

**A thesis submitted to the Department of Environmental Sciences and Policy of  
Central European University in part fulfilment of the  
Degree of Master of Science**

**Carpooling and carsharing in Hungary:  
barriers, possibilities, potentials**

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**July, 2012**

**Budapest**

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# CENTRAL EUROPEAN UNIVERSITY

## ABSTRACT OF THESIS

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Climate change mitigation scenarios focus primarily on technological measures and overlook the non-technological options which are considered as negligible or unrealizable. This paper aims to evaluate the mitigation potentials of carpooling and carsharing in Hungary as two non-technological options to utilize the untapped capacities associated with one of the most basic, but typically underused assets of people. To achieve this aim, surveys targeting the general public, the users of a carpooling scheme and the stakeholders of carpooling and carsharing were performed and analyzed in order to identify travel patterns, the willingness to carpool, as well as the barriers and possibilities of these services. Then, using different assumptions based on the survey and literature results, three different GHG emission reduction potentials of carpooling and carsharing were estimated.

The estimations suggest that, while the maximal potentials, which assume a maximum-intensity use of carpooling and carsharing, are rather large, the potentially available practical and cultural potentials are significantly lower primarily due to the too low cost of car use. Moreover, the GHG emission avoided by the current level of carpooling is only a small fraction even compared to the cultural potentials due to the lack of information and initiatives by employers, and the fact that no carsharing scheme operates in Hungary is presumably due to the high investment cost, to the lack of political will and to certain cultural concepts. At the end of the thesis, policy recommendations are formulated in order to achieve larger emission savings by these mobility services in Hungary.

**Keywords:** carpooling, carsharing, GHG emission reduction potential, barriers, commuting

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## CHAPTER 1 - INTRODUCTION

Greenhouse gas (GHG) emission driven climate change can have devastating effects on the global economy and human society, therefore global mitigation measures are indispensable in order to avoid massive economic and social problems (Population and Development Review 2006). This recognition has led to a plethora of scenario documents produced by different stakeholders representing the governmental, civil and business sectors: the European Commission (EC 2011a, 2011b), the Netherlands Environmental Assessment Agency (Bakkes 2009), Friends of the Earth (Heaps *et al.* 2009) Greenpeace (Teske 2010), and the Union of the Electricity Industry (ECF 2011), to take just a few examples. These scenarios, while describing the different mitigation measures necessary to reduce GHG emissions by 80-95% in the EU by 2050, focus primarily on technological options (e.g. renewable energy sources, insulation, etc.), and little attention is paid to non-technological options.

One of these non-technological options is collaborative personal car transport (CPCT), when people share the use of the same car either at the same time (carpooling) or at different times (carsharing) rather than using individual cars separately. The more conventional ways of car use are in fact very ineffective: while cars could carry comfortably an average of 4 people roughly in 20-50% of the day (considering the lower overall need for cars outside the peak periods and some time necessary for maintenance), they usually carry an average 1.55 people in the U.S. and Western Europe (Transportation Energy Data Book 2009, EEA 2010b) and 1.9 people in Hungary (EEA 2010b), and they are used only in the 2-5% of the day<sup>1</sup>. At the same time, car production and use consume a significant part of Earth's resources:

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<sup>1</sup> Assuming that the average car travel annually 10-18,000 km in at average speed of 40-60 km/hour

approximately 4.4% of global steel production is used up by personal car production<sup>2</sup> and 31% of global oil production is used up by personal car use<sup>3</sup>; thus personal cars are responsible approximately for 8.8% of global GHG emissions<sup>4</sup>. So it seems that there is plenty of room to improve efficiency of personal cars by increasing vehicle occupancy (carpooling) and intensity of use (carsharing), which could entail a significant reduction in demand for cars and fuel and so in GHG emissions. In addition, in the case of carsharing the non-proprietary use enables the use of vehicles with lower emissions, e.g. hybrid or electric cars, as (i) typically high acquisition cost of those vehicles do not have to be paid at once but rather through the carsharing rates; (ii) the cost of carsharing reflects the overall cost of car use rather than the acquisition cost so the use of these expensive but fuel-efficient cars becomes even more affordable; and (iii) the shorter lifetime due to the more intensive use allows more frequent upgrading to newer and so more efficient vehicles. And, since in the case of carsharing the costs are proportional to the intensity of car use regardless the level of intensity (aside from the usually low membership costs) in contrast to the costs of private cars which is the lower the intensity of use is higher due to the high acquisition costs, carsharing does not encourage a more intensive use from an economical point of view. Finally, both versions of CPCT are economically favourable (at least in most cases) for the users compared to individual use, as they can share fuel or maintenance costs.

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<sup>2</sup> Assuming that 60 million personal cars were produced in 2010 (OICA 2010), an average car weighs 1.5 t, 70% of which is steel (OECD 2010) and the global steel production was 1430 Mt in 2010 (Worldsteel Association 2012).

Assuming that personal cars combust 1080 Mtoe fuel per year for their operation globally (Holmberg et al. 2011) which results in 3,402 Mt CO<sub>2</sub> emissions (Metz 2010) and that the global CO<sub>2</sub> emissions was 28,999 Mt in 2009 (IEA 2011).

<sup>4</sup> Assuming that the following: (i) CO<sub>2</sub> emissions of car use (tank-to-wheel stage of the lifecycle) represents approximately 77.5% of the lifecycle GHG emission of a car (Nemry *et al.* 2008), thus the global car fleet is responsible for 4,390 Mt CO<sub>2</sub>eq GHG emissions, and (ii) the global GHG emissions in 2009 was 50,000 Mt CO<sub>2</sub>eq (Metz 2010).

On the other hand, in certain situations either version of CPCT might contribute to a more intensive car use at the expense of public transportation, which might result in increased GHG emissions. In the case of carpooling, the lower travel cost due to cost-sharing might encourage public transportation users to switch to carpooling which not only reduces the efficiency of public transportation, but can even result in an increase in total vehicle kilometres travelled (VKT) if both the driver and the passenger(s) renounced public transportation for the sake of carpooling (as in this case an additional vehicle would consume fuel, too). In the case of carsharing the downside risk is that the easy (and relatively cheap) access to a car might encourage car use in cases when the user would have travelled by public transportation without the possibility of carsharing. Therefore, supportive policies need to be carefully applied (especially in the case of subsidizing CPCT) in order to maximize the GHG emission mitigation potential of CPCT.

As CPCT is economically favourable in most cases, its application does not require massive financial support. Moreover, the more and more comprehensive use of telecommunication systems (internet, GPS, smartphone), which is the main and probably the most costly prerequisite for the effective use of CPCT, is taking place anyway. The enhanced possibility to share the cost of car use could also make the higher taxation of fuel more acceptable by the public, to cover the external cost of car use. For example, several studies detected an external cost of approximately 0.5-1 euro/liter for petrol (Mayeres *et al.* 1996, Spadaro *et al.* 1998) which should be covered by the fuel users according to the “polluter pays” principle. In addition, higher taxes on fuel could encourage the use of even more environmental-friendly possibilities when they are available (for example public transportation or biking).

If CPCT is so beneficial, why is it not common practice in countries such as Hungary? According to Sadeghi and Lüthi (2009), there are various barriers to energy efficiency of household mobility, which can be categorized into the following six major types: physical or structural, economic, political, knowledge-based, cultural-normative or

social, individual-psychological barriers. The identification of the role of these barriers and their gradual abolition is essential to facilitate a comprehensive use of CPCT.

The present thesis aims to investigate the barriers and potential drivers of CPCT in Hungary as well as to estimate its potential in the reduction of GHG emissions. Based upon the findings, the thesis also aims to formulate recommendations in order to facilitate the application of CPCT as a measure to mitigate climate change. The objectives are:

- (1) To reveal the travel habits and motivations of carpoolers and the general public in order to understand the role of carpooling in the reduction of VKT;
- (2) To identify the barriers and possibilities of carpooling;
- (3) To identify the barriers and potential possibilities of carsharing;
- (4) To estimate the maximal, practical and cultural potential of carpooling and carsharing in the reduction of GHG emissions: maximal potential assumes a maximal intensity of CPCT use, practical potential assume an intensity which is convenient and economically favourable, and cultural considers that the cultural-normative or social, and the individual-psychological barriers may further reduce the willingness to use CPCT;
- (5) To formulate policy recommendations which can facilitate considerable reductions in VKT and so in GHG emissions through the application of carpooling and carsharing.

Chapter two provides a literature review focusing on the history, the present situation and the potential environmental impact of carpooling and carsharing in the international and the Hungarian context. Chapter three elaborates the methodology of the surveys, data analyses and estimations and describe the limitations. Chapter four presents the results of the research, while chapter five explains those results. Finally, chapter six aims to answer the research questions presented in the introduction.

## CHAPTER 2 – LITERATURE REVIEW AND THEORETICAL FRAMEWORK

The definition, the history and the environmental impacts of carpooling and carsharing, the different types of barriers and potential estimations, as well as the scope of the research are reviewed in this chapter.

### 2.1 Carpooling

#### 2.1.1. *Definition of carpooling*

There are several definitions of carpooling. The broadest version is the collaborative use of a car (a motor vehicle with a maximum capacity of seven persons) by at least two persons for a certain ride determined by the driver's will, without the primary purpose of gaining profit (though the travel cost may be shared among the carpoolers). This definition might be narrowed by excluding some categories of users: while the broader conception of carpooling (somewhat more common in the U.S.) allows even household members as passengers (though this is usually distinguished by the term of "fampooling" or internal carpooling) (Li *et al.* 2007), the narrower one, usually applied in Europe, excludes household members as well as persons with accompanying purposes<sup>5</sup> (external carpooling) (Vanoutrive *et al.* 2012). The narrower conception can be further narrowed down according to the way of arranging the ride: (i) hitchhiking is a completely random form of carpooling when the ride (destination, etc.) is arranged anywhere on the road where the driver and passenger(s) meet, the passengers cannot predict the waiting time until they are picked up if it takes place at all, and the ride is usually free; (ii) in the case of 'slugging', drivers and

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<sup>5</sup> Those persons who make the travel exclusivelyly for the purpose of accompanying an other traveller, i.e. they otherwise they would have not travelled; for example transporting a friend to the airport, transporting a sick relative to the hospital, etc.

passengers meet at defined locations, the routes are set, the passengers can expect to be picked up in a relatively short time, and the ride is always free (but sharing rides allows drivers to go faster by using designated lanes); (iii) in the case of narrowly defined carpooling all details (place and time of departure and arrival, amount of financial contribution, etc.) are set in advance through a medium (usually the internet), and passengers usually contribute to the travel cost. Real-time carpooling is the state-of-the-art form of carpooling, when setting the detail can take place as little as a few minutes in advance of the meeting through e.g. smartphone applications and the passenger is picked up in her/his current location. In the present thesis I use the term ‘carpooling’ for the narrowly defined version (iii) but I provide an overview of the other forms as well.

### ***2.1.2 History of carpooling***

#### **2.1.2.1 In the U.S.**

Jitneys, a kind of mix between carpooling and an unregulated taxi service, carried people in Los Angeles for a ‘jitney’ (as the five cent streetcar fare was named) as early as 1914 (Amey 2010). At its peak in 1915, an estimated 62,000 licensed jitneys operated in twenty-seven localities, car owners had to get a license for carrying people in their cars, but then the practice declined rapidly due to the drastically increased insurance and license fees issued by the local authorities in order to reduce competition for streetcars (streetcars operators paid taxes from their revenues). It is not clear, however, how far jitneys can be considered as carpooling, as some jitneys operated clearly as a taxi with the purpose of gaining profits. Others probably shared rides mainly on their way to work, but the ratio between the taxi and carpooling form is rather vague (Amey 2010).

Hitchhiking, as a random form of carpooling, has been taking place since cars have become common on the roads: Bill Ganzel (2003) mention a man from 1921 “who got

into the Chicago Adventurer's Club by hitching 3,023 miles in 27 days". The Great Depression then boosted hitchhiking, when many people could not afford other kinds of transportation, and it became so common that a Transit Bureau with 300 centres was set up by the New Deal program to help hitchhikers around the U.S. However, hitchhiking lost its popularity soon after the Depression and became outlawed (but still practiced by a subculture) in many states (Ganzel 2003).

The rationing of tyres (and to a lesser extent of fuel) due to shortages in World War II gave the next boost for carpooling when the U.S. government encouraged people to join car-sharing clubs (which meant carpooling at that time) in order to cut back on driving, as a measure to save resources for war efforts. While its success was never reported, several posters preserve the memory of this heavily advertised campaign (Amey 2010).

Another shortage of fuel (which almost culminated in rationing, too) during the 1970s crises induced the next step in the development of carpooling (Amey 2010). It was the first time that supportive measures other than advertising were applied to encourage carpooling, such as funding carpooling demonstration projects, construction or designation of high occupancy vehicles (HOV)<sup>6</sup> lanes, creation of rideshare agencies and research into carpooling. Environmental concerns (related to air quality) also appeared as an incentive to carpooling in this era. The above-mentioned initiatives, campaigns and concern as well as the high price of fuel kept carpooling at a high level (around 20%) until at least the beginning of the 1980s, but then it decreased to a 13,4 % level by the 1990's and stabilized at a 10-11% level in the first decade of 21th century as the effect of falling fuel prices and increasing living standards (Amey 2010). Nevertheless, it should be noted that approximately 75% of carpool is "fampool" in

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<sup>6</sup> High occupancy vehicle (HOV) lanes are separated lanes of overcrowded roads which can be used by only those vehicles which carry at least two or three persons and so they normally can go faster than the vehicles in the other lanes. Thus, HOV lanes encourage higher occupancy, and so fewer cars, which results in smaller congestion.

the U.S. i.e. consists only family members according to a study focusing on Texas carpoolers (Li *et al.* 2007). The internet-based applications which have made carpooling much easier and more reliable since the 1990s, virtually did not have an impact on the popularity of carpooling (though they may have helped to halt the fall of the carpooling rate). On the other hand, rising fuel prices and falling disposable income in the second half of the 2000s have resulted in a slight increase (less than 1%) of the carpooling rate (Amey 2010).

#### **2.1.2.2 In Europe**

Hitchhiking (or lorry-hopping as it was called at the time) probably came into existence during World War I, when it was a common practice of British soldiers and officers in France (Rinvoluceri 1974). After the war, hitchhiking was limited to football fans following their teams, except during the two-weeks general strike in the UK in 1926, when it became a “nationwide, mass activity” (Rinvoluceri 1974). Then hitchhiking stepped into its golden age during World War II in Britain, where it became a normal way of travelling. It was probably essential because the frequently damaged public transport was not able to serve the huge demand for a newly formed commuting community which evolved thanks to the air-raids of major cities, as a considerable part of the population found shelters in the countryside but commuted for work to the cities. At its peak, the Ministry of Transport introduced a large-scale, remarkably successful scheme called ‘Help your Neighbour’ in London, which offered petrol allowance to drivers who filled their cars with commuters within a twenty miles radius around central London. As a result, more than 20,000 motorists carried 60-80,000 commuters each weekday (usually based on a permanent agreement) until the scheme was abolished in March, 1941 due to the fuel scarcity (Rinvoluceri 1974).

Hitchhiking experienced a sharp decline in the U.K. after the war, as there was neither a patriotic duty nor a necessity to help others in travelling because there was no

feeling of a common threat and the public transportation regained its former state. But the generation of young servicemen who had enjoyed the benefits of hitchhiking during the war soon became motorists, and they were ready to take others in their cars. Thus, hitchhiking became an accepted way of travelling during the 1950s, 1960s and in the 1970s (Rinvoluceri 1974). Afterwards, it started to decline slowly as the society changed and hitchhiking received negative publicity regarding its safety issues and it virtually came to an end when a French girl was murdered by a lorry-driver in 1995 (Monbiot 1999). Other parts of Europe probably have gone through a similar path in the postwar period, though hitchhiking is still more present in continental Europe and in some Eastern European countries, such as Romania, where it is not uncommon to hitchhike and contribute to the fuel cost of the travel even today (Pettersen 2007).

At the same time, organized carpooling has gained popularity since the 1980s though there were some informal initiatives in the 1960s and 1970s, such as Allostop Association in France (Certu 2008). Non-operation of public transportation during general strikes gave a temporary boost to carpooling in several places, but it was the spread of the internet which triggered a “mass” carpooling, as it made arranging rides much more easy and effective. Today, the European-level carpooling.com scheme alone has 3.6 million users (more than 1% of the population of the operating area) and moves around one million people per month (*Carpooling.com* 2012a).

### 2.1.2.3 In Hungary

In Hungary, organized carpooling has been present at least since 1991, when the Kenguru Lift Centre (*kenguru.hu*) started its operation, though this centre has been organizing only international trips (Cs. Köbli András pers. comm.) Later, as the internet became more and more available and globalized, more and more Hungarian departure and destination points were added to Western European or international carpooling systems, such as *mitfahrgelegenheit.de* or *hitchhikers.org*; the latter was even translated into Hungarian. A real boost for a national system came in 2007, when *oszkar.com* started operating. It was soon followed by *utazzunkegyutt.hu*, *telekocsi.eu*

and most recently by *collectivetraffic.net*. At present *kenguru.hu*, *oszkar.com* and *utazzunkegyutt.hu*, which are the most popular schemes, have approximately 30,000 (Cs. Köbli András pers. comm.), 31,000 (Prácser and Gyűrűs pers. comm.) and 27,000 (*utazzunkegyutt.hu*) users respectively, though the user communities of the two latter schemes might significantly overlap.

### ***2.1.3 Environmental impacts of carpooling***

The environmental benefit of carpooling seems to be obvious for the first glance: it improves the fuel economy of cars, since, when carpooling, cars carry more persons by using almost the same amount of fuel<sup>7</sup> (Jacobson and King 2009). At the same time, it is not the fuel economy of cars what defines the total environmental benefit of carpooling, but the total VKT reduction attributed to it. Therefore, if carpooling is not coupled with a VKT reduction of a different vehicle, it does not reduce the GHG emissions. This can take place when carpoolers redeem public transportation by carpooling, provided that the level of public transportation remains the same. But even if the level of public transportation decreases, the total GHG emissions still can grow as public transportation utilized on close to full capacity is more fuel-efficient than cars, i.e. public transportation can carry the same number of people by using less fuel than all cars necessary to this transportation (Metz 2009). Moreover, the lower cost of car use due to the contribution of carpoolers can encourage otherwise public transportation users to switch to car use, which can even increase the total VKT and so the GHG emissions. However, this possibility is usually not taken into consideration by the studies focusing on carpooling. Another factor, which can reduce the overall fuel economy is the extra fuel consumption required to transfer the passengers to their destination. According to Jacobson and King (2009) these extra travel can significantly reduce potential fuel savings. Nevertheless, this possibility

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<sup>7</sup> The impact of extra weight of additional persons on fuel economy is very small (Jacobson and King 2009), therefore it was ignored in this study.

was not taken into consideration in this study, as in Hungary carpooling is typically takes place on long distance when the extra distance covered by transferring passengers to their destination is minimal compared to the overall distance covered by carpooling. However, it can have significant implications in the case of short-distance carpooling.

Nevertheless, carpooling is still considered as the most effective measure (besides a driving ban) to save fuel in a potential emergency case due to a shortage of fuel, which could save 17.6% of fuel consumed normally in the OECD countries if one additional person is added in each urban-area car trip (IEA 2005). Jacobson and King (2009) revealed significant fuel saving potentials even in those cases when the additional person is added in every 10 or every 100 vehicles. Finally, Caulfield (2009) also detected a “sizable annual savings in CO<sub>2</sub> emissions in a case study of Dublin. However, all these results apply only when all the additional persons forgo solo driving for the sake of carpooling. By contrast, in this study special attention will be paid for the effect of otherwise public transport users, especially, since in Hungary public transportation has a more significant role in the passenger transport.

## **2.2 Carsharing**

### ***2.2.1. Definition of casharing***

There are different versions of carsharing. Traditional carsharing is a type of car rental which is available non-stop in several location for as short period of time as twenty minutes and can be booked through internet or phone (Arbouet 2011). Peer-to-peer carsharing takes place when car owners rent their underused vehicles to registered users of a carsharing schemes when they do not use them (The Economist 2010). Finally, informal carsharing occurs when friends, relatives, neighbours or people

socially-bonded by other means jointly maintain and use cars. In the present thesis I use the term ‘carsharing’ for the traditional carsharing, as the other forms of carsharing are difficult to measure due to their informality; and therefore, it is more difficult to predict their impact, too.

### ***2.2.2 History of carsharing***

The first carsharing initiative was operated in Zurich in 1948, but did not last for long (Arbouet 2011). There were several other attempts in the 1960s and 1970s and 1980s in France, in the Netherlands, in Sweden and in the UK but all failed sooner or later (Shaheen 2007). Then a slow growth started in the second half of the 1980s resulting in at least one million users worldwide by 2010 (Arbouet 2011) and leading to the start of Autolib project in Paris in December 2011, which plan to deploy a fleet of 3,000 electric car by 2013 (Hiver’t-Klokner 2011).

At present, no carsharing operator works in Hungary or in other Eastern European countries as far as the researcher knows. Nevertheless, some years ago one of the car-rental companies operated a limited version of carsharing for some years, which allowed IKEA customers to rent cars for the period of time till the customers transport the large items they purchased (pers. comm. Szenohradszki).

