

# Economic benefits of peer- to-peer transport services

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## Executive summary

Copenhagen Economics has been commissioned by Uber to estimate the economic impact of having a well-functioning peer-to-peer transport service in the Nordics within a *Mobility-as-a-Service* concept, using Stockholm as a case study. Peer-to-peer transport services allow citizens (peers) to provide on-demand transport to other citizens (peers) using their personal vehicles. The idea behind the Mobility-as-a-Service concept is to allow citizens of a city to purchase their preferred choice of transport using a mix of public (subway, train or bus) and private (taxi, car, bike) transportation providers. In the ultimate case, citizens can buy all their transport services from mobility providers.

We conclude that a well-functioning peer-to-peer transport service, within a Mobility-as-a-Service concept, is likely to create **significant economic benefits** by changing the overall composition of demand for transport and thereby influencing traffic flows. In addition, such a system comes with very low investment costs, unlike many infrastructure projects with similar effects.

Due to their low costs and ease of use, peer-to-peer transport services are likely to immediately attract demand from other types of transport, and to induce car owners to give up car ownership, thereby reducing the use of private cars. Under conservative assumptions, the combined effect reduces the number of daily car trips by **up to 37,000 trips (3 per cent of total)** and leads to a reduction of the total number of active cars in Stockholm by **up to 18,000 (5 per cent of total)**. The former effect lowers traffic intensity and congestion, which in turn decreases time spent in traffic, creating a total value for society of up to **SEK 870 million per year**. For example, a commuter travelling by car would save up to a full working day per year previously spent waiting in traffic.

An effective peer-to-peer transport service therefore generates **comparable reductions in travel time as Förbifart Stockholm**, a large infrastructure investment project, but at a significantly lower price tag. Förbifart Stockholm is expected to generate time savings at a value of around SEK 600 million per year at a cost of nearly SEK 30 billion. The **effects are also comparable to those of Stockholmsförsöket**, the system of congestion charges in Stockholm city. Stockholmsförsöket is (also) expected to generate time savings of around SEK 600 million, but levies SEK 750 million per year in congestion charges on drivers.

Well-functioning peer-to-peer transport services are also likely to create new jobs. In the short run, a peer-to-peer service creates almost **3,000 full-time jobs**, as citizens who normally drive their own car shift to commercial peer-to-peer transport. The new jobs reduce unemployment if the jobs are filled by persons having difficulties finding employment elsewhere. In the long run, labour supply increases for two reasons. *First*, some citizens with full-time jobs drive peer-to-peer during their spare time, increasing their total labour supply. *Second*, the lower traffic intensity reduces congestion and generates time savings, some of which will be spent working. Overall, a well-functioning peer-to-peer transport service can in the **long run sustain almost 1,000 new full-time jobs in**

**Stockholm.** Similar effects can be expected in the other Nordic capitals Oslo, Copenhagen and Helsinki, at a scale proportional to their number of inhabitants relative to Stockholm.

Finally, well-functioning peer-to-peer transport services are likely to have an impact on the environment, in particular emissions and land use. Emissions in the form of particle and CO<sub>2</sub> pollution decrease when the number of vehicle trips declines, and since vehicles in the peer-to-peer fleet are likely to be newer models (with lower emissions) than an average private vehicle. We estimate, conservatively, that emissions in Stockholm decrease, at an economic value of up to **SEK 200 million**. The improved utilisation of vehicles will also reduce the demand for parking in the city centre. This will free up space in streets, which can be used for other transport purposes. As an example, we estimate that the space made available from a peer-to-peer could make room for **63 km of new bike lanes**. In addition, it would become easier and less costly to remove snow in Nordic capitals.

The abovementioned effects occur since citizens adjust their transport demand in the presence of peer-to-peer car transport services. Peer-to-peer transport is attractive to citizens since they imply low prices and low transaction costs.<sup>1</sup>

Peer-to-peer fares are likely to be 40 to 60 per cent lower than a similar ride in a taxi. The low costs are made possible by a better utilisation of existing private cars through ridesharing. Ridesharing enables private citizens to offer a ride against a fare to other citizens with a transport demand, and enables private citizens in real time to offer rides for a (lower) fare to other independent citizens who need to go in the same direction.

Peer-to-peer transport implies low transactions costs because riders and passengers are connected using GPS-based apps. Such apps allow citizens to share their identity, convey their position, and manage payments, thus facilitating a real-time connection between people looking for a ride with those who have a spare seat. These features also reduce the risk normally associated with the taxi industry by letting both parties know in advance who are involved in the transaction and what the price will be. These features make peer-to-peer transport feasible and safe, both for drivers and passengers.<sup>2</sup>

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<sup>1</sup> A well-functioning peer-to-peer transport service within a Maas concept also implies more choice for passengers. More choice is generated since passengers can choose transport services of different quality, according to their preferences. Choices can include different kinds of carpooling and carsharing options, or varying levels of service quality of rides. Greater choice and diversity enables citizens to get a better match with their preferences and stimulates demand.

<sup>2</sup> We assume that peer-to-peer transport services assure that drivers are qualified, that cars are safe, and that passengers are covered by adequate insurance.

## Chapter 1

# Introduction: Urban growth and pressured infrastructure creates a need for new solutions

Metropolitan areas have long attracted citizens who enjoy the benefits of jobs, education, culture, and social life. Stockholm is not an exception. Each year Stockholm welcomes 36,000 new citizens, and the population of Greater Stockholm is expected to exceed 2.5 million by 2030.<sup>3</sup> The growing number of new residents will boost the strong economy of Stockholm and reinforce its position as a centre of population and economic activity in Sweden.<sup>4</sup>

The urban growth creates an increasingly mounting need for basic services such as housing and transport. Housing supply in Stockholm has long fallen short of demand, and the need for transport is expected to do the same: Swedish authorities expect demand for road transport to increase by more than three times (80 per cent) the population growth (25 per cent) by the end of 2030.<sup>5</sup> The surge in demand for transport will inevitably create problems for both citizens and businesses in Stockholm.

### **Stockholm has significant congestion and expensive public transport**

There is currently a large gap between the demand for transport and the available infrastructure in Stockholm. Virtually all roads into the city centre are congested in the morning, with traffic often coming to complete standstills. A citizen with a daily 30-minute commute (each way) loses more than two working weeks per year in delays. At its current pace, this number will increase to more than four weeks by 2030.<sup>6</sup> Lack of parking space wastes significant amounts of time for citizens: one study found that as much as 30 per cent of city-centre traffic is trying to find a parking space at any given time.<sup>7</sup> The congested Stockholm traffic means that residents have less time for leisure, work and shopping, and that businesses are less productive.

The City of Stockholm is actively trying to close the gap between transport demand and supply by investing in large infrastructure projects aimed at improving both public and private transport. An example is Trafiksatsning Stockholm: a 112 billion SEK (11.7 billion EUR), multi-modal programme that will create more bus lanes, set up new train lines (e.g. Citybanan), build new roads (e.g. Norra Länken), and reserve more urban space for

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<sup>3</sup> Stockholms Handelskammare (2015).

<sup>4</sup> Half the Swedish population growth until 2045 takes place in Greater Stockholm. By then Greater Stockholm houses 25 per cent of the Swedish population, while generating more than 50 per cent of Sweden's GDP. See European Commission (2011).

<sup>5</sup> The population of Stockholm is forecasted to grow at a rate of 20,000 people per year until 2030. See Trafikanalys (2011).

<sup>6</sup> Today, a resident with a daily 30-minute commute (each way) loses 87 hours per year due to congestion, and is expected to lose 156 hours in 2030 if nothing is done. See Trafikanalys (2011).

<sup>7</sup> Roland Berger Strategy Consultants (2014).

bike lanes.<sup>8</sup> These initiatives aim to facilitate the overall flow of transport and steer demand towards transport modes with lower congestion problems: public transport and bikes. Despite the magnitude of these investments, however, they are not poised to meet their objective. When Trafiksatsning Stockholm is complete, average commuters in Stockholm are still expected to lose one workweek per year due to congestion in addition to the two weeks they waste today.<sup>9</sup> The projects also put additional pressure on the public finances of the City of Stockholm; public finances struggling to cope with one of the most expensive urban transport systems in the world.<sup>10</sup>

### **Technology offers new possibilities for peer-to-peer transport**

The availability of information technology has opened up new possibilities for transport planning in large cities. Innovation in the realms of communication technology creates new ways of connecting things and processes over the web. The growth of smartphone use and the entry of internet platforms have already transformed several other areas, where consumption increasingly goes from buying a certain good to buying *access* to that good: a notion sometimes branded collaborative consumption.<sup>11</sup> Collaborative consumption is based on an economic model in which people swap, barter, trade, rent or share resources with each other, and covers areas such as space sharing, co-working, household item rental, funding and lending, and currency exchange.

Transport systems planned using information technology are often referred to as ITS or Intelligent Transport Systems.<sup>12</sup> An example is the Mobility-as-a-Service (*MaaS*) concept developed and promoted by the city of Helsinki.<sup>13</sup> The idea behind the Mobility-as-a-Service concept is to let citizens of a metropolis purchase all types of transport (by bus, train, bike, car or boat) from public and private transportation providers. Citizens can choose comprehensive mobility packages according to their financial capabilities, their preferred travel modes and preferred choice of booking and payment. The contact between the citizens and the various mobility providers is organised through a GPS-based app. The application allows a rider to request a ride with the push of a button and track the car's progress toward the requested pickup location.

*It is not new* to offer citizens access to (public) transport in various packages. One example is the *SL Access-kort*, which provides access to public metro, train, bus and bikes in Greater Stockholm. *What is new* is integrating private transport modes such as taxis and rental cars in the public offer, thereby increasing the possibility to meet largely all of a user's needs. *What is also new* is incorporating peer-to-peer transport services, allowing citizens (peers) who need a ride with other citizens who are car owners (peers) with an idle seat in their car. The combination of public and private transport modes makes it easier to design transport offerings that match users' individual preferences, and is thus likely to appeal to more citizens than otherwise. In the ultimate case, citizens buy all

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<sup>8</sup> [www.trafiksatsningstockholm.se](http://www.trafiksatsningstockholm.se).

<sup>9</sup> Trafikanalys (2011).

<sup>10</sup> See for example <http://www.va.se/nyheter/2013/12/16/stockholms-kollektivtrafik-bland-de-dyraste-i-varlden/>.

<sup>11</sup> See for example Botsman & Rogers (2010). The website [www.collaborativeconsumption.com](http://www.collaborativeconsumption.com) defines Collaborative Consumption as "An economic model based on sharing, swapping, trading, or renting products and services, enabling access over ownership. It is reinventing not just what we consume but how we consume." See <http://www.collaborativeconsumption.com/2013/11/22/the-sharing-economy-lacks-a-shared-definition/>.

<sup>12</sup> See for example European Commission (2015).

<sup>13</sup> Heikkilä (2014).

transport services from mobility providers. In this setting, peer-to-peer transport adds a new brick to the transport system: a solution that encourages private car owners against a fare to share their car with citizens in need of a ride.

