



MOBILITY SERVICES FOR URBAN SUSTAINABILITY

Environmental assessment

Report WP 6

***moses* deliverable D6.2**

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1 Introduction

1.1 Overview of the *moses* project

moses - mobility services for urban sustainability – is a European project that will develop mobility services to reduce dependence on the private car on a European scale - without restricting mobility. The existing small-scale system of *moses* is to be improved significantly, with better service, integrated innovative technologies, intermodal co-operation with other mobility services (e.g. public transport, taxi, cycling etc.) and integration of these innovative services into strategies of urban revitalization and new developments to increase urban efficiency. The *moses* project is practice orientated and will examine the demonstrator sites (London, Stockholm, Genoa, Palermo, Turin, the Walloon Region, Bremen and Bucharest) under real-life conditions. *moses* will achieve sizeable impacts on the environment and traffic.

1.2 Overview of WP 6 and this report

The evaluation process of *moses* is to a great extent handled in work package 6 (WP 6) – monitoring and assessment. There is two main parts in WP 6, where the first part already has been reported in delivery 6.3: Legal, political and fiscal incentives and barriers for car-sharing. These horizontal issues may influence the expansion and development of *moses* quite severely and is therefore handled in a separate report.

This report is focused to explore the direct impacts (on space consumption, CO2 emission, local emissions etc) of the implemented measures. In order to calculate this a lot of other areas has been investigated such as changes in car ownership and transport mode usage, as well as some background information about the users. Both private users and corporate users of car-sharing has been surveyed.

The original plan was naturally to survey all involved cities in the project. It has however only been possible to perform surveys in Bremen, Stockholm and Belgium (Brussels and Wallonie), primarily due to a lack of enough clients to receive a valid result in some cities. Regarding private users the results are coming from Bremen and Belgium, and for corporate users the results are coming from Bremen and Stockholm.

The term “car-sharing” will at times in this report be abbreviated with CS.

1.3 Method

To assess the effects of car-sharing, information has been collected from users as well as providers of car-sharing. Four questionnaires have therefore been developed, one for each of the following groups:

- A) private users
- B) corporate members: managers
- C) corporate members: drivers
- D) operators/providers

Together these four questionnaires provide enough data for assessment of the set objectives.

The questionnaires were first constructed in English. Each site then interpreted them to the relevant language, distributed them to an adequate amount of users and compiled the answers into a reporting tool. The filled in reporting tools were sent to the work package leader who then put the results together and analyzed it.

In order to reach a high response rate, incentives were offered to private participants of the survey. It was up to each site to decide on a suitable incentive.

At the Bremen site, with some 2,000 private customers at the time, the questionnaire was sent to 30% of the private users. At all other sites – where the number of users at this time has reached only a few hundred – every user received a questionnaire, in order to get a high quality result.

For corporate members, questionnaires were sent to both drivers and transport managers at each company. The reason for this was that drivers were not expected to have the full overview on changes in mileage of the employees, effects on travel to and from work etc. These two questionnaires therefore complimented each other.

Possible sources of error

Evaluations based on questionnaires are in general faced with two major questions that can be problematic:

- 1) are the responses received representative for the whole population we would like to describe
- 2) did the respondents answer the questions correctly.

In this case we do not expect the representativeness to be a major problem due to a relatively high response rate. The correctness of each respondents answer is of course hard to estimate, but we have not experienced any critical issues that indicate this. The biggest problem is probably the estimation of mileage before joining car-sharing, but there is however very few other ways than using a questionnaire to estimate the change in mileage. A few calculations of variations have been made which did not show any major changes, and together with the fact that the results are in line with previous studies the results are judged to be reliable.

1.4 Writers and contributors to this report

The City of Stockholm has been responsible project partner for work package 6, but the work has been contracted to and performed by Trivector Traffic, in dialogue with the City of Stockholm. The work of Trivector Traffic has been operated by Christian Rydén and Emma Morin. The input from the sites has been collected primarily by an evaluation manager at each site, to whom we are very grateful:

Stockholm	Sven Alexanderson, City of Stockholm
Bremen	Roy Trau, Cambio, Bremen
Belgium	Dirk Dufour, Espaces Mobilites, Brussels
Italy	Massimo Coccozza, ATM, Turin
United Kingdom	Roger Swinbourne, SEA, London

2 Private users

2.1 General information

For private users it has only been possible to collect results from Bremen and Belgium (Brussels and in Wallonie: Namur, Liege, Louvain la Neuve, Dinant). Stockholm, London and Bucharest did at the time of the survey not reach enough private customers to produce results that prove to be statistically valid (in some cases it was never planned to have a large private customer base, as in Stockholm for example). In Italy a large national survey was done just before this *moses* survey was planned, which made it inadequate to launch another survey at about the same time.

The response rate among private users was 38-45% which means about 300 respondents from each site. These figures are reckoned to give a valid result.

Table 2.1 Response rate among respondents, private users.

	Bremen	Belgium
Nr of returned questionnaires	301	272
Response rate	45%	38%

2.2 Background information on users

Age

The average respondent is 44 years old in Bremen and 39 years old in Belgium. This might not seem as a big difference, but by looking at the age distribution in Figure 2.1 one can see that a large share of Bremen's respondents are around 40-60 while most Belgian respondents are younger than 40.

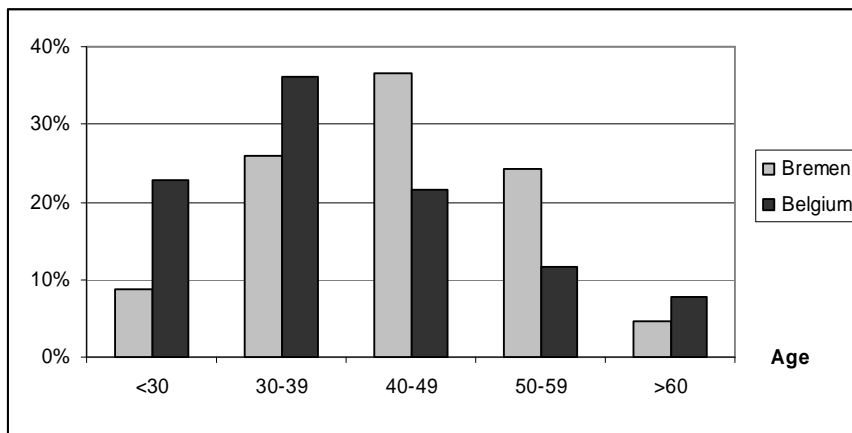


Figure 2.1. Age distribution among respondents.

Sex

In Bremen the share of men and women among the respondents is exactly 50%. However in Belgium the share of men (59%) is a bit higher than the share of women (41%).

Type of household

In both Bremen and Belgium, half of the respondents live in single households and half live in couple households.

Children

In Bremen 34% of the respondents have children under the age of 18 living in the household. The corresponding number in Belgium is 25%.

The respondents in Bremen have on average 1,5 children under 18 years old living in the household. The average number in Belgium is 0,7 which apparently is quite lower than in Bremen.

Level of education

Figure 2.2 shows the car sharing users' level of education. The majority of the users have a university education or similar. Over 50% of the members have a university education which is estimated to be higher than the average citizen at each site.

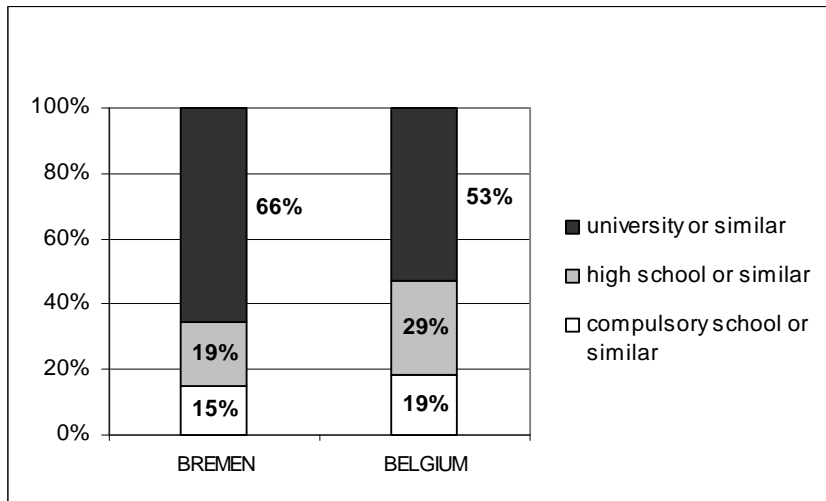


Figure 2.2 Level of education among respondents.

Monthly income

Figure 2.3 and Figure 2.4 show the stated net income of members separated on single and couple households. Unfortunately it has not been possible to find average figures to compare this with, but it is still clear that car-sharing does not only attract low income households but also a large share of household fairly well off.

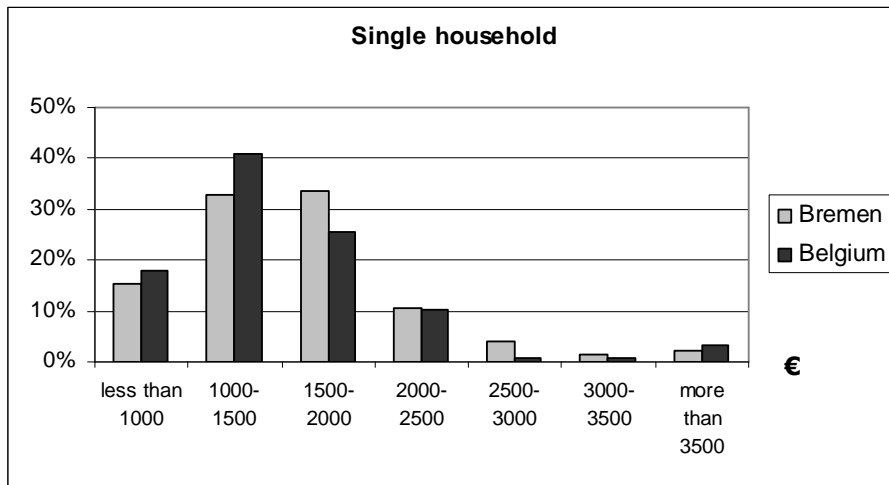


Figure 2.3. The households monthly net income (€ after tax). Single household

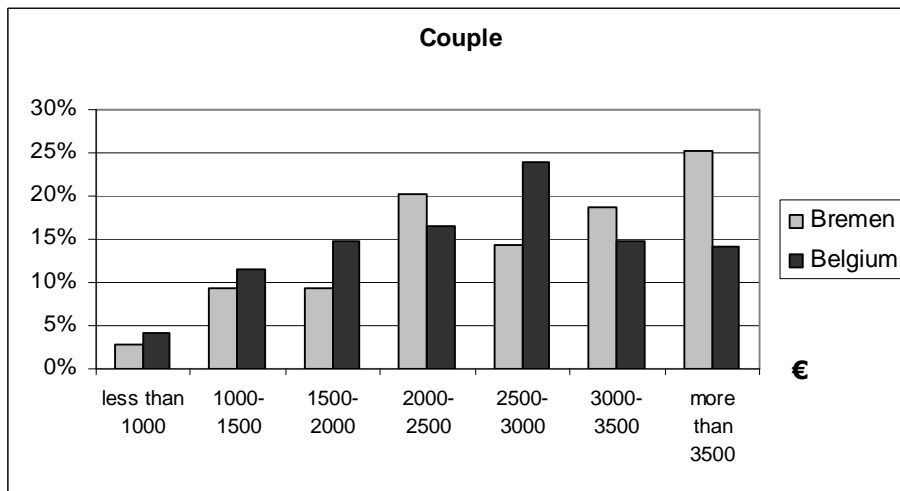


Figure 2.4 The household monthly net income (€ after tax). Couple households

2.3 Car-sharing membership

Distance

The distance to nearest car-sharing car is on average 700 m in Bremen and 2800 m in Belgium.

The very high figure for Belgium is due to a small number of extremely high values that skew the average (up to 65km). This is probably because they work or have rooms in a CAMBIO city far away from their place of residence. However the median is exactly 1 km (50% live within this range). At the same time, the station density in Belgium is not as high as in Bremen, so even within Brussels people probably go further to a station. As the number of stations increases, the distances will drop.

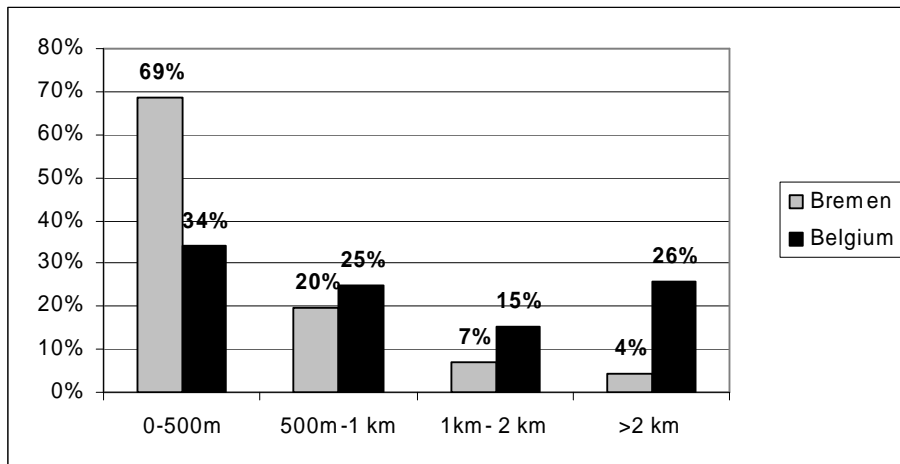


Figure 2.5 Share of members distance to nearest car-sharing car.