### ***2.2.3 Environmental impacts of carsharing***

The GHG emission reduction of carsharing is not obvious for the first glance: one might think that people cover the same distances regardless whether they drive their or shared cars. Nevertheless, according to most studies, most people who join a carsharing scheme significantly reduce his or her VKT (Rydén and Morin 2005, Martin and Shaheen 2011). The major reason of this reduction is the difference between the motivations which encourage car use: while in the case individual car ownership the cost invested to the acquisition of the car and other fixed costs as the

costs maintenance or insurance encourage a more intensive car use, the use-dependent costs of carsharing encourages car use only when cheaper options are not available (or when the benefits (e.g. flexibility, quickness) attributed to the car use are larger than the difference between the cost of car use and the other option.

In contrast, one might think that there is a much lower demand for cars if people share them: e.g. if a shared car is used for 20% of the day instead of 2.6 % as the average VKT of a private car, it suggests<sup>8</sup> that one car can substitute 7.7 cars, i.e. only 13% of the private car fleet would be necessary to supply the population at a certain time. However, in the long term only the average car lifetime VKT (the distance covered during its lifetime) determines the number of cars needed to cover a certain demand of travelling. As the car lifetime-VKT is expected to be similar in the case of private and shared cars, approximately the same number of private or shared cars is needed to cover a certain travel demand, i.e. although far fewer shared cars are needed at a certain moment compared to private cars, shared cars have to be replaced much more frequently. Therefore, the lower demand for cars in the case of carsharing can be attributed only for the reduction of personal VKT. In this study, the impact of this smaller demand on the reduction of GHG emissions was taken into account by using the total GHG emissions of a car's lifecycle (instead of the GHG emissions attributed only to the use phase of the car).

Thus, the most important environmental impact of carsharing roots in the lower GHG emissions attributed to the lower VKT carsharing consumers cover compared to their VKT prior to joining a carsharing operator. Nevertheless, carsharing has other important benefits, too. A shared car can replace 4-8 private cars, therefore much less place is needed for parking the cars (Arbouet 2011). In addition, the carsharing fleets typically consists of vehicles of lower impacts, either because the cars are modern or because they are electric or hybrid cars. Finally, carsharing is more egalitarian, as it

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<sup>8</sup> Assuming that the 9,050 km was covered by 226 hour (2.6% of the year) at a speed of 40 km/h.

allows those low-income people access to cars who otherwise could not afford to maintain a car.

## **2.3 Type of barriers**

There are several ways of categorizing barriers to a certain possibility. For this study, the categories applied in a Swiss study (Sadeghi and Lüthi 2009) focusing mobility services, including carsharing, were selected, as they are often used in mobility researches. According to this study the physical or structural barrier refer to the difficulties in the access to a mobility service, while in the case of economic barrier the size of economic incentive to choose a certain mobility service is the main factor, that is economic barrier is important when there is no economic incentive to use a service. Political and knowledge based barriers refer to the need for regulation and the need to disseminate information, respectively. Cultural-normative or social, and individual-psychological barriers refer to the presence of cultural concepts and personal attitudes, which may hinder a certain type of mobility service.

## **2.4 Potential estimations**

The few studies which estimate the GHG emission reduction potentials of carpooling and carsharing use rather different methods and assumptions for the calculations. The basic feature of all method is the calculation of total VKT avoided due to carpooling or carsharing. In the case of carpooling the estimations assume that carpooling increases the average occupancy of cars by a certain value, which range can be one (IEA 2005), i.e. each ride is shared by an additional person, as well as 0.1 or 0.01 (Jacobson and King 2009), i.e. one additional person is added in every 10 or every 100 car. In addition, other factors, such as the extra distance covered due to the demand

for a transport to the passengers' destination, might be taken into consideration, too (Jacobson and King). Another important assumption is that these additional persons would have taken the same trip with their own car. Finally, in order to get the total VKT avoided, the total number of personal-km can be divided by a higher occupancy value; the difference between the original VKT and the result of this division is equal with the VKT avoided.

The next step is the calculation of fuel saving due to the lower VKT. While some studies apply a flat rate per VKT (IEA 2005), others consider the various consumptions of different cars by using a model, such as the COPERT4 (Caulfield 2009). One study considers even the weight of passengers, applying different average weights in the case of different scenarios (Jacobson and King, 2009). Finally, either an average GHG emission is attributed to each VKT avoided, or the difference between the various fuels is taken into consideration, too.

In the case of carsharing the calculations estimate the number of carsharing costumers, their average yearly VKT and the fraction of this VKT they avoid after joining a carsharing operator (Rydén and Morin 2005). The multiplying of these data results in the total VKT avoided, which then can be transformed into the GHG reduction potential by attributing a certain GHG emission to each VKT avoided.

## 2.5 The scope of the research

The research aim to investigate the potentials, barriers and possibilities of CPCT in Hungary, as data necessary to the analyses could be obtained only from one country regarding the need for the close cooperation between the researcher and the CPCT operators. Hungary was chosen as the researcher is Hungarian and he has already known some of the stakeholders, which has facilitated the research. In addition, very few studies have investigated CPCT in Hungary so far, and even those have focused primarily on the telematics of either form of CPCT (Csiszár 2009, Gyűrűs *et al.* 2008, Sélley 2007). Thus the result of this research can fill up the knowledge-gap associated with this topic.

Nevertheless, this narrow geographic scope does not mean that the conclusions can be applied only in Hungary. The cultural and economical characteristics, as well as the travel patterns, are presumably very similar in the Eastern European countries. In addition, the provision of public transportation, which has important implications for the application of CPCT, is similarly rather high all over the European Union. Therefore, the conclusions of this research might be extrapolated to these regions.

## CHAPTER 3 - METHODOLOGY

To investigate the barriers and potential drivers of CPCT, the results of opinion surveys were analyzed, while the estimations of GHG reduction potentials were performed primarily by using literature data and rational assumptions (some of the latter based on the result of the opinion surveys). In the case of carpooling there are several operators in Hungary, therefore, beside an analysis of stakeholders' opinion, it was possible to survey and analyze directly the opinions of carpoolers, too, through an online questionnaire. In addition, as a national survey about carpooling to work was conducted incidentally in parallel this research and its data were provided by the surveyor, and so the result of this survey could be utilized, too. At the same time, the analysis regarding carsharing relied exclusively on stakeholder's opinions as carsharing is not available in Hungary.

The opinions of carpoolers were surveyed by the researcher through an online questionnaire (hereinafter referred to as 'carpooler survey') between 1<sup>st</sup> and 24<sup>th</sup> of June 2012. The users of the *oszkar.com* scheme, the most popular carpooling site with 31,220 registered members on 19 May, 2012 participated in the survey, which included 24 questions regarding the demography, the travel purposes, the travel patterns and the experiences of carpoolers as well as the barriers which discourage them from carpooling more intensively and the reasons why they carpool. The latter addressed not only the motivations for carpooling, but those possibilities as well which would encourage users to carpool more frequently. As some questions do not make sense for both driver and passenger carpoolers (e.g. drivers might be not able to answer a question regarding their reasons to favour carpooling over public transportation as they might not use the latter), two different questionnaires were designed for the two groups (see the questionnaires in Appendix 1.). In order to offer rides, drivers have to register their cars at *oszkar.com*, thus, those who registered at least one car were considered as drivers (9,101 users, 84.6% male), while the others

were considered as passengers (22,119 users, 53.4% male). As some of those who registered a car may carpool only as a passenger, the drivers were asked to fill in the questionnaire only if they actually carpool as a driver. The links to the online questionnaires originally were sent by email to 2,074 randomly selected passengers as well as 1,981 randomly selected drivers but as drivers' response rate was low (235 of them responded within two weeks) 1,000 additional drivers were emailed about the driver questionnaire. In order to raise the response rate, USB memory sticks were offered for 3 randomly selected passengers and drivers in each group among those who filled in the questionnaires.

The questionnaires were filled in by 348 passengers and 468 drivers (17% and 15.6% response rate, respectively). The margin of error was  $\pm 2.6\%$  in the case of passengers and  $\pm 2.2\%$  in the case of drivers, at a 95% confidence level. The representativeness of respondents was ensured by the random selection of those passengers and drivers who got the emails containing the link of the questionnaires. Nevertheless, the pattern may be biased towards those who are more interested in getting a memory stick (e.g. students, younger people, etc.), who have more time to spend on filling out questionnaires (e.g. students, ordinary employees) or who are more interested in carpooling (and so might use it more often). The compulsory registration of gender at the *oszkor.com* site provided the possibility to test representativeness, as the respondents were asked to indicate their gender, too. In the case of drivers only four more male (400 versus 396) respondents filled in the questionnaire than it could be expected from the gender proportion of the registered drivers (i.e. the actual percentage of males in the sample is less than 1% larger than the expected value based on the gender ratio of all registered drivers). On the other hand, in the case of passengers thirty-two more women (196 versus 162) filled in the questionnaire compared to the expected value (i.e. the actual percentage of females in the sample is nearly 10% larger than the expected value) (Figure 1.), which is significant (Chi-square=13.351, df=1, asymp. sig.<0.001). Different demographic features of the two sexes might be able to explain such a difference in the response

rate but there is no considerable intersexual difference in the case of place of residence, age and (occupational) position – though female respondents are somewhat more likely to be from a large town, be older and have a higher position. There was no considerable intersexual difference in the case of non-demographic variable either, except the case of security concerns, which the female respondents considered as more important (see later). Therefore no weight for gender was applied during the analyses.

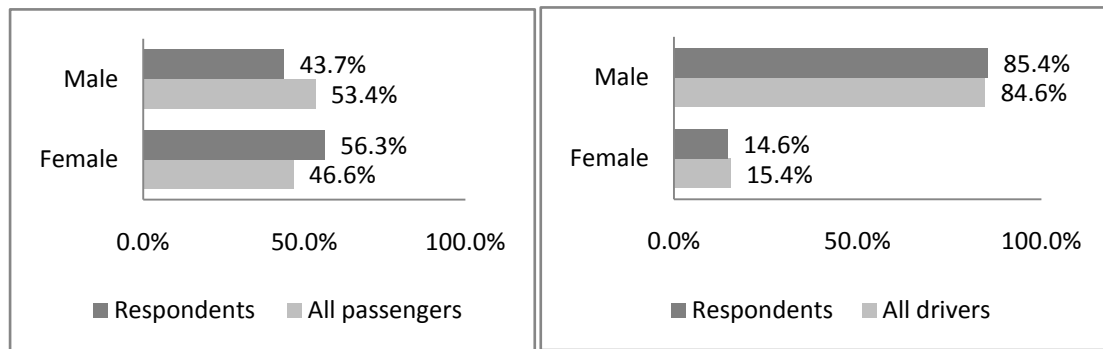


Figure 1. The gender distribution of respondents (passengers and drivers) compared to all passengers and drivers.

In addition, the database of offered and booked rides in 2011 (hereinafter referred to as ‘route database’), which were provided by the *oszkar.com* operators, was analyzed, too. The databases contained the number of rides offered as well as booked for each route in 2011, and the number of rides offered in the different days of the week. It should be noted that in some (especially commuting) routes a considerable proportion of offers might be attributed only to a few drivers, as they might offer rides every weekday in those routes; *oszkar.com* even facilitates this by allowing the declaration of a ride as regular and such an offer appears in the database as if it was offered separately each day. Another important issue is that a match can be arranged without booking if the passengers contact drivers directly by email or phone. Moreover, in the case of regular rides, certain drivers and passengers might arrange carpooling outside the *oszkar.com* site and so these rides do not appear in the databases. Therefore, the actual number of booked rides (and to a smaller extent the number of offered rides)

generated by *oszkar.com* site is somewhat larger than the databases show.

To compare the popularity of different routes among passengers, the booking rate (the rate of rides booked and offered in a certain route) was calculated for each route. It should be noted that one ride can be booked by as many passengers as the number of free places - which is indicated by the driver of each ride. Therefore, the booking rate is not identical with the proportion of those offered rides when actual carpooling was realized but somewhat larger. In addition, the temporal distribution (within a week) of offers and bookings were analyzed, too.

A national survey on a representative sample of 1,200 persons over 18 in Hungary in 18-22 May, 2012 (hereinafter referred to as 'national survey') was performed by Policy Solutions with help of Median Public Opinion and Marketing Research Institute. The data of the survey were provided by Clean Air Group (Levegő Munkacsoport), which was the creator and organizer of the survey. Apart from demographic data, the level of willingness to use carpooling to work and arguments for and against it were gathered (see the questionnaire in Appendix 2.). Nevertheless, the sample size of one of the most important groups, those who travel to work by car, is very small (153 persons), which entails a rather large margin of error (3.95%) at a 95% confidence level. The data of this survey were analyzed in order to get an insight about who are the potential carpoolers as well as what are the barriers and potential drivers of carpooling in the case of the general public. However, the aim of this survey was to identify people's attitude to carpooling only in the case of travelling to work, which might be different from the attitudes to carpooling in general. For example, carpooling to work might be preferred more than carpooling for other purposes, as it is a regular activity on a certain route, thus it is likely to occur that the same group of people carpool every day (so after a while people will not be strangers anymore). On the contrary, carpooling to work might be disfavoured as lot of people are in a hurry when they travel to work, thus they do not want to adapt to others. These differences can limit the extrapolation of the result of the national survey to

general carpooling.

The stakeholders' view about the barriers to carpooling and carsharing (hereinafter referred to as 'stakeholder's survey') were also surveyed. The opinions of university and civil experts on transportation as well as CPCT operators were gathered through personal interviews and an online questionnaire between 20<sup>th</sup> of May and 15<sup>th</sup> of July, 2012; in the latter case the stakeholders valued on a scale of ten the six different barriers mentioned in the introduction (see the questionnaire in Appendix 3.). Experts first were identified due to their contribution to the CPCT literature; then they were asked to provide contacts of other experts in CPCT-related fields, who were subsequently emailed about the questionnaire. Carpooling operators were identified through their carpooling scheme and were subsequently emailed about the questionnaire, too. Three experts from universities (one professor and two PhD students), two experts from the civil sector and a carpooler scheme operator (the latter ranked only the barriers related to carpooling) filled in the questionnaire about the barriers to carpooling and carsharing.

Finally the maximal, economic and cultural potentials in the reduction of GHG emissions were estimated based on the CO<sub>2</sub> emissions avoided due to the lower personal VKT attributed to CPCT. At first the reduction of VKT was estimated in the case of each potential, which was then transformed into reduction of CO<sub>2</sub> emissions, assuming an average 158.5 g CO<sub>2</sub> emission per km<sup>9</sup>. The reduction of CO<sub>2</sub> emissions was considered to be equal to the reduction of GHG emissions in the use phase (i.e. tank-to-wheel phase), as the emissions of non- CO<sub>2</sub> GHG gases (mainly methane and N<sub>2</sub>O) in this phase are negligible (Metz 2010). Finally, the total reduction of GHG emissions was calculated assuming that the tank-to-wheel phase contributes to 77.5% of the total GHG emission of an average car's lifecycle (Nemry *et al.* 2008). Thus, the

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<sup>9</sup> This was the average CO<sub>2</sub> emission of passenger cars registered in Hungary in 2004 (EEA 2010a). 2004 was selected as a reference year as the average age of passenger more than 8 years (Bosch 2010).

GHG emission per km is approximately 205 g CO<sub>2</sub>eq in average.

As a rule of thumb, maximal potential was defined as the maximal reduction in GHG emissions achievable by an intensive, but still comfortable way of CPCT without any consideration to its cost. The estimation of practical potential took into consideration that practically only a certain fraction of carpoolers redeem car use by carpooling and so realize any VKT reduction<sup>10</sup>, and only those will use carsharing for whom it is economically favourable compared to owning a car. Finally, for the estimation of cultural potential it was assumed that a certain proportion of the population would certainly not use CPCT for reasons rooted in cultural-social concepts such as ‘car is the symbol of freedom’ or in individual attitudes such as ‘distrust toward strangers’ (note that the individual attitudes are also influenced by cultural-social concepts).

In the case of carpooling two possibilities were considered in the case of maximal potentials depending on whether the maximum car occupancy is set as four persons (which still allows for a comfortable ride) or as an average 2.9 persons (i.e. one person is added to each ride, since the average car occupancy is 1.9 in Hungary according to EEA 2012). The reason of considering two possibilities was that the occupancy of four persons presumes so much coordination (to synchronize the travel routes and time of many passenger) which would compromise the convenience of travelling by car to a too much extent. Therefore, an estimation for the case of increasing occupancy by an additional person, which was applied in the potential estimations of carpooling in the case of International Energy Agency (IEA 2005), was performed, too. Finally, it was also assumed that carpooling always substitutes car use and not public transportation.

In the case of practical potential the occupancy of 2.9 was applied and it was assumed, that a significant fraction of passenger carpoolers redeems public transportation with

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<sup>10</sup> Those who redeem public transportation by carpooling normally do not contribute to the VKT reduction, as the public transport vehicle redeemed by them still cover the same distance.

carpooling, in which case no VKT reduction is realized. That is, in the case of practical potential a VKT reduction was attributed only for those who forgo car use when they carpool, and it was assumed that no additional rides were performed by cars used exclusively by otherwise public transport passengers (which could generate additional VKT). On the other hand, the potential emission saving of the presumably decreased VKT of public transportation due to the lower demand was ignored, too. The size of the population fraction which redeems public transportation by carpooling was estimated by using the results of the carpoolers' survey. Then, for estimating the cultural potential, the level of willingness to carpool to work was applied, suggested by the results of the national survey.

Finally, the GHG emission savings of carpooling in 2011 was estimated (i) by using the data of the route database (the number of rides booked and the average distance of rides), (ii) by assuming that the actual VKT reduction generated by the *oszkas.com* scheme was twice as large as the aggregated VKT of all rides due to those rides which were arranged without booking, (iii) by using the estimated value of the fraction of the population who substitute car use when carpooling as a passenger (see above), and (iv) by assuming that the total VKT reduction generated by all carpooling scheme in Hungary is twice as large as the VKT reduction generated by the *oszkas.com* scheme<sup>11</sup>.

Several assumptions were applied for estimating the different potentials of carsharing, too. Firstly, it was assumed that joining a carsharing operator reduces the VKT of the person by 32%, which is the mean value of the 28-36% detected by carsharing studies (Rydén and Morin 2005). Secondly, it was also assumed that an average car user

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<sup>11</sup> Through there are 6-7 carpooling scheme in Hungary *oszkas.com* is far the most popular. For example, in 20<sup>th</sup> of July 2012 there were around six times as many rides offered by *oszkas.com* than by the *utazunkegyutt.hu* scheme. Assuming that the booking rate is similar among the different carpooling schemes, the twice as large aggregated VKT reduction (of all schemes) seems to be reasonable.

drives 8,100 km a year, again a mean of data from two different sources<sup>12</sup>. Thirdly, the average age of shared cars was estimated to be two years, assuming that a shared car used 20% of a day runs 60,000 km a year<sup>13</sup> and therefore it is subject to upgrading to a newer version in four years, considering that an average car's longevity is around 240,000 km (USA Today 2006). Thus the average age of a shared car would be 8 years younger than the average age of a private car in Hungary (Bosch Medián Survey 2010) which would entail approximately 10% less CO<sub>2</sub> emissions per km due to its better efficiency (EEA 2010a). Even further emission reductions could take place if the share of low-emission vehicles, such as hybrid or electric cars, is larger in the fleet of shared cars than in the fleet of private cars. This is likely to occur considering that the usually high price of such a vehicle manifests only in a relatively small increase in the operational cost of shared cars as the acquisition of a car represents only a small fraction (5-50% according to Clean Air Group (2010)) of its lifecycle costs; therefore their application can be more acceptable and favoured by the public. Nevertheless, this option was not incorporated into the estimation as the application of such vehicles is highly unpredictable and so it is difficult to quantify its impact.

Technically speaking, it is possible that each of the 3 million car users in Hungary (assuming that number of car users is equal to the number of cars that is approximately 3 million (KSH 2012a)) forgo private car use and join a carsharing operator, therefore this case was considered for estimating the maximal potential. However, it can be assumed that from the users' point of view carsharing is practical (i.e. economically beneficial) to using a private car if the latter is used for less than 7-18,000 km a year (Shaheen *et al.* 1998), while from the operators' point of view

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<sup>12</sup> The average yearly distance covered by a driver is around 12,000 km according to the Bosch survey. However, according to the Hungarian Central Statistical Office (KSH 2010) the Hungarian population travelled 23,7 billion passenger km in 2009, which transforms into 12.5 billion km covered by the 3 million registered cars (assuming an average 1.9 persons travelling in a car). This means 4,200 km/year by car. For the estimation 8,100 km/year was used as the mean of the two values.

<sup>13</sup> Assuming that it runs 1500 hours a year (17% of every day) at an average speed of 40 km/hour.

carsharing is economically feasible only if the cars are frequently used, i.e. a sufficiently large number of people live (or work) in the proximity of the shared cars. This means that at an early stage of carsharing when it is not well-known and not popular, carsharing can be economically viable only in an urban environment. Therefore, to perform the estimation of practical potential the economic breakeven point was set at 10,000 km per year and an urban environment was defined as towns of more than 50,000 inhabitants, and it was also assumed that those who meet these conditions drive 5,000 km a year (assuming an even distribution of VKT per person between 0 and 10,000 km). Finally, in the case of cultural potential it was assumed that roughly half of those for whom carsharing is economically favourable would join a carsharing operator, while the others would insist on private car use for various reasons, e.g. they are emotionally bound to their own car. Therefore, the cultural potential was estimated to be half of the economic potential.