We distinguish between two types of peer-to-peer transport: Sharing *without* and *with* at least another unrelated passenger. Ridesharing with a single passenger means that a private driver picks up a customer for a fare<sup>14</sup>, either on his or her way somewhere, or as a way to earn money. Ridesharing *with* another passenger means that the private driver picks up two or more unrelated customers riding on similar routes. The app matches riders in real time and assigns them to the same car, provided of course that the first customer is interested in sharing the trip. The latter type of ridesharing comes at a lower price for consumers, but is logistically more complex as you need to match transport demand for specific rides in real time in order to avoid excessive waiting time. A study from New York finds that ridesharing with several independent customers per ride is technically realistic for at least 25 per cent of all taxi rides, and that that cumulative trip miles ideally can be reduced by 40 cent by exploiting the technical potential for ridesharing in the city.<sup>15</sup>

Whether a ride is shared with unrelated passengers or not, peer-to-peer transport increases consumers' mobility choices. With a new choice available, some consumers will switch to peer-to-peer transport depending on how attractive they see the new transport mode relative to others.

### **Low prices, low transaction costs and more choice attracts citizens to peer-to-peer**

We judge that three key features of a peer-to-peer transport service will make it attractive to citizens: *low prices*, *low transaction costs*, and *more choice*.

Peer-to-peer transport implies *low prices*. Experiences with peer-to-peer transport show that ridesharing with a single customer (such as uberPOP<sup>16</sup>) can be offered at prices that are at least 40 per cent lower than the taxi prices, while ridesharing with several independent passengers (such as the experimental uberPOOL<sup>17</sup>) can be offered at prices that are at least 60 per cent lower than taxi. The lower prices stem from the fact that peer-to-peer transport allows those providing rides to share their spare capacity (of cars), and consumers to share the cost of the ride by travelling with someone else.

Peer-to-peer transport also implies *low transaction costs*, primarily facilitated by GPS-based apps. The technology makes it possible to connect two citizens in real time who can share identity, rating, location and price in advance. In addition, the technology facilitates payment transactions. These features assign properties to peer-to-peer transport that very

<sup>14</sup> The trip can also include more customers known to each other in advance. To simplify, we use the phrase 'single passenger' to signify this kind of trip.

<sup>15</sup> Santi et al (2014).

<sup>16</sup> uberPOP is a peer-to-peer transport service that allows private citizens (once they and their cars have been approved by Uber) to offer rides to other citizens against a fare.

<sup>17</sup> uberPOOL is a peer-to-peer transport service that allows private citizens to offer rides to more than one other resident riding on similar routes. uberPOOL is not yet active in Stockholm, but is operated in the US on trial basis.

much resembles the properties of using one's own car (once it is bought). Finally, the information conveyed through the app reduces many of the problems that have traditionally plagued the taxi industry.<sup>18</sup> The social or public element of the app enables evaluation and feedback channels that provide a kind of "insurance": unreliable providers and users are exposed for all market players to see. This lessens the need for regulation and opens up to more competition in the taxi market, which increases the incentives for taxi companies to improve their services. Thus, overall market efficiency improves to the benefit of consumers. Peer-to-peer transport, though, also has the potential to *increase* transaction costs if uncertainty arises whether peer-to-peer rides are insured, or whether cars and drivers meet satisfactory minimum standards. If not adequately handled, the result may be lower demand for peer-to-peer transport.

Peer-to-peer transport allows for *more choice* because it is possible to define different qualities of peer-to-peer transport and communicate the identity of these concepts to citizens.<sup>19</sup> Examples are the various versions of Uber: uberX, uberBLACK, uberLUX and even uberBoat. Additionally, the mobile platforms used for peer-to-peer services increase choice for the individual service, as a customer's online request for a ride can include a particular route, and even what music to listen to during the ride. Wider choice is a direct source of economic welfare gain for consumers.

In summary, peer-to-peer ridesharing within a MaaS concept has the potential to meet increasing transport needs, and to alleviate some of the pressure on public budgets. Such a system will also have wider impacts on the economy, environment and employment. Copenhagen Economics has been commissioned by Uber to assess these impacts, using Stockholm as a case study. We do this using standard economic theory, conservative assumptions from a range of – mainly academic – sources, available empirical studies and statistics for transport patterns in Greater Stockholm in 2014.<sup>20</sup>

### **The analysis: A well-functioning peer-to-peer service in Stockholm**

The report analyses a scenario where a well-functioning peer-to-peer transport service is existent in Greater Stockholm. A well-functioning peer-to-peer service is defined as one where citizens can offer rides to other citizens in their private car for a fare, either with a single customer, or with several customers on the same route. The system operates under certain regulated conditions, for example with respect to insurance and safety, but is otherwise unrestricted and can grow in line with demand.

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<sup>18</sup> The presence of what is called *informational asymmetries* is one of the main reasons for regulating taxi services. Informational asymmetries mean that riders cannot compare information on price or service quality before choosing a vehicle, resulting in poor service quality. This issue along with low barriers to entry enabling over-competition, leading to aggressive and unsafe driver behaviour, poor vehicle maintenance, and congestion has long been an important argument for regulating the taxi industry (Rayle et al, 2014). Regulatory responses include restrictions on market entry and supply (i.e., medallion systems), fare regulation, and vehicle and driver safety standards. Today, new technologies can mitigate the asymmetry problem and reduce the need for regulation as prices are known in advance (also opening for choice), and as the driver and passenger are known to each other in advance (through rating systems).

<sup>19</sup> The availability of different types of peer-to-peer transport makes it easier to match the demand from citizens whose preferences may change over time and to match demand from citizens with different likes and dislikes towards public and private transport.

<sup>20</sup> This means we calculate all effects *as if they would happen immediately* i.e. based on current traffic volumes and transport market shares. The reason for this approach is that a large number of factors play a role for future development, making the projections of the future very uncertain. In combination with the large number of parameters involved, this would make the analysis overly complicated.

We assume that peer-to-peer services are offered via a GPS-based app used to share the identity and location of drivers and passengers, and to facilitate payments and driver assessments. The transaction costs of peer-to-peer services are low, as the technology reduces the risk for being wrongly charged, enhances the likelihood of getting good service, and reduces administrative hassle.<sup>21</sup> The user costs are also low because peer-to-peer transport allows those providing rides to share their spare capacity of cars, and consumers to share the cost of the ride by travelling with someone else. The former enables the existing capital stock to be put into better productive use, which is far from the case today.<sup>22</sup>

### **Immediate and induced effects and consequences for economy, employment, and environment**

The low user costs and transaction costs will spur an *immediate* increase in demand for peer-to-peer transport, the magnitude of which ultimately depends on the preferences of citizens of Stockholm. Some citizens will prefer to use peer-to-peer transport instead of driving their own cars, using public transport and using bikes, and some citizens may travel more than they did before. The initial transport structure and standard economic parameters like price elasticities and cross price elasticities of transport are used to calculate immediate effects in chapter 2.

The immediate change in transport demand will lead to further *induced* changes in transport structure as citizens now have access to a peer-to-peer transport service, with properties making it a close substitute to driving one's own car. The implication is that some citizens choose against owning their own vehicles, which in turn reduces the use of personal vehicles and increases the use of other types of transport. The induced consequences for traffic are assessed in chapter 3.

Together, the immediate and induced effects on traffic imply that a typical citizen of Greater Stockholm will use private vehicles less often and use other transport modes more often, among them peer-to-peer services. There will be fewer vehicles on the streets of Stockholm any given day, thus reducing traffic intensity and congestion, which in turn reduces the amount of time citizens spend in traffic. We will see that changes in congestion and unproductive time spent in traffic can improve labour supply and competition in Greater Stockholm and thereby give rise to economic benefits for citizens. The economic value of reduced congestion is assessed in chapter 4.

Peer-to-peer transport will also have an impact on employment, some of which is likely to be permanent through increases in labour supply. In the short run, employment (in particular part-time employment) will increase, primarily since commercial drivers will take over some transport that was previously handled by citizens themselves. The short-run employment effect may be permanent to the degree that peer-to-peer transport attracts persons who otherwise are difficult to employ. In the longer run, employment will increase because some of the (part-time) drivers will expand their labour supply over and

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<sup>21</sup> A 'well-functioning system' also implies that it works as if it has been active for a few years, i.e. potential technical problems relating to the GPS-based app etc. have been solved.

<sup>22</sup> Private cars in Stockholm are parked 96 per cent of the day, based on Gullberg (2015).

beyond their main job, and because less congestion will free up time, of which some will be converted into additional labour supply. Employment effects are assessed in chapter 5.

The reduced number of car owners and the more efficient usage of cars mean that demand for parking space within Stockholm will be reduced, freeing up square meters that can be used for other purposes, such as further investment in infrastructure. The level of pollution will also go down in Stockholm when time spent in traffic goes down. Environmental effects are assessed in chapter 6.

## Chapter 2

## Immediate effects: More efficient utilisation of capital and slightly higher traffic volumes

The introduction of a well-functioning, low-price peer-to-peer transport service will create an immediate change in transport patterns in Greater Stockholm. The magnitude of change depends on the current demand for transport, how much prices are lowered from the introduction of peer-to-peer, how much citizens trust the availability of peer-to-peer transport, and how much citizens change their demand for transport in response to lower prices.

### Current transport demand

Today, citizens of Greater Stockholm conduct more than 4.5 million *person trips* per day using all kinds of transport, cf. Table 2.1. A *person trip* is a trip performed by one individual irrespective of whether he or she is travelling together with others. More than 2.5 million *person trips* take place on roads; the large majority of which are made in private cars, cf. Table 2.1.

**Table 2.1 Initial transport structure in Greater Stockholm**

'000	Person trips/day	Vehicle trips/day	Vehicles/day
Private car	1,954	1,221	357
Bus	420	21	3
Taxi	135	84	6
P2P ridesharing, alone	0		
P2P ridesharing, several	0		
<b>Total road</b>	<b>2,509</b>	<b>1,327</b>	<b>366</b>
Rail	665		
Walking & bicycling	1,259		
<b>Total non-road</b>	<b>1,924</b>		
Other	113		
<b>Total</b>	<b>4,546</b>	<b>1,327</b>	<b>366</b>

Note: A *person trip* is defined as a trip performed by one individual irrespective of whether he or she is travelling together with others or not. A *vehicle trip* is defined as a trip performed by a single vehicle irrespective of the number of passengers. A *vehicle* is defined as the average number of vehicles in use per day. Therefore, a car that makes five average trips per day with on average three persons corresponds to a single vehicle that is doing five vehicle trips and fifteen person trips per day. Conversion of person trips to vehicle trips to vehicles is done using the values in Table 2.2.

Source: Copenhagen Economics based on AB Storstockholms Lokaltrafik (2005) and Stockholms läns landsting (2014).

Person trips require a certain number of *vehicle trips*, depending on the transport efficiency of the vehicle in question. A *vehicle trip* is defined as a trip performed by a single

vehicle irrespective of the number of passengers. The number of passengers carried for each trip determines the efficiency of the vehicle. Private cars and taxis are, with an average of 1.6 passengers per trip, less efficient than buses, which carry 20 persons on average per trip, cf. Table 2.2.