Family members access to car-sharing

In Figure 2.6 below, the access to car-sharing cars among other household members is shown (for couple households). Only 12-22% of the couple households have more than one person with access to the cars, which can seem somewhat surprising. It was checked whether this could be because more couples also have a private car, but it is only around 20% (18-22%) of all couples who have a private car beside their car-sharing membership.

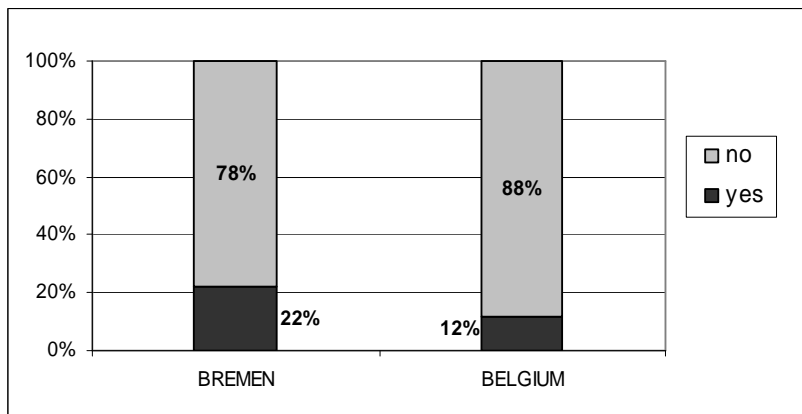


Figure 2.6 Family members access to car-sharing among couple households.

Year of joining car-sharing

In Figure 2.7 the year of joining car-sharing in Bremen and Belgium is shown. Car-sharing in Belgium started in 2002 which explains that all Belgian members belong to the latest bracket. In Bremen car-sharing has existed since early nineties and has therefore a wider distribution in year of joining, but still more than 50% of the respondents joined in 2000 or later.

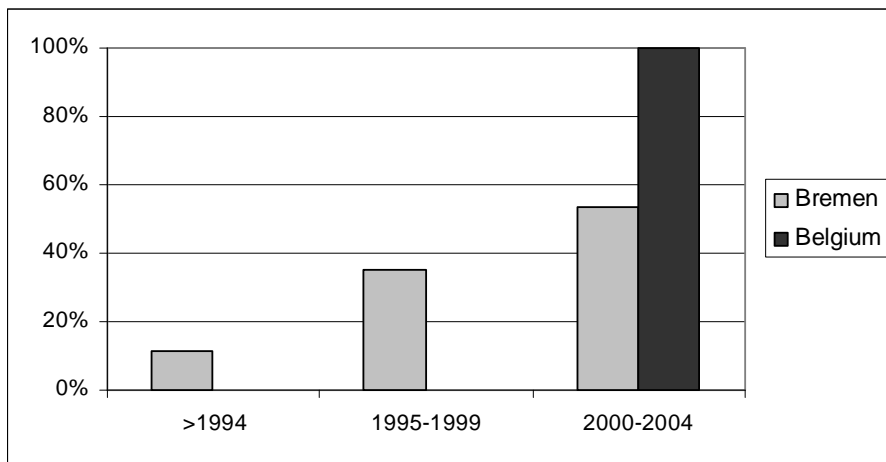


Figure 2.7 Year of joining car-sharing.

Reasons for joining car-sharing

In the questionnaire the private users were asked about reasons for joining car-sharing. The most common reasons are to contribute to environmental protection and getting rid of maintenance issues and general hassle.

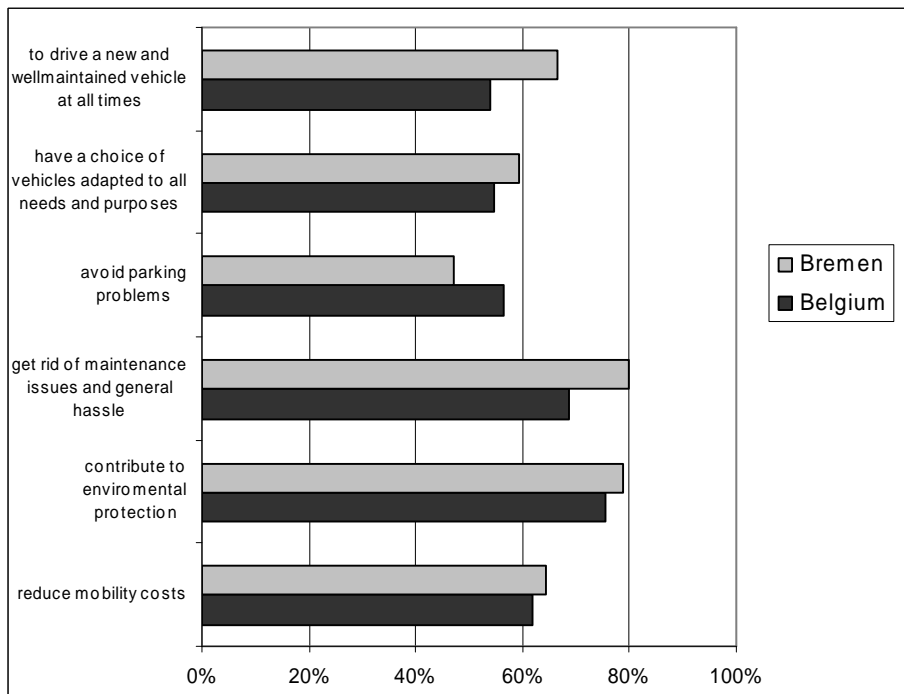


Figure 2.8 Members' statements of very important and rather important reasons for joining car-sharing.

Many of the private users (25% in Bremen and 47% in Belgium) also mentioned other reasons for joining besides for the reasons mentioned in the questionnaire. Common reasons mentioned by the private users are shown in Figure 2.9, and the most common reason mentioned is the flexibility given by car-sharing. Many drivers also state that they drive very little and therefore do not see the point in owning a private car.

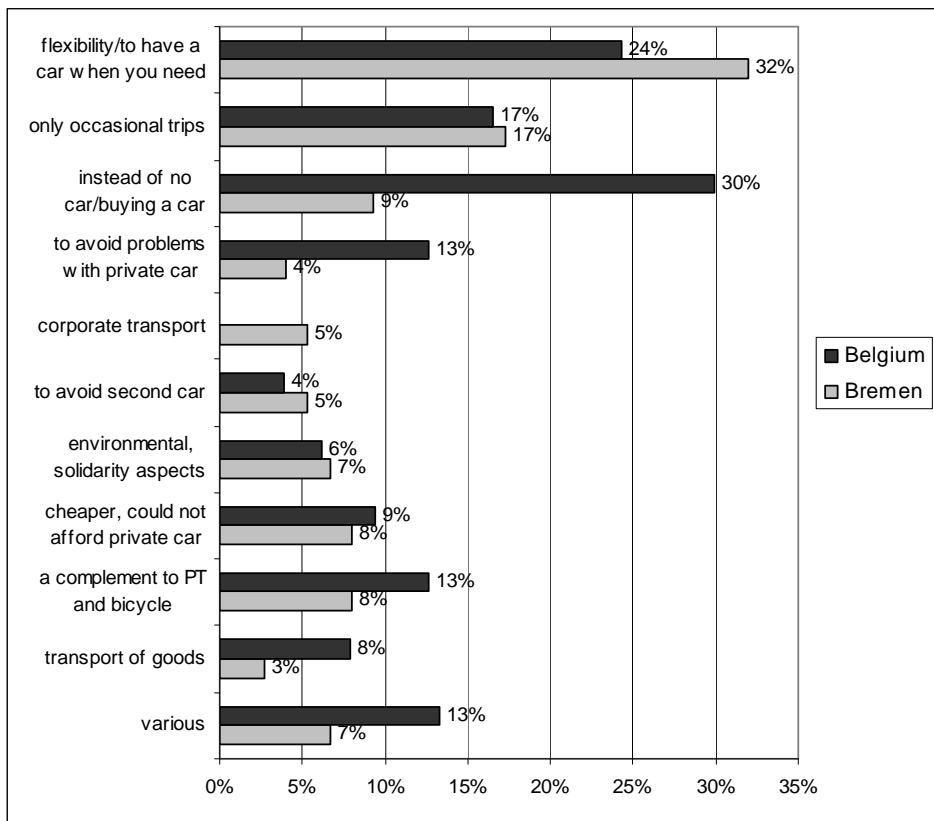


Figure 2.9 Other reasons for joining car-sharing.

2.4 Car-ownership

The majority of the respondents in both countries (60-65%) have owned a car before but do not own a car today. Slightly more than 10% own a car today and the remaining (20-30%) do not own a car and have never owned one before.

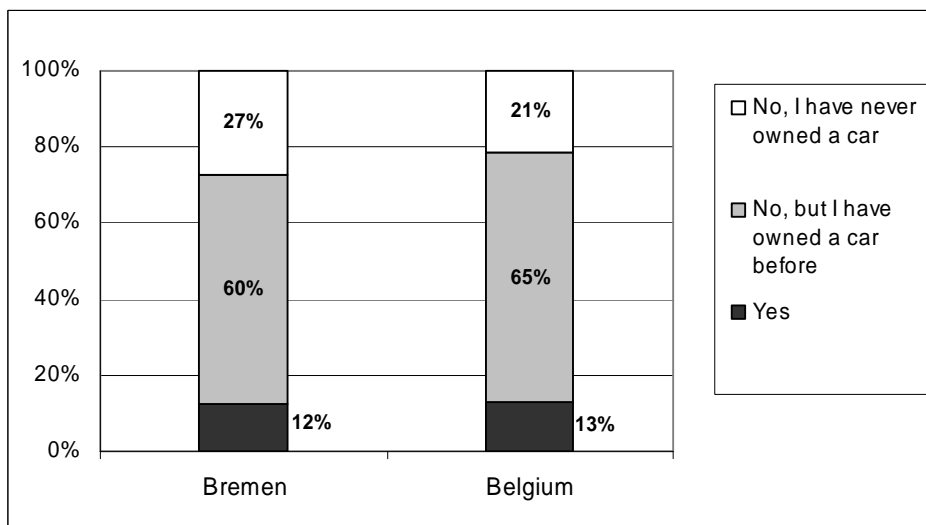


Figure 2.10 Does your household own a car today?

Car abolition influenced by car-sharing

The users who do not own a car today but have owned a car before were asked whether the abolition was influenced by car-sharing. In Bremen 57% percent of the former car owners stated that car-sharing did influence them, which means that 34 percent of the respondents in Bremen have got rid of a car at least partly because of car-sharing. The corresponding figures for Belgium are 33% percent of the former car owners influenced by car-sharing, which means that 21 percent of the respondents got rid of a car at least partly because of car-sharing.

Figure 2.10 shows that 12-13% of the respondents own a car today. In Bremen, three of these households (13% of present car owners) state that car-sharing influenced them to get rid of a car, which means that car-sharing has replaced their second car. The corresponding number of households in Belgium is five households (17% of present car owners).

If not joining car-sharing

The previous section deals with the actual effect of car-sharing on car abolition. But it is probable that car-sharing also make people give up plans to buy a car. A question was therefore asked about if they had not joined car-sharing, would they then have bought a car? By looking at answers of the respondents who did not get rid of a car, we can make an interesting estimate of the potential of cars that is not bought because of car-sharing. The responses to the four possible answers are presented in Figure 2.11 below.

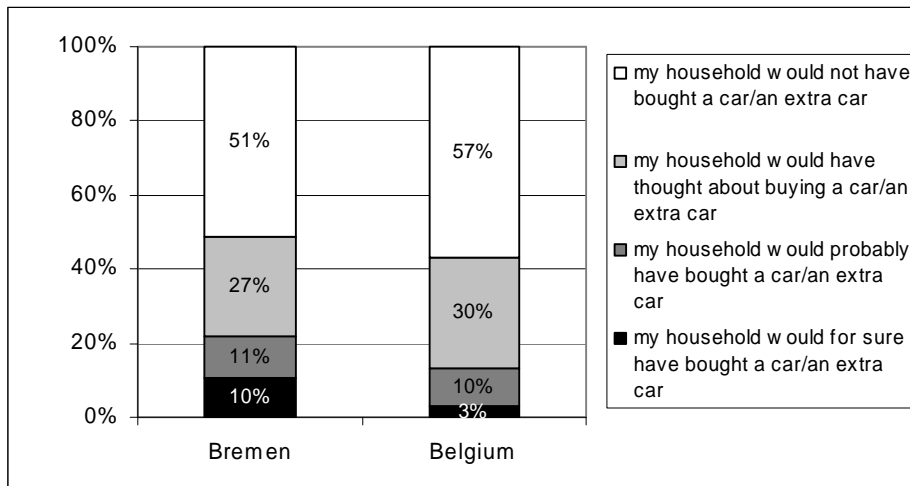


Figure 2.11 Respondents who did not get rid of a car due to car-sharing, would they have bought a car if they had not joined car-sharing?

In order to calculate the effect of cars not bought, the responses are assumed to give the following results.

The answer	"would not have bought"	means	0% chance of purchase
	"thought about buying"	means	25% chance of purchase
	"probably have bought"	means	75% chance of purchase
	"would for sure have bought"	means	100% chance of purchase

This means for Bremen that 25% of the members who have not got rid of a car influenced by car-sharing would have bought a car if they had not joined car-

sharing ($0\% \cdot 51\% + 25\% \cdot 27\% + 75\% \cdot 11\% + 100\% \cdot 10\% = 25\%$). This corresponds to 17% of all members ($25\% \cdot 66\% = 17\%$).