As it was described in the ‘environmental impacts of carsharing’ subchapter, the lower demand for cars can be attributed only to the reduction of personal VKT (and not to the smaller number of the cars due to their shared use). The impact of this lower demand on the reduction of GHG emissions was taken into account by using the total GHG emissions of a car’s lifecycle (instead of the GHG emissions attributed only to the use phase of the car).

Clearly, there are serious limitations to the potential estimating models described above. For example, assuming that half of those people for whom carsharing is economically favourable would forgo their private cars might be a highly optimistic idea today. But as society changes continuously, the high cultural value attributed to a private car can decrease soon, especially in the case of the younger generation. The result of a global survey that young people between 18-24 prefer internet access over owning a car (Philips 2011) might be the first sign of the devaluation of private cars.

## CHAPTER 4 - RESULTS

This chapter presents the results obtained by analyzing the carpooler, the national and the stakeholder surveys, the route database, and by performing estimations for the reduction potentials in GHG emissions. The results related to carpooling are aligned in order to the following questions: who (demography), where (carpooling routes), for which purposes (travel purposes), how (travel patterns and experiences), why not (barriers) and why (motivations and possibilities) carpools? Finally, the results of estimating the maximal, economic and cultural potentials are presented. In the case of carsharing only the ‘why not’ question and the three potentials are addressed as the data for answering the other question were not available.

### 4.1 Carpooling

#### 4.1.1 Demography

According to the membership data provided by the *oszkar.com* operators, the number of carpooler has been growing dynamically since the beginning of the operation (Figure 2.).

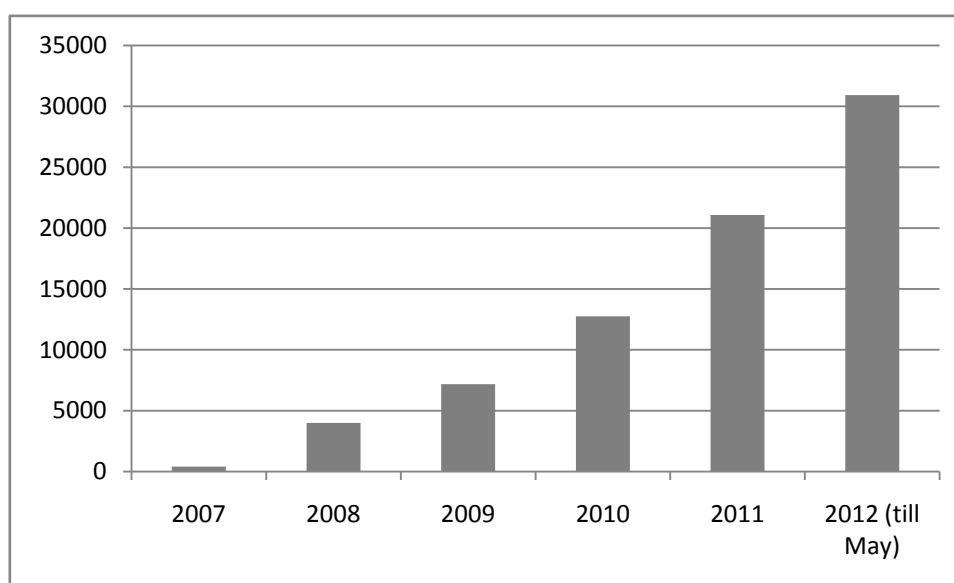


Figure 2. Number of registered users at *oszkar.com* scheme.

Based on the carpooler survey, carpoolers are strongly overrepresented in the 26-40 age groups and among those who live in Budapest or in large cities of more than 50,000 inhabitants, while people over 60 or living in villages are strongly underrepresented (Figure 3. and Figure 4.).

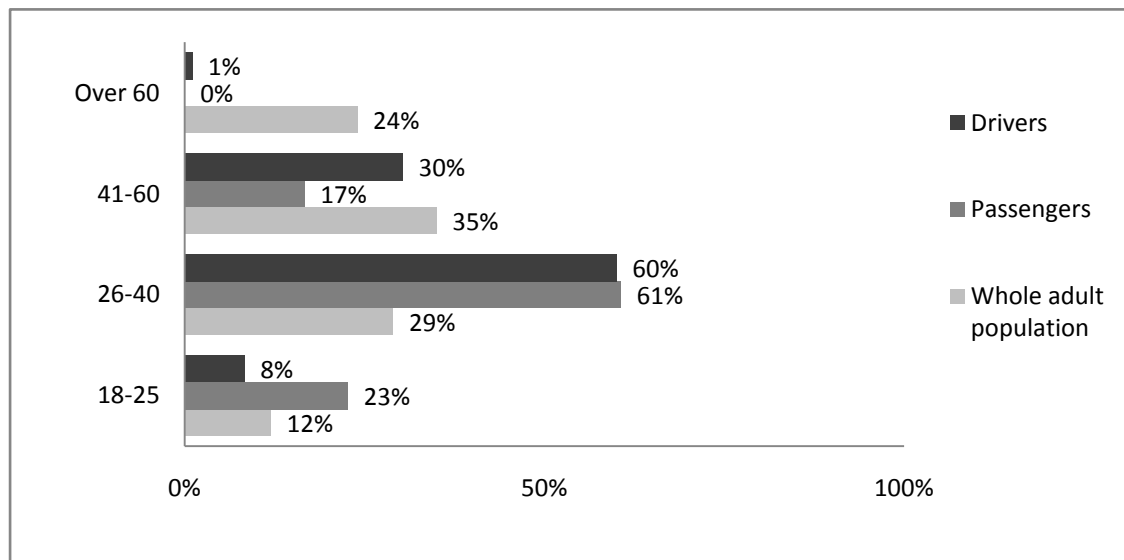


Figure 3. Age of respondents compared to the whole population of Hungary

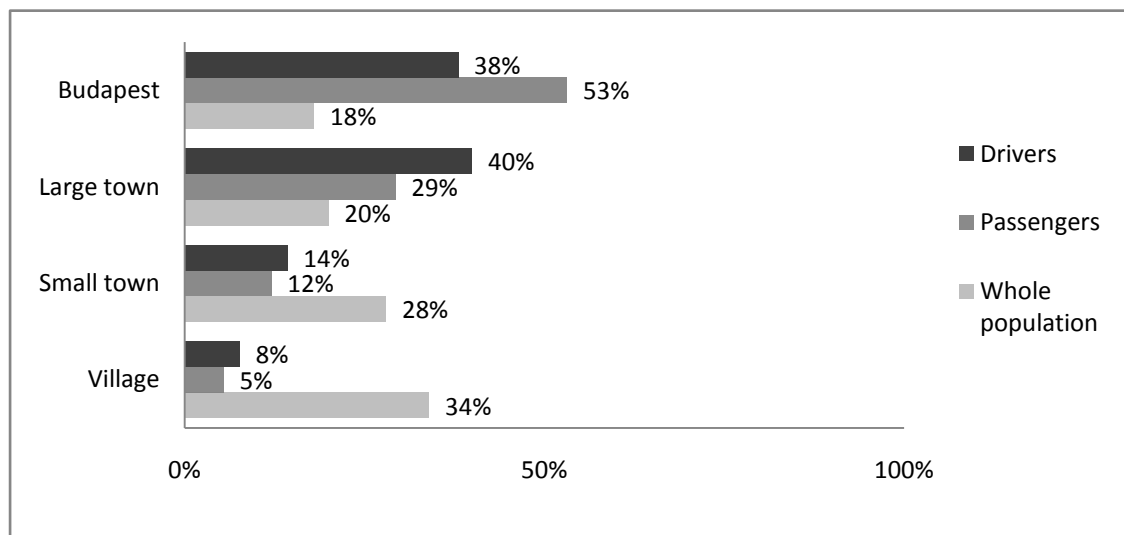


Figure 4. Respondents' place of residence compared to the whole population of Hungary.

Considering occupation, students are overrepresented among the passengers (approximately 5% of the adult population of Hungary are students (KSH 2012b)),

while self-employed people are overrepresented among both drivers and passengers (approximately 5.5% of the adult population of Hungary are students (KSH 2012b)). As managers and employees constitute approximately the 42% of the adult population (KSH 2012b), their aggregated group is also overrepresented. Since the answers whether a respondent is a manager or an employee relied on self-conception (it is not always obvious, e.g. in the case of group leaders), it is difficult to compare their proportion in the sample and in the whole population. Nevertheless, it might be assumed that their ratio is maximum 1:3 (i.e. there are at least three employees for every one manager), in which case the managers are overrepresented among the employed people, too, especially in the case of drivers, when this ratio is almost as high as 1:1 (Figure 5.) Regarding the differences between drivers and passengers, the data suggest that, while the main demographic trends are similar, drivers are more likely to be older, to have a higher position at work and to be from a large town rather than from Budapest.

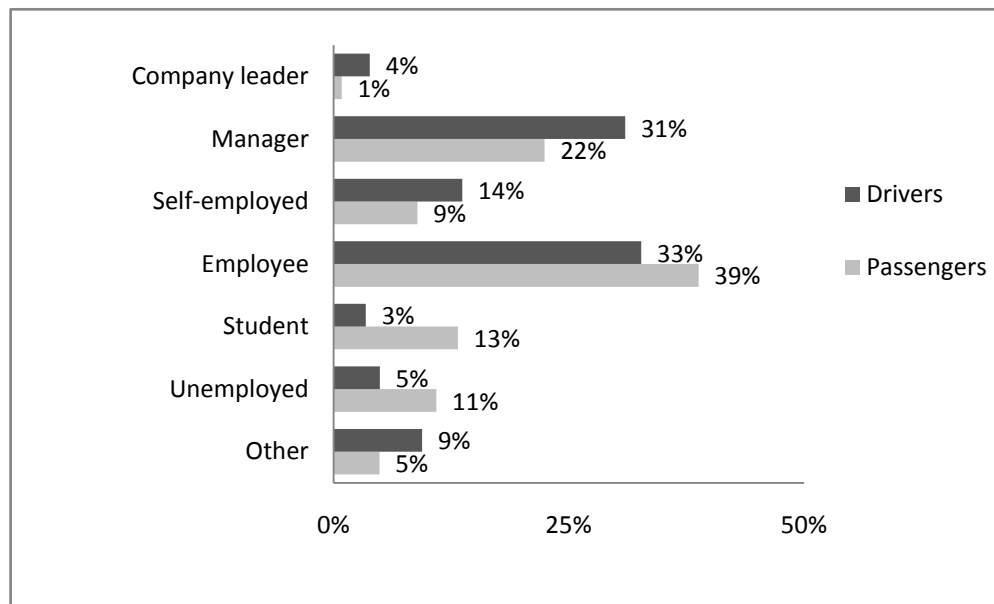


Figure 5. Occupation of respondents.

Regarding gender differences, there is a rough balance of male and female passengers in the case of passengers, though female carpoolers have responded in a greater

proportion compared to male carpoolers (see methodology for further explanation), while there are much more males among the drivers (Figure 1.).

According to the national survey, 13% of the population over 18 travel to work by car; note that according to the survey 49% of the population over 18 do not work in Hungary; this is consistent with the national statistic data (KSH 2012b). Nearly half of those who travel to work by car might be engaged in carpooling as a driver, while 43% might do so as a passenger (Figure 6.). Thus 58% of those travelling to work by car might be engaged in carpooling either as a driver, as a passenger or both (16% only as a driver and 8% only as a passenger). On the other hand, 51% of those who travel to work by means other than car might carpool as a passenger. Surprisingly enough, 31% of those who might carpool to work would certainly not use a service which organizes carpooling. It may be assumed that a potential high price attributed to such a service by those respondents might be the reason for such a high level of rejection (the gratuity or the price of the service was not specified in the question).

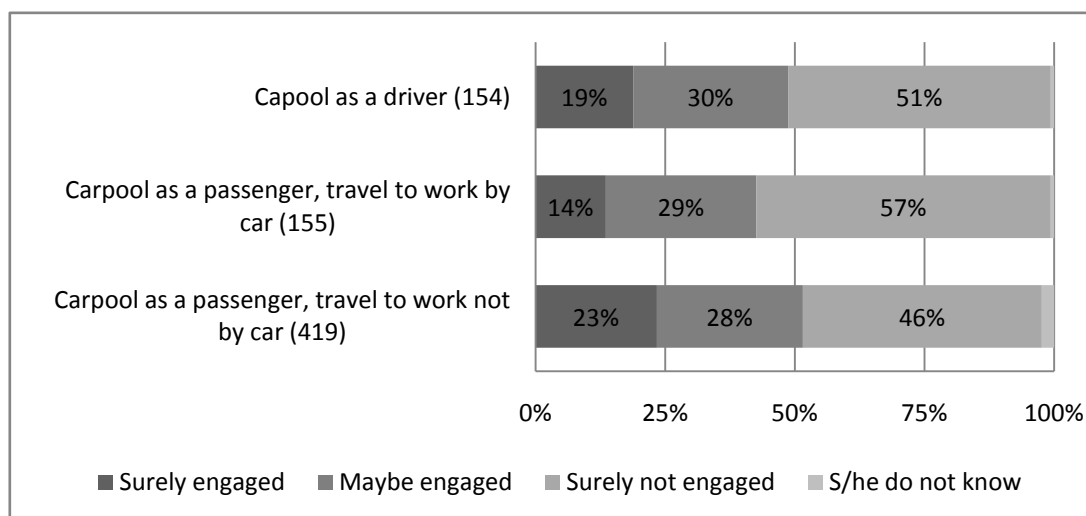


Figure 6. Level of engagement in carpooling (number of respondents). Data source: Policy Solutions 2012.

As far as the demography of potential carpoolers (those who maybe or certainly would be engaged in carpooling to work) is concerned, the national survey suggests a somewhat different picture of potential carpoolers: they are less strongly

overrepresented among the younger people (Figure 7.), and they are not underrepresented at all among those who live in a village (Figure 8.).

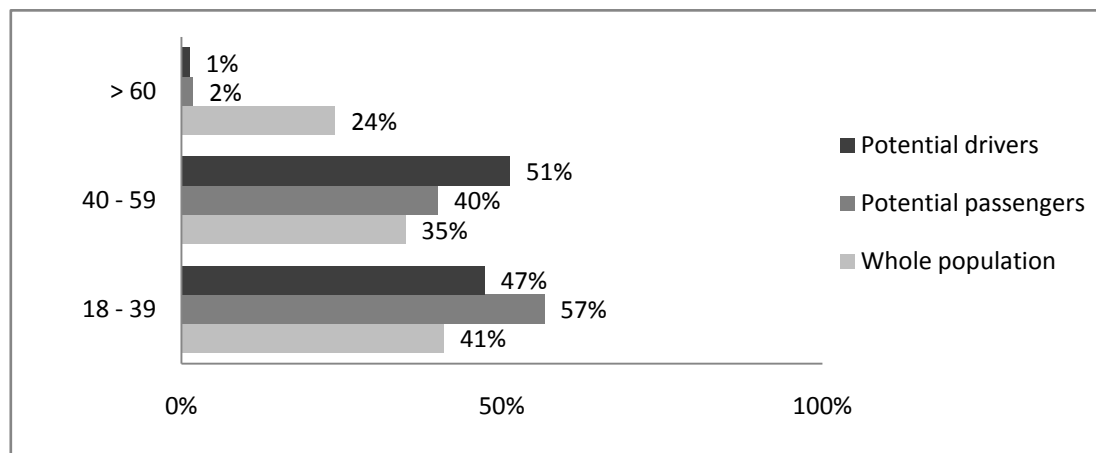


Figure 7. Age of potential carpoolers compared to the whole population of Hungary.  
Data source: Policy Solutions 2012.

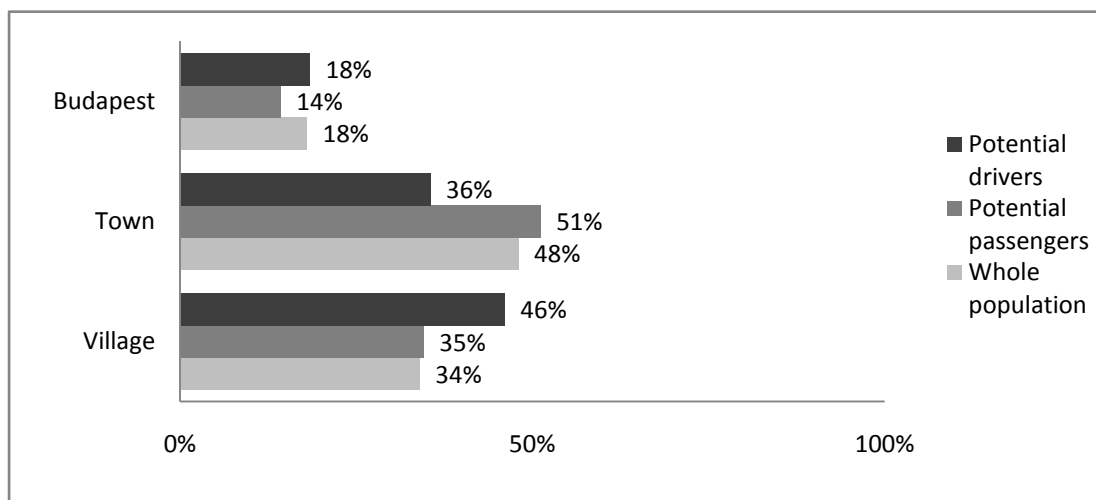


Figure 8. Potential carpoolers' place of residence compared to the whole population of Hungary. Data source: Policy Solutions 2012.

#### 4.1.2 Carpooling routes

According to the databases of rides in 2011, 194,362 rides were offered in 15,820 routes (in 54% of routes there was only one ride offered). 10,870 bookings were

realized, which means that less than 6% of rides were booked (as one ride can be booked by more than one user, the exact number cannot be specified). The most rides were offered between Budapest and Pécs and within Budapest, followed by routes between Budapest and other large towns (e.g. Miskolc), Balaton resorts (e.g. Siófok), or Budapest's agglomeration (e.g. Veresegyház) (see Figure 9. and Table 1. for details). Between Pécs and Szekszárd and within Győr were the most often offered routes not including Budapest (though as Szekszárd is on the route between Budapest and Pécs, a considerable part of offers on this route might be offered as a part of the Budapest-Pécs route).

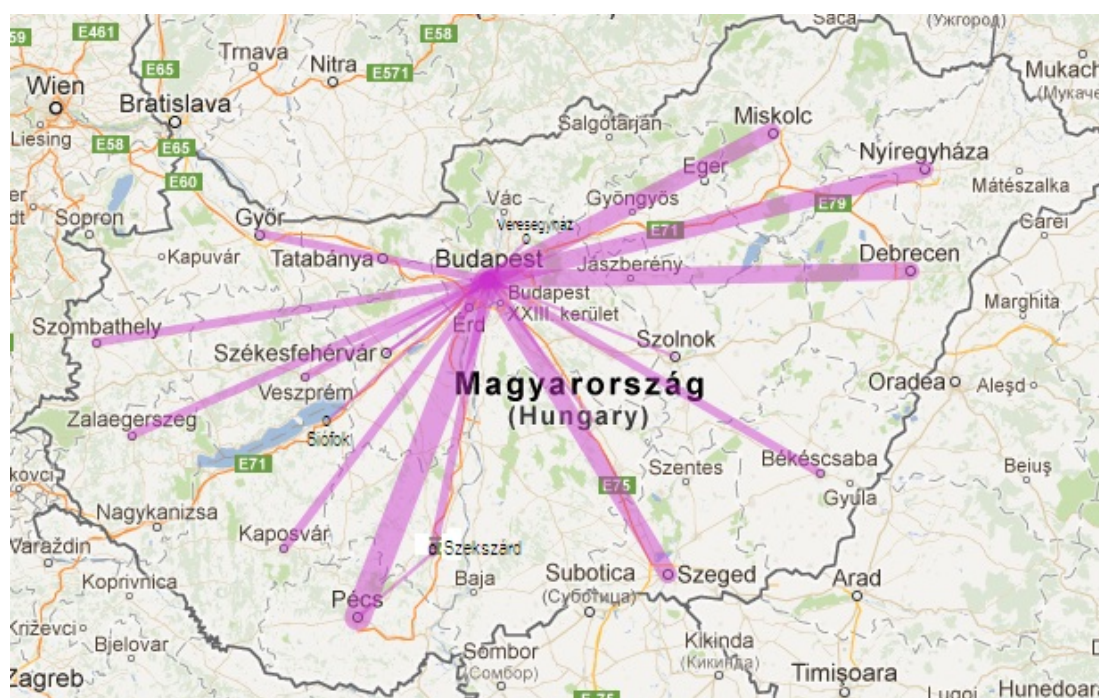


Figure 9. Some of the routes most often offered in 2011. The width of the line indicates four different categories of booking rate (rate of booked and offered rides): 0-0.1; 0.1-0.3; 0.3-0.6; >0.6 from the thinnest to the widest. Map source: [googlemaps.com](http://googlemaps.com)

Table 1. The routes where rides were most often offered in 2011 and their booking rate (rate of rides booked and offered on a certain route).