**Table 2.2 Efficiency of vehicle types**

	Persons/trip	Trips/day	Person trips/day
Private car	1.6	3.4	5.5
Bus	20.0	7.8	156.0
Taxi	1.6	13.1	21.0
P2P ridesharing, alone	-	-	-
P2P ridesharing, several	-	-	-

Note: The average number of passengers for private car trips is 1.6. As we lack data for the corresponding number for taxis, we assume that the average number of passengers per taxi trip is also 1.6. Due to rounding, some totals may not correspond to the sum of the individual figures.

The average number of journeys made by each car in Stockholm in a day is 2.1 according to Rigole (2014). A "journey", here, means a trip where the origin and destination are the respondent's permanent residence, vacation home, workplace, school, trainee post or temporary sleeping accommodations, according to the definition in the Swedish National Travel Survey. Every day, ca 0.8 million of these journeys are made in Stockholm. However, for the purpose of this study, we use trips to mean movement between any origin and destination. For example, travelling from one's home, to the supermarket, and then on to one's place of work would constitute one journey, but two trips. Every day, some 2.1 million trips are made. Hence, the 2.1 journeys per days means that every car makes 5.5 ( $2.1 \cdot 2.1 / 0.8$ ) trips per day. With an average occupancy rate of 1.6, the average number of trips per person is 3.4 per day.

The average number of persons per trip for buses is based on data from Trafikanalys (2013): local buses with a maximum occupancy of 50 people on average have an occupancy rate of 40 per cent. The number of buses run by SL (the Stockholm public transport company) is around 2,200. The total number of person trips by bus is about 420,000 (see Table 2.1). From these numbers, the trips per day and person trips per day are calculated.

The average number of trips per day for taxis is calculated based on the number of taxis in Stockholm in 2014 (6,379) multiplied by the average yearly distance driven (65,640 km in 2012). The average distance of a taxi ride is about 8.5 (data for 2006), which gives the daily number of trips of ca 135,000.

Source: Copenhagen Economics based on AB Storstockholms Lokaltrafik (2005), Bussmagasinet (2014), Gullberg (2015), Rigole (2014), Trafikanalys (2013) and Transek (2006a).

Vehicle trips require a certain number of *vehicles*. The more trips a vehicle does per day, the higher its usage and the fewer vehicles (and lower capital costs) are needed to service the transport demand. The number of vehicles used to meet a given amount of demanded transport, determines the capital productivity of the transport fleet. Private cars and buses – with daily averages of 3 and 8 trips – are less efficient than taxis, which conduct around 13 trips on average per day.

The number of passenger trips is in the end determined by consumers' preferences. The number (and temporal and spatial distribution) of vehicle trips determines how congested roads in Stockholm are. For example, an increase in the number of passengers per vehicle trip will reduce congestion, as fewer trips are needed to carry out the same amount of person trips. The higher usage of vehicles, the fewer vehicles needed to accommodate the required vehicle trips.

### Lower prices affect demand for peer-to-peer transport

When citizens in Stockholm get access to lower prices and lower transaction costs from peer-to-peer service they will, according to economic theory and empirical evidence, change their transport use. For the purpose of the analysis, we assume that the introduction of a peer-to-peer transport service leads to prices for ridesharing with a single customer corresponding to the prices set by uberPOP in Stockholm in 2015.<sup>23</sup> This means that prices will be (at least) *40 per cent lower* than standard taxi prices, cf. Table 2.3.

**Table 2.3 Standard prices for taxi and peer-to-peer transport services, Stockholm, 2015**

SEK	Fixed fare	Fare/ km	Fare/ h	Total fare	UberPOP lower
uberPOP	25	6.2	122	<b>116</b>	-
Taxi 08	-	-	-	<b>198</b>	-42%
uberX	40	7.5	339	<b>199</b>	-43%
TaxiKurir	42	9.1	434	<b>242</b>	-53%
Taxi Stockholm	45	9.2	445	<b>248</b>	-54%
Taxi 020	39	9.6	457	<b>249</b>	-54%
Topcab	45	11.5	460	<b>275</b>	-59%

Note: A standard trip is defined as a journey of 10 km that takes 15 minutes. The fares represent the companies' lowest daily rates. Taxi 08 does not disclose their fare structure.

Source: Copenhagen Economics based on data from Uber and [www.taxipriser.se/stockholm](http://www.taxipriser.se/stockholm), Taxi 020 (2015), TaxiKurir (2015), Taxi Stockholm (2015), Topcab (2015).

Most of the companies in Table 2.3 apply higher prices during certain periods of the day. TaxiKurir, for example, charges prices that are one quarter higher than the company's lowest fares on Fridays after 21:00.<sup>24</sup> uberPOP uses dynamic pricing in periods when demand significantly surpasses supply, in order to stimulate more drivers to become active. During these periods, prices increase by two-thirds on average, but they are only relevant for about six per cent of all Uber trips in Stockholm.<sup>25</sup> In our calculations, we do not take into account of these price deviations since they apply to all services and only relate to a limited share of trips.

Furthermore, we assume that a well-functioning peer-to-peer transport service leads to prices for ridesharing with two or more unrelated customers that are *60 per cent lower* than standard taxi prices in Stockholm. This corresponds to the price difference between uberPOOL and taxi prices, in cities where uberPOOL is active.<sup>26</sup>

<sup>23</sup> uberPOP is a peer-to-peer transport platform that facilitates private citizens (once they and their vehicle have been approved) to offer rides to other citizens at a cost that is at least 40 per cent below standard taxi rates in Stockholm. uberPOP is currently operative in Stockholm, but only on a limited trial basis.

<sup>24</sup> The corresponding price hike for the other services in Table 2.3 is Taxi Stockholm: 31%; Taxi 020: 23%; Topcab: 15%.

<sup>25</sup> Copenhagen Economics based on calculations on data from Uber.

<sup>26</sup> uberPOOL is a peer-to-peer transport service that allows ordinary private drivers to offer rides to more than one other citizen on the same ride, provided both passengers consent to this. uberPOOL requires that ride requests for rides can be matched to drivers who are already on active trips with a similar route and which can be deviated without creating too much delay for any of the passengers. uberPOOL is not yet active in Stockholm, but operates in the US and France. Source: Santi et al (2014) and Uber (2015).

### **Changes in demand are determined by *price-* and *cross price-elasticities***

We use price- and cross price-elasticities<sup>27</sup> of demand based on studies from taxi markets to estimate how the lower price of peer-to-peer will affect transport demand. This is necessary since peer-to-peer transport is a relatively new concept, and, to our best knowledge, there are no empirical estimates of the effect on demand for peer-to-peer transport from price changes. We assume instead that the effect of an introduction of peer-to-peer transport can be compared to a price reduction of 40 to 60 per cent of the price of taxi.<sup>28</sup> This is subject to some consideration. On the one hand, Rayle et al (2014) describe ridesharing as serving “a previously unmet demand for convenient, point-to-point urban travel”, and their findings show differences in users and the user experience between taxi and peer-to-peer.<sup>29</sup> On the other hand, the authors state that that ridesharing and taxis serve a similar market demand. We thus deem using findings from the taxi market as the best available option in the absence of further evidence.

We use a price elasticity of -1.4 for ridesharing with a single passenger. This means that the total demand for ridesharing increases by 14 per cent when the price decreases by 10 per cent. The elasticity is in the medium-to-upper range of the estimated taxi elasticities for three reasons. *First*, few studies include the lower transactions costs associated with peer-to-peer transport. *Second*, we expect peer-to-peer transport to be attractive in particular for leisure passengers who have documented larger price sensitivity. *Third*, the investigated studies are often performed in settings with (close to) monopoly pricing where price elasticities tend to be low, cf. Box 2.1.

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<sup>27</sup> *Price* elasticities measure how much citizens expand consumption (for example peer-to-peer transport) when prices go down. An elasticity of for example -1.5 for means that a price reduction of 10 per cent will boost demand by 15 per cent. The higher is the numerical value of the price elasticity of demand, the more sensitive citizens are to price changes, i.e. the more they will increase their purchase of the good when the price goes down. *Cross-price* elasticities measure how much citizens change consumption of one type of good (for example public transport) when the price of another, similar good (for example peer-to-peer transport) changes.

<sup>28</sup> Technically, we assume that the total demand for taxi and peer-to-peer transport is determined by the price elasticity of demand for taxi, here assumed to be -1.4. If the initial demand for taxi is 100 and prices drop by 10 per cent, the final demand for taxi and peer-to-peer transport will be 140. It means that peer-to-peer transport will have a net volume of at least 40. However, substitution will also take place between taxi and peer-to-peer, but we have at this stage no information how much of demand would shift to peer-to-peer transport from taxi.

<sup>29</sup> The study finds that ridesharing wait times were markedly shorter and more consistent than those of taxis. Ridesharing also differs from traditional taxis due to the efficiency and reliability of the matching platform and pricing mechanisms, along with the accountability of the rating system.

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## Box 2.1 Own-price elasticities of demand for taxi

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The available literature contains a wide range of own-price elasticities for taxi services. A large literature review by Rose & Hensher (2014) covers studies from Australia, France, the Netherlands, the UK, and the US, and finds elasticities in the range of -0.22 to -1.75. However, none of the studies included in the review are recent: only one uses data from the 2000s. Using sample data from 2012, the authors themselves estimate elasticities for travelling in Melbourne, Australia with a resulting weighted average elasticity of -1.04. For the tourism segment, the elasticity is found to be -1.48, and for the business segment -0.65. Two other – slightly more recent – studies by Liu (2006) and Ward (2002) find elasticities of -2.05 and -2.67 respectively. Overall, we find a range of elasticities between -0.22 and -2.67.

We use an own price elasticity of -1.4 for ridesharing with a single passenger, which is in the medium-to-upper range of elasticities in the literature. There are several reasons for this. *First*, earlier studies generally do not include effects from the lower transaction costs that are associated with peer-to-peer transport service compared to ordinary taxi services. The lower transaction costs indicate that the decline in the implicit prices is larger than the decline in listed prices. *Second*, we expect peer-to-peer transport to be attractive in particular for leisure passengers rather than business passengers. Leisure passengers tend to have significantly higher elasticities, almost three times as high as business passengers in Rose & Hensher (2014). *Third*, most of the empirical studies have been done for monopoly markets or with regulated prices that are close to monopoly prices. For such markets, the elasticity for demand can easily be asymmetric: very low for price increases due to nearness to monopoly prices, but much higher for price reductions as in our case.

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Source: Liu (2006), Rose & Hensher (2014) and Ward (2002).

We use a price elasticity for ridesharing with two or more unrelated passengers of -1.0. This means that the demand for ridesharing will increase by 10 per cent (relative to the demand for taxi) when the price drops by 10 per cent. The elasticity is lower than for ridesharing with a single passenger because riders must accept more waiting time and some loss of privacy by sharing the trip with another person.

### Net increase in total person trips due to lower prices

Using the price elasticities described above, we estimate that the introduction of peer-to-peer would boost total demand for taxi and peer-to-peer from the current 135,000 daily person trips, to around 216,000 daily person trips. The net increase in daily person trips would thus be 81,000 trips, or 60 per cent. The increase stems partially from ridesharing with a single customer, and, to a lesser degree, from ridesharing with several unrelated customers.<sup>30</sup>

There are three main sources for the net increase in daily person trips.