This means for Belgium that 18% of the members who have not got rid of a car influenced by car-sharing would have bought a car if they had not joined car-sharing ($0\% \cdot 57\% + 25\% \cdot 30\% + 75\% \cdot 10\% + 100\% \cdot 3 = 18\%$). This corresponds to 14% of all members ($18\% \cdot 79\% = 14\%$).

Conclusion on car replacement

In Bremen 34% percent of respondents say they were influenced by car-sharing and got rid of a car, while the corresponding figure for Belgium is 21%. This can be considered the actual or minimum effect of car replacement by car-sharing.

To this minimum effect the potential effects of reduced buying of cars can be added (as calculated in the previous section), which gives a maximum effect. The maximum effect of car replacement would then for Bremen be 51% ($34\% + 17\%$) and for Belgium 35% ($21\% + 14\%$).

The car-sharing operator in Bremen has 5 cars per 100 private members¹, which means that as a minimum 34 cars are replaced with 5 cars (per 100 members), or more simplified: each car-sharing car replaces close to 7 private cars ($34/5=6,8$). Using the maximum replacement, 51 cars are replaced with 5 cars (per 100 members), which means that each car replaces 10 cars.

The car-sharing operator in Belgium has 5,6 cars per 100 members,² which means that as a minimum 21 cars are replaced with 5,6 cars (per 100 members), or more simplified: each car-sharing car replaces close to 4 private cars ($21/5,6=3,75$). Using the maximum replacement, 35 cars are replaced with 5,6 cars (per 100 members), which means that each car replaces 6 cars.

Car-sharing reduces the need for a private car and therefore reduces the amount of cars in urban areas.

In Bremen, each car-sharing car replaces 7-10 private cars.

In Belgium, each car-sharing car replaces 4-6 private cars.

¹ 91 cars are used by 1727 household clients ($91/1727=0,05$ cars per client) but also by 648 corporate clients. Considering this cross-use of the cars, the replacement effect could be considered to be even higher than calculated above.

² 63 cars are used by 1126 household clients ($63/1126=0,056$ cars per client) but also by some corporate clients. Considering this cross-use of the cars, the replacement effect could be considered to be even higher than calculated above.

Change in parking space needed

The reduced number of cars according to the above section also reduces the need for parking bays. Space needed for parking varies between on street parking and parking lots or garages. Average size for a parking lot or garage is 20-30 m² per car, including space needed for driveways etc. For on street parking only about 10 m² is needed. An average figure of 15 m² is used here, which means a mix of about 70% on street parking and 30% in parking lots.

In Bremen each car-sharing car replaces 7-10 private cars, which means that each car-sharing car also reduces space of 6 to 9 bays which is equivalent to 90-135 m². The saved space in Belgium is calculated to be 45-75 m² per car-sharing car.

The parking space reduced in relation to each car-sharing member is 4-7 m² in Bremen (20 private members per shared car) and 2-4 m² in Belgium (18 private members per shared car).

An extra reduction could be calculated depending of the amount of "micro-sized" cars in the CS-fleet, since such cars need less parking space. However, the fleets in both Bremen and Belgium consist of very few micro-sized cars, so this effect is negligible.

Since car-sharing reduces the need for a private car, a lot of space for parking can be saved and used for other purposes.

In Bremen, each car-sharing car reduces the need for parking space by 90-135 m².

In Belgium, each car-sharing car reduces the need for parking space by 45-75 m².

2.5 Change in type of cars used

It is sometimes said that car-sharing changes the type of cars used to newer and smaller cars, which are more efficient and less pollutant compared to the cars replaced. The respondents who got rid of a car influenced by car-sharing were therefore asked what type of car they abolished in terms of size, year of production and fuel type.

In Belgium 54% percent of the cars abolished were medium sized or larger (30% medium, 16% large and 8% extra large). This should be compared to the car-sharing fleet consisting of only 15 percent medium sized cars (the rest is small cars) which means a replacement of this type of car with about 40%. A possible explanation for this is that the private car is often bought to suit the owners most extreme need in terms of size, for instance family summer vacation etc. Car-sharing build on the principle to have cars that meet the specific need each time of usage, which means that a much smaller share of the fleet need to be large cars. Another theory is that car-sharing customers are less likely to use cars as status symbols, which make smaller cars more adequate and popular.

65% percent of the Belgian cars gotten rid of were manufactured in 1995 or earlier. 17 percent were even from 1987 or older and therefore did not have catalytic converters, which means they were relatively heavy polluters regarding carbon monoxide (CO), hydrocarbons (HC) and nitrogen oxides (NO_x). This should be compared to the car-sharing fleet where the average production year was 2002 (which is not only due to the fact that car-sharing in Belgium started in 2002 but

also that car-sharing usually keep their cars for 3 years and then they are replaced with new cars).

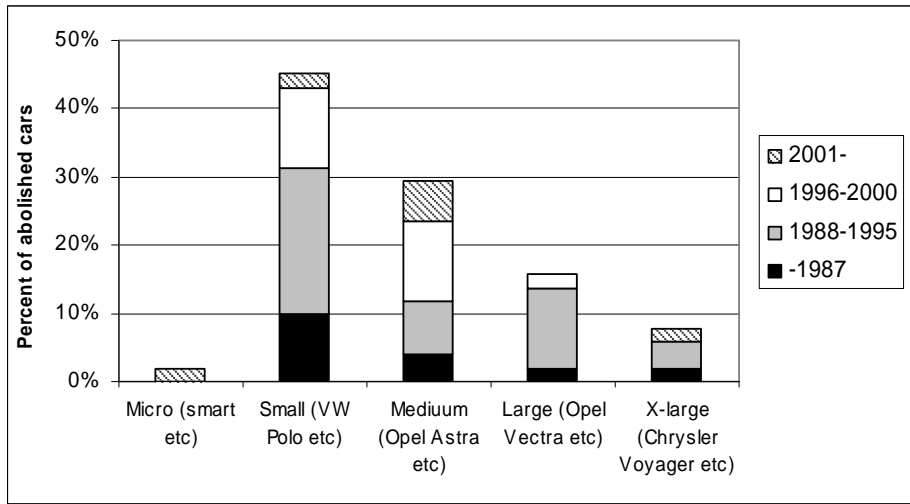


Figure 2.12. Type of cars abolished in Belgium (influenced by car-sharing membership). Total numbers of cars abolished was 51.

The age and size of cars abolished in Bremen is shown in Figure 2.13. 69 % of the cars were medium sized ore larger, to be compared to the car-sharing fleets share of only 30% (which equals a replacement of this type of car with about 40%). More than half of the cars were older than from 1987, but since some of the respondents in Bremen joined car-sharing already in the early 1990's it is not fair to compare these replaced cars with the newer car-sharing cars (if car-sharing was not an option in Bremen it is likely that some members would have replaced their cars with newer ones). However, the results should not be very different from the Belgium results (especially not since the average joining year for Bremen respondents abolishing a car is as recent as 1999, and the cars abolished are still much older than the Belgium cars).

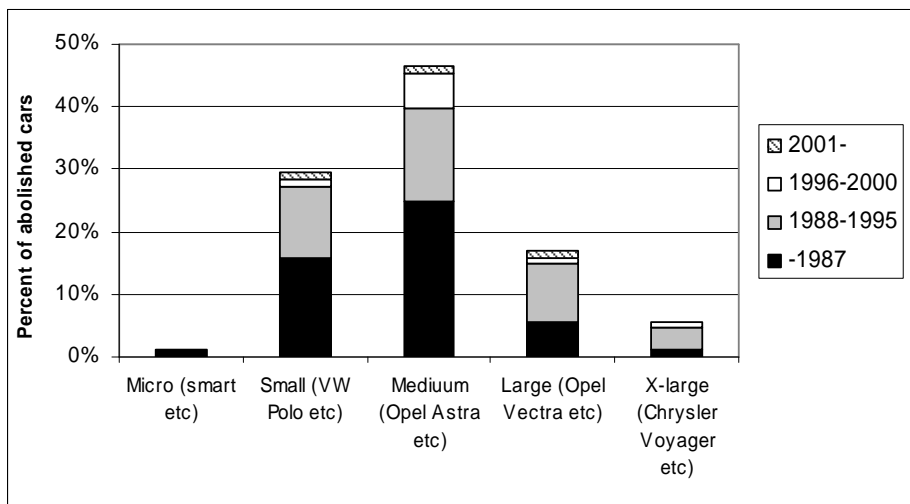


Figure 2.13. Type of cars abolished in Bremen (influenced by car-sharing membership). Total numbers of cars abolished is 88.

A shift in fuel used (diesel or petrol) can also be noticed when abolishing a private car and using car-sharing instead. Both in Bremen and Belgium about 25% of the abolished cars run on diesel, while the share of diesel cars in the car-sharing fleet is lower than 5%. Whether this effect is good or bad is however somewhat ambiguous, but a general view is that petrol is better for city traffic and diesel better for highway traffic (this view is based on the fact that diesel usually means lower emissions of CO₂, but higher emission of pollutants that are more directly hazardous to human health such as CO and HC etc). Since the level of pollution in cities usually is a health problem, and most of car-sharing traffic can be assumed to take place in urban areas, the shift from diesel to petrol due to car-sharing can be considered to be positive. To which extent is however extremely difficult to calculate, and therefore no further analysis is made in this report.

Car-sharing cars are smaller and newer compared to the private cars they replace.

Among the total fleet of cars, the share of medium sized cars are reduced by 40% of the total fleet (in Belgium from 54% to 15%, in Bremen from 70% to 30%).

65% of abolished cars in Belgium were from 1995 or earlier, which can be compared to the car-sharing fleets average production year of 2002 (these figures are estimated to be relevant also for Bremen).

2.6 Transport mode usage

Car usage

The car usage before joining car-sharing was on average 9 400 km in Belgium and 6 900 km in Bremen. The distribution of mileage among the clients is shown below in Figure 2.14.

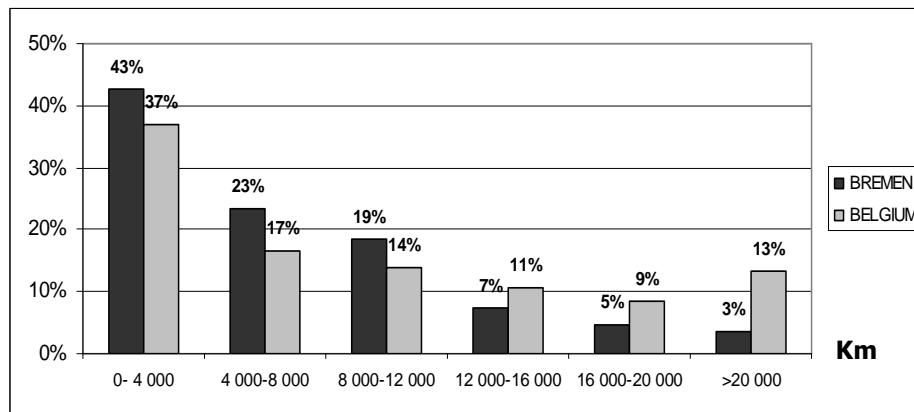


Figure 2.14 Annual mileage (km) by car **before** joining car-sharing

The respondents were also asked to estimate their change in mileage since joining car-sharing. Among those who increased their driving the average increase was 800 km in Bremen and 1 200 km in Belgium (which means +60% and +14% increase compared to their own previous mileage. However, because of the low

share of "increasers" this only corresponds to 1% of the total previous mileage of all respondents.

Among those who decreased their driving, the average decrease was 6 600 km in Bremen and 11 100 km in Belgium. In Bremen this corresponds to -46% and in Belgium -29% of the total previous mileage of all respondents.

If the groups of decrease, increase and "no change" are put together, the average change in Bremen is -45% and in Belgium -28%.

Table 2.2 Change in car usage since joining car-sharing ($N_{Bremen}=267$, $N_{Belgium}=234$)

	Share of respondents	Mileage before CS, km per person and year	Change km per person and year	Change % of own group's previous mileage	Change % of all respondents previous mileage
Bremen	100%	6 900	-3 100		-45%
"Increasers"	7%	1 300	+800	+60%	1%
"No change"	45%	5 500	-	-	-
"Decreasers"	48%	9 000	-6 600	-73%	-46%
Belgium	100%	9 400	-3 000		-28%
"Increasers"	7%	8 800	+1 200	+14%	1%
"No change"	65%	9 000	-	-	-
"Decreasers"	28%	15 500	-11 100	-72%	-29%

The change in car usage since joining car-sharing is also described in Figure 2.15 below.

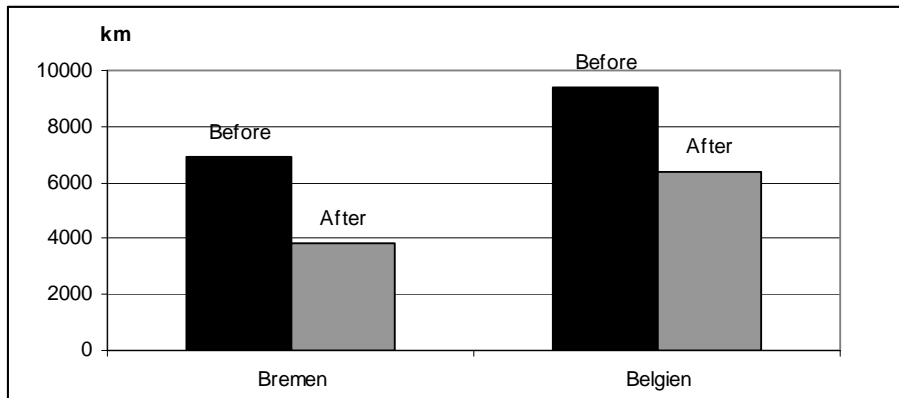


Figure 2.15. Change in car usage since joining car-sharing

Car-sharing reduces car mileage by 3 000 km per member and year, which corresponds to 28-45% of previous mileage.