	Number of offers			Booking rate (aggregated for the two direction)
	Outward	Return	Total	
Budapest – Pécs	1,904	2,036	3,940	0.94
within Budapest			3,714	0.01
Budapest – Miskolc	1,125	1,177	2,302	0.54
Budapest – Siófok	1,193	997	2,190	0.08
Budapest – Debrecen	986	1,093	2,079	0.49
Budapest – Győr	1,070	920	1,990	0.17
Budapest – Veresegyház	863	882	1,745	0.01
Budapest – Szeged	776	813	1,589	0.42
Budapest – Gödöllő	528	860	1,388	< 0.01
Budapest – Nyíregyháza	628	625	1,253	0.49
Pécs – Szekszárd	509	456	965	0.01
within Győr			732	0

The booking rate in 2011 showed a large variability even on routes where more than 100 rides were offered. Apart from a few individual routes (Budapest-Pécs, Budapest-Kaposvár, Budapest-Veszprém), the booking rates of routes between Budapest and other towns were correlating surprisingly well with the towns' population size and especially their distance from Budapest (Table 2.). The booking rate was relatively high between Budapest and other large towns further than 150 km from Budapest, while in the case of closer and smaller towns it reduced sharply. It was even lower (less than 0.02) within cities, large towns and agglomeration of large towns (Table 1., Veresegyház and Gödöllő are small towns in Budapest's agglomeration). A highly concentrated distribution of bookings is also indicated by

the fact that 70% of all bookings took place on routes where the offers represent only 6.3% of all rides offered; these routes are between Budapest and the largest towns of Hungary (Pécs, Miskolc, Debrecen, Szeged, Nyíregyháza).

Table 2. The effect of population size and distance from Budapest on the booking rate.

Population size	Distance from Budapest (km)	Towns	Booking rates
Over 100.000	Over 150	Debrecen, Miskolc, Nyíregyháza, Pécs, Szeged	0.42 – 0.54 (except Pécs: 0.94)
	100-150	Győr	0.17
	Less than 100	Kecskemét, Székesfehérvár	0.02 – 0,05
Less than 100.000	Over 150	Baja, Békéscsaba, Eger, Hajdúböszörmény, Hódmezővásár-hely, Kaposvár, Sopron, Szombathely, Szekszárd, Zalaegerszeg,	0,16 - 0,32 (except Kaposvár: 0,08)
	100 – 150	Siófok, Szolnok, Veszprém	0,03 – 0,1 (except Veszprém: 0,21)

The number of offers and bookings also shows an uneven temporal distribution: there are approximately two times as many offers and four times as many bookings on Fridays and Sundays than in other days (Figure 10.), which is consistent with the main purpose of carpooling (home trips at the weekends), as it came to light from the result of the carpooler survey (see next paragraph).

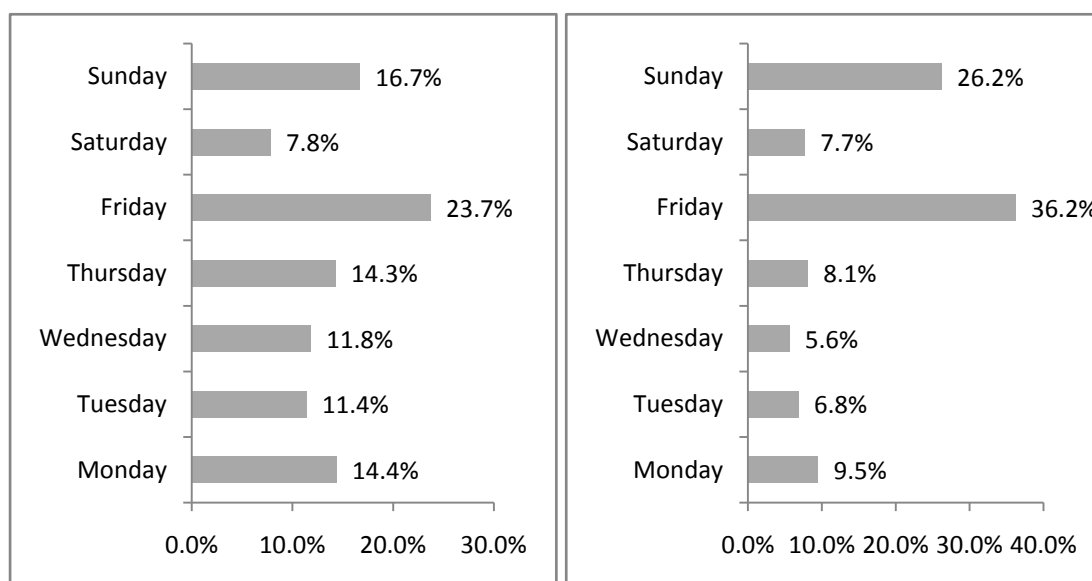


Figure 10. The temporal distribution of offerings and bookings in the percentage of all offerings and bookings in 2011.

Finally, according to the carpooler survey, the overwhelming majority of respondents living in Budapest or in a large town considers carpooling primarily as a means of non-local travel regardless whether they carpool as a driver or as a passenger (Figure 11.).

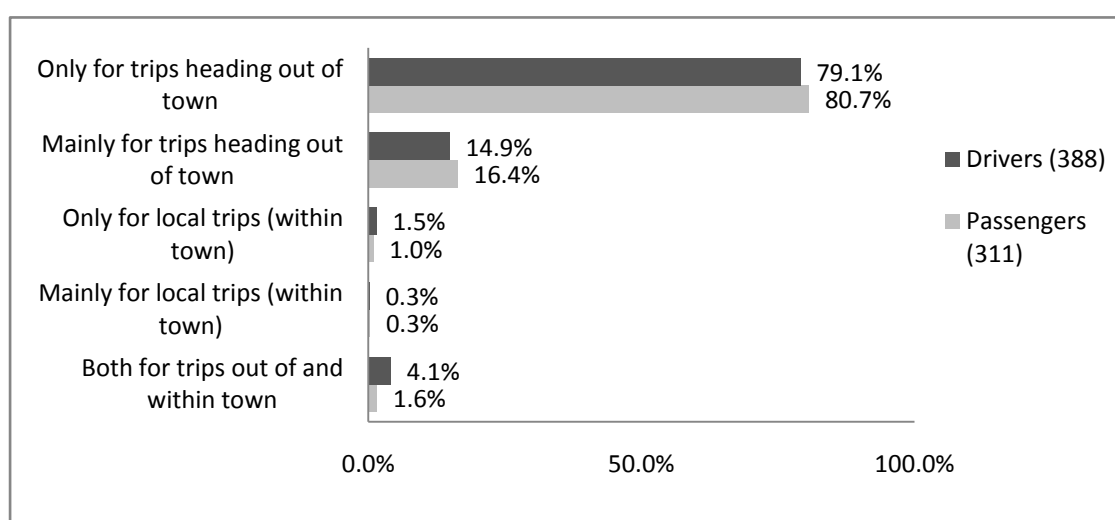


Figure 11. Destinations of carpooling in the case of passenger rides and in the case of drivers' offers (number of respondents living in towns of more than 50,000 persons).

### 4.1.3 Travel Purpose

The most important purpose of use is weekend trip home (see in details in Figure 12.) both in the case of drivers and passengers according to the carpooler survey. In spite of the large number of passengers who never use carpooling for commuting, carpoolers still consider carpooling as a potential mean of commuting: 21% of drivers offer rides almost exclusively for commuting, the majority (69%) of commuting passengers would carpool to work/school if there were rides offered on their routes (Figure 13.), and the 62% of commuting drivers either offers regularly rides or used to do it but stopped due to the lack of any match (Figure 14.).

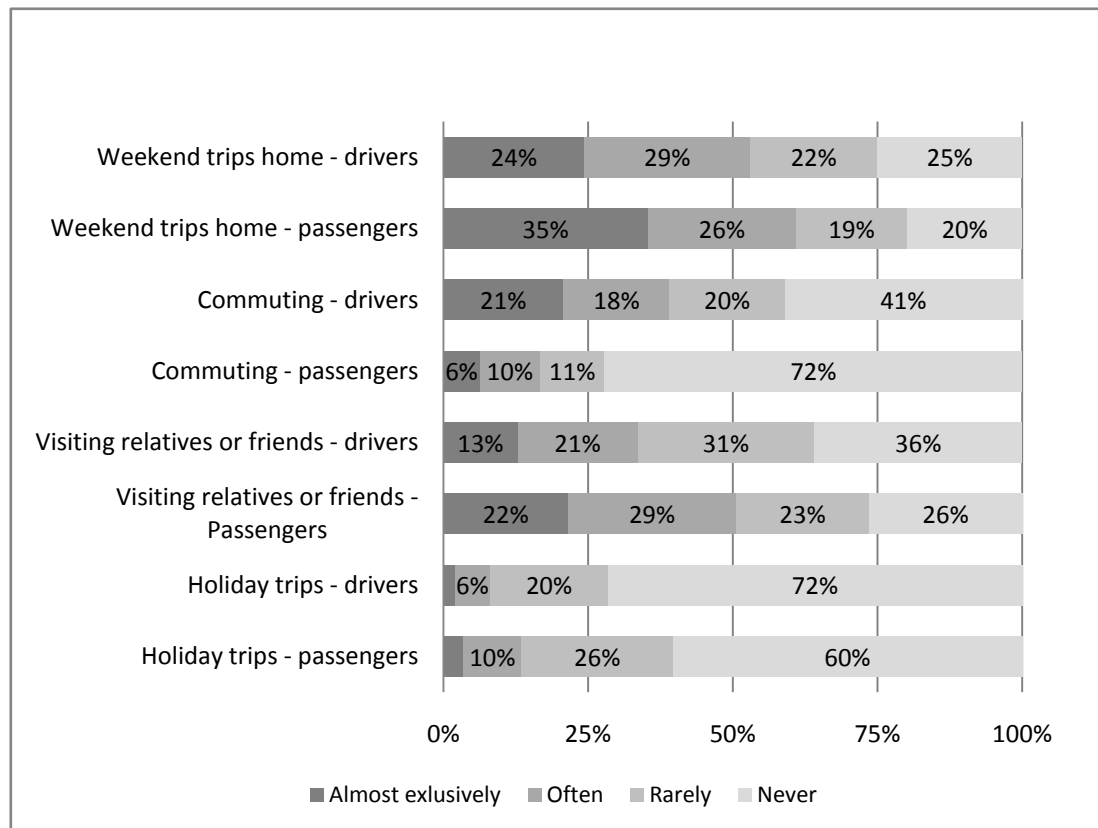


Figure 12. Answers for the question how often passengers carpool and how often drivers offer rides for different purposes.

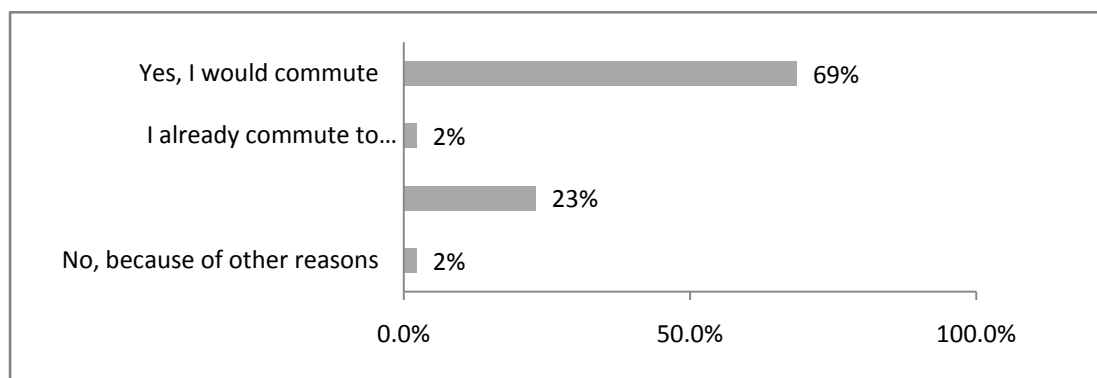


Figure 13. The answers of commuters for the question if they would use carpooling for commuting (195 respondents, the others do not commute).

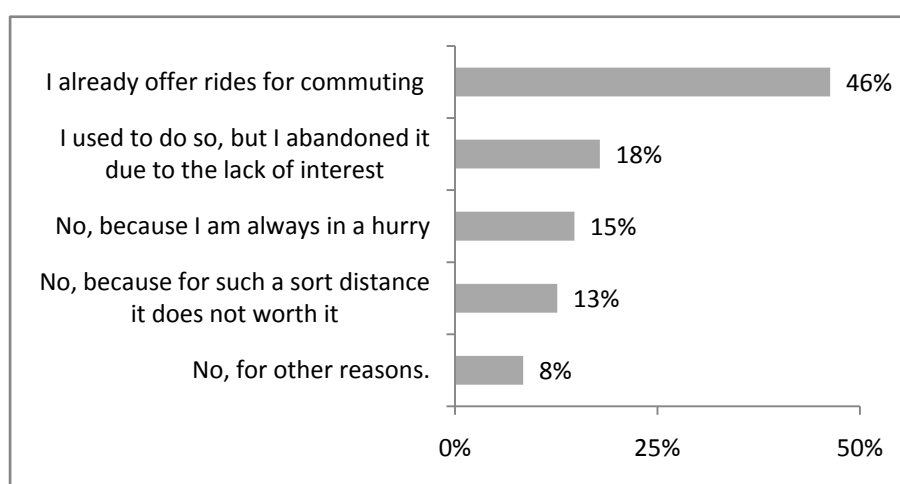


Figure 14. The answers of commuters for the question if they would offer rides on commuting routes (190 respondents, the others do not commute).

#### ***4.1.4 Travel patterns and experiences***

There is a large variability in the frequency of carpooling among those respondents who registered more than a year ago (204 drivers and 115 passengers) both in absolute terms (Figure 15.) and in the percentage of their non-local trips (Figure 16.) though the majority of them carpools relatively rarely (in fewer than 30% of all their trips). The majority of passengers manage to find a match quite easily, especially those who use carpooling exclusively for home trips at the weekends (Figure 17.); in contrast to the drivers majority of who have difficulties in finding a match, especially those who offer carpooling almost exclusively for commuting (Figure 18.).

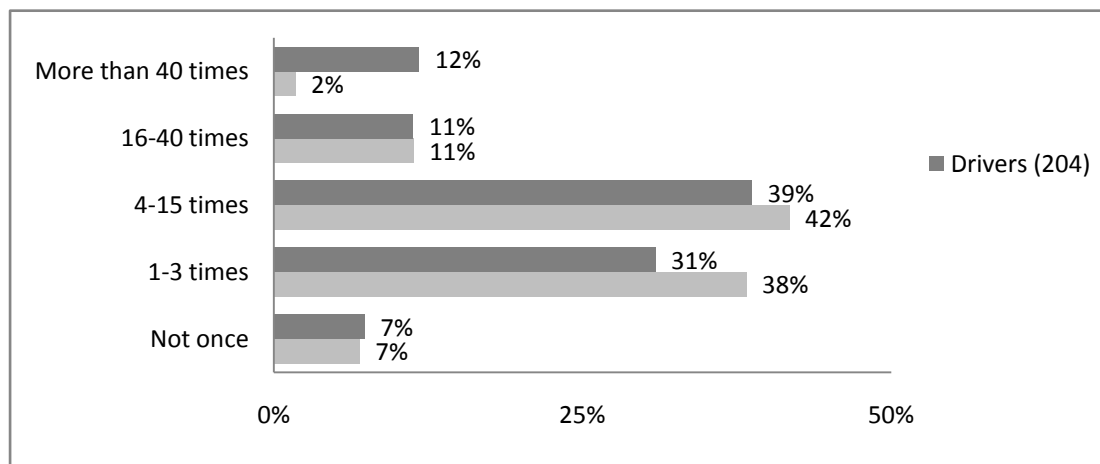


Figure 15. Answers for the question how many times drivers have offered rides and how many times have passengers carpoled over the past year? (only those respondents who registered more than a year ago)

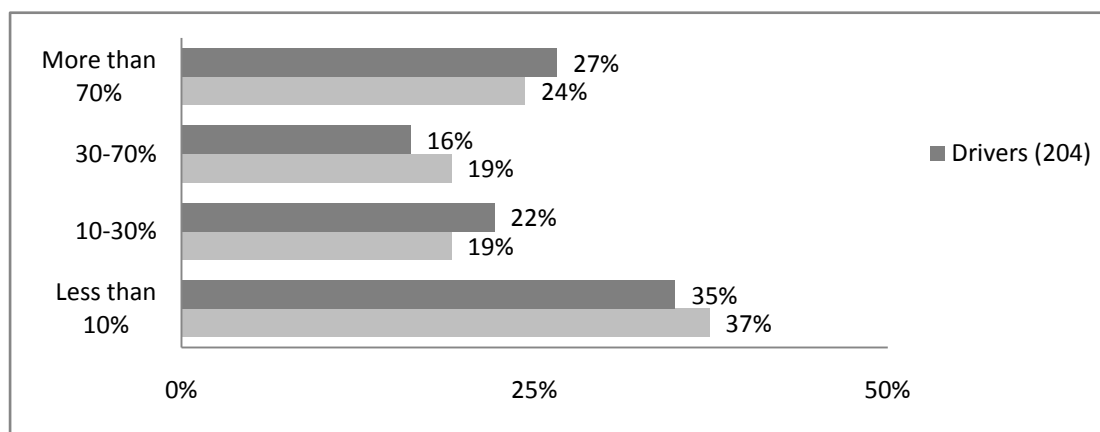


Figure 16. Answers for the question in what the percentage of their non-local trips passengers carpool and drivers offer rides. (only those respondents who have registered more than a year ago)

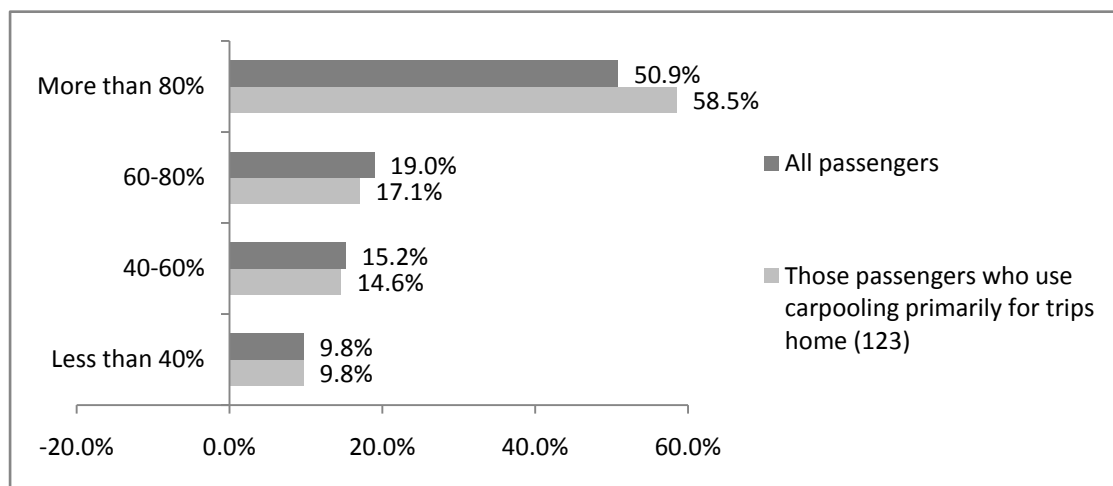


Figure 17. Answers for the question in what percentage of cases (in which they have planned to carpool) passengers actually manage to find a match?

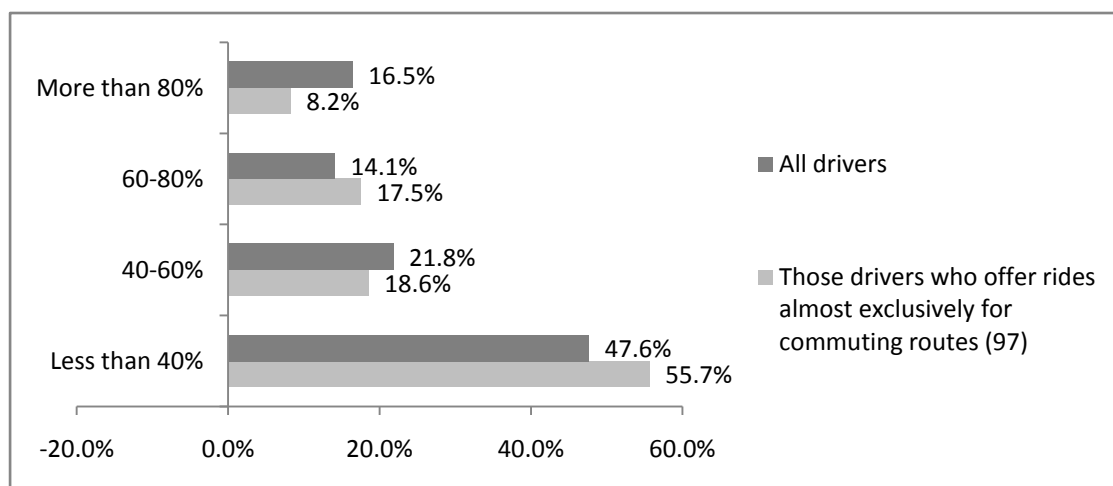


Figure 18. Answers for the question in what percentage of their offered rides drivers actually find a match.

Regarding the relation between carpooling and public transportation, the answers show that only 31% of passengers have steady access to a car, compared to half the households in Hungary which owns a car (KSH 2012a). As a consequence, the majority of passenger carpoolers travel mainly by public transport, 21% travel mainly by car, while the rest travels either by car or public transport, when not carpooling (Figure 19.). On the other hand, majority of drivers still go by car even if they do not manage to find passengers and only a fraction of them travel in another way (mainly

by public transportation, etc.) or forgo the trip (Figure 20.).