*First*, some of the new person trips would never have happened before, i.e. these are what we call *additional* trips resulting from peer-to-peer service. For example, a person may visit relatives rather than calling them since now there is a low cost, flexible alternative in

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<sup>30</sup> The introduction of ridesharing with a single customer increases daily person trips by  $-1.4\% \times -40\% \times 135,000$  trips = 75,000 trips. The introduction of ridesharing with several unrelated customers increases daily person trips by an additional  $-1.0\% \times -60\% \times 135,000 = 75,000$  trips = 6,000 trips.

the form of peer-to-peer transport. Travelers who previously avoided trips to neighbourhoods with poor transit access or scarce parking may now consider them accessible and chose to travel there. The volume of additional trips is determined by the overall price elasticity of demand for transport (of any kind) in Greater Stockholm. We use an overall price elasticity for transport of  $-0.5$  per cent.<sup>31</sup>

Using this price elasticity, we estimate the number of additional rides to amount to around 27,000 daily person trips. This means that around 27,000 of the 81,000 new peer-to-peer person trips (about 30 per cent) are additional; i.e. they would not have been made if a peer-to-peer transport option was not available.

*Second*, the remaining 54,000 daily peer-to-peer person trips (about 70 per cent) are made by people who would travel anyway, but with another transport modes. We measure the propensity to switch between transport options by the so-called *cross price elasticities of demand* between transport modes. For example, a cross price elasticity of 0.2 for peer-to-peer transport relative to walking indicates that the number of person trips done by walking will decline by 2 per cent when the price of peer-to-peer transport declines by 10 per cent. High cross price elasticity for two transport modes indicates that these are close substitutes, and that a price change for one will significantly affect the use of the other.

We are again in a situation where we have no information about cross price elasticities of demand for peer-to-peer transport, and instead assume that we can use cross price elasticities of demand for taxi. We use literature based cross price elasticities of  $+0.35$  for private cars;  $+0.2$  for bus;  $+0.07$  for subway and  $+0.10$  for walking and biking<sup>32</sup>, and split the increase in peer-to-peer daily person trips between these transport modes proportional to the size of their cross-price elasticities. This means that the largest share of peer-to-peer travellers would previously have used their private car to travel (elasticity of  $+0.35$ ), the second largest gone by bus (elasticity of  $+0.2$ ) etc.

*Third*, we need to take into account the substitution from taxi to peer-to-peer transport. The calculated increase in daily person trips is the net increase and does not capture substitution from taxi to peer-to-peer. We find it likely that peer-to-peer transport will capture market shares, but also that taxi and peer-to-peer transport are going to exist side-by-side as segmented parts of the same transport market.<sup>33</sup>

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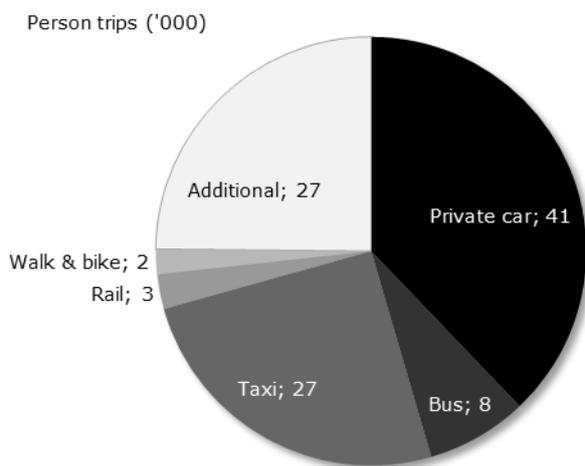
<sup>31</sup> The overall price elasticity is numerically low since there are little possibilities for substitution. All additional trips must stem from the fact that no other means of transport were previously attractive enough for those trips to occur. Low overall elasticities are also supported by empirical evidence as in Fouquet (2012), and consumer responses in the consumer surveys on the demand response to peer-to-peer transport available, such as Rayle et al. (2014).

<sup>32</sup> Based on Liu (2006) and Ward (2002).

<sup>33</sup> There is likely also a positive impact on the taxi segment from increased competition, especially in the long run, leading to lower prices and higher quality. This positive economic effect is not included in our calculations.

We do not know the cross price elasticity between peer-to-peer transport and taxi. Based on US experiences, we therefore assume that taxi and peer-to-peer transport will have approximately the same number of trips (and vehicles in operation).<sup>34</sup> Accordingly, we assume that the gross volume of peer-to-peer transport and taxi will each capture 50 per cent (or 108,000 each) of the total 216,000 daily person trips. Figure 2.1 summarises the sources of the 108,000 peer-to-peer person trips.

**Figure 2.1 Sources of peer-to-peer transport demand, person trips per day**



Note: The chart shows what peer-to-peer travellers would have done in the absence of a peer-to-peer alternative. For example, 27,000 would have chosen not to travel at all ('additional'), 41,000 would have travelled by private car, 27,000 would have travelled by taxi, 8,000 would have travelled by bus etc.

Source: Copenhagen Economics.

### Immediate effect on the transport structure

The changes in person trips calculated will immediately affect the number of *vehicle trips* (i.e. a trip performed by a single vehicle irrespective of the number of passengers), but not the number of *vehicles* used in Stockholm. The number of vehicle trips will go *down* when citizens shift from less efficient to more efficient transport modes. This is the case when citizens shift from driving private cars to peer-to-peer transport and – to a lesser extent – when they shift from taxi. The number of vehicle trips will go *up* when citizens shift from more efficient to less efficient transport modes. This is the case when citizens shift from bus or from non-road transport modes such as subway and biking/walking and when they make trips they would have otherwise abstained from.

We assume slightly higher efficiency for ridesharing with a single customer than for taxi: 10 per cent on average. The reason is that some of these trips in a well-functioning peer-

<sup>34</sup> In for example New York, the number of Uber vehicles is comparable to the number of yellow cabs in the city. In the beginning of 2015 there were 14,100 Uber vehicles (black cabs) and 13,600 yellow cabs. See for example: <http://www.nydailynews.com/new-york/uber-cars-outnumber-yellow-taxis-new-york-city-article-1.2154997>.

to-peer transport system in reality are likely to be shared.<sup>35</sup> We also assume that ridesharing vehicles with several unrelated customers carry one additional passenger compared to ridesharing with a single customer. Finally, we assume that all peer-to-peer vehicles make 15 per cent more trips per day than taxis, based on US experiences, cf. Table 2.4.

**Table 2.4 Efficiency of road transport modes used for calculations**

	Persons/ trip	Trips/ day	Person trips/day
Private car	1.6	3.4	5.5
Bus	20.0	7.8	156.0
Taxi	1.6	13.1	21.0
P2P ridesharing, alone	1.8	15.0	27.0
P2P ridesharing	2.6	15.0	39.0

Note: Persons per trip for private car trips is 1.6. We assume that the same holds for taxi. Persons per trip for ridesharing with a single passenger are 10 per cent higher than taxi because we assume 10 per cent of the trips in reality are ridesharing with others. For ridesharing with two or more unrelated passengers, we add one person on average per trip compared to taxis as there will always be two sets of customers. Trips per day for peer-to-peer transport are based on US experiences for Uber having a usage efficiency 15 per cent larger than taxi. Due to rounding, some totals may not correspond to the sum of the individual figures.

Source: Copenhagen Economics based on AB Storstockholms Lokaltrafik (2005), Bussmagasinet (2014), Gullberg (2015), Rigole (2014), Trafikanalys (2013) and Transek (2006a).

The number of vehicles in Stockholm will not change immediately, since it takes time for people to sell or buy cars, and for bus lines to be planned and changed. However, private vehicles and buses will be used *less* by passengers, which in the short run will lower the usage efficiency of these transport modes. Private car owners who become peer-to-peer drivers will make use of the car they already own to provide peer-to-peer services.

The immediate effect from introducing a well-functioning peer-to-peer transport service in Stockholm would be to increase the number of daily person trips by 27,000 or about 0.6 per cent, cf. Table 2.5. Citizens would travel more. The increase in person trips would be accompanied by an increase in the number of vehicle trips by 17,000 or about 1.3 per cent. Vehicle trips increase in relative terms more than person trips because of a limited shift from non-road based transport such as bikes and walking to road based peer-to-peer transport.

<sup>35</sup> Ridesharing with a single passenger is assumed to have a slightly higher number of person trips per day than taxi, since some drivers pick up passengers on a trip they were already making, for example a driver picking up a passenger for going to work each day.

**Table 2.5 Immediate transport structure in Greater Stockholm**

'000	Person trips/day		Vehicle trips/day		Vehicles/day	
Private car	1,913	-41	1,196	-26	357	-
Bus	411	-8	21	-	3	-
Taxi	108	-27	67	-17	5	-
P2P ridesharing, single	100	+100	57	+57	4	-
P2P ridesharing, several	8	+8	3	+3	0.2	-
<b>Total road</b>	<b>2,540</b>	<b>+32</b>	<b>1,344</b>	<b>+17</b>	<b>369</b>	<b>-</b>
Rail	663	-3				
Walking & bicycling	1,257	-2				
<b>Total non-road</b>	<b>1,920</b>	<b>-5</b>				
Other	113					
<b>Total</b>	<b>4,573</b>	<b>+27</b>	<b>1,344</b>	<b>+17</b>	<b>369</b>	<b>-</b>

Note: A *person trip* is defined as a trip performed by one individual irrespective of whether he or she is travelling together with others or not. A *vehicle trip* is defined as a trip performed by a single vehicle irrespective of the number of passengers. A *vehicle* is defined as the average number of vehicles in use per day. Therefore, a car that makes five average trips per day with on average three persons corresponds to a single vehicle that is doing five vehicle trips and fifteen person trips per day. Conversion of person trips to vehicle trips to vehicles is done using the values in Table 2.2.

Source: Copenhagen Economics basad on AB Storstockholms Lokaltrafik (2005), Bussmagasinet (2014), Gullberg (2015), Rigole (2014), Trafikanalys (2013) and Transek (2006a).

## Chapter 3

# Induced effects: Less car ownership and lower traffic volumes

The immediate effect of introducing a well-functioning peer-to-peer transport service will be a slight increase in the number of vehicles on the roads in Greater Stockholm, since some of those who start using peer-to-peer transport previously did not travel, or travelled by train, bus, bike, or by foot. However, the immediate effects will set in motion further *induced* effects, which has an impact on incentives to own a personal vehicle. Car ownership or non-ownership has a subsequent impact on how citizens use other transport modes.

### Peer-to-peer transport affects car ownership in two ways

Access to peer-to-peer transport has an impact on car ownership in two, counteracting ways. *First*, peer-to-peer transport makes car ownership less attractive because it provides access to a low-cost, flexible and easily accessible alternative to a private car. *Second*, peer-to-peer transport makes it more attractive to own a car, since citizens can earn additional income by offering peer-to-peer service with their car.