(Belgium 28% and Bremen 45%)

It should be mentioned here that the above calculations regarding mileage are dependent on respondents' memory, which of course can be a source of error. The results are however rather well corresponding to other studies of car-sharing (see Table 2.3). Those studies usually report around 30-50% reduction of mileage. In Bremen a reduction of 45% can be seen, which is significantly higher than the study in Bremen performed in 1998, but very similar to a study made in 2003 (which has not yet been published though).

Table 2.3 Change in car usage since joining car-sharing, from previous studies.

Country/City	Change in mileage	Source
Netherlands	-33% -2 700 km	Meijkamp, 2000
Switzerland	-36% -1 500 km	Muheim, 1998
Bremen	-32% -2 600 km	Koch, 1998
Bremen	-54% -2 480 km	Koch, 2003 (not yet published)

There are other studies that show up to 80% reduction of car use (Munich, 1996 and 2002). These studies are unfortunately only considering the use of *car-sharing cars* after joining car-sharing; the use of borrowed and rented cars are not asked about in the "after" situation, which might give inadequate results.

Not all respondents have estimated their absolute change in mileage but they have at least stated whether they have changed their car usage or not after joining car-sharing. As can be seen in Figure 2.16 most of those respondents state that their car usage has decreased or is the same as before, and they are thereby rather well corresponding to the group from which the reduction calculation above is made.

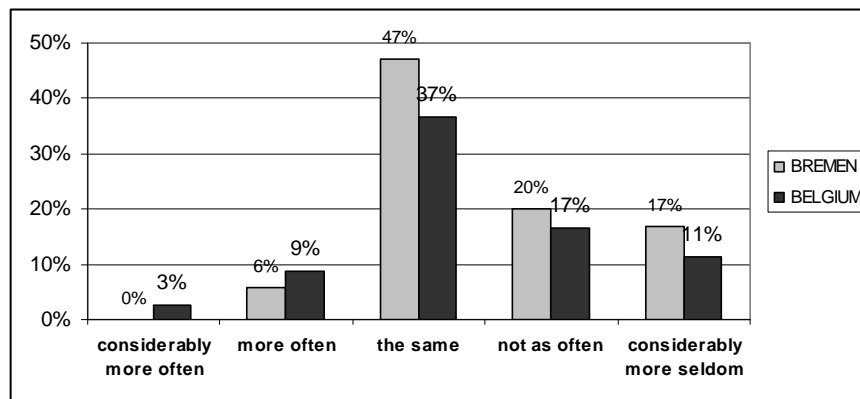


Figure 2.16 Change in car-usage estimated by the group who has not stated a change of mileage in figures (the group called "no change" above).

To analyze the mileage changes further, the change in mileage can be divided into different groups. In Figure 2.17 all respondents have been divided into the groups **car owners** (own a car today), **substituters** (do not own a car today but have owned before) and **car free** (have never owned a car). A decrease in car use can be noted for all three groups, but the size of the change is quite different; The respondents who have never owned a car reduce their mileage very little, while the persons who have owned a car before show a dramatic reduction by 4 000-5 000 km per year. The present car owners who uses car-sharing as a second car are somewhere in between.

It might seem surprising that even present car owners and especially those who have never owned a car before do not increase their mileage after joining car-sharing. This survey has not involved questions to investigate why this is so, but other car-sharing surveys have reported the same effects, and Meijkamp (2000) argue that in the case of the car free the decrease is due to the fact that car-sharing replaces car borrowing from friends etc. Since car-sharing gives a better transparency of costs it will reduce the driving even among those who did not own a car before.

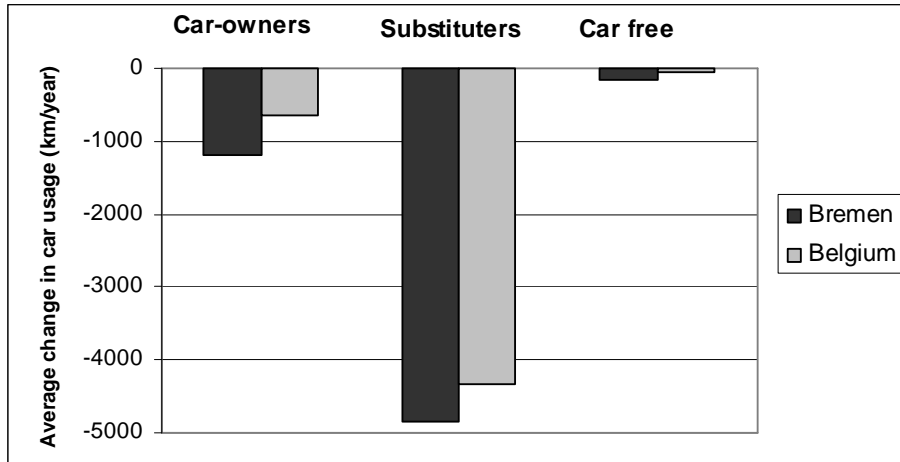


Figure 2.17 Average changes in car usage for different groups.

Figure 2.18 and Figure 2.19 show the change in usage of different transport modes stated more qualitatively by the respondents. The use of transport modes have either stayed the same or increased for every mode except for car. Slightly more than half of all car-sharing users have decreased their use of car. Only about 10-15% have increased their car use. This number is rather low, considering that 20% of the car-sharing users did not own a car before.

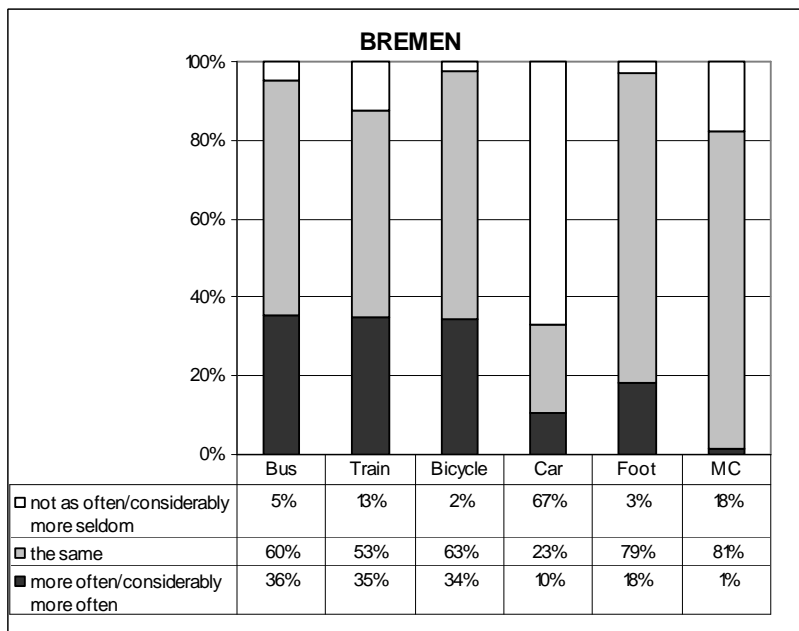


Figure 2.18 Changes in usage of different transport modes in BREMEN since joining car-sharing.

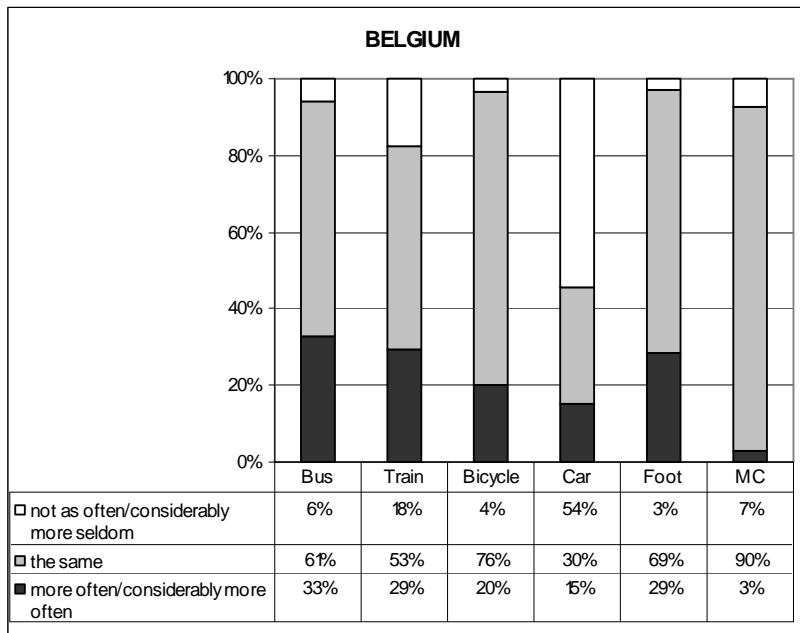


Figure 2.19 Changes in usage of different transport modes in BELGIUM since joining car-sharing.

Public transport usage

Before car-sharing has been introduced in a city, region or country, the relation between car-sharing and public transport can be strained. PT operators sometimes suspect that car-sharing is a competitor to public transport. When the relation between the modes has been studied more in detail, car-sharing is usually considered to benefit public transport. In this survey the total effect on public transport usage is on average +1 100 km/year for respondents both in Bremen and Belgium. This can be compared to Muheim (1998) who reports a 2000 km increase and Baum & Pesch (1994) who reports a 1500 km increase³. In Table 2.4 below the changes in use of public transport is shown in total as well as separated in the groups increasers, decreaseers and no change.

Table 2.4 Change in public transport usage for different groups since joining car-sharing ($N_{Bremen}=291$, $N_{Belgium}=256$)

	Share of respondents	Change km per person and year
Bremen	100%	+ 1 100
"Inceasers"	32%	+3 900
"No change"	63%	-
"Decreasers"	5%	-1 900
Belgium	100%	+ 1 100
"Inceasers"	22%	+5 200
"No change"	73%	-
"Decreasers"	5%	-1 700

³ Baum, H. Pesch., Stephan (1994). Untersuchung der Eignung von Car-Sharing im Hinblick auf die Reduzierung von Stadtverkehrsproblemen. Köln.

Even though car-sharing leads to a more frequent use of public transport, one objection could be that the increased use is mostly done in peak hours and that car-sharing will steal customers from public transport at evenings and weekends. This hypothesis is not confirmed in this study, on the contrary the increase in PT use is actually slightly larger during weekends than weekdays (more in Bremen than in Belgium though). No major difference can be seen on weekdays when comparing peak and off-peak hours.

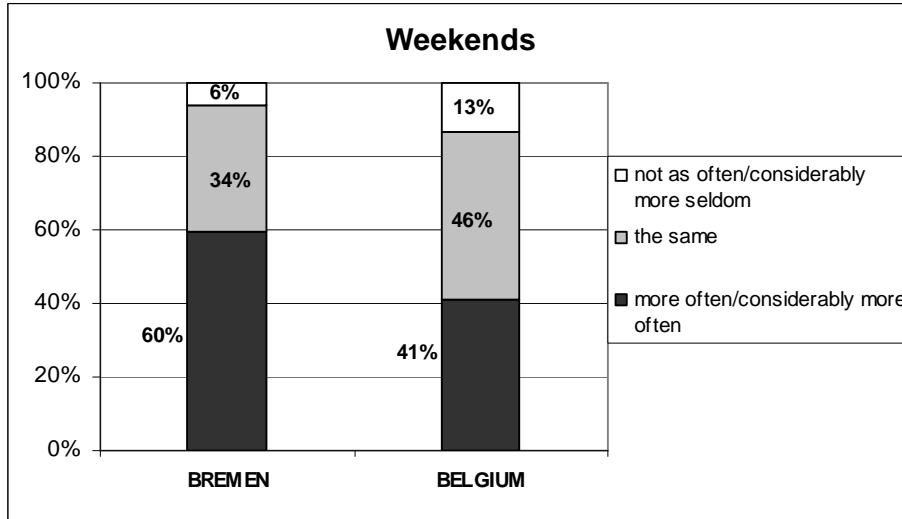


Figure 2.20 Change in public transport usage on weekends.

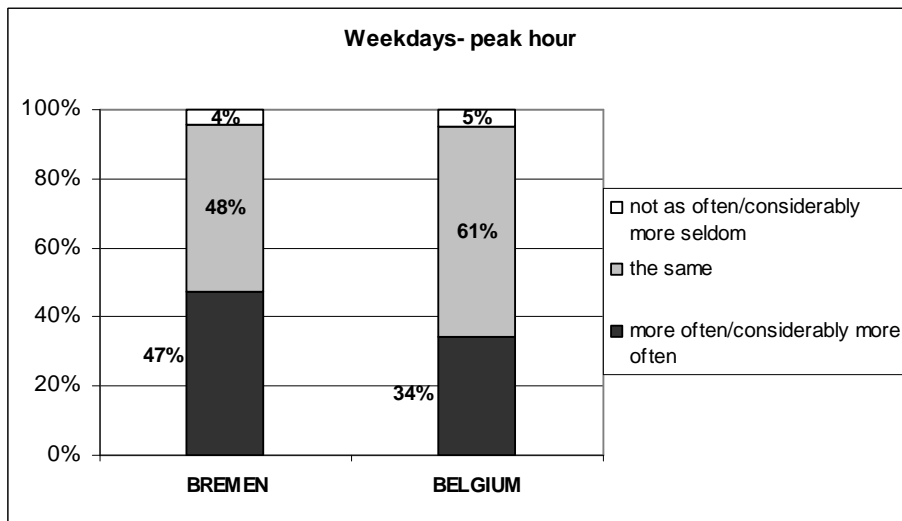


Figure 2.21 Change in public transport usage on weekdays – peak hours.