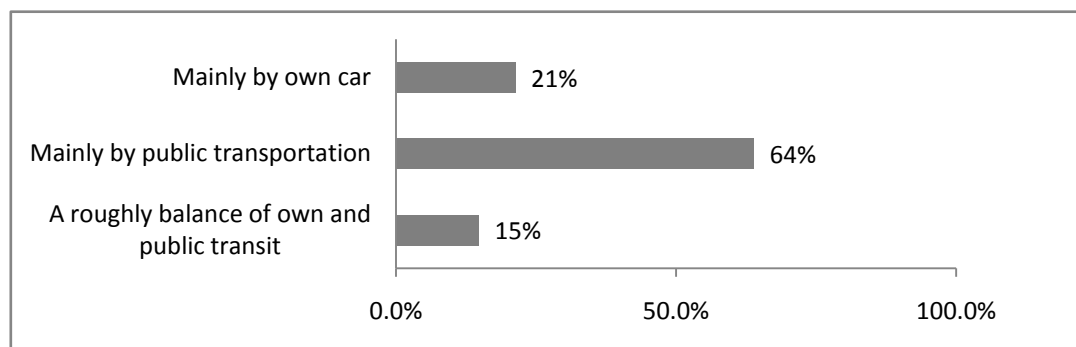


Figure 19. Transportation modes of passengers when not carpooling.

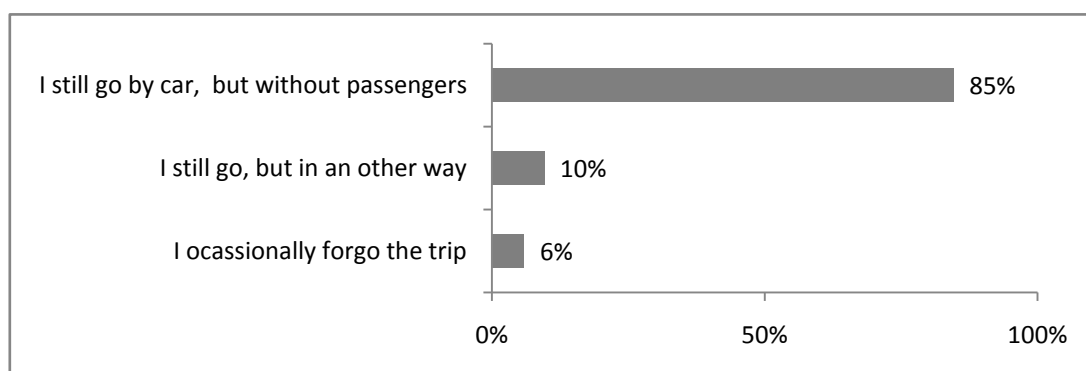


Figure 20. Answers for the question what drivers do if they do not find passengers (135 drivers have responded this question).

The experiences of carpoolers regarding the journeys are very positive for both drivers and passengers though it is slightly more positive in the case of the latter (Figure 21.).

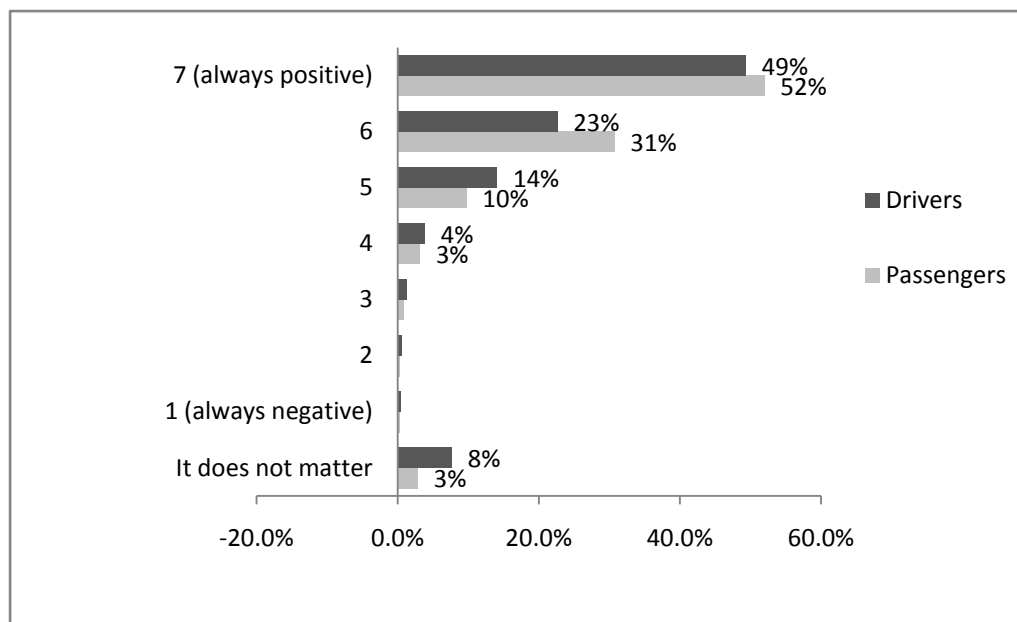


Figure 21. The experiences of carpoolers regarding the carpooling trips.

#### 4.1.5 Barriers

The barriers of carpooling were surveyed through the carpooler, the national and the stakeholder survey. According to the carpooler survey, the most important factor discouraging passengers from carpooling more often is the lack (or rarity) of rides offered (Figure 24.) even among those who successfully find a match in more than 80% of the cases (42% of the latter considered the lack of rides offered as a main factor). Safety concerns (e.g. the passengers do not know the driver) were considered as a main reason by 7% of all respondents, though it played a slightly more important role in the case of female passengers (9%). Flexibility of own car use, potential cancellation of rides and complexity of arranging rides were the least important factors, though those who mainly drive their own car when not carpooling considered the flexibility of own car use more important (15% of them considered it as a main reason) compared to all respondents. The high price of carpooling (overpricing by drivers, its higher price compared to student tickets for public transport, etc.) was given most frequently when other potential factors were asked (3% of all respondents).

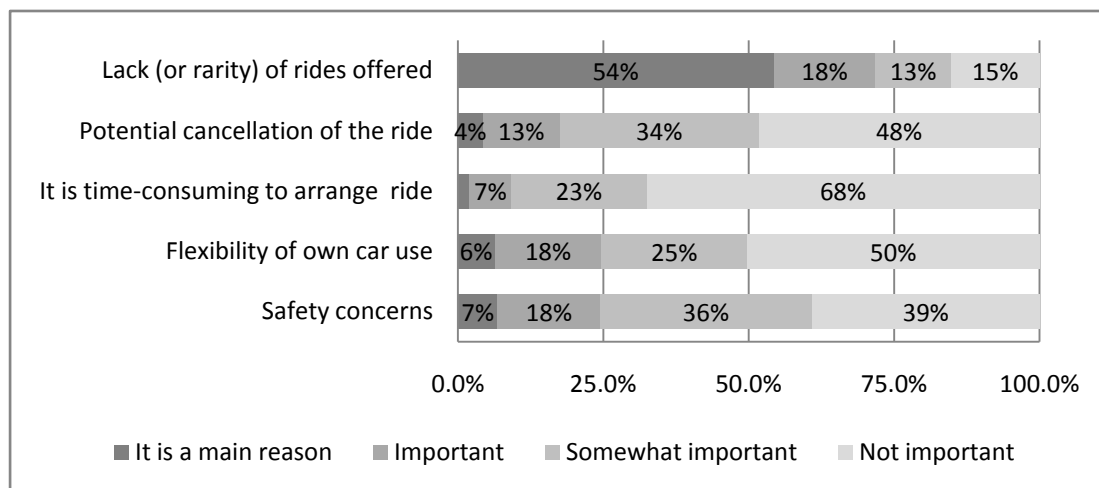


Figure 22. The importance of different factors discouraging passengers from carpooling more often.

In the case of drivers, the most important factor discouraging them from offering more rides is the uncertainty of their trip, that is e.g. respondents do not know in advance what time they will leave and therefore cannot advertise the ride (Figure 23.). Also, many respondents consider it worthless to advertise rides for short distances where the benefits and likelihood of successful match are small. Preference for solo driving, complexity of arranging rides and safety concerns played considerably less important roles.

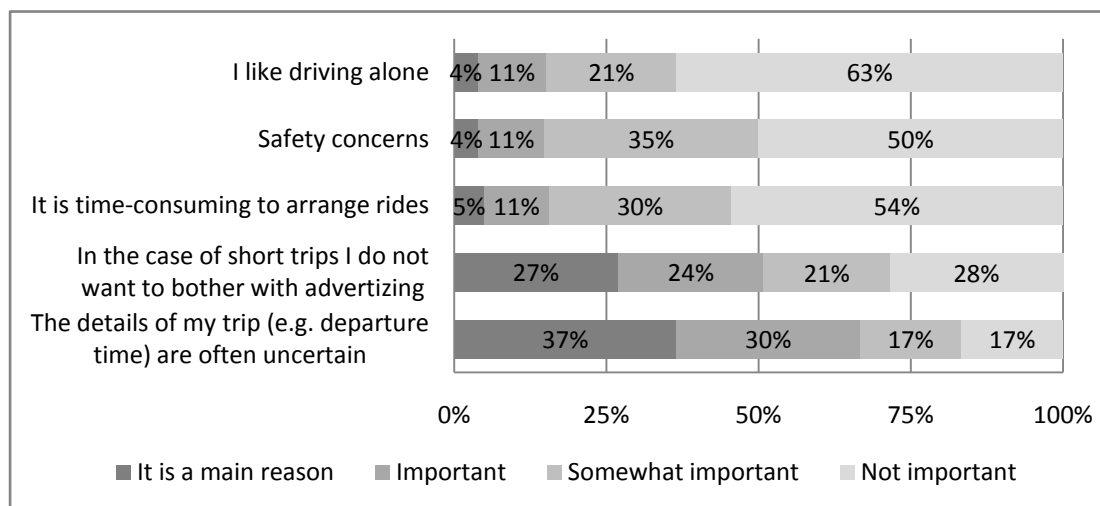


Figure 23. The importance of different factors discouraging drivers from carpooling more often.

The difficulties of adapting to others, which can be perceived as a reflection of the lack of ride offers or the uncertain trip details (the most important barriers among carpoolers), was the most important barrier both for potential drivers and passengers (Figure 24. and Figure 25.), based on the national survey. Distrust toward strangers, which can be perceived as a reflection of security concerns, was an also frequently mentioned argument against carpooling, especially in the case of drivers. Finally, the feeling of dependence and high cost of carpooling appear as a somewhat important barrier for prospective passengers (the former both for those who travel to work by car and by means other than car, while the latter only for those who travel to work by other means than car).

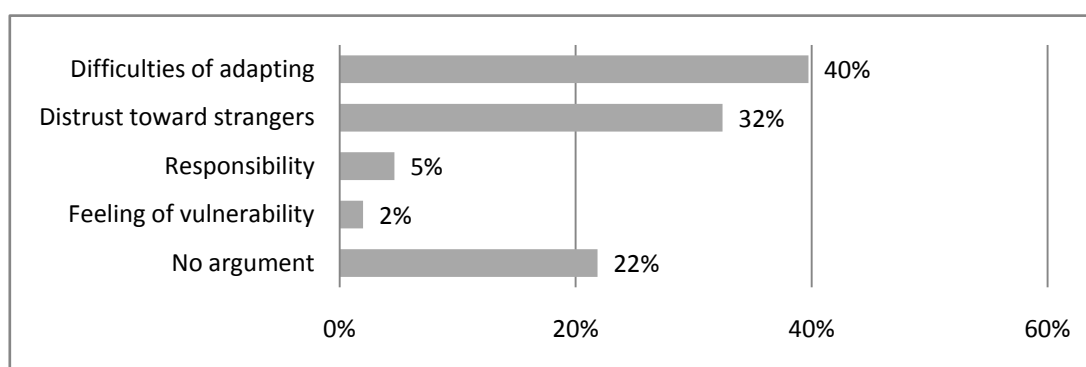


Figure 24. Arguments against carpooling as a driver (in percentage of those who travel to work by car (151 respondents), one or two arguments could have been selected). Data source: Policy Solutions 2012.

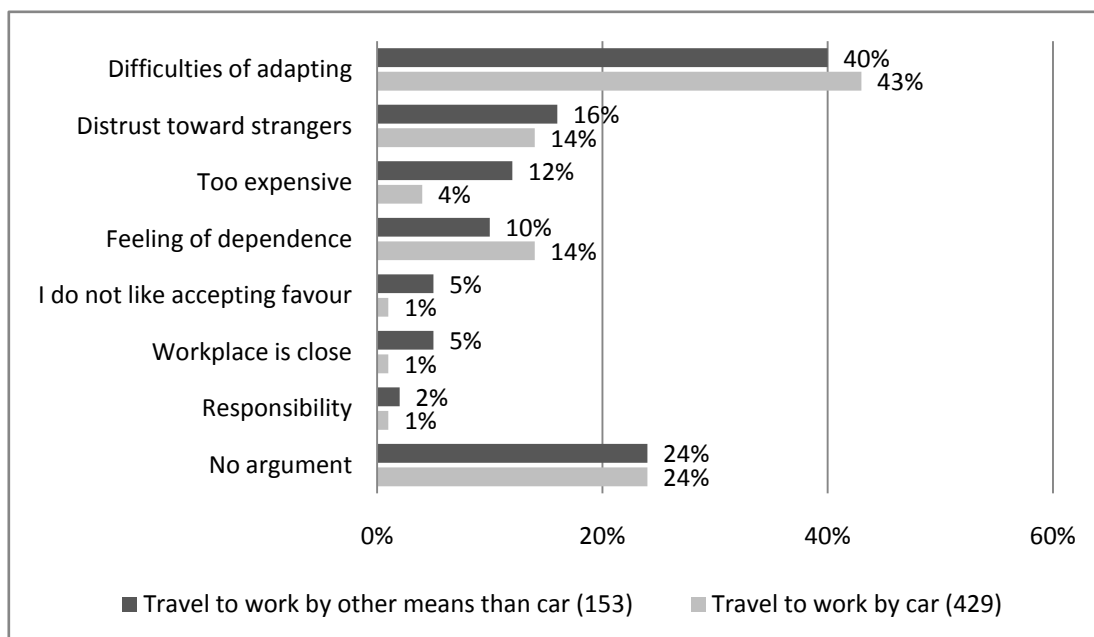


Figure 25. Arguments against carpooling as a passenger (in percentage of those who travel to work not by car and by car, one or two arguments could have been selected). Data source: Policy Solutions 2012.

Finally, the barriers to carpooling were surveyed among the stakeholders. The physical-structural barrier, i.e. the low number of possibilities to carpool, is clearly the most important barrier according to most respondents (8.7 on average out of 10). Similarly, the knowledge-based barrier received a relatively high rank (7 on average) rather uniformly; the stakeholders presumed that only few people are aware of the possibility of carpooling though many of them would be interested in it. In contrast, the economic barrier (perceived as the lack of economic incentive) received a rather low rank (5.3 on average). Two experts presumed that the economic incentive is sufficiently high, i.e. car use is expensive enough to motivate people to cut back on it, while three experts presumed that most drivers ignore the economic incentive, i.e. those who travel mostly by car would insist on doing so at a higher cost, too (though one of them also presumed that an approximately 50% rise of fuel price would be a significant economic incentive for encouraging people to consider lowering the cost of their car use). Finally, one expert considered the economic barrier as somewhat important, but he did not explain his choice.

The other barriers were valued highly differently reflecting the rather different views of stakeholders about their importance. In the case of the political barrier, two experts thought that a regulation of carpooling could significantly raise the willingness to carpool, while the others thought that carpooling should remain free from politics and regulation (5.5 on average). The opinions regarding the cultural barrier showed the greatest variations (6.3 on average). One expert presumed that the concepts of car as a symbol of status and freedom or as an expansion of personal space are the most important barriers to carpooling, while two others emphasized the importance of a kind of selfish concept: ‘what is mine should not be used by others’. Still others considered these concepts either as common but changing toward a favourable direction or as untypical. The ranking of the individual-psychological barrier was highly various, too, though more experts considered it as rather important (7.5 on average). Some experts emphasized the importance of distrust toward strangers or the flexibility of solo driving, which give substantial advantages to solo driving over carpooling, while others presumed that positive experiences or economic benefits can override those barriers.

#### ***4.1.6 Motivations and possibilities***

According to the carpooler survey, for passengers, the main motivation for favouring carpooling over both public transportation and solo driving is its lower cost (Figure 26. and Figure 27.). In the case of those passengers who usually travel by public transport, the speed of carpooling also counts as an important advantage while rare public transport, disliking public transport, carpooling being environment-friendly and the claim that “it is a good way to get to know others” played significantly less important roles (Figure 26.). In the case of those passengers who usually travel by car the claim that “carpooling is environment-friendly” was somewhat more important, while the claims that “it is a good way to get to know others” and “I do not like driving” played

the least important roles (Figure 27.).

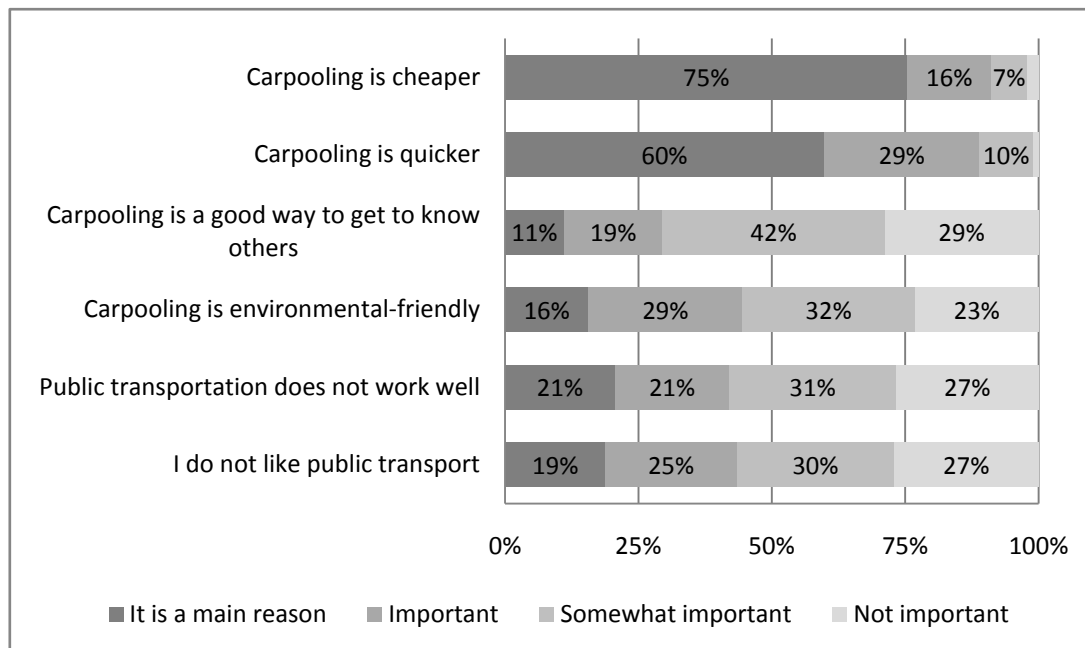


Figure 26. The importance of different motivations regarding why carpoolers favour carpooling over public transportation (281 respondents).

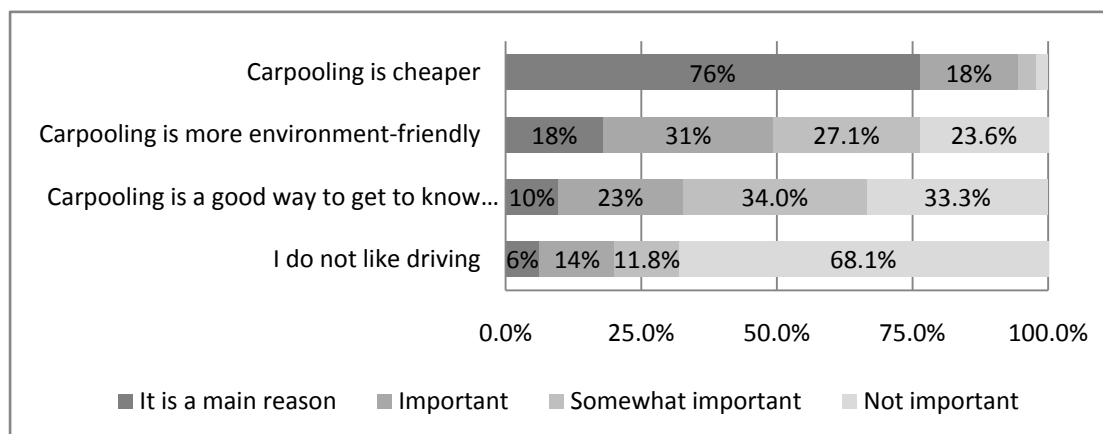


Figure 27. The importance of different reasons why carpoolers favour carpooling over solo driving (144 respondents).

For drivers, the main reason for favouring carpooling over solo driving was its lower cost, too (Figure 28.). The claims that carpooling is more environment-friendly and “it

is a good way to get to know others” played significantly less important roles.