The first effect is a well-established effect from the empirical literature on *carpooling*,<sup>36</sup> and some very recent peer-to-peer studies. These studies show that by having access to low-cost, flexible, and easily accessible transport, citizens do not feel the need to invest in, bear the costs and endure the hassle of owning and maintaining a car. Empirical studies show that for each carpooling car available, citizens tend to reduce the number of cars they own by between 9 and 23 cars, cf. Box 3.1. It means that a well-functioning carpooling scheme with 100 cars available would lead to a reduction in the ownership of cars by between 900 and 2,300 cars, either through disposing of cars that members already own (shedding) or by postponing decisions to buy new cars (avoiding).

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<sup>36</sup> Traditional carpooling provides members with access to a car for short-term, and in some cases long-term use. Cars are distributed throughout a network of locations. Members can access the vehicles at any time with a reservation and are charged per time and often per mile.

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### Box 3.1 Carsharing reduces ownership of private cars

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Access to a joint car reduces ownership of private cars. A study from 2015 conducted by Trivektor found that one carsharing car could cause 4 to 6 private cars to be shed (i.e. sold or otherwise disposed of), based on an online survey of 7,500 carpool members in Stockholm, Gothenburg and Malmö. The same number of cars shed per carpool vehicle is found by Martin et al (2010). Another study by Lane (2006) found that one year into a carsharing program in Philadelphia, there was evidence that each carsharing car had reduced the car stock by an average of 23 private cars.

Notably, much of the shift found throughout the studies involved households becoming carless. Martin, et al (2010) found in a survey of North American carsharing members that 80 per cent of the sample owned no vehicle after joining carsharing, compared to 62 per cent before joining. Most of this shift was the result of one-car households becoming no-car households. A smaller change occurred with two-car households becoming one-car households.

Carsharing not only reduces the number of personal vehicles owned across the sample; it can also deter carless households from ever acquiring a vehicle. Most of the households that join carsharing are carless: 62 per cent of households joining carsharing owned no vehicle when they joined, while 31 per cent of households owned one vehicle. That is, some carsharing members who consider buying a car ultimately decide against it and use carsharing instead. A carsharing service in San Francisco compares the purchases of new cars among members in a carpool and non-members. 16 per cent of the members increased their number of cars by one compared to 29 per cent of the non-members. The results were obtained through surveys in 2003 and 2005.<sup>37</sup> Martin, et al (2010) found that the number of avoided purchases of cars for each carsharing car was 5 to 7.<sup>38</sup>

Despite the relatively short time period in which peer-to-peer services have been available, the most recent studies suggest that peer-to-peer transport is affecting car ownership in the same way as carpooling.

One such study investigates the effect of carsharing services based on a survey of 1000 carsharing users. Carsharing services are defined as services where drivers rent vehicles commercially or through peer-to-peer networks without going to a traditional car-rental location. The survey was carried out in ten metropolitan areas in the U.S, where carsharing services had achieved a degree of scale with respect to fleet size or number of competitors: Austin, Boston, Chicago, Miami, New York, Portland, San Diego; San Francisco-Oakland, Seattle, and Washington, D.C. The results show that 32 personal vehicle purchases were avoided per each carsharing vehicle. Respondents name ease of access, convenience and economics as key reasons for using carsharing instead of using their own car.

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Source: AlixPartners (2014), Cervero et al. (2006), Hara Associates Inc. (2013), Lane (2005), Martin et al. (2010) and Trivektor (2015).

The same pattern is found in studies of how the access to public transport affects car ownership. There is a wide body of evidence showing that when the accessibility of buses, un-

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<sup>37</sup> Cervero et al. (2006).

<sup>38</sup> Martin et al. (2010).

derground services, and light rail increases, people tend to give up their cars or defer purchases.<sup>39</sup> Studies for British and French cities have shown that good public transport access reduces car ownership, even when socioeconomic factors and population density are controlled for.<sup>40</sup> The quality of transport services is key, however. The quality of public transport services needs to be high and costs low for car ownership to fall when accessibility increases.<sup>41</sup>

Based on these findings we conclude that when alternative means of transport are available and accessibility is good, people feel a weaker need to own their own car. As a response, some will choose to sell their car or avoid buying a car. For the purpose of the calculations, we assume that the access to a well-functioning peer-to-peer transport service will have a similar *qualitative* effect as carpooling and accessible public transport, i.e. inducing citizens to give up ownership of a car. We assume a *quantitative* effect of a well-functioning peer-to-peer transport service in the lower-medium range of the estimates from carpooling studies: in the range of **15** cars shed or avoided for each full-time equivalent peer-to-peer vehicle.<sup>42</sup> The 15 shed or avoided cars correspond to the shedding of around **6** *active* cars in the calculations we perform.<sup>43</sup> This means that a well-functioning peer-to-peer transport service with 3,000 cars would lead to a reduction in ownership of owned cars by around 45,000 cars, and of active cars by around 18,000 cars. This former figure represents about 5 per cent of all owned cars in Greater Stockholm.

This is a conservative approach for several reasons. *First*, studies that include peer-to-peer indicate that the quantitative effect is in the upper range of the estimates from the literature.<sup>44</sup> As these are very recent and few, and not from academic sources we chose to be more conservative than they suggest. *Second*, most of the studies are recent and cannot capture the long-term effects on car ownership that are likely to be stronger than the short-term effect. *Third*, most of the studies focus on small-scale carpooling and peer-to-peer transport services within a limited geographical area. A full-scale peer-to-peer transport service in Greater Stockholm would provide a greater scope for bringing benefits that will reduce the incentive for car ownership. *Fourth*, the linking of a peer-to-peer transport service to a MaaS concept with very broad and easily accessible transport options is likely to provide a very competitive alternative to transport by own car.

Despite these considerations, we have chosen to be conservative about the effect on car ownership from peer-to-peer transport services for three reasons. *First*, there is a limited but realistic countervailing effect in that car owners have the option to earn an income from being peer-to-peer drivers. This reduces the cost of owning a car ownership and can thereby stimulate ownership. *Second*, the number of empirical studies focusing on the effects of peer-to-peer transport services is (naturally) still limited, and we cannot rule out

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<sup>39</sup> Goodwin (1992).

<sup>40</sup> Crampton (2006).

<sup>41</sup> Crampton, (2007).

<sup>42</sup> The studies we have reviewed find an estimate of between 9 and 32 cars are shed due to access of peer-to-peer transport services. We narrow this range down to around 15 cars.

<sup>43</sup> By active cars, we mean those that are used to meet the demand for vehicle trips in Stockholm every day. As of 2014, there are around 864,000 registered cars in Stockholm County according to Statistics Sweden. In our calculations, we find that about 358,000 of those cars, or 41 per cent, are used in a given day. This means that car shedding of 15 cars per peer-to-peer vehicle for *all* cars corresponds to 6 (41%) of *active* cars.

<sup>44</sup> AlixPartners (2014).

that the effects of peer-to-peer transport have a different effect on car ownership than carpooling schemes. *Third*, current users of carpooling schemes, on which the empirical studies are based, may not be average citizens and could have a larger disposition for reducing car ownership than the average user of a peer-to-peer transport service.

### **Fewer private cars leads to less car travel**

When car *ownership* changes, transport *usage* also changes. In many studies, car ownership has been proven to be a strong driver of total demand for travel by car, cf. Box 3. That is, when you own a car you tend to travel more overall, especially by car, since it is convenient and habitual. Studies have also found that when you *do not* own a car, a larger share of trips is serviced by walking, biking and public transport.

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### **Box 3.2 Car ownership changes citizens transport use**

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Car ownership is a decisive factor when making transport decisions, and has been found to cause an overuse of cars (Barter, 2008). There are several mechanisms that make cars the transport mode most used by their owners. One such mechanism is the sheer convenience of having a car on hand, which is found to increase the propensity to use it for more trips than necessary (Stradling, 2002). Routine travel behaviour can also cause the overuse of personal cars. Due to a lack of motivation to change routines, and uncertainties associated with change, most people stick with tried-and-tested travel routines (Harms, 2003). Such impacts of past behaviour seem strong for car owners (Thogersen, 2006). Information problems and uncertainty over alternatives are also relevant to people with cars, many of whom rarely need or seek information about alternatives (Harms, 2003). Additionally, Simma and Axhausen (2003) note that people tend to commit themselves to particular travel behaviour through the ownership of mobility tools such as cars and public transport subscriptions. Finally, the possession of a car has traditionally been a mobility tool with unrivalled characteristics such as independence and social status, which have encouraged the desire to own a car and thus overuse it.

However, Barter (2008) find that these mechanism are reversible. If you do not own a car, you will use a car less frequently and use other modes of transport more. For example, the self-reinforcing behaviour of not owning a car is evident in a carsharing study in San Francisco, where despite the fact that several new members began driving instead of traveling by transit, foot, or bicycle, their average daily fuel consumption fell significantly, as they became carsharing members. In fact, carsharing reduced private car usage by 15 per cent. Additionally, vehicle miles travelled was found to drop 67 per cent for carsharing members, compared to a 24 per cent *increase* for non-members. Moreover, according to Cervero et al. (2006) members began using *other* means of transport significantly more, such as public transport and biking. While the reductions in travelling and fuel consumption did not entirely stem from the tendency to sell off private cars and forego the purchase of additional ones, it was a large part of the explanation. The authors conclude that: "*CarShare membership was also seen to be a self-reinforcing behaviour, much like car ownership is for inducing car use. Membership was associated with reduced car ownership, and reduced car ownership was associated with more car share use for trips*"

Additionally, mobility in the absence of one's own car has the potential to significantly improve with a peer-to-peer service. Without a car but with a peer-to-peer option, the use of your car is not *always* the preferred option, as people face a more comprehensive set of mobility choices. Peer-to-peer can thus fill the gaps that have previously

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not been easily be addressed without convenient access to cars, and create a system where people purchase the optimal transport mix for any given trip.

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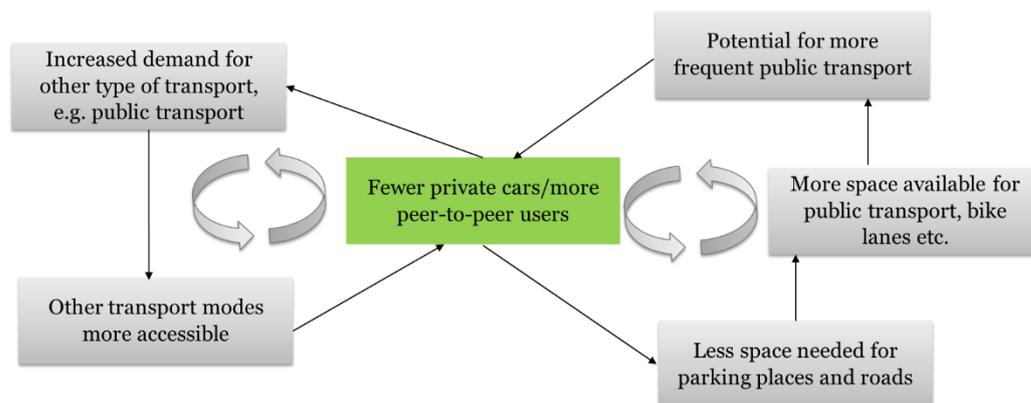
Source: Barter (2008), Cervero et al (2006), Harms (2003), Litman (2007), Simma & Axhausen (2003), Stradling (2002), Thogersen (2006).