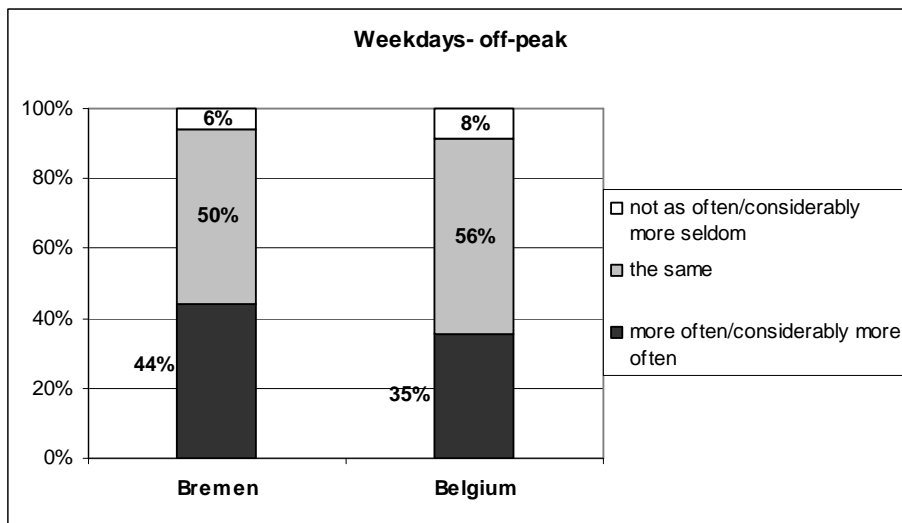


Figure 2.22 Change in public transport usage weekdays – off-peak hours.

Car-sharing increases the use of public transport by 1 100 km per year and member.

The increase takes place during both weekends and weekdays, during peak hours and off-peak hours.

2.7 Emission reduction

Change of emission volumes due to car-sharing can be derived from the following three aspects:

- Change in car mileage
- Change in vehicles used
- Change in public transport usage

This type of calculations are extremely difficult to make, but the estimates below are made to give an idea on what effects that can be expected.

The focus of the calculations is CO₂ emissions, based on reduction of fuel consumption. Changes of other pollutant emissions are more difficult to estimate, but it is clearly not lower than the reduction in CO₂ (see below for further discussion on this).

Change in car mileage

The average mileage reduction is calculated to 45% in Bremen and 28% in Belgium. It is reasonable to believe that this means a reduction in fuel consumption as well as CO₂ emissions by the same amount. Actually the effect is probably a little bit higher, since car-sharing tends to reduce the shorter trips more than longer trips – and shorter trips need more fuel and cause larger emissions per km due to cold start of the engine.

Change in vehicles used

Car-sharing in Bremen is over 10 years old, hence the respondents of the survey are partly car-sharers who got rid of their cars a long time ago which would make the calculations in this section less reliable and adequate. This section therefore focuses on the Belgium situation, but the case of Bremen should not be very different (which is also shown by other studies referred to below).

As stated in chapter 2.5 above, car-sharing means that smaller and newer cars are used compared to the private cars they replace. Among the total fleet of cars, the share of medium sized cars are reduced by 40% (In Belgium from 54% to 15%, in Bremen from 70% to 30%).

The fuel consumption of car size is difficult to estimate since there is a large variety depending on brands and models as well as engine.⁴ To be able to get some idea of the effects though, a very general estimate has been done in Table 2.5 below.

Table 2.5. Estimated average fuel consumption for different car sizes and the share of different sizes among abolished cars and car-sharing cars.

Car size	Fuel consumption (l/100 km)	Share of abolished cars	Share of car-sharing cars
Micro	5,0	2 %	0 %
Small	6,0	45 %	85 %
Medium	7,0	30 %	15 %
Large	8,5	15 %	0 %
X-large	10,0	8 %	0 %

Average fuel consumption of the abolished cars regarding size is from the above estimations calculated to 7,0 l/100 km and car-sharing cars to 6,2 l/100 km, which means a reduction of 11%.

Regarding change due to abolished cars being older than the car-sharing fleet, a study from the EU is helpful. CO₂ emissions of new petrol cars within the EU has on average gone down 9% between 1995 and 2002.⁵ Between 1985 and 1995 no improvement among new cars in Sweden could be observed,⁶ and this is assumed to be valid for assessed countries too. During 2004 there has however been discussions about the validity of these calculated emissions, and the European Environmental Agency (EEA) claims that emissions are underestimated since "current test cycles do not reflect how engines are used in the real world".⁷ Table 2.6 shows the shares of car age among the abolished cars and car-sharing cars, concluded with the estimated fuel efficiency improvements.

⁴ According to VCA, fuel consumption among similar size cars can vary as much as 45% (www.vcacarfueldata.org.uk).

⁵ COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT. Implementing the Community Strategy to Reduce CO₂ Emissions from Cars: Fourth annual report on the effectiveness of the strategy (Reporting year 2002). 2004.

⁶ Bilismen i Sverige 2004, Bil Sweden, 2004.

⁷ TERM 2004: Ten key transport and environment issues for policy-makers, European Environmental Agency (EEA), 2004.

Table 2.6. Estimated fuel efficiency improvements depending on production year, and the share of production year among abolished cars and car-sharing cars.

Year of production	Share of abolished cars	Share of car-sharing cars	Fuel efficiency improvements until 2001
-1987	18 %	0 %	10%
1988-1995	45 %	0 %	10%
1996-2000	25 %	0 %	4%
2001-	12 %	100%	0%

Average improvements in fuel efficiency of car-sharing cars compared to the abolished cars only due to age of cars used is from the above estimations calculated to 7 %.

When the effects of size and age are multiplied the reduction in fuel consumption comes to 17%. This can be compared to a study by Muheim (1998) who estimated a reduction of 24%⁸ and Meijkamp (2000) estimating the reduction to 14%.⁹

Regarding emissions other than CO₂ it is very risky business to estimate the reductions over the years. There are no good average figures available that are suitable for Germany as well as Belgium, and it can differ a lot between different cars. Swedish studies show decreases of 40-60% among all cars in Sweden between 1990 and 2000 regarding CO, HC and NO_x, and if looking at only new cars the reductions would probably be even higher. But due to the lack of good data and the extreme differences in such emissions depending on driving conditions and driving patterns, no specific calculations of emissions other than CO₂ is made here. However, the reduction of these substances is at least the size of the CO₂ reductions.

Change in public transport usage

Section 2.6 above show that use of public transport increases by 1100 km per year when joining car-sharing (same figure for both Belgium and Bremen). If this is done mostly during peak hours it might mean that extra buses and trams etc would need to be put in service, which in turn would generate extra emissions. If the increase takes place during off peak hours it is not likely it will cause any new traffic and thereby it will not generate any extra emissions – only increased revenues for public transport.

Figure 2.20 to Figure 2.22 shows that the largest increase is made during weekends; 60% of the Bremen respondents say they use public transport during weekends more often than before, compared to 44-47% during weekdays. In Belgium 41% say they use public transport more often during weekends compared to 35 % during weekdays. On weekdays there is hardly any difference between the increase in peak hours and off-peak hours.

⁸ Muheim, P. P. (1998). CarSharing - the key to combined mobility. Bern, Switzerland, Energie 2000, Bundesamt für Energie.

⁹ Meijkamp, R. (2000). Changing Consumer Behaviour Through Eco-Efficient Services; an Empirical Study on Car Sharing in The Netherlands. Faculty of Industrial Design Engineering. Delft, Delft University of Technology.

Even though the result of the survey does not exactly tell when the increase is taking place, we can at least say that the increase is not mostly made during weekday peak hours.

To get some kind of idea of the magnitude of this increase, the following data and very rough assumptions have been made:

- 50% of the increase in public transport is made during peak hours
- Average change in car mileage is -36%
- In terms of mileage, the public transport increase is 35% of the car reduction
- All public transport is made by diesel bus
- A bus emits 5 times the amount of CO₂ as an average car per vehicle km
- A bus has 15 times more passenger than the average car

These assumptions mean that increased use of CO₂ is about 2% of the previous emissions from car use ($50\% * 36\% * 35\% * 5 \div 15 = 2\%$).

Total estimate of emission change

The estimated total change in emissions is for Belgium about -40% and for Bremen over -50% (see Table 2.7 below).

Table 2.7 The estimated total change in emissions of CO₂

	Belgium	Bremen
Change in car mileage	- 28%	- 45%
Change in vehicles used	- 17%	- 17%*
Change in public transport usage	+ 2%	+ 2%
Total	- 39%	- 54%

** This figure is estimated from calculations from the Belgium case.*

Changes of other pollutant emissions are at least at the same levels as the CO₂ reductions, probably even a bit higher (see discussion under section "Change in vehicles used" above).

Car-sharing reduces transport CO₂ emissions by 40-50% (among its members).

Other pollutant emissions are estimated to decrease even more.

2.8 Mobility in leisure time

The previous figures deal with the change of use of different transport modes etc due to car-sharing membership. But has there been any changes regarding mobility for leisure activities? Naturally it is very difficult to isolate the effects of car-sharing from other changes in life, but the questions asked can at least assess if any major changes have occurred when it comes to diversity of leisure activities, number of occasions of leisure activities and distances to leisure activities. But as can be seen in the following figures, 50-80% respond that there is a constancy in these matters. A decrease in diversity, number of occasions and distances has been experienced by 10-20% of respondents, but around twice as many have experienced an increase. From these figures it **cannot** be concluded that car-sharing in general limits the possibilities to a mobile leisure time.

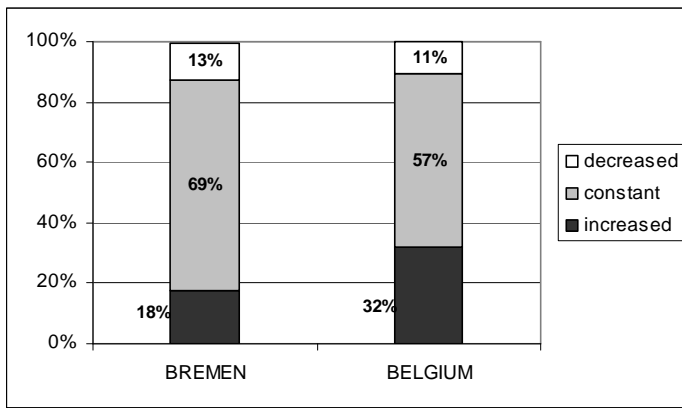


Figure 2.23 Changes in **diversity** of leisure activities.

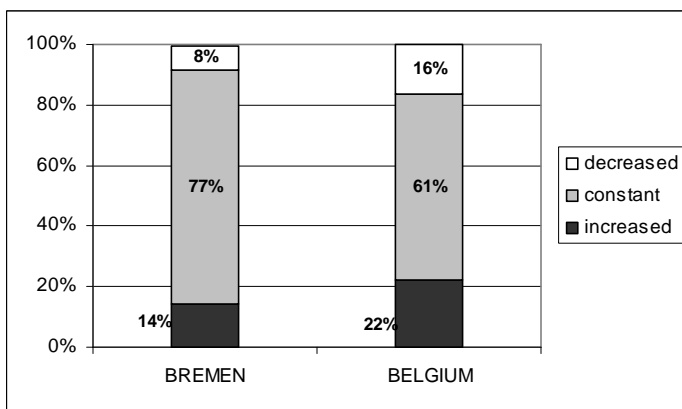


Figure 2.24 Changes in **number of occasions** of leisure activities.

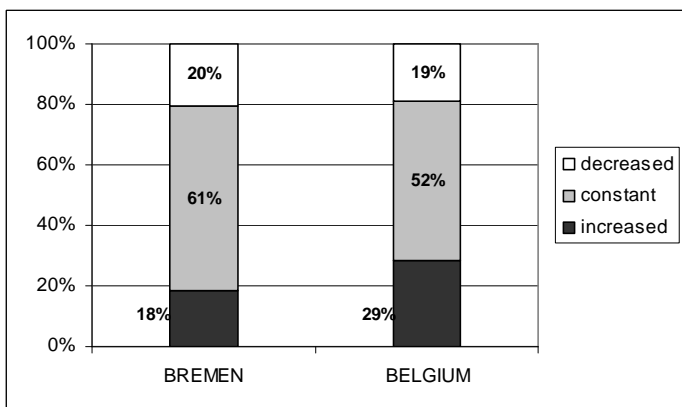


Figure 2.25 Changes in **distances** to leisure activities.

3 Corporate users

3.1 General information

The results of corporate users are from Bremen and Stockholm, since these are the only sites with such numbers of corporate users that can be considered statistically relevant. Both transport managers and drivers have been surveyed, since their statements are expected to complement each other.

Transport managers were asked about their company's car-sharing membership, transport mode usage and the effects that car-sharing has had on the employees' driving. Since only a few transport managers from each country have filled in the questionnaire, no percentage numbers have been calculated here. Instead the results are shown in number of persons.

Table 3.1 General facts about companies and questionnaires sent to transport managers.

	Bremen	Stockholm
Total number of companies	648	5
Number of surveys sent out	20	5
Number of surveys returned	11	5
Response rate	55%	100%

Also drivers were asked to fill in a questionnaire, since they may have a better view of how car-sharing has affected their travel behavior. Some issues are therefore answered by both managers and drivers, and not always are the results corresponding.