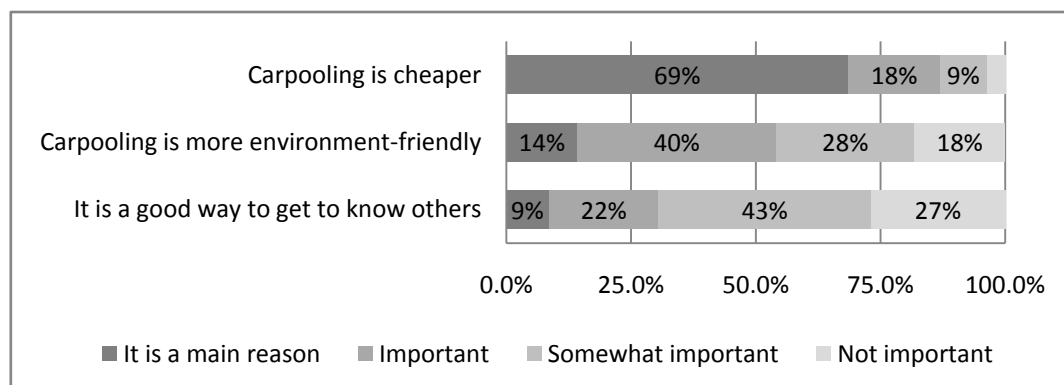


Figure 28. The reasons why carpoolers favour carpooling over solo driving (144 respondents).

The arguments for carpooling surveyed in the national survey reflect the potential motivations of the general public. Cost saving, especially in the case of drivers appears as the most important potential motivation in this case, too, while travelling with others, helping others and environment protection are considered as somewhat less important arguments by drivers (Figure 29). To carpool as a passenger cost saving and comfort (no limitation to a schedule) is nearly equally important among those who travel to work by other means than car, followed by time saving. Those who travel to work by car value cost saving the most, too, when considering carpooling as a passenger (Figure 30).

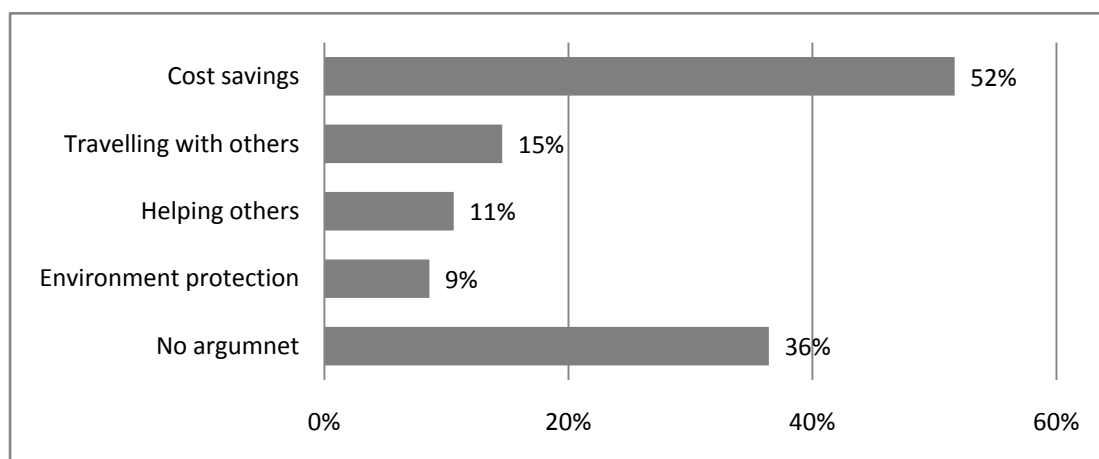


Figure 29. Arguments for carpooling as a driver (in percentage of those who travel to work by car (151 respondents); one or two arguments could have been selected). Data source: Policy Solutions 2012.

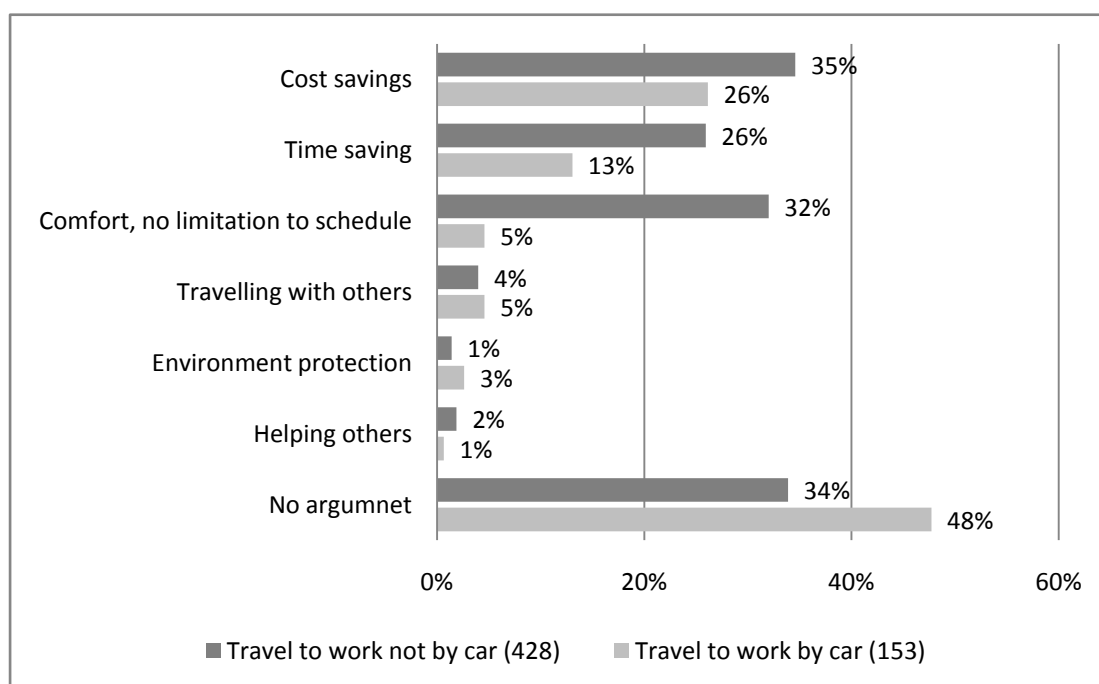


Figure 30. Arguments for carpooling as a passenger (in percentage of those who travel to work not by car and by car (number of respondents); one or two arguments could have been selected). Data source: Policy Solutions 2012.

The possibilities which encourage a more frequent use of carpooling are rather similar in the case of passengers and drivers, as the results of the national survey suggest. In

accordance with the motivations, a potential lower price (e.g. through governmental incentive) would be the most important possibility for both groups though it plays a considerably more important role in the case of passengers (Figure 31.). Quicker travel (e.g. through HOV lanes reserved for carpoolers), especially in the case of passengers, officially registered users in order to reduce safety concerns<sup>14</sup>, and mobile applications for arranging rides more easily would be less important possibilities, though all of these options were still indicated as ‘a main reason’ by a significant minority of both groups.

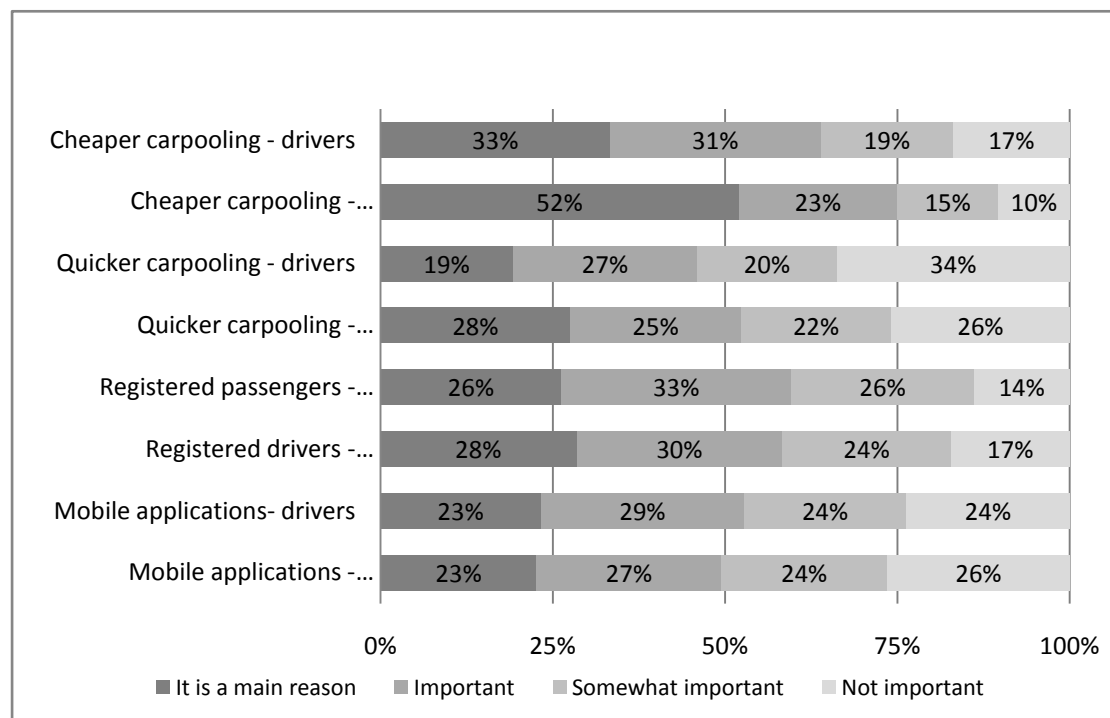


Figure 31. The importance of different possibilities encouraging respondents to carpool more often.

<sup>14</sup> Users might be registered at some authority (e.g local government) which would made them trackable in the case of any illegal activity and so restrain them to act illegally. Users might be even provided with a registration card which they could present when the drivers and passengers meet.

#### ***4.1.7 Potential estimations for carpooling***

The results of potential estimations are summarized in Table 3. which also allow their comparison to the total GHG emission of Hungary in 2010 (64.3 million t CO<sub>2</sub>eq according to UNFCCC 2012), to the GHG emission accounted for the total GHG emissions of personal cars (2.6 million t CO<sub>2</sub>eq assuming that 12.5 billion km were covered by personal cars) and to the maximum potential of the building energy retrofit programme (12 million t CO<sub>2</sub>eq according to Ürge-Vorsatz *et al.* (2010)), which is the most significant well-known emission mitigation measure. The following texts explain the process of estimations.

##### **4.1.7.1 Maximal potential**

According to the Hungarian Central Statistical Office (KSH 2010), the Hungarian population travelled 23.7 billion passenger km by car in 2009, which transforms into 12.5 billion vehicle km covered by the 3 million registered cars (assuming an average 1.9 persons travelling in a car). By setting the capacity of a car as four persons, the same amount of passenger km transforms into 5.9 billion VKT, i.e. 6.6 billion VKT were saved, assuming that the cars were filled up with drivers lured out of their cars. Applying an average 205 g/km GHG emissions, the total GHG emission saving attributed to the 6.6 billion VKT saved is 1.350,000 t CO<sub>2</sub>eq. By setting the average vehicle occupancy at 2.9, the same amount of passenger km transforms into 8.2 billion VKT, i.e. 4.3 billion VKT and so 882,000 t GHG emissions could be saved.

##### **4.1.7.2 Practical potential**

Extrapolating the result of the passenger carpoolers' survey, according to which only

28.7% of carpooling rides redeem car use<sup>15</sup>, 253.000 t CO<sub>2</sub>eq GHG emissions (the 28.7% of estimated emission values of the previous estimations when the occupancy of 2.9 was achieved only by adding otherwise car users) are estimated to be avoided.

#### 4.1.7.3 Cultural potential

According to the results of the national survey, 42% of those who travel to work by car would be certainly not engaged in carpooling either as driver or as a passenger, i.e. they insist on driving their car without strangers. Assuming that the attitude to carpooling is the same in the case of travel to work and travels for other purposes, and assuming that anti-carpoolers cover the same VKT as other car users (which might be a false assumption considering that anti-carpoolers might be fond of driving), the practical potential is 106,000 t CO<sub>2</sub>eq GHG emissions (58% of the estimated emission in the case of maximal potential) if the occupancy is set at a level of 2.9.

#### 4.1.7.4 Present GHG emissions saving

According to the assumptions described in the methodology section 21,740 ride (twice as many as the actual number) was generated by the *oszkas.com* scheme. The data of the route database suggest that the average distance of rides was around 200 km (approximately the average distance between Budapest and the other large cities), while presumably the 28.7% of the passengers substitute private car use with carpooling (see the explanation at the practical potential). Thus, the total VKT reduction presumably generated by *oszkas.com* is around 1,248,000 VKT which is responsible for approximately 256 t CO<sub>2</sub>eq GHG emissions reduction. The presumably twice as large aggregated VKT reduction generated by all carpooling

---

<sup>15</sup> Assuming that those who travel otherwise mainly by car (21%) or public transportation (64%) always carpool as a passenger instead of driving or public transportation, respectively, and those, who use otherwise own car and public transportation roughly equally (15%), carpool as passengers in half of the cases.

schemes is then responsible for around 512 t CO<sub>2</sub>eq GHG emissions reduction which equals around the 0.24% of cultural potential.

Table 3. GHG emissions reduction potentials of carpooling.

	Car occupancy (persons)	GHG emission (CO <sub>2</sub> eq, thousand t)	Compared to the total GHG emission of Hungary in 2010	Compared to the GHG emission of all passenger cars in Hungary 2009	Compared to the mitigation potential of building energy retrofit programme
Maximal potential	4	1,350	2.1%	51.9%	11.3%
	2.9	882	1.4%	33.9%	7.4%
Practical potential	2.9	253	0.4%	9.7%	2.1%
Cultural potential	2.9	106	0.2%	4.1%	0.9%
Reduction generated by all carpooling scheme in 2011		0.51			

## 4.2 Carsharing

In case of carsharing only the barriers and GHG emissions reduction potentials were addressed as carsharing is not operating yet in Hungary, and surveys about the attitudes of the general public were not available.

### 4.2.1 Barriers

The barriers to carsharing were assessed by the stakeholder survey. It was only the individual-psychological barrier which was valued by a somewhat uniform, rather low rank (3.6 on average); the experts presumed that people in general are not bound emotionally to their cars and the majority of them would be willing to use shared cars in the case of sufficiently high economic benefits. In contrast, the cultural barrier was considered mostly as much more important (7 on average). The four out of five

experts who attributed a somewhat high rank to this barrier emphasized either the concept of status symbolism or ‘disrespect of common property’, which can hinder carsharing.

The other barriers were assessed rather differently. Two experts considered the knowledge-based barrier (6.8 on average) as relatively important, while the others presumed either carsharing could become easily well-known or the potential users who would be interested in carsharing for some reasons would get to know it anyway. Similarly, the political barrier (6.8 on average), which refer to a need of change in regulation, was considered as essential by two experts, while the others presumed that only small changes would be necessary to allow carsharing operation. Three experts considered the structural barrier (7.8 on average), which refer to the difficult access to shared cars in the early stage of carsharing operation, as highly important while the others attributed higher importance to other barriers. Finally, two experts considered the economical barriers (5.5 on average), which refer to the low level of economic incentive to use carsaring, as relatively important, other two experts attributed a little importance to it, while one experts could not assess the question. On the other hand, two experts emphasized the high investment cost of carsharing and the lack of political will to its introduction as very important barriers (Csiszár pers. comm., Kocsárdi Zsolt pers. comm.).

#### ***4.2.2 Potential estimations for carsharing***

The results of potential estimations are summarized in the Table 4. which also allow their comparison to the total GHG emission of Hungary in 2010 (64.3 million t CO<sub>2</sub>eq according to UNFCCC 2012), to the GHG emission of the Hungarian transport sector in 2010 (11.9 million t CO<sub>2</sub>eq according to UNFCCC 2012) and to the maximum potential of the building energy retrofit programme (12 million t CO<sub>2</sub>eq according to Ürge-Vorsatz *et al.* (2010)), which is the most significant well-known emission

mitigation measure. The following texts explain the process of estimations.

#### **4.2.2.1 Maximal potential**

If all the 3 million car users in Hungary (assuming that number of car users is equal to the number of cars, which is approximately 3 million) forgo private car use and join a carsharing operator, the 32% reduction of an average VKT of 8,100 km would result in 1,594,000 CO<sub>2</sub>eq GHG emissions saving per year, assuming 205 g/km GHG emission by an average car. Moreover, a 10% more efficient car fleet due to frequent upgrading of shared cars could realize an additional 262,000 t CO<sub>2</sub>eq GHG emission saving (10% of the 2,620,000 t CO<sub>2</sub> emissions attributed to the total VKT covered by all shared cars ignoring the emissions of GHGs other than CO<sub>2</sub>). Therefore, the total maximal potential in GHG emission reduction is 1,856,000 t per year.

#### **4.2.2.2 Practical potential**

According to a survey conducted by Robert Bosch Ltd. (Bosch Medián Survey 2010) and based on interviewing 2400 inhabitants, approximately 51% of all car-owners travel less than 10.000 km a year (and 12% of them drive less than 5,000 km). There are approximately 3 million car users in Hungary (see above) and 38% of the population live in cities or town of more than 50.000 persons. This means, assuming that the likeliness of being a car user and the VKT covered by a person is the same regardless of whether s/he lives in a town of more than 50,000 inhabitants or not, that 581,000 car users (51% of the 38% of the 3 million car users) could join carsharing operators based on sound economical reasons. Therefore, 930 million VKT could be avoided which accounts for 190,000 CO<sub>2</sub>eq GHG emission, while the 10% better emission performance of shared cars account an additional 31,000 t GHG emission saving (10% of the 310,000 t CO<sub>2</sub> emissions attributed to the total VKT covered by all shared cars ignoring the emissions of GHGs other than CO<sub>2</sub>). Therefore, the total

practical potential in GHG emission reduction is 221,000 t per year.

#### 4.2.2.3 Cultural potential

Assumed that roughly half of those for whom carsharing is economically favourable would join a carsharing operator, 290,500 users (2.8% of the Hungarian population) could avoid approximately 110,000 t CO<sub>2</sub>eq GHG emissions. This value might be not so far from the real value: in Switzerland already 2.4% of the population is a member of the national-level carsharing operator.

Table 4. GHG emissions reduction potentials of carsharing.

Potential	GHG emission (CO <sub>2</sub> eq, thousand t)	Compared to the total GHG emission of Hungary	Compared to the GHG emission of all passenger cars in Hungary in 2009	Compared to the mitigation potential of building energy retrofit programme
Maximal	1,856	2.9%	71.4%	15.5%
Economic	221	0.3%	8.5%	1.8%
Cultural	110	0.2%	4.2%	0.9%

## CHAPTER 5 - DISCUSSION

The demographical data of the carpooling and national survey suggest that there are considerable reserves in the population who still could use carpooling. While there are approximately one million people (13% of the adult population) who travel to work by car and 19% of these people (190,000 drivers) would be surely willing to carpool as a driver, there are less than 10,000 drivers registered in *oszkar.com*, the most popular carpooling scheme. (assuming that the whole carpooler population is less than three times as large as the membership of the *oszkar.com* scheme, the number of all carpooler drivers probably less than 30,000). From the passengers' view, 23% (660,000 passengers) of those who travel to work by means other than car would be surely engaged in carpooling as a passenger, as opposed to the presumably less than 66,000 registered passengers of the carpooling schemes (*oszkar.com* had around 22,000 passenger users in May, 2012). The largest reserves of potential carpoolers are among the people between 41 and 60 and among the inhabitants of villages, who, though equally or even more strongly willing to carpool, are strongly underrepresented among the carpoolers. It can be assumed that lower internet penetration or the lower awareness of new concepts, such as carpooling, are the main reasons for this underrepresentation.

The analysis of the carpooling routes and travel purposes suggest that at present passengers primarily consider carpooling as a cheap and convenient alternative of public transportation for long-distance trips between the working place (usually Budapest) and the place where carpoolers spend the weekends (hometown, parents' place, relatives' or friends' place, etc): it is mainly practiced on Friday and Sunday (62% of rides were booked on these two days in 2011), on routes where the trains tend to be overbooked or overused, i.e. between Budapest and the five largest cities of Hungary (70% of rides were booked on these routes in 2011), and people use carpooling more often for weekends trips home. Interestingly enough, the idea of *oszkar.com* scheme

roots in the crowded journeys between Budapest and their hometown, too, where the *oszkar.com* operators often had to travel standing on the long trips during their university years (Prácser and Gyűrűs pers. comm.). It seems that the profit, i.e. the difference between the price of public transportation and carpooling, is not sufficiently large to encourage passengers to carpool on short-distance routes; therefore, the booking rate is very low on these routes. E.g. in spite of the ample offers on routes between Budapest and other towns in the 100 km radius of Budapest, less than five out of a hundred offers are booked. For drivers, on the other hand, the available profit seems to be large enough (especially if they could fill up all the empty capacities of the car) to motivate them to find passengers for short routes, thus several short routes were among the routes most frequently offered.

The analysis of the travel patterns of carpoolers suggests that carpooling is considered as a complementary means of travelling: most people use it in a rather small fraction of all their non-local travels. This might correlate with the hypothesis described in the previous paragraph, assuming that the long-distance interurban travels (in which case carpooling is frequently used) constitute only a small fraction of non-local trips in the case of most people. An interesting finding of this analysis was the considerably higher likeliness of finding a match in the case of passengers compared to drivers. This finding seems also to be consistent with the hypothesis described in the previous paragraph, according to which passengers prefer to carpool only in long-distance trips, thus the overwhelming majority of short-distance offers remains unmatched. The low number of drivers who carpool as a passenger can also contribute to the low success of drivers to find matches, since those who carpool as a driver have to rely on the potentially moderate travel demand of public transport passengers<sup>16</sup>.