Feedback loops are important in reducing car ownership and car use. Once you avoid the trouble of owning a car, you are less likely to go back to driving. The reduction of private car ownership thus creates a virtuous cycle, cf. Figure 3.1. Fewer private cars (when peer-to-peer becomes available) leads to higher demand for other transport forms which again makes it possible to strengthen scale and quality of peer-to-peer, leading to a further reduction in the usage of private cars. Fewer private cars also free up road space that can be used for expanding bus and bike lanes, stimulating demand and leading to a further reduction in the usage of private cars.

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**Figure 3.1 Virtuous cycle of fewer cars**

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Source: Copenhagen Economics based on Åkerman (2014).

### Induced effect on transport demand

Accordingly, some car owners give up owning a car once they are offered a well-functioning peer-to-peer transport alternative, either by shedding an existing car or by deciding not to buy a car. We assume that for each full-time peer-to-peer vehicle, the number of active cars goes down by 6 vehicles (which corresponds to a decline in the total number of cars by 15 vehicles). However, the former car owners still have a transport demand that now must be served by other transport forms, among them peer-to-peer services.

We assume that the former car owners' demand for transport (person trips) that now cannot be met by private car is distributed among the other transport forms (bus, rail, bike, and peer-to-peer) according to their initial share of total trips. It means for example, that taxi will take up three per cent of the transport demand from foregone private car trips, because taxis make up three per cent of the total number of person trips in Greater Stockholm today. Each of the other transport forms (bus, rail, bike, peer-to-peer) therefore experience an increase in demand proportional to its initial share of person trips.

However, since private car is the least efficient means of transport by road (i.e. that carries the fewest passengers per trip and day), a shift from private car to other means of transport increases the efficiency of transport. Fewer vehicle trips and vehicles are now needed to produce the same amount of person trips. As a result, we therefore find that the total number of vehicle trips declines by up to 37,000 trips per day, or around 3 per cent. Likewise, the total number of vehicles trafficking the streets of Stockholm a given day is reduced by up to 22,000 vehicles, cf. Table 3.1.

**Table 3.1 Induced transport structure in Greater Stockholm**

	Person trips/day		Vehicle trips/day		Vehicles/day	
Private car	1,819	-135	1,137	-84	332	-25
Bus	426	+6	21	-	3	-
Taxi	112	-23	70	-15	5	-1
P2P ridesharing, alone	104	+104	59	+59	4	+4
P2P ridesharing, several	8	+8	3	+3	0.2	+0.2
<b>Total road</b>	<b>2,468</b>	<b>-40</b>	<b>1,290</b>	<b>-37</b>	<b>345</b>	<b>-22</b>
Rail	686	+21				
Walking & bicycling	1,301	+42				
<b>Total non-road</b>	<b>1,987</b>	<b>+63</b>				
Other	117	+4				
<b>Total</b>	<b>4,573</b>	<b>+27</b>	<b>1,290</b>	<b>-37</b>	<b>345</b>	<b>-22</b>

Note: A *person trip* is defined as a trip performed by one individual irrespective of whether he or she is travelling together with others or not. A *vehicle trip* is defined as a trip performed by a single vehicle irrespective of the number of passengers. A *vehicle* is defined as the average number of vehicles in use per day. Therefore, a car that makes five average trips per day with on average three persons corresponds to a single vehicle that is doing five vehicle trips and fifteen person trips per day. Conversion of person trips to vehicle trips to vehicles is done using the values in Table 2.2.

Source: Copenhagen Economics based on Trivector (2005).

For peer-to-peer transport, the total number of vehicle trips increases slightly to 112,000 vehicle trips, of which a small part is ridesharing with several customers. These vehicle trips are serviced by around 4,000 peer-to-peer vehicles that already circulate in private ownership.

### Engineering studies of the potential for car sharing

A number of engineering studies have estimated the technical potential of peer-to-peer transport. These studies generally assess how many vehicles (taxis, personal vehicles or self-driving vehicles) are needed to meet a given transport demand if customers are willing to share cars (ridesharing with several independent customers), and are prepared to accept some waiting time while riders and vehicles are matched.

Box 4 summarises the results for three such studies for Stockholm, New York, and a hypothetical European city. All results indicate that the number of vehicles required to meet transport demand could be significantly reduced, down to 10-20 per cent of the current car stock. However, total traffic volumes, congestion, and environmental effects are either positive or negative depending on how strong assumptions the authors make about how

many rides are shared, and how much waiting time customers are willing to accept. Generally, to achieve positive environmental effects and reduced congestions, the studies need to assume that ridesharing with several customers is used to the highest degree possible independently of personal preferences, as well as the maximum acceptable waiting time. The main reason is that none of the studies include the changes in transport demand induced by reduced personal car ownership.

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### **Box 3.3 Case studies of the technical potential for ridesharing**

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Santi et al (2014) use a dataset of 150 million taxi trips in New York to estimate how many of these could be shared with a reasonable level of waiting time and discomfort for passengers. Using a mathematical optimisation framework and assuming that passengers would accept maximum 5 minutes additional waiting time, they show that the number of taxi trips could be cut by almost 50 per cent and that the total travel time could be reduced by around 24 per cent. The results hold under the assumption that *all* taxi rides have at least two independent customers in the same vehicle.

A study by Rigole (2014) estimates how large a fleet of shared, self-driving vehicles is needed to replace private car commuter trips in Greater Stockholm. The study uses a model where the current private trip demand in Greater Stockholm is matched with the street network of Stockholm, and where the author compares scenarios with varying levels of passenger waiting time. The core result is again that a much smaller fleet of vehicles is needed to serve demand. However, in order to reduce congestion and environmental effects, customers would largely have to share their rides with an independent customer, accept up to 30 per cent increase in travel time, and accept a potential 10 minutes delay to allow for matching of customers. In this case, the total travel distance would be reduced by 11 per cent and the demand would be serviced by less than 10 per cent of today's active private car fleet. In other cases, congestion and environmental impact would increase. It is not clear what happens to the ownership of personal cars in this study, nor to public transport, biking or walking.

Finally, a study by OECD (2014) shows how a fully self-driving door-to-door transport system would affect the number of vehicles in a hypothetical, medium-sized European city. The authors use a model that simulates daily travel to estimate the number of shared, self-driving cars needed to accommodate demand currently met by public transport, taxi and personal cars, given that the trip may take no more than 5 minutes longer than a conventional car trip. The results show that when ridesharing with several independent customers is used as much as possible, the number of vehicles required to provide the same trip volume as before is less than 10 per cent. In the scenario where only ridesharing with a single customer is possible, the number of required vehicles is still just 20 per cent. However, the model also predicts that the total volume of car travel in any case will increase. In the former case with significant ridesharing with independent customers the increase is modest 6 per cent. In the latter case, the increase is a significant 89 per cent. Congestion is likely to increase despite the low number of vehicles, since these are used extensively during peak hours.

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Source: OECD (2014), Rigole (2014), Santi et al (2014).

## Chapter 4

# Economic effects: Time savings and increased productivity

We have found that the introduction of a well-functioning peer-to-peer transport service is likely to slightly increase personal travel activity, but it will also change the transport structure such that travel intensity on roads will decline. On average, there would be fewer cars on the roads of Stockholm at any given time. Fewer cars will tend to reduce congestion and therefore reduce the time citizens spend waiting in traffic. This has an economic value.

We investigate how fewer cars (vehicle trips) in Stockholm affects congestion levels, and time spent in traffic by citizens, and what economic value this creates. Box 4.1 describes the calculations and the model used for the first step: calculating the decrease in congestion levels from fewer vehicle trips in Stockholm.

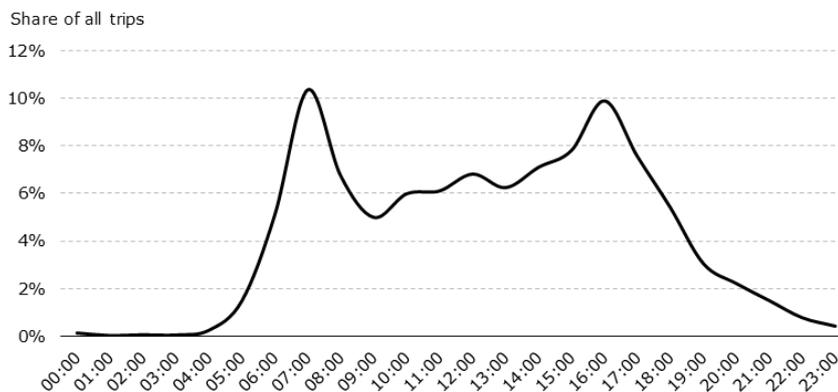
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### Box 4.1 Calculating congestion levels

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In order to calculate how reduced traffic volumes affect congestion in Stockholm, we need to establish a few things. Consolidated data on traffic habits and regional volumes are not widely available in Stockholm. In 2005, a large-scale travel survey of Stockholm traffic was conducted in order to measure the effects of the congestion charges that were introduced the following year. Much of the data below is gathered from this survey.

*First*, we need to know when car trips are made; one trip less during rush hour will reduce congestion more than a trip during outside rush hour. Car trips made on weekdays spike twice during the day as commuters head to and from work, once in the morning around 07:00, and once in the evening around 16:00, cf. the figure below.

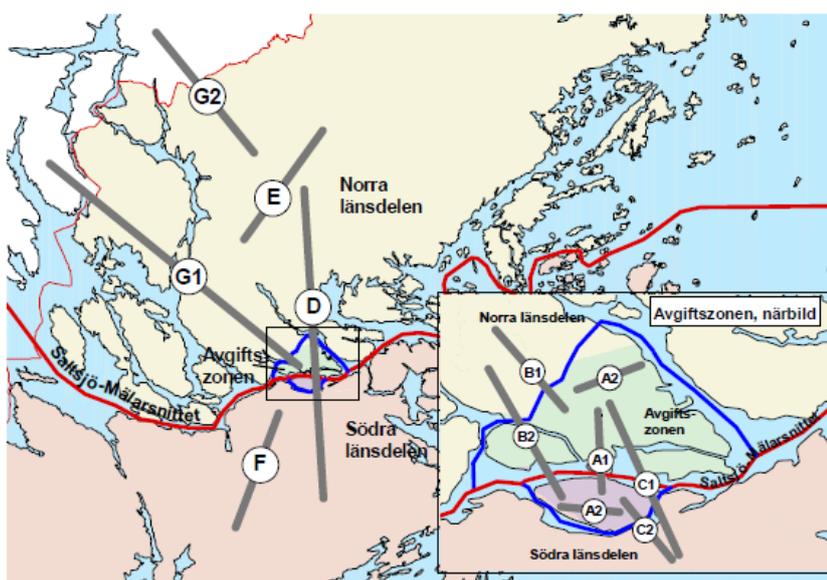


Source: Copenhagen Economics based on Sika (2007).