In Stockholm in particular there are a large number of employees who can use car-sharing, but a lot fewer who actually use it regularly. Therefore only employees who have used car-sharing at least 5 times during the last 6 months were asked to fill in the driver questionnaire.

Table 3.2 General facts about companies and questionnaires sent to drivers.

	Bremen	Stockholm
Number of employees with CS access	1100	850
Number of surveys sent out	100	215
Number of surveys returned	24	142
Response rate	24%	66%

3.2 Background information

The companies using car-sharing in Bremen are quite different from the companies in Stockholm. The Bremen companies are relatively small with on average 12 employees (answers range from 2 to 40), of which 40% have access to car-sharing

cars. The Swedish organizations who responded to the questionnaire are public companies and administrations with on average 550 employees (answers range from 190 to 1080), and 31% of these have access to car-sharing cars.

Slightly more than half of the managers say that their employees receive compensation if they drive their private car on duty. The existence of such compensation can have effects on the use of car-sharing, especially if the compensation is high. Among the companies who do have such benefits, the average reimbursement per kilometer is € 0,26 in Bremen and equivalent to €0,31 in Stockholm (2,9 SEK).

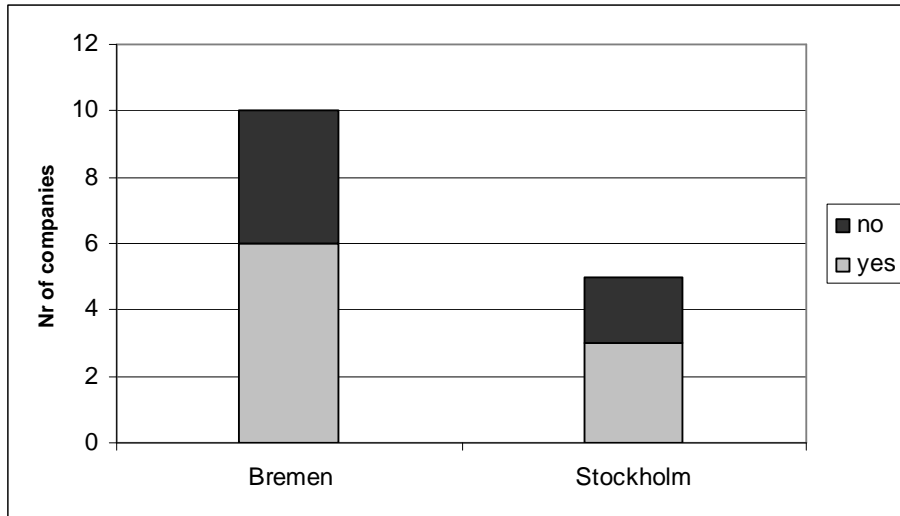


Figure 3.1 Number of companies where the employees receive compensation if driving their private car on duty.

When looking at the reasons why the company joined car-sharing, the dominating reason in both Bremen and Stockholm is to contribute to environmental protection. Other common reasons mentioned are to have a choice of vehicles, to reduce mobility costs and to drive new and well maintained vehicles. Differences between the cities can be noted regarding the factors "be rid of maintenance issues" (a lot more important in Bremen), "to have a choice of vehicles (more important in Bremen) and "to drive new and well maintained vehicles" (more important in Stockholm).

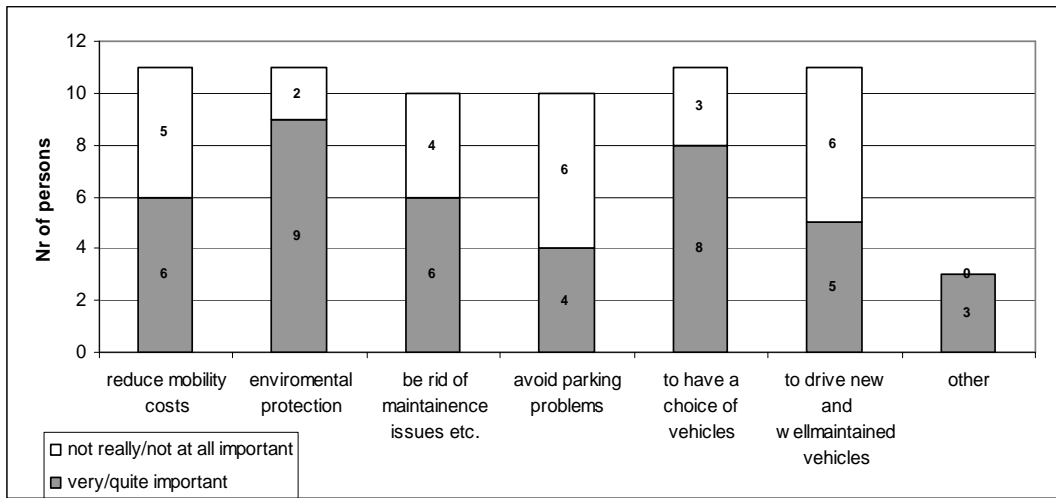


Figure 3.2 Reasons why the Bremen companies joined car-sharing.

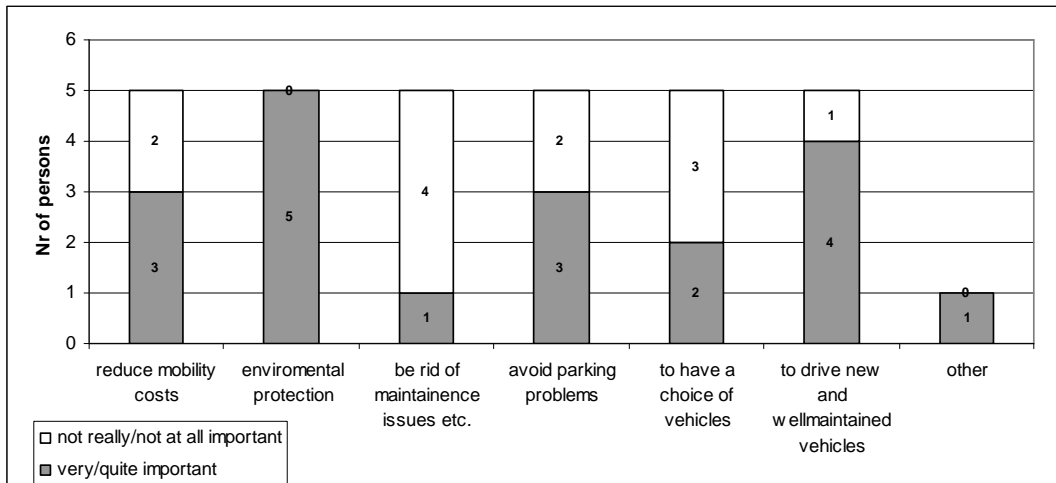


Figure 3.3 Reasons why Stockholm companies joined car-sharing.

The majority of the companies use cars that are shared only within their own company. However a few managers declare that both companies and private members share the cars.

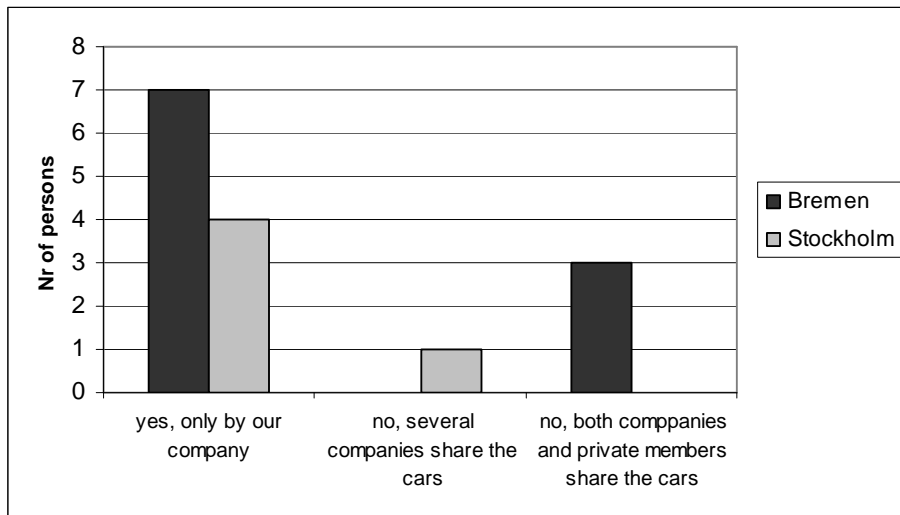


Figure 3.4 Are the car-sharing cars only used by your company?

3.3 Transport mode usage at present

The average total use of car-sharing cars differs between the cities, which is very natural since the average number of employees in Stockholm is much higher than in Bremen.

Table 3.3 The average company use of car-sharing per year and company (according to the managers)

	Bremen (km/year)	Stockholm (km/year)
Use of car-sharing, per company	3 005	19 258

Table 3.4 shows the average use of car-sharing on duty in the cities according to the drivers. The average use of car-sharing is 1100 to 1400 km per year and driver.

Table 3.4 Car-sharing use on duty per year and driver (according to the drivers)

	Bremen (km/year)	Stockholm (km/year)
Use of car-sharing, per driver	1392	1099

In the two tables below the on-duty traveling by different modes among the employees is estimated by the managers and the drivers. In Bremen managers and drivers gave very similar answers, but Stockholm showed quite extreme differences regarding the use of car-sharing cars, company-owned cars and private cars. This is probably due to the fact that the managers' response is based on the company's total mileage, while the drivers asked are employees who have used car-sharing at least 5 times during the last 6 months (employees who like to use their own car are thereby excluded in the drivers response).

Table 3.5 Share of mileage traveled on duty for each mode – managers' estimate

	CS cars	Company cars (excl. CS)	Private cars	Rental cars	Taxi	Public transport	Other
Bremen	37 %	14 %	10 %	2 %	2 %	17 %	19 %
Stockholm	9 %	30 %	34 %	1 %	4 %	19 %	3 %

Table 3.6 Share of mileage traveled on duty for each mode – drivers' estimate.

	CS cars	Company cars (excl. CS)	Private cars	Rental cars	Taxi	Public transport	Other
Bremen	32 %	13 %	18 %	0 %	1 %	22 %	12 %
Stockholm	53 %	5 %	4 %	0 %	2 %	31 %	5 %

3.4 Transport mode usage – change since joining car-sharing

The corporate drivers as well as the managers were asked to estimate how their company's usage of different transport modes has changed since they got access to car-sharing.

Bremen

Figure 3.5 and Figure 3.6 show the changes in transport modes estimated by the corporate drivers and the corporate managers in Bremen. The usage of company cars has increased whereas the usage of private cars has decreased according to both drivers and managers.

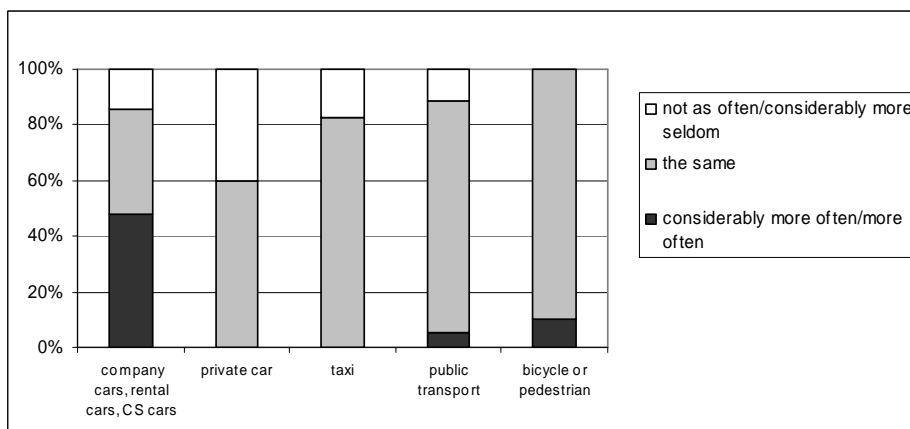


Figure 3.5 Changes of usage of different transport modes since getting access to CS – according to drivers in Bremen

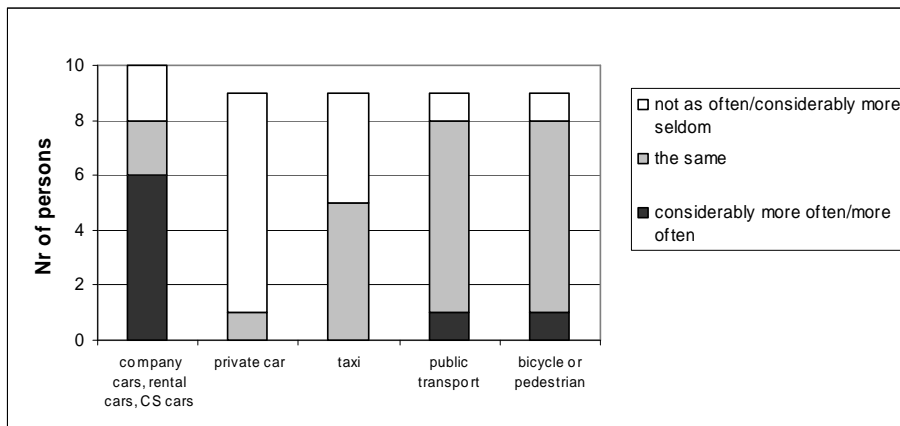


Figure 3.6 Changes of usage of different transport modes since getting access to CS – according to managers in Bremen.

Stockholm

Figure 3.7 and Figure 3.8 show the changes in transport modes estimated by the corporate drivers and the corporate managers in Stockholm. The changes in Stockholm are very similar to the ones in Bremen.