From an environmental point of view, the primary aim of carpooling is to lure drivers

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<sup>16</sup> Although *oszkar.com* has more than twice as many registered passengers as drivers, public transport users might have smaller per capita travel demand due to the lack of car and to their lower income.

out of their cars by providing a cheaper alternative which is, at the same time, almost as quick (or even quicker) as driving their own car and is relatively comfortable and flexible (compared to public transportation). In this sense, the travel patterns of carpoolers suggest that at present the environmental benefits of carpooling in Hungary is not especially large: 68% of passengers do not have a car, so they cannot forgo using it and as a consequence, 64% of passengers use carpooling mainly instead of public transportation, the direct environmental benefit of which is zero or slightly negative (as it reduces the efficiency of public transportation). Even worse, the possibility of carpooling can generate (at least in some cases) additional car use for 15 % of drivers: those who claimed that they occasionally forgo the trip or travel by public transport if they do not find passengers for their rides; though, whether this figure is high or not, could be debated, one could expect even a higher value. Finally, only 26% of drivers carpool as a passenger and 96% of them only rarely do so, which suggests that most drivers insist on using their car and consider carpooling only as a way to reduce the cost of their car use.

On the other hand, it seems that 21% of passengers really redeem private car use with carpooling, which can result in significant reduction of GHG emission. In addition, there are at least two indirect benefits of carpooling: (i) the possibility of carpooling (and the highly positive experience many carpoolers have of using it) may reduce the motivation to buy a car or delay its realization; (ii) carpooling can contribute a more comfortable travel on public vehicles by reducing the overload of public transportation on Fridays and Sundays. Finally, the high interest in using carpooling for commuting (71% of passengers and 64% of drivers consider carpooling as an option for commuting) as well as the high willingness to carpool to work in general (half of those who travel to work would be maybe or surely engaged in carpooling) suggests that carpooling could gain a considerable position in a field which is highly suitable for carpooling for several reasons. First of all, the need to get to the workplace is the most important reason why people travel, generating approximately 33% of all travel (KTI 2012). Secondly, the occupancy of cars on the way to work is

rather low, around 1.1 - 1.2 (EEA 2001), which assumes a lot of solo drivers, who presumably more willing to share rides; in contrast to those cases when the occupancy of the car is higher, i.e. drivers travel with family members or with friends. Thirdly, travelling to work is usually regular and time-bound, which makes arranging rides easier (note that for drivers the most important barrier to carpooling is the uncertain details of the trip). Finally, as commuting often takes place on routes where travelling to work is rather complicated by public transportation, commuters are more prone to travel by car.

In the case of barriers to carpooling, the results of the three surveys were rather consistent. The low number of carpooling possibilities reflected in the lack (or rarity) of rides offered in the case of the carpooler survey, in the difficulties of adapting to others in the case of the national survey, and in the importance of the physical-structural barrier in the case of the stakeholder survey is clearly the most important barrier to carpooling. As the number of carpoolers is quickly growing, this barrier will be likely to decrease by time, especially if the similarly important knowledge-based barrier is addressed by information campaigns. The role of such campaigns was proven in the beginning of 2012, when the registration of new users significantly increased after the *oszkar.com* scheme was presented in the evening news as a possibility to reduce driving cost by carpooling (Prácsér and Gyűrűs pers. comm.).

However, the current low-level position of carpooling in commuting mentioned above presumes the existence of another dimension of the physical-structural barrier: the lack of carpooling schemes in workplaces (referred to as ‘workplace carpooling schemes’ hereinafter), which was not mentioned by the stakeholders, and so remained unrevealed among the barriers. Though commuting by carpooling is possible in the frame of public carpooling schemes, the workplace carpooling schemes have some special features which make them much more effective for commuting, especially in the case of large employers. Firstly, at least one of the endpoints of the trip is common

for each user: the site of the company. In addition, people prefer to carpool with someone they already know or to whom they are socially bonded, such as workmates (Amey 2010). Finally, companies are often interested in the carpooling of their employees, as then they have to provide fewer parking places. While the rationale of workplace carpooling schemes is demonstrated by the several workplace carpooling scheme in Western Europe and North America (Amey 2010, [carpooling.com](http://carpooling.com) 2012b), where the working carpooling schemes contributes to the green image of a company, too, no operating workplace carpooling scheme is known in Hungary by the author or by the stakeholders; aside from the project idea of the Futureal Group about launching a workplace carpooling scheme for the employees in its office building in the close future (Radványi and Németh pers. comm.).

There are several potential reasons why workplace carpooling is almost completely missing in Hungary. Firstly, companies might be not aware of the concept of carpooling; though the presence of a workplace carpooling scheme is positively acknowledged by the increasingly recognised environmental assessment method and rating systems for buildings (BREEAM 2012), which could encourage office building operators to run such schemes, as it was the case for Futureal Group. Secondly, the know-how necessary for operating workplace carpooling schemes might be not readily available in Hungary, as this concept is new and no business model for its application has been developed yet. In contrast, the business model of the free carpooling operators in Western Europe is based on collecting revenues from workplace carpooling schemes and offer free carpooling for the public; the benefit of the latter is that the working schemes can connect to the huge public schemes, too ([carpooling.com](http://carpooling.com) 2012b, [liftshare.com](http://liftshare.com) 2012). Finally, it is conceivable that the large employers simply are not interested in having a green image, and they have plenty of parking places, either because they are situated in places where many parking places are available (on the outskirts of cities) or in places well-supplied with public transportations (in the city centres).

In the case of carsharing, the structural barrier was also considered as relatively important by most stakeholders, since the presumably difficult access to the shared cars in the initial phase of carsharing is a significant disadvantage compared to the always accessible private cars. To overcome the issue of difficult access, one of the stakeholders suggests that cars might be driven by the employees of the carsharing operators to places specified by those who booked the car (Vargha pers. comm.). On the other hand, the knowledge-based barrier might play a minor role in the case of carsharing, as stakeholders seem to believe that the idea of carsharing would penetrate more easily to its target group than the idea of carpooling. In other words, the presumably small initial group of potential carsharing users (the somewhat environmental-conscious and middle-income city dwellers (Vargha pers. comm.)) would be aware of the carsharing operation anyway, while the much wider target group of carpooling need to be informed more intensively.

Distrust toward strangers is a significant barrier only in the case of general public, especially in the case of potential drivers, while it is almost absent in the case of actual carpoolers (categorizing the safety concerns as distrust towards strangers). An obvious explanation of this difference is that probably those people register at carpooling schemes who have had a lower level of distrust prior to registration; however, their positive carpooling experiences, which may reduce the level of distrust in carpoolers, might contribute to this difference as well. The distrust toward strangers also contributed to the rather high value, which stakeholders attributed to the individual- psychological barrier to carpooling. In contrast, the stakeholders considered the individual- psychological barrier to carsharing as much less important. Their view suggests that, while most people are concerned about sharing the ‘personal space’ of a car, they would not mind sharing the car as an object, i.e. emotionally they are not especially bound to an individual car. On the other hand, the cultural concepts seem to be more important barriers to carsharing than to carpooling, which reflects the different cultural concepts hindering the two CPCT forms. Stakeholders believe that, while the concept of a car as a symbol of status or freedom (which contribute to the

cultural barrier in both forms) is fading, the concept of disrespect of common properties (which plays a role only in the case of carsharing) is highly persistent in today's society of Hungary.

The role of political barrier is somewhat controversial. While some stakeholders believe that some regulation of carpooling could reduce concerns about some issues, such as taxation of the contribution to the travel cost, others' opinion suggest that (over)regulation of carpooling might reduce its attractiveness. In the case of carsharing, almost all stakeholders presume that some regulation is necessary, but they disagree regarding its extent. At the same time, two experts presume that political support is essential to overcome the initial financial difficulties (high investment costs) of carsharing.

Cost saving is the main motivation of carpooling both for actual and potential carpoolers, and it would be the most important possibility for using carpooling more intensively, too. This high importance of cost saving suggests that there is a significant economic incentive to carpool, i.e. the economic barrier is rather small. At the same time, the existence of a strong economic incentive is recognized only by some experts, while others believe that many drivers ignore the present level of economic incentive and would consider carpooling as a cost saving possibility only at a considerable higher level of economic incentive (i.e. in the case of much more expensive car use). This apparent contradiction can be resolved after a closer look at the results: according to the national survey, cost saving is much more important for those who are willing to carpool than for those who not. So it seems that while cost saving is the main motivation to carpool for many people, it is ignored by many others. It can be assumed that many people ignore the possibility of cost saving in the case of carsharing, too, which assumption might have contributed to the rather different opinion of stakeholders.

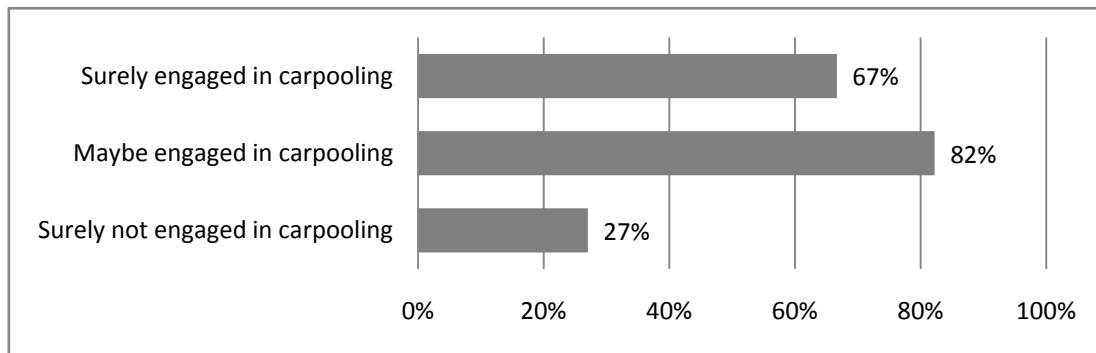


Figure 32. The percentage of those drivers who mentioned cost saving as an argument for carpooling.

The results regarding the motivations to carpooling also show that environment protection plays only a minor role in carpooling compared to cost saving. However, it was a main reason for almost every fifth carpooler driver and was mentioned as an argument for carpooling by almost every tenth of those who travel to work by car in the case of the national survey. It can be debated whether these numbers are very low or not, but it is undeniable that the concept of environmental protection has a position in carpooling.

The results of potential estimations indicate that the maximal potentials are significant in both forms of CPCT, especially when compared to the total GHG emissions of all passenger cars in Hungary. They are also significant compared to other measures of reducing GHG emissions of vehicles: technological improvements can achieve 50% reduction by 2050 (*Green et al.* 2011). Finally, the maximal potentials could realize 10% of the mitigation potential achievable by a building energy retrofit programme which is the most significant possibility for GHG emissions reduction (Metz 2009).

On the other hand, their practical and cultural potentials constitute a rather small fraction of the maximal potentials. In the case of carpooling, the bulk of the difference between the cultural and maximal potentials can be attributed to the fact that car users are less willing to carpool as a passenger than public transportation users. Therefore, even if the carpooling was common in Hungary, the majority of rides offered by

drivers would be filled up with public transportation users. In the case of carsharing the bulk of that difference can be attributed to the fact that carsharing is not practical to the majority of the Hungarian population, either because they live in small settlements where the low number of potential client does not allow a profitable operation, or as they drive more than the breakeven point, therefore carsharing is not rational for them from economic point of view. At the same time, the cultural and psychological barriers seems to have a smaller effect on the size of potentials, as they reduce it only 50-58% (though in the case of carsharing this is based only an assumption not supported by any data).

Nevertheless, it should be noted that the practical potential of carsharing might be significantly underestimated by the application of the 10,000 km (or other yearly VKT) as a breakeven point between those for whom carsharing is cost-effective and those for whom it is not. This commonly applied approach assumes that most people drive so long distances, because they really favour to do so despite the fact that car use can cost 3-5 times more than public transportation, at least in the case of city dwellers (Clean Air Group 2010). For a different approach, it is useful to get an insight into why people might favour travelling by in spite of its much higher cost compared to public transportation. The common belief that car use provides a quick and comfortable possibility, which is otherwise often not valid in the case of overcrowded urban roads, does not seem to justify the neglect of such a large difference between the costs. A different potential answer might be based on the assumption that people want to have a permanent access to a car, because they attribute freedom to them or there might be cases when they really need a car, e.g. when they suddenly need to get somewhere or they need to carry something large, etc. Since at present only car ownership or leasing can provide permanent access to a car<sup>17</sup>,

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<sup>17</sup> Assuming that the access to cars provided by car rental and taxis are not suitable, as the former is too complicated and time-consuming and the latter is not flexible enough or too expensive for longer distances.

people are forced to own or lease one if they want this permanent access. As car ownership or leasing have substantial fix costs (e.g. acquisition, maintenance and insurance costs or leasing fees), they strongly encourage an intensive car use for two reasons: (i) each additional km covered by the car reduces the overall per km cost of car use and so justifies the spending on fixed costs and (ii) when a car is already owned, only the use-dependent costs (e.g. cost of fuel, road fees, part of service fees) are compared to the cost of public transportation, as the fixed costs are covered anyway. In other words, it would be irrational and perhaps frustrating to buy and maintain a car but not using its capacity.

In contrast, carsharing can provide a quasi<sup>18</sup> permanent access to a car without fixed costs: users pay an amount for each km and for each hour<sup>19</sup> of the car use which covers all the costs associated with the car use over the lifetime of the car, as well as for the profit of the carsharing operator (which can be zero in the case of non-profit operators). In this case a more intensive car use is not encouraged; therefore, it can be assumed that people use cars less intensively, as the costs of car use are still 3-5 times higher than the costs of public transportation<sup>20</sup> (or even higher due to the profit of carsharing operators), and this difference is much more obvious. Therefore, it can be

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<sup>18</sup> Assuming that the density of users allows locating shared cars in the proximity (e.g. less than 200 m) of every user and that the booking of a car can be arranged through smartphone applications in a very short time (e.g. within a minute).

<sup>19</sup> The payment for each hour is necessary to discourage people to book cars when they do not need it; otherwise people may book cars without using them and the costs of acquisition, maintenance and insurance would be never recovered.

<sup>20</sup> Note that sharing a car may not substantially reduce the per km cost of car use, since the majority of fix costs are associated with the distance covered by a car. For example, roughly the same number (approximately 4) of private or shared car can cover one million km, but shared cars can cover it in a much shorter time. Therefore, actually only those costs are shared by carsharing which have to be paid regardless of the distance covered by the car, e.g. taxes, exam fees, insurance fees, parking fees, cost of amortization costs resulting from the passage of time rather than from the distance covered by the car.

assumed that when carsharing is available, many of those who drive more than the breakeven point mainly in order to utilize the car's capacity would drive significantly less, and so carsharing would be economically favourable for them, too. That is, the practical potential (and so the cultural one as well) might be significantly larger due to the higher number of potential users. In addition, if carsharing becomes popular, it can efficiently operate in settlements much smaller than towns of 50,000 inhabitants, and so the practical potential can be even larger.

Finally, the results revealed a remarkably large difference between the actual GHG emission saving by carpooling and the cultural potential. That is, although the majority of people would be willing to carpool (at least when they travel to work), only a very small fraction of them actually carpool and even they do it rarely. It can be assumed that the lack of information about the existing carpooling schemes and the lack of workplace carpooling schemes accounts for this difference. In addition, the results of the carpooler survey suggests that larger economic benefits achievable by carpooling (e.g. more expensive individual car use or smaller parking or congestion fees for carpoolers) would encourage more people to share rides and so would result in larger GHG emission savings.

## CHAPTER 6 – CONCLUSIONS

(1) The first aim of the research was to reveal the travel habits and motivations of carpoolers and the general public in Hungary in order to understand the role of carpooling in the reduction of VKT.

The results of the carpooler survey suggest that the majority of passengers substitutes public transportation with carpooling and therefore carpooling **contributes to the reduction of total VKT only in 20-30% of cases** (assuming that the lower number of public transportation passengers does not entail a reduction in the public transportation VKT). This finding has serious implications for estimating the GHG emission reduction potential of carpooling, as GHG emission reduction is the consequence of the total VKT reduction. Therefore, while potential estimations focusing on carpooling in regions where public transportation is undeveloped or unfavoured (such as most regions in North America) may assume properly that each carpooling passenger substitute a travel with another car, estimations in regions where public transportation is well-supplied and favoured (such as in Europe, especially in the Eastern part) should consider the effect of public transportation passengers, **which can reduce the potential of carpooling by up to 70-80%**. Moreover, the results of the carpooler survey also suggest that in some cases carpooling actually generates a rise in the total VKT, and so in the GHG emission, as the driver has also substituted public transportation or travels only because the contribution of passengers reduced her or his travel cost (10% and 6% of drivers reported occasionally to do so, respectively).

On the other hand, carpooling may contribute to **a lower GHG emission in indirect ways**. The results also show that most passengers have very good experiences with carpooling; moreover most of them carpool on interurban routes on Fridays and Sundays where and when public transportation is often overcrowded. These finding suggest that carpooling can contribute to a more convenient travel experience of not

only carpoolers but of public transportation users, too, which experiences may reduce the motivations for buying a car. As fewer cars presumably cover fewer VKT, the GHG emission attributed to the fewer VKT will be lower, too.

The findings regarding the willingness to carpool to work and the travel purposes have important implications, too. Around 20% and 30% of those who travel to work by any means would be surely or perhaps willing to carpool to work, respectively, which means that the **carpooler population should be at least eight times larger**, but could be even twenty times larger. Moreover, what is even more important, 43% of those who travel to work by car might consider carpooling as a passenger; in their case the reduction of GHG emission is guaranteed. This means that carpooling could gain significant ground in the case of travelling to work, which then could result in a significant reduction of GHG emission. Nevertheless, at present only a small fraction of commuting carpoolers share rides to work, despite the fact that the majority of them would carpool to do so.

(2) The second aim of the research was to identify the barriers and possibilities of carpooling.

The most important barrier is clearly structural: **the low number of carpoolers hinders** the formation of further matches between passengers and drivers. Nevertheless, the role of this barrier continuously decreases, as the number of carpoolers dynamically grows. At the same time, faster growth could be achieved by targeting the also important knowledge-based barrier; that is popularization of carpooling could really boost the carpooler population. The individual-psychological barrier, i.e. distrust toward strangers or security concerns, plays a role only in the case a minority, though more than half of the carpoolers considers the official registration of carpoolers as important or very important, which can reduce safety concerns.

Cultural concepts, such as 'driving one's own car is a sign of success', do not seem to

play a major role in hindering carpooling, while the present level of economic benefits encourages only less than half of those who travel to work by car. Nevertheless, it can be assumed that larger economic benefits over solo driving, e.g. in the case of higher travel cost due to more expensive fuel or in the case of cheaper carpooling due to reduced road fees for carpooling vehicles, could significantly raise the number of those who are interested in carpooling. This idea is supported by the results of the carpooler survey, too, according to which **the possibility of cheaper carpooling** would be the most important factor to encourage more intensive carpooling (considered as important or very important by 69% of carpoolers). Finally, the need for regulation is controversial: while some interviewed experts considered it important, none of the carpoolers mentioned any concern regarding regulation issues. It is conceivable that the overregulation of carpooling would even deter some carpoolers, as it could discount the ‘cool’ and community-oriented concept of carpooling.

Apart from the already mentioned official registration of users and cheaper carpooling, quicker carpooling due to HOV lanes and smartphone applications to arrange rides more easily are also important or very important possibilities for approximately half of the carpoolers. Nevertheless, it can be assumed that smartphone applications will be important for even more carpoolers, as smartphones become common.

(3) The third aim of the research, which was to identify the barriers and possibilities of carsharing, was approached only through the opinions of stakeholders, as no carsharing operation takes place in Hungary.

**The structural barrier is the major barrier** in the case of carsharing, too: the difficulties in accessing the shared cars, especially in the initial phase could significantly hinder carsharing according to most experts interviewed during the research. The knowledge-based barrier seem to have a less important role here than in the case of carpooling, as the initial target group (the young, environmental-conscious

and middle-income city dwellers) would be aware of the possibility of carsharing anyway. Similarly to carpooling, while the present level of car use costs would encourage only a part of the people to use carsharing, raising fuel prices or parking fees would significantly increase the number of those interested in carsharing.

The individual-psychological barrier, perceived as the need to have an own car for emotional reasons, seems to play only a minor role, as the importance of cars is progressively fading partly due to the growing importance of communication devices, which can provide continuous access to the essential social networks. On the other hand, a cultural barrier, **the disrespect toward common properties**, might conceal a serious risk to carsharing in Hungary, as well as in other post-communist countries, where this concept might be still present as a heritage from the communist era. Finally, it seems that, compared to carpooling, political support is more needed to take the necessary measures. Nevertheless, taken together, it seems that the barriers to carsharing in Hungary, except for the concept of ‘disrespecting the common properties’, **do not significantly differ** from the barriers to carsharing in Switzerland, which is a good news, as Switzerland is the world’s leading country<sup>21</sup> regarding carsharing.

(4) The forth aim of the research was to estimate the maximal, practical and cultural potential of carpooling and carsharing in the reduction of GHG emissions.

The results of the estimations suggest that **the maximal potential is significant** in both cases: approximately 2% reduction of the total GHG emissions of Hungary could be avoided by the maximal-intensity application of either carpooling or carsharing. At the same time, **the practical and cultural potentials are only a small fraction of the maximal potentials**: the practical potential is approximately the fifth and the

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<sup>21</sup> In the world, Switzerland is the country where carsharing is the most popular: the single Mobility carsharing operator has more than 190,000 members (2.4% of the population).

tenth of the maximal potential in the case of carpooling and carsharing, respectively, while the cultural potential is around the half of the practical potential in both cases. The bulk of the difference between the cultural and maximal potentials is the consequence **of the low cost of individual private car use**, which discourages drivers from carpooling (especially as a passenger) or from using shared cars.

