	109	109	109	109	109	109	110	110	110	110	110	110	110	110	111
95	102	102	102	102	102	102	102	102	102	103	103	103	103	103	103	103	103	103	103	104	104
100	96	96	96	96	96	96	96	96	96	96	96	96	97	97	97	97	97	97	97	97	97

Figure 62: Delta $PM_{2.5}$ emissions cost [€] in Turin (BAU – Rupture scenarios)

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	368877	368870	368863	368856	368849	368841	368833	368826	368818	368810	368802	368793	368785	368776	368767	368758	368749	368740	368731	368721	368711
5	369068	369062	369055	369049	369042	369035	369028	369021	369014	369007	368999	368991	368984	368976	368968	368960	368951	368943	368934	368926	368917
10	369234	369228	369222	369216	369210	369204	369197	369191	369184	369177	369171	369164	369157	369149	369142	369135	369127	369119	369112	369104	369095
15	369382	369376	369371	369365	369360	369354	369348	369342	369336	369330	369324	369317	369311	369304	369297	369291	369284	369277	369269	369262	369255
20	369516	369511	369506	369501	369496	369491	369485	369480	369474	369468	369463	369457	369451	369445	369439	369432	369426	369420	369413	369406	369399
25	369641	369636	369631	369627	369622	369617	369612	369607	369602	369597	369591	369586	369581	369575	369569	369563	369558	369552	369546	369539	369533
30	369757	369753	369749	369745	369740	369736	369731	369727	369722	369717	369712	369707	369702	369697	369692	369686	369681	369675	369670	369664	369658
35	369868	369864	369861	369857	369852	369848	369844	369840	369835	369831	369826	369822	369817	369812	369808	369803	369798	369793	369787	369782	369777
40	369974	369971	369967	369964	369960	369956	369952	369948	369944	369940	369936	369932	369927	369923	369918	369914	369909	369904	369900	369895	369890
45	370076	370073	370070	370066	370063	370059	370056	370052	370048	370045	370041	370037	370033	370029	370025	370020	370016	370012	370007	370003	369998
50	370175	370172	370169	370165	370162	370159	370156	370152	370149	370145	370142	370138	370134	370131	370127	370123	370119	370115	370111	370107	370103
55	370269	370267	370264	370261	370258	370255	370252	370249	370246	370242	370239	370236	370232	370229	370225	370222	370218	370214	370211	370207	370203
60	370361	370358	370356	370353	370350	370348	370345	370342	370339	370336	370333	370330	370327	370324	370320	370317	370314	370310	370307	370303	370300
65	370449	370447	370444	370442	370439	370437	370434	370432	370429	370426	370423	370420	370418	370415	370412	370409	370406	370402	370399	370396	370392
70	370534	370532	370529	370527	370525	370523	370520	370518	370515	370513	370510	370508	370505	370502	370499	370497	370494	370491	370488	370485	370482
75	370615	370613	370611	370609	370607	370605	370603	370601	370598	370596	370594	370591	370589	370586	370584	370581	370578	370576	370573	370570	370567
80	370693	370691	370690	370688	370686	370684	370682	370680	370678	370676	370673	370671	370669	370667	370664	370662	370659	370657	370654	370652	370649
85	370768	370766	370765	370763	370761	370759	370757	370755	370754	370752	370750	370748	370746	370743	370741	370739	370737	370735	370732	370730	370727
90	370839	370838	370836	370834	370833	370831	370829	370828	370826	370824	370822	370820	370819	370817	370815	370813	370811	370809	370806	370804	370802
95	370907	370905	370904	370903	370901	370900	370898	370896	370895	370893	370892	370890	370888	370886	370884	370883	370881	370879	370877	370875	370873
100	370971	370970	370969	370967	370966	370965	370963	370962	370960	370959	370957	370956	370954	370952	370951	370949	370947	370946	370944	370942	370940

Figure 63: Total emissions costs [€] and identification of the Rupture scenario in Turin