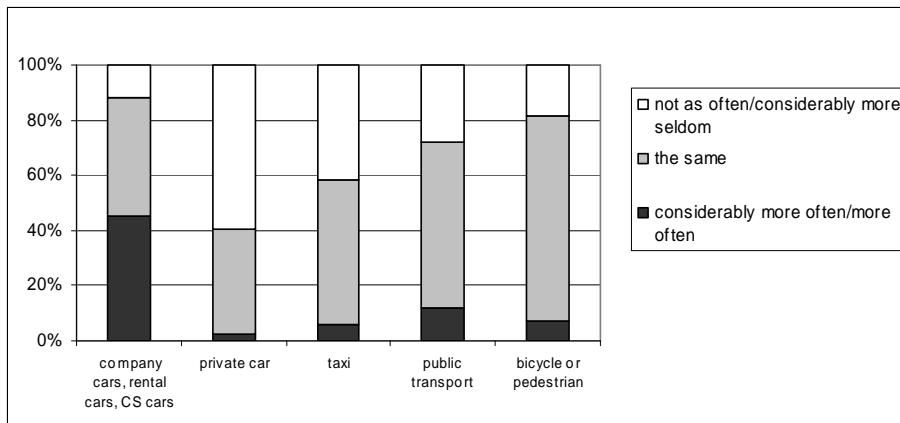


Figure 3.7 Changes of usage of different transport modes since getting access to CS – according to drivers in Stockholm.

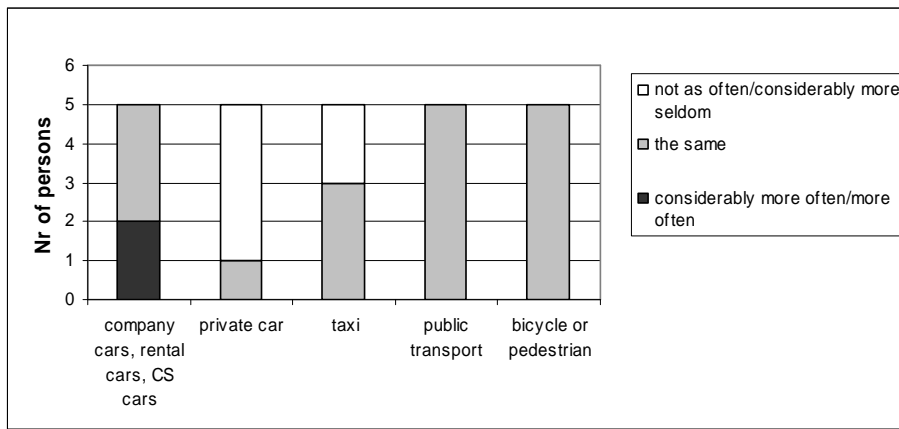


Figure 3.8 Changes of usage of different transport modes since getting access to CS – according to managers in Stockholm.

By introducing corporate car-sharing the use of private car on duty is replaced by use of car-sharing cars.

Change in car mileage

The effect on total car mileage on duty since joining car-sharing estimated by the managers is shown in the figure below. The majority of the managers declare that the car-sharing membership has not lead to any changes in total mileage.

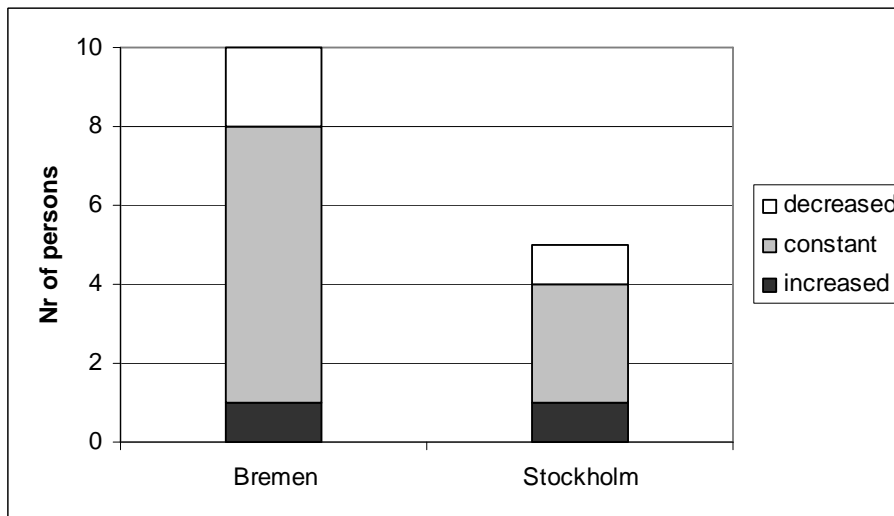


Figure 3.9 Changes in total car mileage since getting access to car-sharing – according to managers.

In Bremen two transport managers declare that the total car mileage has decreased. The managers say that the reason for the decrease is that car-sharing cars are further away and that car-sharing cars must be booked in advance. One manager of a small business also says that the reason for the decrease could be that the business trips now are easier to distinguish from the private trips, and

another manager explains the reduction with the company having worked a lot with mobility management. In Stockholm, one manager declares that fewer trips are made with car now, and the main reason is that car-sharing cars must be booked in advance.

Both in Bremen and Stockholm a few managers state that the amount of driving have increased since joining car-sharing. The reason stated by the managers is that the employees now have better access to a car.

Figure 3.10 shows the changes in driving mileage on duty estimated by the drivers. A majority of them have not changed their driving mileage. In Bremen about 20% have increased their driving, and only a few percent have decreased their driving. In Stockholm, the number of drivers who have increased their driving is equal to the number who has decreased their driving.

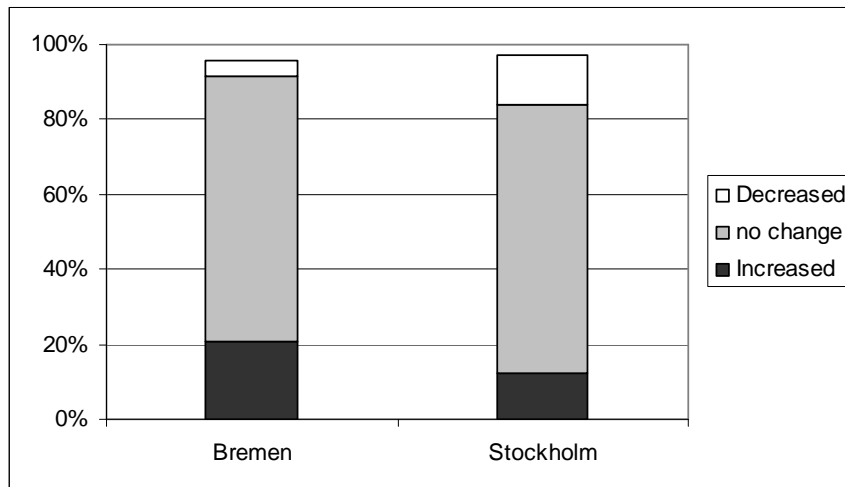


Figure 3.10 Changes in driving mileage estimated by drivers

Corporate car-sharing does not seem to lead to a reduction in total car mileage –most companies see no change, and a few state a decrease and a few state an increase.

In Bremen about 17% of the corporate drivers have increased their mileage, on average with 19%. The corresponding numbers for Stockholm are 10% and an average mileage increase of 45%.

The most stated reason by drivers for increasing their driving was better access to a car. Some drivers declared that the reason was that car-sharing cars are newer and better. Some mentioned other reasons like a higher demand for traveling in their work.

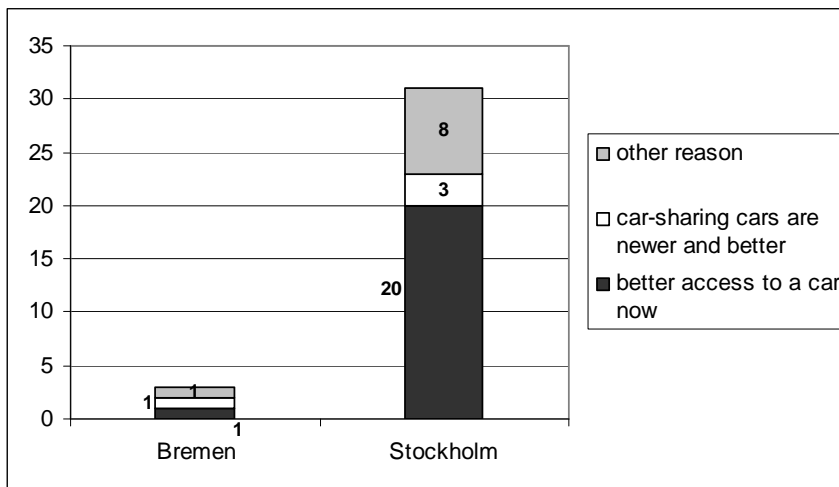


Figure 3.11 Reasons for increasing the amount of driving (number of answers)

Somewhat fewer drivers state that they have decreased their driving. In Bremen only one person has decreased his/her driving and in Stockholm 13 persons.

In Bremen only 4% of the drivers state that they have decreased their mileage, on average with 66%. The corresponding numbers for Stockholm are 9% and an average mileage decrease of 32%.

When describing the reason for decreasing their driving, the most common answer is that car-sharing cars must be reserved in advance. Some mentioned other reasons like changes in working tasks etc.

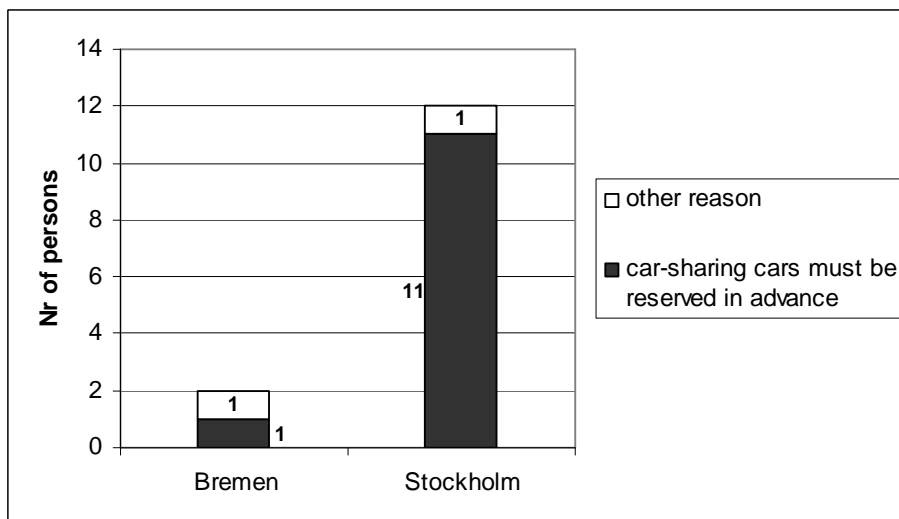


Figure 3.12 Reasons for decreasing the amount of driving (number of answers)

3.5 Access to cars on duty and in leisure time

Most companies still have access to the same number of cars as before (see Figure 3.13). However, a few companies have increased the number of cars they have access to, and one company state a decrease.

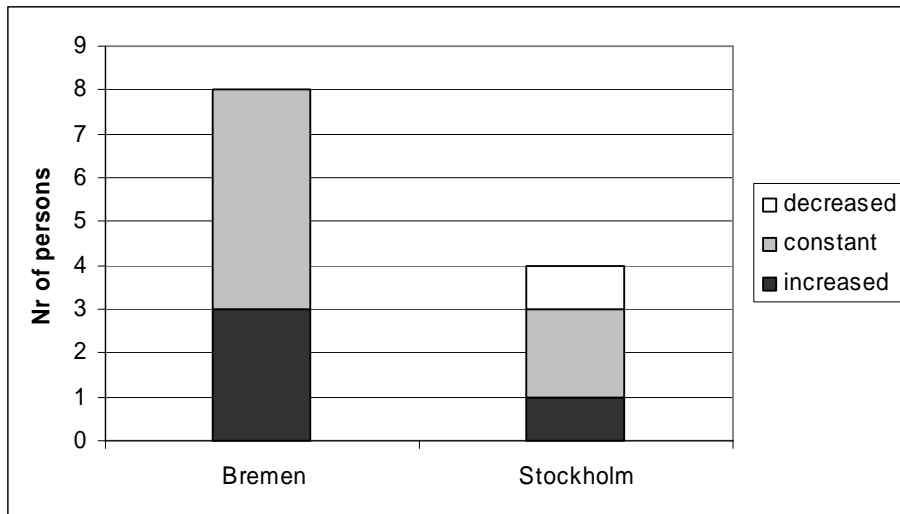


Figure 3.13 Has there been a change in the number of cars that the company has access to since joining car-sharing?

Figure 3.14 shows the employees' access to car-sharing cars in their leisure time. The results show that almost 50% of the companies state that the car-sharing cars are possible to use by their employees in their leisure time.

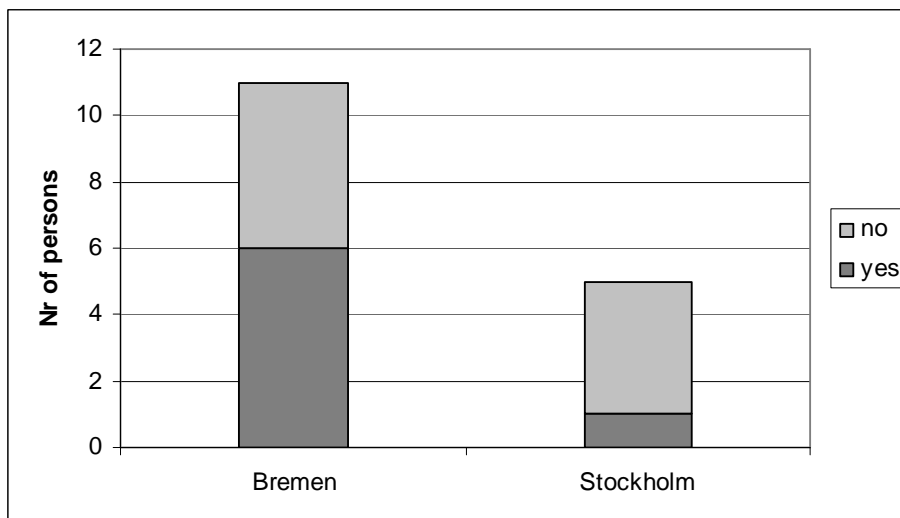


Figure 3.14 Access to car-sharing in leisure time.