The cultural-normative and social as well as the individual-psychological barriers also contribute to the small size of cultural potential, but their contribution is significantly smaller. Therefore, it can be assumed that those policies which focus on reducing the difference between the maximal and practical potentials can achieve larger GHG emissions reduction than those which focus on increasing the cultural potentials. The former policies can use measures which reduce the cost of public transportation or increase the cost of private car use, while the latter ones can use measures which make carpooling and carsharing more popular and accessible.

(5) The fifth aim of the research was to formulate policy recommendations which can facilitate considerable reductions in VKT and so in GHG emissions through the application of carpooling and carsharing in Hungary.

*(a) Large-scale policies*

As the previous paragraph describes, policies focusing on increasing the cost of private car use can have the largest impact on GHG emission reductions of both forms of CPCT. Moreover, policies focusing on reducing the cost of public transportation can have a significant effect, too, as in the case of carpooling they can encourage the use of public transportation, especially among those who travel often by public transportation and by car. In addition, it also makes carsharing more popular, as carsharing customers typically increase their travel by public transportation. As the description and implications of such policies exceeds the scope of this study, they are

presented only briefly. It should be noted that these policies can be implemented primarily by political decision-makers, such as the parliament and the government or their local (or regional) equivalents.

Obviously, higher taxes on fuel, on vehicles and on car ownership, as well as higher road tolls, parking and congestion fees can all contribute to a higher cost of private car use. Nevertheless, these policies are inherently unpopular, as they make driving, a popular activity, more expensive; therefore their application might be limited. On the other hand, there are policies which, while not changing the overall cost of car use, raise the use-dependent cost at the expense of fixed cost. These policies do not increase the overall cost of car use, but allow car users to get aware of the real cost of driving and to compare it with the cost of alternative possibilities such as public transportation or carsharing. These policies include the ‘pay as you drive’ insurance and taxation or measures which favour leasing of cars over car ownership, such as the application of extreme high tax on car ownership coupled with facilitated leasing options.

**Subsidizing public transportation** is the obvious way to reduce its cost. The cost of subsidizing might be covered by the revenues collected from the higher taxation of private car use or the higher fees associated with it. Policies other than subsidizing can include the formation of common ticket systems of different public transportation companies, or creation of lanes maintained for public transportation vehicles, which allows a faster travel on them. These policies do not reduce the cost of public transportation, but make it more attractive.

In addition, the possibility of real-time dynamic carpooling is described in the Appendix 4. This approach presumes that there are cases when CPCT can work more efficiently than public transportation and may be encouraged accordingly.

*(b) Small-scale policies*

Those policies which make carpooling and carsharing more popular and accessible might have smaller impact on GHG emissions. Nevertheless, they are much more likely to be implemented, as they are small-scale and they can be implemented primarily by stakeholders, i.e. carpooling and carsharing operators, who have stronger interest in these mobility services than decision-makers do.

In the case of carpooling, considering the dynamically growing membership of carpooling schemes in the recent years, it can be assumed that the popularity of carpooling, and so its GHG emission reduction potential will continue to grow steadily even without any policy taken. Nevertheless, some policies can further facilitate carpooling and can help to maximize its GHG emission reduction. First of all, the rather high willingness of the people to carpool suggests that information campaigns could really boost the membership of carpooling schemes and so alleviate the most important knowledge-based and structural barriers. These campaigns can use celebrities to popularize carpooling, or as far as decision-makers are include, can take the form of politician's speech or the form of public interest advertisements. As the people living in villages are strongly underrepresented, a campaign addressing them could be especially efficient.

Another important possibility is to facilitate workplace carpooling. As companies are presumably not aware of either the concept of carpooling or the know-how necessary for its operation, **carpooling scheme operators should take the initiative and approach large employers**, especially office building operators, present carpooling possibilities and offer their services to set up a carpooling scheme if needed, similarly to the business model of the Western European and North American carpooling scheme operators. In addition, large companies might provide a back-up option for those passenger carpoolers whose trip home have been cancelled for some reason and they cannot get home by public transportation (the cancellation of trip home is a major concern in existing workplace carpooling schemes (Vanoutrive 2012 *et al.*)). This back-up option can take a form of providing a company car or subsidizing a taxi ride.

Carpooling operators should consider **developing smartphone applications**, too. These applications are already important or very important for half of the carpoolers and their importance is likely to grow, as smartphones are getting more common. In addition, **developing a GIS-based matching software**, which can find matches for any subsection of the route, might be considered, too. This can facilitate the arrangement of rides, as it becomes much quicker. Finally, an option for female carpooler to form matches only with female carpoolers, which is available e.g. in the UK *liftsahre.com* scheme, can be considered in order to reduce safety concerns of women, though the level of safety concerns or distrust towards strangers are not considerably higher in the case of women compared to men.

In the case of carsharing, special attention should be paid to the concept of **‘disrespect toward common property’** which can be manifested in two ways. Carsharing users might use the shared cars carelessly, e.g. they may accelerate or brake unnecessarily often, or cars might be used in improper roads. Or some users might consider shared cars as a free store of car accessories and might steal the easily removable items such as bulbs, the spare wheel or even the fuel. These attitudes can be addressed by the application of on-board computers or by frequent checks of the cars by carsharing employees, which can help to identify the careless or stealing customers, who then can be excluded from the membership. Nevertheless, these applications may significantly increase the cost of carsharing, especially in the initial phase, when the manifestation of attitudes is more expected to occur. On the other hand, it should be noted that some of those experts who were interviewed considered these attitudes as rather unlikely, especially among the initial target group of young, environmental-conscious, middle-income people. Besides, ‘disrespect toward common property’ takes place in Western Europe, too, e.g. 30 to 40 cars out of total fleet of 250 electric cars have had to be withdrawn from the service due to vandalism one month after the Autolib carsharing system was launched in Paris in December, 2011 (Leclerc 2012).

The structural barrier manifested in the difficult access should be addressed by prospective carsharing operators. Certainly, the low number of cars and stations in the initial phase not only entails the difficult access to them but carries the possibility of overbooking, as it happened with Autolib in Paris, when the access to cars was highly limited in certain days partly due to the twice as much registration as expected (Yoney 2012). To avoid overbooking, either sound studies might be performed to estimate properly the number of expected registrations or the number of registrations might be limited in the initial phase. Another solution to overcome the problem of difficult access is a scheme, in which the booked cars might be driven by the employees of carsharing operators to places specified by those who booked them.

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# APPENDICES

## Appendix 1 – Questionnaire of the carpooler survey

### *Passenger questionnaire*

1. How long have you been carpooling?
  - 0-2 months.
  - 3-6 months.
  - 7-12 months.
  - More than a year.
2. How many times have you carpooled as a passenger over the past year?
  - Never.
  - 1-3 times.
  - 4-15 times.
  - 16-40 times.
  - More than 40 times.
3. You carpool as a passenger for
  - weekend trips to your hometown (if you work/study far from home).
  - commuting to work.
    - visiting relatives or friends.
    - holiday trips.

(Each option could be valued according to one of the following: 'almost exclusively', 'usually', 'sometimes', 'never'.)

5. Is there any other purpose for which you regularly carpool?
  - No.
  - Yes, please specify:
6. If you commute would you carpool to work/school as a passenger if there were rides offered on your route?
  - I do not commute.
  - I often commute by carpooling already.
  - Yes, almost certainly.
  - No, because the public transportation works very well in my route.

- No, because I am always in a hurry in the morning.
- Other, please specify:

7. What percentage of your long journeys (longer than 20 km) do you carpool as a passenger?

- Less than 10%.
- 10-30%.
- 30-70%.
- More than 70%.

8. In what percentage of cases (in which you have planned to carpool as a passenger) do you actually manage to find a match?

- Less than 20%
- 20-40%
- 40-60%
- 60-80%
- More than 80%

9. If you do not find carpooling for your route then

- you go by your own car (or family/company car).
- you go by public transportation.
- you forgo the trip.

(Each option could be valued according to one of the following: 'always', 'usually', 'sometimes', 'never'.)

10. When you carpool you favour it over public transport for the following reasons:

- Carpooling is cheaper.
- Carpooling is faster.
- Carpooling is a good way to get to know people.
- Carpooling is more environment-friendly.
- Public transportation does not work very well on my route (rare, bad connections, etc.).
- I do not like using public transportation.

(Each option could be valued according to one of the following: 'very important', 'important', 'moderately important', 'unimportant'.)

11. Is there any other reason for which you favour carpooling over public transportation?

- No.
- Yes, please specify:

12. Do you have your own car (or steady access to a family/company car)?

- Yes.
- No. (If you chose this option you can skip questions 13-14.)

13. You favour carpooling over private car use for the following reasons:

- Carpooling is cheaper.
- Carpooling is more environment-friendly.
- Carpooling is a good way to get to know people.
- I do not like driving.

(Each option could be valued according to one of the following: 'very important', 'important', 'moderately important', 'unimportant'.)

14. Is there any other reason for which you favour carpooling over private car use?

- No.
- Yes, please specify:

15. How important are the following factors in discouraging you from carpooling more often?

- There are no rides offered on my route at the preferred time.
- I am afraid that the arrangement might be cancelled.
- It is time-consuming/complicated to arrange rides.
- I prefer to go with my car as it much more flexible.
- I have safety concerns (I do not know the driver, etc.).

(Each option could be valued according to one of the following: 'very important', 'important', 'moderately important', 'unimportant'.)

16. Is there any other factor which discourages you from carpooling more often?

- No.
- Yes, please specify:

17. How important might the following possibilities be in encouraging you to carpool more often?

- More travel offers on my routes (so I could travel more flexibly).
- If it was even cheaper compared to other options (e.g. through government incentives).
- If it was even faster compared to other options (e.g. through HOV lanes reserved for carpooling).
- If users were officially registered (to reduce safety concerns).

(Each option could be valued according to one of the following: 'very important',

‘important’, ‘moderately important’, ‘unimportant’.)

18. Is there any other possibilities which could encourage you to carpool more often?

- No.
- Yes, please specify:

20. Please rate your experiences related to carpooling:

- 7 (Only positive, it was always great.)
- 6
- 5
- 4
- 3
- 1 (Only negative, I always felt uncomfortable).

21. Please indicate your gender:

- Female
- Male

22. Please indicate your age:

- Under 18
- 19-25
- 26-40
- 40-60
- Over 60

23. Please indicate your place of residence:

- Budapest
- Larger town (over 50.000 persons)
- Small town (less than 50.000 persons)
- Village

24. Please indicate your occupation/position:

- Student
- Employee
- Manager
- Company leader
- Self-employed
- Unemployed
- Other, please specify:

### *Driver questionnaire*

1. How long have you been carpooling?
  - 0-2 months.
  - 3-6 months.
  - 7-12 months.
  - More than a year.
2. How many times have you offered rides over the past year?
  - Never.
  - 1-3 times.
  - 4-15 times.
  - 16-40 times.
  - More than 40 times.
3. You offer rides for
  - weekend trips to your hometown (if you work/study far from home).
  - commuting to work.
    - visiting relatives or friends.
    - holiday trips.

(Each option could be valued according to one of the following: 'almost exclusively', 'usually', 'sometimes', 'never'.)

5. Is there any other purpose for which you regularly offer rides?
  - No.
  - Yes, please specify:
6. Would you carpool to work/school as a driver?
  - I do not commute.
  - I often commute by carpooling already.
  - No, because I am always in a hurry in the morning.
  - Other, please specify:
7. What percentage of your long journeys (longer than 20 km) do you offer rides?
  - Less than 10%.
  - 10-30%.
  - 30-70%.
  - More than 70%.
8. In what percentage of cases (in which you have planned to carpool as a driver) do you actually manage to find a match?
  - Less than 40%
  - 40-60%

- 60-80%
- More than 80%

9. If you do not find carpooling for your route then

- you go by your own car (or family/company car).
- you go by public transportation.
- you forgo the trip.

(Each option could be valued according to one of the following: 'always', 'usually', 'sometimes', 'never'.)

13. You favour carpooling over private car use for the following reasons:

- Carpooling is cheaper.
- Carpooling is more environment-friendly.
- Carpooling is a good way to get to know people.

(Each option could be valued according to one of the following: 'very important', 'important', 'moderately important', 'unimportant'.)

14. Is there any other reason for which you favour carpooling over private car use?

- No.
- Yes, please specify:

15. How important are the following factors in discouraging you from carpooling more often?

- I am afraid that the arrangement might be cancelled.
- It is time-consuming/complicated to arrange rides.
- I prefer to go alone as it much more flexible.
- I have safety concerns (I do not know the driver, etc.).

(Each option could be valued according to one of the following: 'very important', 'important', 'moderately important', 'unimportant'.)

16. Is there any other factor which discourages you from carpooling more often?

- No.
- Yes, please specify:

17. How important might the following possibilities be in encouraging you to carpool more often?

- If it was even cheaper compared to other options (e.g. through government incentives).

- If it was even faster compared to other options (e.g. through HOV lanes reserved for car-pooling).
- If users were officially registered (to reduce safety concerns).

(Each option could be valued according to one of the following: 'very important', 'important', 'moderately important', 'unimportant'.)

18. Is there any other possibilities which could encourage you to carpool more often?

- No.
- Yes, please specify:

20. Please rate your experiences related to carpooling:

- 7 (Only positive, it was always great.)
- 6
- 5
- 4
- 3
- 1 (Only negative, I always felt uncomfortable).

21. Please indicate your gender:

- Female
- Male

22. Please indicate your age:

- Under 18
- 19-25
- 26-40
- 40-60
- Over 60

23. Please indicate your place of residence:

- Budapest
- Larger town (over 50.000 persons)
- Small town (less than 50.000 persons)
- Village

24. Please indicate your occupation/position:

- Student
- Employee
- Manager
- Company leader
- Self-employed
- Unemployed
- Other, please specify:

## **Appendix 2 – Questionnaire of the national survey**

1. Do you commute by car?
2. Would you regularly take strangers with your car when you commute?)
3. Please provide 2 arguments for and against taking strangers with your car when you commute.)
4. Would you regularly commute in others' car?
5. Please provide 2 arguments for and against commuting in others' car.)
6. If you got to know about a service organising carpooling would you use it?)

The questions regarding the demography of respondents are not specified here.

## Appendix 3 – Questionnaire of the stakeholder survey

### *Questions related to carsharing*

1. Structural barrier: how important is the easy accessibility of shared cars, which means that the members could access the cars without a long walk or public transportation trip. For example, it can be assumed that the shared cars would be available only in a few places in the first phase of carsharing, thus lot of members might need some time to access it. It raise the queston that how easy it would be to find enough users who would use carsharing in spite of the initial difficulties – until carsharing achieve a level which allow to operate with much more cars.

Importance (1 - 10):

Explanation:

2. Economic barrier: how important is the reduction of driving costs for drivers. Maybe the driving costs constitute such a small share of household incomes for many drivers that they are not interested to reduce it. In other words: do a higher financial incentive (e.g. if a higher fuel price would make carsharing relatively cheaper compared to private car use) make carsharing much more popular?

Importance (1 - 10):

Explanation:

3. Political barrier: in what extent a better regulation (e.g. related to parking, insurance, etc.) is necessary to operate carsharing?

Importance (1 - 10):

Explanation:

Knowledge-based barrier: how much is the low awareness of the concept of carsharing is a barrier to its popularity?

Importance (1 - 10):

Explanation:

4. Cultural barrier: how much are the following concepts embedded into the society: „it is a democratic right to have an own car”, or „common use entail bad maintenance” or other ones which might hinder the application of carshaing?

2. Importance (1 - 10):

3. Explanation:

5. Individual-psychological barrier: how much do people insist emotionlly on having their own car (e.g. for the brand or for the individual decoration)?

Importance (1 - 10):

Explanation:

### *Questions related to carpooling*

1. Structural barrier: how important is the number of carpoolers and offered rides? Would carpooling be muc more popular if more offered rides and passengers are available?

Importance (1 - 10):

Explanation:

2. Economic barrier: how important is the reduction of driving costs for divers. Maybe the driving costs constitute such a small share of household incomes for many drivers that they are not interested to reduce it. In other words: do a higher financial incentive (e.g. if a higher fuel price would make carpooling relatively cheaper compared to solo driving) make carpooling much more popular?

Importance (1 - 10):

Explanation:

3. Political barrier: in what extent a better regulation (e.g. related to insurance, subsidizing work-related carpoolingetc.) is necessary to make carpooling more popular?

Importance (1 - 10):

Explanation:

4. Knowledge-based barrier: how much is the low awareness of the concept of carpooling is a barrier to its popularity?

Importance (1 - 10):

Explanation:

5. Cultural barrier: how much are the following concepts embedded into the society: „those who do not drive their own car are not successful”, or „I want to use alone the things I have worked for” or other ones which might reduce the popularity of carpooling?

Importance (1 - 10):

Explanation:

6. Individual-psychological barrier: how much are people afraid of strangers emotionally or how much importance do they attribute to the freedom of choice regarding their travel (e.g. destination time, etc.)?

Importance (1 - 10):

Explanation:

## Appendix 4 – Real-time dynamic carpooling and its implications

Real-time dynamic carpooling can theoretically provide a very effective way of car use. It works in the following way: drivers and passengers set their destination in a GPS connected to their smartphone (or to other online communication device) right at the moment (or some minutes earlier) when they want to start carpooling. A software compares the demands and form the most suitable matches (for which the drivers do not have to make large detours and the passengers do not have to wait for too long) and then notify the drivers and passengers about where and when they can meet. Payments can also arranged automatically through the smartphones if the per km rates are set. If sufficiently large number of people (e.g. 20-30% of the population) participates in this system, passengers could probably rely on carpooling as much as on public transportation considering that there is hardly any section of a public transportation route where no car passes at least in every five minutes. Therefore, real-time ridesharing could even redeem public transportation completely, except some of the most important routes (e.g. most subway routes) where the capacity of public transportation exceeds the free capacity of cars.

At the same time, it still has to be born in mind that efficient public transportation (i.e. utilized by close to full capacity) always has significantly lower GHG emissions per passenger-km than cars even when the latter run with full capacity. Therefore, the use of even a full car principally reduces GHG emissions only when efficient public transportation is not suitable to redeem car use<sup>22</sup>. (Certainly, the suitability of public transport depends on several questions, e.g. for how long people can be expected to

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<sup>22</sup> Biking or walking have even lower GHG emissions, but for the sake of simplicity they are not considered as suitable options to redeem car use for the majority of the car trips, as those trips are usually too long. Nevertheless, due to their almost zero GHG emission biking (and walking) always should be privileged and encouraged in the case of local travels which can be manifested e.g. in the lower taxation or subsidizing of bikes or subsidizing biking as a way of travelling to work (as it often occurs when employees use public transportation or cars to get to the workplace).

wait for public transportation when they could travel by car in today's individual- and time-oriented world, and varies in different circumstances.) Therefore, it is worth to overview what the level of suitability of public transportation is in different cases. Lower the level of suitability stronger the justification of car use and hence the justification of encouraging carpooling.

As a rule of thumb, suitability of public transportation could be defined as an ability to provide a relatively frequent possibility to travel in an efficient and a relatively quick and comfortable way<sup>23</sup>. The frequency of efficient public transportation primarily depends on the density of travel demands on a certain route (i.e. the number of travel demands within a certain time period, such as an hour): denser demand can fill up more high-capacity public vehicles and thus it allows more frequent public transportation. And there are certain circumstances when public transportation is not really suitable, such as in the case of transportation of ill persons or large items. Finally, urban, interurban and rural passenger transport might be distinguished, too, due to their basically different circumstances.

In the light of the above, in urban areas public transportation can be considered as highly suitable when the huge travel demands at peak time of the weekdays allows a rather frequent public transportation. The suitability then reduces along the density of travel demands: lower at off-peak time during the day, even lower in the weekends. The dense travel demands in the case of interurban transport (between large cities) make public transportation highly suitable, too. However, the typical Friday and Sunday evening peaks might occur too rarely to justify the maintenance of a large

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<sup>23</sup> Certainly, car use is always more flexible (as car user can go whenever and wherever they want), usually quicker and often more comfortable than public transportation. The acceptable level of reduction in flexibility, speed and comfort depends on several circumstances.

(and often under-utilized) public transportation fleet, which might entail more GHG emissions than passenger car transport. Therefore, carpooling as a way of relief of public transportation in the case of increased demand, could be justified in this case (assuming that a sufficiently large car fleet exists anyway).

In the case of rural passenger transport, public transportation is less suitable in general due to rare travel demands, except on commuting routes between large cities and their agglomerations. Therefore, car use can be justified in all those cases when biking is not an option such as the case of unsuitable weather condition or inability to bike; and beside the cases mentioned for the urban passenger transport. In the non-local case (including trips between urban and rural places) biking is not an option due to the large distances while public transportation can work efficiently only on routes with relatively dense travel demands such as the commuting routes in general or on routes which constitute part of interurban routes. Car use can be justified in all other cases.

Therefore, frequent public transportation should be provided (and subsidized) only when it is sufficiently suitable, i.e. in the rush hours in urban areas and in commuting routes and in interurban routes; thus avoiding the very high per passenger-km GHG emissions of empty (or strongly underutilized) public transportation vehicles. In all other cases, dynamic carpooling should be encouraged. This could take place through the differentiation in the pricing of carpooling: the software could attribute higher prices to routes where and when frequent public transportation is suitable. That is this system could increase the efficiency of car use and public transportation at the same time.