Car sharing cost increase [%] \ Parking cost increase [%]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	3439	3446	3453	3461	3468	3475	3483	3491	3499	3507	3515	3523	3532	3540	3549	3558	3567	3576	3586	3596	3605
5	3248	3255	3261	3268	3275	3281	3288	3295	3303	3310	3317	3325	3333	3341	3349	3357	3365	3373	3382	3391	3400
10	3083	3089	3094	3101	3107	3113	3119	3126	3132	3139	3146	3153	3160	3167	3174	3182	3189	3197	3205	3213	3221
15	2935	2940	2946	2951	2957	2963	2968	2974	2980	2987	2993	2999	3006	3012	3019	3026	3033	3040	3047	3054	3062
20	2800	2805	2810	2815	2821	2826	2831	2837	2842	2848	2854	2860	2866	2872	2878	2884	2890	2897	2903	2910	2917
25	2676	2680	2685	2690	2695	2699	2704	2709	2715	2720	2725	2730	2736	2742	2747	2753	2759	2765	2771	2777	2783
30	2559	2563	2567	2572	2576	2581	2585	2590	2595	2600	2604	2609	2614	2620	2625	2630	2636	2641	2647	2652	2658
35	2448	2452	2456	2460	2464	2468	2472	2477	2481	2485	2490	2495	2499	2504	2509	2514	2519	2524	2529	2534	2540
40	2342	2346	2349	2353	2357	2361	2364	2368	2372	2377	2381	2385	2389	2394	2398	2403	2407	2412	2417	2422	2427
45	2240	2243	2247	2250	2254	2257	2261	2264	2268	2272	2276	2280	2284	2288	2292	2296	2300	2305	2309	2314	2318
50	2142	2145	2148	2151	2154	2158	2161	2164	2168	2171	2175	2178	2182	2186	2190	2193	2197	2201	2206	2210	2214
55	2047	2050	2053	2056	2059	2062	2065	2068	2071	2074	2077	2081	2084	2088	2091	2095	2098	2102	2106	2110	2114
60	1956	1958	1961	1963	1966	1969	1972	1975	1978	1980	1984	1987	1990	1993	1996	1999	2003	2006	2010	2013	2017
65	1867	1870	1872	1875	1877	1880	1882	1885	1888	1890	1893	1896	1899	1902	1905	1908	1911	1914	1917	1921	1924
70	1783	1785	1787	1789	1792	1794	1796	1799	1801	1804	1806	1809	1812	1814	1817	1820	1823	1826	1829	1832	1835
75	1701	1703	1705	1707	1709	1712	1714	1716	1718	1721	1723	1725	1728	1730	1733	1735	1738	1741	1743	1746	1749
80	1623	1625	1627	1629	1631	1633	1635	1637	1639	1641	1643	1645	1648	1650	1652	1655	1657	1659	1662	1665	1667
85	1549	1550	1552	1554	1555	1557	1559	1561	1563	1565	1567	1569	1571	1573	1575	1577	1580	1582	1584	1587	1589
90	1477	1479	1480	1482	1484	1485	1487	1489	1491	1492	1494	1496	1498	1500	1502	1504	1506	1508	1510	1512	1514
95	1410	1411	1412	1414	1415	1417	1418	1420	1422	1423	1425	1427	1428	1430	1432	1434	1436	1438	1440	1442	1444
100	1345	1347	1348	1349	1351	1352	1353	1355	1356	1358	1359	1361	1362	1364	1366	1367	1369	1371	1373	1375	1376

Figure 64: Total costs difference between BAU and Rupture scenario in Turin[€]

Appendix 11: Air pollution emissions and derived costs of others scenarios

The following tables contains the quantification of each pollutants deriving from private car fleet and car sharing fleets of Milan and Turin, for all the scenario described in par. 3.3. All tables contain a row named "Total [€]" that reports the economic evaluation of such quantification. In addition, one last row named "GAP [€]" report the cost difference between each scenario and the business as usual scenario (clearly Table 66 and Table 71, which refer to business as usual scenarios do not contain such differences). In this row, values marked in green represent savings for the city, while red values costs.