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During these periods of peak congestion, the congestion level is around 60 per cent compared to 30 per cent for the entire day (TomTom Traffic Index, 2014). Official sources reported values of up to 120 per cent for certain types of roads leading in and out of the city (Trafikkontoret, 2014). A congestion level of 60 per cent means that the time needed to drive a given route would take 60 per cent longer compared to a situation with free flow. For example, a route that takes 30 minutes to drive would need 48 minutes with 60 per cent congestion and 39 minutes with 30 per cent congestion.

Second, we need to know where car trips take place. Data for this has been gathered from travel surveys (Stockholms läns landsting, 2014; Trivector, 2005).



Source: Trivector (2005)

The distribution of trips within the Stockholm county follows the distribution in the table below.

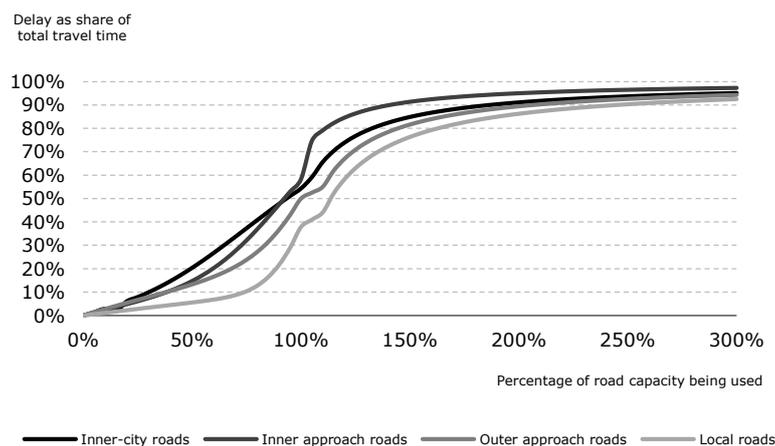
Travel relationship	Share of total
Trips within the zone (A)	4%
Trips between the northern part of the county and the zone (B)	7%
Trips between the southern part of the zone (C)	7%
Trips through or around the zone (D)	8%
Trips outside the zone, northern part of the county (E)	38%
Trips outside the zone, southern part of the county (F)	33%
Trips starting and ending outside the county (G)	3%

Note: By "the zone", the study means the zone inside the limits of the Stockholm congestion charge. We take this to be synonymous with the city centre of Stockholm.  
 Source: Copenhagen Economics based on Trivector (2005).

Third, we need to know the relationship between traffic volumes and traffic delays. The amount of congestion on a stretch of road depends on the number of vehicles traveling on that road at the same time. As the number of vehicles increases towards the maximum capacity of the road, so does congestion. This causes travel delay. However, the relationship between congestion and time delay is not linear.

Travel time will not increase substantially until the road comes close to reaching its maximum capacity, at which point delays increase exponentially. In other words, at high levels of traffic, every additional car causes more delay than at lower levels. This also implies that getting rid of the last few cars on a road when congestion is high can have a large impact on travel time for the remaining motorists.

The relationship between traffic volumes and traffic delays are described by volume-delay functions. There are similar functions for nine different types of representative roads in Stockholm. To get an idea of how the total amount of congestion in Stockholm is related to the traffic volumes, we assume that a portion of each trip made in Stockholm to a varying extent takes place on these different types of roads. For simplification, we assume that there are four different types of roads: inner-city roads (A1+A2), inner approach roads, outer approach roads, and local roads. We also assume that the nine different types of volume-delay functions are representative of these four different types of roads. For example, trips made in central Stockholm take place on inner-city roads, trips made into the central Stockholm take place on approach roads and inner-city roads, cf. the figure below.



Note: The kink in the volume-delay functions is due to the functions being discontinuous: There are separate functions for when traffic flows exceed 100 per cent of road capacity.  
Source: Copenhagen Economics based on VTI (2006).

By distributing the total amount of trips made in Stockholm during a day to different types of roads and different times of day, using the volume-delay functions we can model how congestion changes when the traffic volumes change.

Source: Stockholms läns landsting (2014), TomTom Traffic Index (2014), Trafikkontoret (2014), Trivector (2005), VTI (2006).

Today in Greater Stockholm, a trip that would take 30 minutes with zero congestion is delayed by 9 minutes on average. It means that the average congestion level is around 31 per cent for all drivers – congestion that translates into two full working weeks per year lost waiting in traffic.<sup>45</sup>

The introduction of a peer-to-peer transport service will reduce the average number of vehicle trips on the roads of Stockholm by up to 3 per cent. However, as cars make up

<sup>45</sup> 87 hours, with a standard Swedish working week being 40 hours.

around 80 per cent of the total vehicle traffic<sup>46</sup>, this translates into a reduction of total traffic of up to 2.5 per cent.

By reducing traffic volumes, the average delay on a half hour trip would fall by up to 8 per cent, cf. Table 4.1. This adds up to significant savings for motorists who spend large parts of their day behind the wheel. For example, commuters who go to work by car spend an average of 87 hours per year stuck in traffic.<sup>47</sup> An 8 per cent reduction in travel time for these commuters translates into a saving of up to 7 hours per year, or nearly a full working day.<sup>48</sup>

**Table 4.1 Change in average delay, 30 minute trip**

Type of road	Minutes delayed in traffic (30 minute trip)		Time saved per trip
	Without peer-to-peer	With peer-to-peer	
Inner-city roads	7.4	7.0	5%
Inner inroads	7.5	7.3	3%
Outer inroads	5.3	4.8	8%
Local roads	5.7	5.2	10%
<b>All</b>	<b>5.8</b>	<b>5.3</b>	<b>8%</b>

Note: These figures represent changes in travel time for private cars. Travel times for other vehicles, such as road freight transport and emergency service vehicles, would also experience time savings if they take place during those times of day when the number of car trips falls. Due to rounding, some totals may not correspond to the sum of the individual figures.

Source: Copenhagen Economics.

Reducing travel time has several economic benefits. *First*, people place an economic value on their time. Rather than spending time travelling, time can be spent on family, leisure, or work. The Swedish Transport Authority uses standardised values of time in the range of SEK 59 (EUR 6) to SEK 291 (EUR 32) per hour, cf. Table 4.2. The value of time differs since the value of arriving at your destination on time is greater for some types of trips. For example, a greater value is placed on arriving in time for an important meeting than at the grocery store.<sup>49</sup> In Stockholm, slightly less than half of all trips are business related, and slightly more than half are private errands or leisure.

We estimate citizens in Stockholm will gain in total up to 3 million hours per year, at a value of up to SEK 600 million when the introduction of a well-functioning peer-to-peer transport service reduces congestion, cf. Table 4.2. Most of the benefits accrue to commuting and business travellers for which the time value is largest.

<sup>46</sup> Copenhagen Economics based on Transek (2006b).

<sup>47</sup> TomTom Traffic Index (2014). Based on a commuter with a 30 minute daily commute.

<sup>48</sup> We assume that the reduction in vehicle trips is distributed proportionally across in space across all types of routes and in time across all 24 hours.

<sup>49</sup> Trafikverket (2014).

**Table 4.2 Value of saved time in traffic in Stockholm**

	Share	Value of time	Cost of initial delay (SEK bn)	Cost of final delay (SEK bn)	Value of saved time (SEK bn)
Private: Commuting	35%	87 SEK/h	2.6	2.4	0.30
Business	10%	291 SEK/h	0.9	0.8	0.10
Private: Errands	27%	59 SEK/h	0.8	0.7	0.10
Private: Leisure	28%	59 SEK/h	1.1	1.0	0.10
<b>Total</b>	<b>100%</b>	<b>-</b>	<b>5.6</b>	<b>5.0</b>	<b>0.60</b>

Note: Only benefits for private vehicle trips have been considered. These account for about 80 per cent of all vehicle trips on roads around Stockholm. Including gains for e.g. commercial transport of goods would lead to higher figures. As buses have separate lines, their travel time would likely not be affected, depending on whether or not peer-to-peer vehicles can drive in bus lanes. Value of time is based on surveys of drivers using stated-preference experiments, see WSP (2010). The Swedish Transport Administration recommends using multipliers for travel time uncertainty, crowdedness and discrepancies from timetables (rarely used for car travel) which increase the value of time. We do not include these due to lack of data, which makes our time values conservative. Due to rounding, some totals may not correspond to the sum of the individual figures.

Source: Copenhagen Economics based on Trafikverket (2014) and Trivector (2005).

The economic value of saved time may be compared to the similar values estimated for transport infrastructure projects around Stockholm. The much-debated planned ring road around Stockholm, *Förbifart Stockholm*, has been estimated to give rise to similar time savings worth about 610 million SEK per year<sup>50</sup> at an investment cost of nearly SEK 30 billion.<sup>51</sup> The effects are also comparable to those of *Stockholmsförsöket*, the system of congestion charges in Stockholm city. *Stockholmsförsöket* is (also) expected to generate time savings of around SEK 600 million, while levying drivers with SEK 750 million per year in congestion charges.<sup>52</sup>

*Second*, there are further economic benefits aside from the value people place on their time, since a part of the time saved is used for work. A study by Copenhagen Economics for the Danish Ministry of Transport found that for every hour saved due to infrastructure improvements, 10-15 minutes are used to work more.<sup>53</sup> The value of this is commonly not captured in traditional cost-benefit analyses.

This means that of the up to 7 hours saved every year by car commuters, 2 hours every year would likely be used for working more. Using an average hourly wage of SEK 159,<sup>54</sup> the yearly value of these extra working hours is up to SEK 60 million per year, cf. Table 4.3.<sup>55</sup>

*Third*, lower travel and transport time has a positive effect on the competitiveness of markets for goods and services. As transport time and costs fall, businesses can deliver more

<sup>50</sup> Transek (2006b) find a total net present value of time savings for private vehicles of SEK 9.2 billion in 1999 price levels for the period 2018-2077. Calculating the annualized value of this in 2015 price levels, using the discount rates in the report, yields a value of 610 million SEK per year.

<sup>51</sup> Trafikverket (2015a).

<sup>52</sup> Transek (2006b).

<sup>53</sup> Copenhagen Economics (2011).

<sup>54</sup> Average pre-tax wage earned by Swedish employees.

<sup>55</sup> SCB (2015).

products and visit more clients. This allows them to increase production of goods and services. Guidelines from the British Department of Transport suggest adding 10 per cent of the calculated time value for business trips and transport of goods to cost-benefit analyses, in order to capture this effect.<sup>56</sup> Adding 10 per cent to the value of time saved by business trip travellers, an additional SEK 10 million per year can be gained from a peer-to-peer transport service in Stockholm, cf. Table 4.3. Including gains for transport of goods as well, this number would likely be several times higher.<sup>57</sup>

**Table 4.3 Economics benefits per year of reduced travel time due to peer-to-peer transport**

	SEK million
Time value	600
Increased hours worked	60
Market for goods and services	10
<b>Total</b>	<b>670</b>

Source: Copenhagen Economics.

In addition, reducing travel time within a city can have positive effects on productivity. The main reason why cities thrive is that urban areas gather businesses and people within a confined location, thereby granting them easy access to their knowledge, skills and productive capacity. As more companies and workers become present within the same geographic market, goods, services and labour will become more abundant and competitive. These *agglomeration effects* make cities productive.