3.6 Effects on driving to and from work

Questions were asked about the effects of car-sharing on the employees' driving to and from work (questions were asked to both managers and drivers). A majority of the managers in Bremen do not think that the access to car-sharing cars have resulted in fewer employees driving to work, while most of the Stockholm managers do believe in such a change (see Figure 3.15).

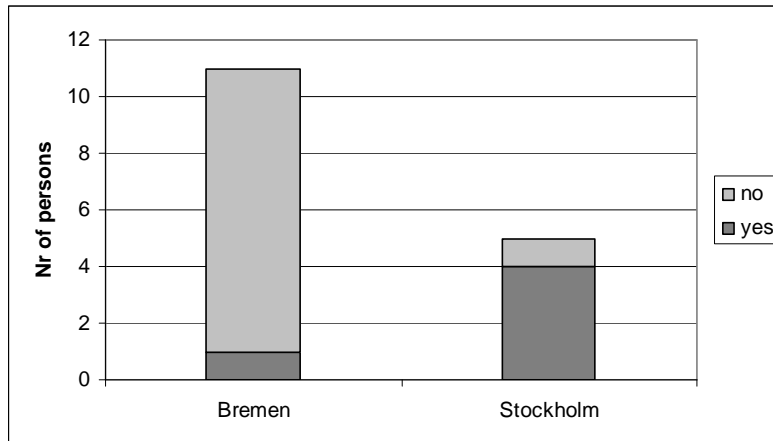


Figure 3.15 Has access to car-sharing resulted in fewer employees driving to and from work? (according to managers)

The drivers who were asked if they had changed their travel habits to and from work gave an answer that at first seem contrary to what the managers answered. In Bremen the drivers were more inclined to think that car-sharing had an effect also in reduction of driving to and from work (29%) compared to the managers (9%). In Stockholm 30% of the drivers declared that car-sharing had resulted in less driving to and from work.

Since the drivers themselves probably are better to estimate whether they have changed their habits or not, it can for the Bremen case be said that the effects on driving to work is probably higher than what the managers expect.

For Stockholm, the drivers' answers are quite a bit lower than what the managers estimate, but the perceived inconsistency could still be completely coherent. If the managers estimate that 30% of their employees have changed their travel habits to and from work, it would be correct for them to say that introducing car-sharing has resulted in fewer employees driving to and from work.

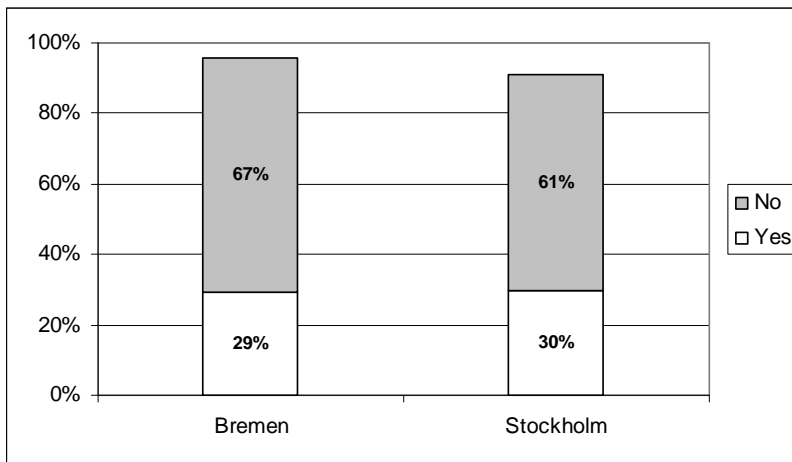


Figure 3.16 Has access to car-sharing made you drive to and from work more seldom? (according to drivers)

Only three of the companies (two in Stockholm and one in Bremen) have introduced other measures to reduce car trips to and from work. The corporate manager in Bremen describes a number of measures performed, such as PT season tickets usable for all staff members and corporate bicycles and racks in front of the building. The companies in Stockholm have introduced measures such as reduced number of parking spaces for private cars and changed the rules for reimbursement of private car usage.

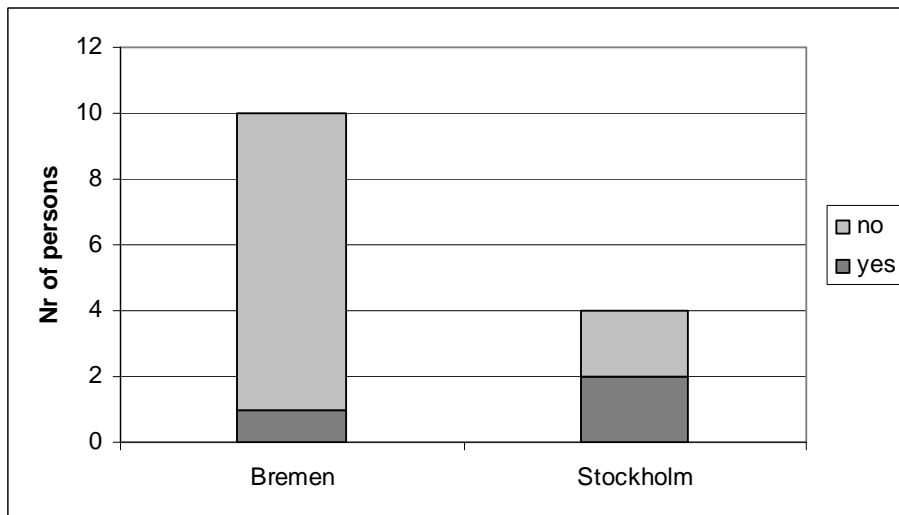


Figure 3.17 Have other measures been introduced by the company to reduce employees' car trips to and from work?

Corporate car-sharing has influenced up to 30% of the employees to drive their own car to work less frequently than before.

3.7 Effects from car-sharing on parking places

In the majority of the companies, car-sharing has not resulted in any change in number of parking places for car-sharing cars, company-owned cars or leased cars. Two Stockholm companies have reduced the number of parking places for employees' private cars though.

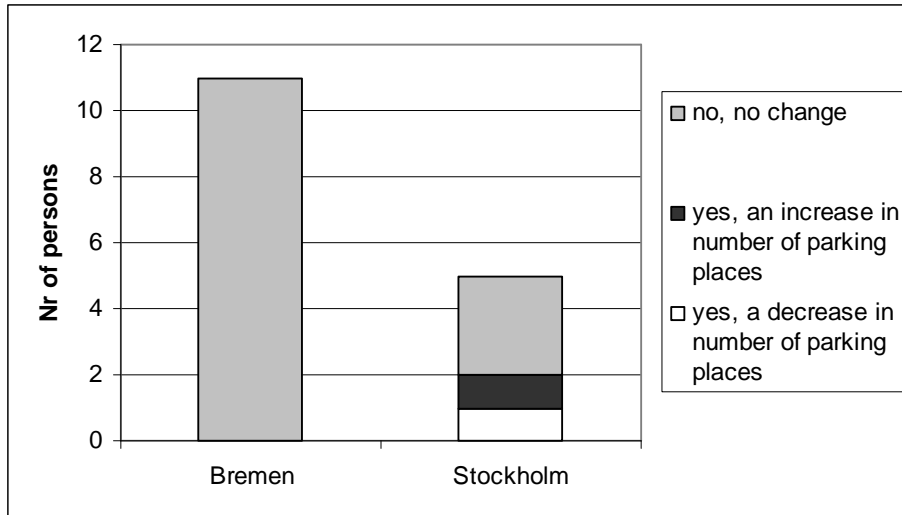


Figure 3.18 Changes in number of parking places for car-sharing cars, company-owned cars and/or leased cars.

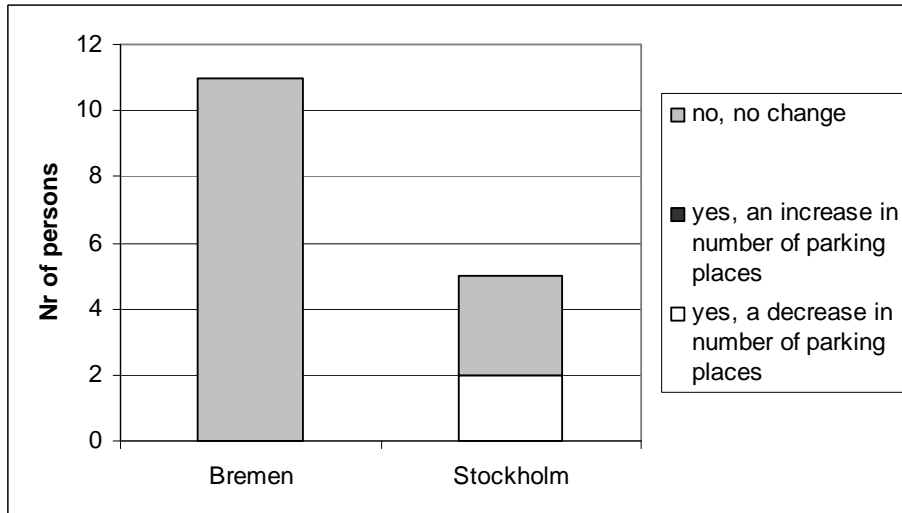


Figure 3.19 Changes in number of parking places for employees' private cars.

Corporate car-sharing seem to have only have minor effects on employees' provision of parking spaces at work.

3.8 Effects of mix use of corporate and private users

It is getting common that car-sharing operators “mix” the users by letting both companies and private members use the same car. By mixing users with different mobility needs a higher utilization rate of the cars can be achieved, since business users usually need cars Monday to Friday during the workday and private users usually need cars during evenings and weekends. If those different types of users use the same cars, a smaller fleet is needed to satisfy the same level of accessibility. This mix of users therefore makes the car-sharing concept even more efficient and in the end more economic for the users.

The operators were asked to make estimation on the “usage overlap”, from which an effect on the reduced number of needed vehicles can be calculated. This is of course a very difficult estimation for the operator, but it is an important effect and must not be neglected.

This “mix use concept” is not usual in Stockholm but very common in Bremen. Bremen estimates that by introducing corporate members the car occupation can be increased by 20% **without** reducing the accessibility for private members within the same fleet of cars. This is of course an extremely good revenue for the operator, which in turn will benefit all users.

The mix of corporate and private users gives a better utilization rate (up to 20%) without reducing the accessibility for clients.

4 Closing comments and conclusions

Private users

This study shows that car-sharing reduces car mileage by 28-45% among private users (Belgium 28% and Bremen 45%), which is quite in line with other studies of car-sharing. Some people increase their driving when joining car-sharing (mainly those who did not own a car before), but the increase is rather small in absolute figures. Some people decrease their driving when joining car-sharing, mainly those who got rid of a car when joining. But all changes put together means an average decrease with 3000 km in both Bremen and Belgium.

On the other hand the use of public transport is increased by 1100 km per car-sharing member and year. The increase takes place during both weekends and weekdays, during peak hours and off-peak hours. So it is not only putting extra passengers in peak hour traffic but also makes public transport more used during evenings and weekends, which increases the use and revenues for off peak public transport.

Car-sharing cars are smaller and newer compared to the private cars they replace. Among the total fleet of cars, the share of medium sized cars is reduced by 40%. 65% of abolished cars in Belgium were from 1995 or earlier, which can be compared to the car-sharing fleets average production year of 2002 (these figures are estimated to be relevant also for Bremen).

Due to the above factors, car-sharing is estimated to reduce CO₂ emissions from car transport by 40-50% (among its members). Other pollutants are estimated to decrease even more than 50%.

Car-sharing reduces the need for a private car and therefore also reduces the amount of cars in urban areas. In Bremen each car-sharing car replaces 7-10 private cars and in Belgium each car-sharing car replaces 4-6 private cars. This in turn reduces the need for parking space by 90-135 m² in Bremen and 45-75 m² in Belgium for each car-sharing car. The reduced space in Bremen at present is equivalent with about two football fields.

Corporate users

This study has not been able to show that car-sharing reduces car mileage or need for parking in a significant way. The results of the survey to corporate users indicate that car-sharing in companies and organisations do influence the travel behaviour of employees, but is however not possible to quantify effects with good validity. There are good reasons to believe that corporate car-sharing is positive in three different ways:

1. By introducing corporate car-sharing the use of private car on duty is (partly or fully) replaced by car-sharing. Since car-sharing cars as well as other cars provided by the company are generally newer than the average private car this leads to better traffic safety and less pollution. If clean vehicles are used, the environmental effect is naturally larger.
2. The need for people to drive their own car to work is reduced, which leads to a higher use of greener modes for commuting, which in turn also reduces the need for parking at the workplace.
3. The use of car-sharing during daytime weekdays is good for the car-sharing operators who mix corporate and private users, and thereby get a better utilization rate (up to 20%) *without* reducing the accessibility for clients. This is good for both operator and client economy, thus making the concept of car-sharing more profitable for all involved partners.