Business as usual scenario - Milan								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_X emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	245941	532978	-	-	-	-	-	-
Bike	109179	373213	-	-	-	-	-	-
Car	974248	22599125	3386.938	4.900	10.803	0.450	0.216	-
CS	17094	112584	9.872	0.005	0.005	0.001	0.000	-
PT	790935	9411337	-	-	-	-	-	-
Total	2137397	33029237	3396.810	4.904	10.808	0.451	0.216	-
Total [€]	-	-	**339681**	**5395**	**274532**	**9745**	**28554**	**657907**

Table 66: Business as usual scenario estimated air pollution daily costs – Milan

All switch scenario - Milan								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_X emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	236456	493587	-	-	-	-	-	-
Bike	100977	352664	-	-	-	-	-	-
Car	884653	21899534	3282.090	4.748	10.469	0.436	0.209	-
CS	201205	1590152	139.440	0.066	0.072	0.015	0.002	-
PT	714106	8580231	-	-	-	-	-	-
Total	2137397	32916168	3421.530	4.814	10.541	0.451	0.212	-
Total [€]	**-**	**-**	**342153**	**5295**	**267739**	**9748**	**27944**	**652879**
GAP [€]	**-**	**-113069**	**+2472**	**-99**	**-6793**	**+2**	**-610**	**-5029**

Table 67: All switch scenario air pollution costs and GAP analysis with BAU scenario - Milan

Rupture scenario - Milan								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	237620	498587	-	-	-	-	-	-
Bike	101444	354421	-	-	-	-	-	-
Car	876774	21750638	3259.775	4.716	10.40	0.43	0.208	-
CS	202150	1641171	143.914	0.068	0.074	0.016	0.002	-
PT	719409	8665757	-	-	-	-	-	-
Total	2137397	32910574	3403.689	4.784	10.472	0.449	0.210	-
Total [€]	**-**	**-**	**340369**	**5262**	**265989**	**9694**	**27765**	**649080**
GAP [€]	**-**	**-118663**	**+688**	**-133**	**-8543**	**-51**	**-789**	**-8827**

Table 68: Rupture scenario air pollution costs and GAP analysis with BAU scenario - Milan

All electric rupture scenario - Milan								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	237620	498587	-	-	-	-	-	-
Bike	101444	354421	-	-	-	-	-	-
Car	876774	21750638	3259.775	4.716	10.40	0.43	0.208	-
CS	202150	1641171	0	0	0	0	0	-
PT	719409	8665757	-	-	-	-	-	-
Total	2137397	32910574	3259.775	4.716	10.398	0.433	0.208	-
Total [€]	**-**	**-**	**325977**	**5187**	**264100**	**9357**	**27462**	**632084**
GAP [€]	**-**	**-118663**	**-13704**	**-207**	**-10432**	**-388**	**-1092**	**-25823**

Table 69: All electric rupture scenario air pollution costs and GAP analysis with BAU scenario - Milan

No car sharing scenario - Milan								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	247106	540653	-	-	-	-	-	-
Bike	110402	381267	-	-	-	-	-	-
Car	978925	22643459	3393.58	4.909	10.82	0.45	0.217	-
Taxi	2055	-	-	-	-	-	-	-
PT	798909	9463858	-	-	-	-	-	-
Total	2137397	33029237	3393.582	4.909	10.824	0.451	0.217	-
Total [€]	**-**	**-**	**339358**	**5400**	**274941**	**9741**	**28589**	**658030**
GAP [€]	**-**	**-**	**-323**	**+5**	**+409**	**-4**	**+35**	**+122**

Table 70: No car sharing scenario air pollution costs and GAP analysis with BAU scenario - Milan

Business as usual scenario - Turin								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	192856	332002	-	-	-	-	-	-
Bike	27735	92717	-	-	-	-	-	-
Car	684452	13496372	1982.356	2.394	5.892	0.253	0.122	-
CS	4500	22805	2.004	0.001	0.001	0.000	0.000	-
PT	364532	3782642	-	-	-	-	-	-
Total	1274075	17726539	1984.360	2.395	5.893	0.253	0.122	-
Total [€]	-	-	**198436**	**2635**	**149672**	**5472**	**16103**	**372316**

Table 71: Business as usual scenario estimated air pollution daily costs - Turin

All switch scenario - Turin								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	181590	306244	-	-	-		-	-
Bike	25578	84928	-	-	-		-	-
Car	615010	13031078	1914.014	2.312	5.688	0.244	0.118	-
CS	120924	924370	81.229	0.039	0.043	0.009	0.001	-
PT	330973	3356660	-	-	-		-	-
Total	1274075	17703280	1995.243	2.351	5.731	0.253	0.119	-
Total [€]	**-**	**-**	**199524**	**2586**	**145579**	**5473**	**15714**	**368877**
GAP [€]	**-**	**-23259**	**+1088**	**-49**	**-4092**	**+2**	**-388**	**-3439**

Table 72: All switch scenario air pollution costs and GAP analysis with BAU scenario - Turin

Rupture scenario - Turin								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	181590	306244	-	-	-	-	-	-
Bike	25578	84928	-	-	-	-	-	-
Car	613404	13021392	1912.591	2.310	5.684	0.244	0.118	-
CS	122530	934056	82.080	0.040	0.044	0.009	0.001	-
PT	330973	3356660	-	-	-	-	-	-
Total	1274075	17703280	1994.671	2.350	5.728	0.253	0.119	-
Total [€]	**-**	**-**	**199467**	**2585**	**145483**	**5471**	**15705**	**368711**
GAP [€]	**-**	**-23259**	**+1031**	**-50**	**-4188**	**0**	**–398**	**–3605**

Table 73: Rupture scenario air pollution costs and GAP analysis with BAU scenario - Turin

All electric rupture scenario - Turin								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	181590	306244	-	-	-		-	-
Bike	25578	84928	-	-	-		-	-
Car	613404	13021392	1912.591	2.310	5.684	0.244	0.118	-
CS	122530	934056	0.000	0.000	0.000	0.000	0.000	-
PT	330973	3356660	-	-	-		-	-
Total	1274075	17703280	1912.591	2.310	5.684	0.244	0.118	-
Total [€]	**-**	**-**	**191259**	**2541**	**144378**	**5274**	**15532**	**358984**
GAP [€]	**0**	**-23259**	**-7177**	**–94**	**-5293**	**-197**	**-571**	**-13332**

Table 74: All electric rupture scenario air pollution costs and GAP analysis with BAU scenario - Turin

No car sharing scenario - Turin								
	Trips	Trips length sum [km]	Daily CO_2 emission [t]	Daily NMVOC emission [t]	Daily NO_x emission [t]	Daily NH_3 emission [t]	Daily $PM_{2.5}$ emission [t]	Total cost [€]
Walk	193213	333557	-	-	-		-	-
Bike	28148	94349	-	-	-		-	-
Car	686043	13505353	1983.675	2.396	5.895	0.253	0.122	-
Taxi	246	-	-	-	-		-	-
PT	366425	3793281	-	-	-		-	-
Total	1274075	17726539	1983.675	2.396	5.895	0.253	0.122	-
Total [€]	**-**	**-**	**198368**	**2635**	**149744**	**5470**	**16109**	**372327**
GAP [€]	**0**	**-23259**	**-68**	**+1**	**+73**	**-1**	**+6**	**+10**

Table 75: No car sharing scenario air pollution costs and GAP analysis with BAU scenario - Turin

Appendix 12: Additional outcomes used in the evaluation of the impacts on public spaces

The sum of the total number of trips reported in the last row is two times the number of car daily trips diverted to car sharing (97474 for the city of Milan and 71048 for the city of Turin), since here both the origin and the destination of each trip were considered.

Zone	Origin			Destination		
	Street (negative)	Parking (negative)	Garage (neutral)	Street (positive)	Parking (positive)	Garage (neutral)
EXT	19591	1319	14624	36896	7178	3326
1	7044	1611	1933	12231	122	3162
2	1158	5200	492	1458	410	216
3	8670	566	4932	3476	0	0
4	947	0	5172	1537	3396	666
5	41	0	81	97	42	0
6	2999	419	2774	5684	373	206
7	995	0	6185	3957	1372	469
8	4546	8	189	1772	0	121
9	4060	296	1622	8350	39	860
Total	**50051**	**9419**	**38004**	**75516**	**12932**	**9026**

Table 76: CS impacts on parking events resulting from the difference between rupture and BAU scenario in Milan

Zone	Origin			Destination		
	Street (negative)	Parking (negative)	Garage (neutral)	Street (positive)	Parking (positive)	Garage (neutral)
EXT	6150	3424	22183	29448	5778	2531
1	3356	974	418	5414	0	769
2	7322	52	1766	4693	0	0
3	4961	273	5649	2973	0	0
4	1823	719	2124	4375	436	1056
5	1968	403	2204	2392	0	0
6	638	302	1030	1121	260	0
7	0	0	1135	1888	52	264
8	1096	243	835	5554	539	1505
Total	**27314**	**6390**	**37344**	**57858**	**7065**	**6125**

Table 77: CS impacts on parking events resulting from the difference between rupture and BAU scenario in Turin