When urban connectivity increases, e.g. through major infrastructure projects, these effects become larger as companies and people become more closely integrated.<sup>58</sup> Reducing travel time through a well-developed peer-to-peer transport service will have effects similar to infrastructure projects that increase mobility in a city. Less congested roads mean that commuters can travel further any given time, effectively enabling co-location of companies, industries, government agencies and citizens. However, it also means that the total number of trips increases, reducing the economic benefits. Thus there are counteracting effects, but on overall the gains seem to outweigh the losses. Analyses of road infrastructure projects in other countries has estimated agglomeration effects in a range 10 and 30 per cent of the total economic value of the projects derived from cost-benefit analyses.<sup>59</sup> This means up to 200 million of additional value would be created, giving total economic effects of up to SEK 870 million.

<sup>56</sup> Department of Transport (2008).

<sup>57</sup> We do not have sufficient information to quantify this effect.

<sup>58</sup> See Copenhagen Economics (2014).

<sup>59</sup> Rognlien (2010).

## Chapter 5

# Employment effects: Commercialised driving and increased labour supply

A well-functioning peer-to-peer transport service in Stockholm will affect the level and structure of employment. There will be an immediate increase in employment as citizens travel more, and since citizens replace driving with buying a ride from a peer-to-peer driver. The total effect will be an immediate increase of almost 3,000 jobs. In the long run, a well-functioning peer-to-peer transport service would generate almost 1,000 full time jobs in Greater Stockholm through increased labour supply.

### Immediate employment effect

For every ride that moves from a private cars, bicycle or walking to peer-to-peer transport, employment is created in the short run. The effect for public transport in the short run is also positive: bus drivers will not lose their jobs, as bus routes are unaffected if slightly fewer passengers use them, while these passengers create employment in the peer-to-peer segment.

We estimate that the immediate increase in demand for peer-to-peer transport leads to a gross increase of almost 4,000 jobs, cf. Table 5.1.<sup>60</sup> The effect stems, as described, from the commercialisation of rides, i.e. people switching from driving cars, biking, walking and using public transport to peer-to-peer vehicles. There will be an immediate counter-vailing decline in employment of taxi drivers around 1,000 jobs depending on the degree of substitution between taxi and peer-to-peer transport.<sup>61</sup> Since the number of taxi rides decreases, so does employment for taxi drivers. The total effect will be an immediate increase of almost 3,000 jobs, cf. Table 5.1. These jobs will only lower unemployment in the longer run to the extent that they create jobs for drivers who are coming from unemployment and would have difficulties finding other employment (that is, they reduce the structural unemployment). For example, if 40 per cent of peer-to-peer drivers come from unemployment and would have difficulties finding other jobs, unemployment would decrease in the long run by around 1,200 persons.<sup>62</sup> We find it likely that peer-to-peer transport can reduce structural unemployment in the long run, but we lack information about the background of future peer-to-peer drivers in Stockholm to make a reliable estimate.

<sup>60</sup> By a job, we mean a full-time equivalent (FTE). For example, ten drivers each working four hours per week drive a combined 40 hours per week: the same number of hours as one driver working 40 hours per week. With a 40-hour workweek, those ten drivers constitute one FTE, as does the driver working 40 hours in a week.

<sup>61</sup> In the longer run, this effect will diminish as the reduction in car ownership also increases demand for taxi.

<sup>62</sup> 40 per cent of 3,000. In Chicago, 40 per cent of Uber drivers come from unemployment, based on Uber (nn).

**Table 5.1 Gains in immediate employment from the introduction of peer-to-peer transport in Stockholm**

	Direct jobs created
Taxi	-1,300
P2P ridesharing, single	3,800
P2P ridesharing, several	200
<b>Total</b>	<b>2,700</b>

Note: By a job, we mean a full-time equivalent (FTE). For example, ten drivers each working four hours per week drive a combined 40 hours per week: as much as one driver working 40 hours per week. With a 40-hour workweek, those ten drivers constitute one FTE, as does the driver working 40 hours in a week.

Source: Copenhagen Economics.

### Long term employment effect

In the longer run, new jobs will only be permanently created if labour supply can grow (or if structural employment can be reduced). Though we cannot say whether a peer-to-peer transport service in Stockholm will affect unemployment in the short run, we can estimate that labour supply will increase. This stems from two sources.

*First*, some drivers with ordinary full-time jobs will work additional hours in their spare time. We expect that the flexibility and freedom of peer-to-peer transport will induce some full-time employees to start to work extra because it is a convenient and hassle-free way of earning an additional income. For some, driving is a thing they would have done anyway: *“I mean, one of the reasons I do this is because I just like to drive; it’s a natural hobby of mine to drive, so getting paid to do it is just a plus.”*<sup>63</sup> The latter will be true additions to labour supply.

We have little information about how peer-to-peer drivers would choose to work in the future, but we can make preliminary calculations based on experiences from Uber in Stockholm during 2013 and 2014. We do not know how many of the extra hours are additional to existing work, i.e. hours which would not have been worked had there not been the option of driving peer-to-peer. Some drivers may substitute other part-time work for peer-to-peer driving, and others may leave other jobs entirely. This means that around 700 jobs are additional, since they are worked *in addition* to other work, thereby increasing total labour supply.

*Second*, the lower traffic intensity reduces congestion and generates time savings for citizens. Experience tells us that a part of the time savings will be converted to increased labour supply. We estimated that the average *commuter* would spend up to 7 hours less per year in traffic because of less congestion. Empirical studies have shown that up to 25 per cent of the time savings would be spent by working more. This corresponds to up to 2 hours per year and commuter, and to little more than 200 jobs per year for all commuters, cf. Table 5.2. We assume that only commuters – making around 35 per cent of all trips – choose to increase labour supply as a response to time savings in traffic, as this is

<sup>63</sup> PBS News Hour (2014).

the only group for which the effect, to our knowledge, has been examined. For this reason, the estimate is conservative.

**Table 5.2 Employment effect of time savings from reduced congestion**

	Time saved by commuters (hours per year)	...of which allocated to work (hours per year)	Full-time equivalent jobs
Effect of time savings	7	1.8	220

Note: Full-time equivalents calculated based on a 2,000-hour working-year (8 hours \* 250 working days) and the number of commuters presented in Chapter 5.

Source: Copenhagen Economics.

In all, we conclude that a well-functioning peer-to-peer transport service in the long run would generate almost 1,000 full time jobs in Greater Stockholm through increased labour supply.

## Chapter 6

# Environmental effects: Lower emissions and freed up space

A well-functioning peer-to-peer transport service in Stockholm is likely to have an impact on the environment, both in terms of emissions and land-use. Emissions, in the form of particle and CO<sub>2</sub> pollution, will decrease because the number of vehicle trips declines. Furthermore, a more intensive use of vehicles means that they will be replaced more often. This in turn means that that new fuel-saving and emission-reducing technology will be rolled out quicker, so that the vehicle fleet as a whole will have a lower environmental footprint. Improving utilisation of vehicles will also reduce the demand for parking in the city centre. This will free up space in streets that can be used – for example – for other urgent transport purposes.

### Effects on emissions of pollutants

Vehicles emit a range of pollutants that are harmful to both public health as well as the local and global environment, cf. Box 6.1.

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### Box 6.1 Effects of emissions from vehicles

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Emissions of *particulate matter* (e.g. PM<sub>2.5</sub> and PM<sub>10</sub><sup>64</sup>) from vehicle exhaust from road and tyre wear are inhaled and cause heart- and respiratory disease. *Carbon monoxide* (CO), due to incomplete fuel combustion, reduces human oxygen intake. *Hydrocarbons* (HC) and *volatile organic compounds* (VOC), unburned fuel released with exhausts, are carcinogenic. *Nitrous oxides* (NO<sub>x</sub>), formed when nitrogen from fuel combustion combines with oxygen damage vegetation, contribute to acidification and, when they react with hydrocarbons, form ozone that destroys crops and weathers historic buildings. *Sulphur dioxide* (SO<sub>2</sub>) has many of the same effects as NO. Emissions of *carbon dioxide* (CO<sub>2</sub>) from road transport make up 30 per cent of all greenhouse gas emissions in Sweden.

Source: Trafikverket (2015b).

Even though the emissions of pollutants have fallen significantly in Sweden over the past two decades, they still have a significant impact on the environment and human health.<sup>65</sup> Environmental quality standards for levels of particulate matter are exceeded on several of Stockholm's inner-city streets as well as roads leading into and out of the city.<sup>66</sup> The same holds true for nitrous oxides and ozone. In all, air pollution kills some 5,000 people in Sweden every year according to the Swedish Environmental Research Institute.<sup>67</sup>

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<sup>64</sup> The subscript number represents the diameter of the particles. PM<sub>10</sub> are all particles with a diameter of less than 10 micrometres.

<sup>65</sup> Trafikverket (2015b).

<sup>66</sup> Stockholms Stad (2015).

<sup>67</sup> IVL (2006).

A well-functioning peer-to-peer transport service in Stockholm is likely to have a positive impact on the environment through lower emissions of pollutants. Emissions are likely to decrease for two reasons.

*First*, the number of vehicle trips will decrease by up to 3 per cent. We assume that emissions will decrease proportionally to the decline in vehicle trips. With an estimated reduction of around 13 million trips per year and an average trip length at 13.5 km<sup>68</sup>, we estimate that in total, a well-functioning peer-to-peer service can reduce the distance travelled on roads by up to 180 million kilometres, which translates into a decrease in emissions, cf. Table 6.1.

**Table 6.1 Reduction of emissions from introducing peer-to-peer transport in Stockholm**

Scenario	Pollutant (tons)					
	CO	CO2	HC/VOC	NOX	PM <sub>M</sub> (fuel)	SOX
With peer-to-peer high	23,088	1,724,569	3,895	3,110	60.6	8.6
Without peer-to-peer	23,742	1,773,425	4,005	3,198	62.3	8.9
<b>Emission reduction</b>	<b>-654</b>	<b>-48,856</b>	<b>-110</b>	<b>-88</b>	<b>-1.7</b>	<b>-0.2</b>

Note: Data for 2012. Data for SO<sub>2</sub> only available for all sulphuric oxides. PM<sub>M</sub> (fuel) are emissions from fuel.

Source: Copenhagen Economics based data from Swedish Environmental Protection Agency.

*Second*, the average vehicle in the peer-to-peer fleet is younger than the average private vehicle in Sweden: six<sup>69</sup> and ten years respectively.<sup>70</sup> The age difference creates an additional reduction in emissions to the degree that newer peer-to-peer cars replace older private cars, and that newer cars employ more environmentally friendly technologies than older cars.<sup>71</sup>

Pollution emissions are costly to society. People assign value to their own health and to the health of the environment. Eco-systems furthermore provide services that are valuable to society. Therefore, an economic value can be assigned to the emissions. For the purpose of cost-benefit calculations of transport projects, the Swedish Transport Administration uses a set of costs for these emissions. The costs of these emissions vary significantly depending on where they occur, cf. Table 6.2.

<sup>68</sup> Trivector (2005).

<sup>69</sup> Based on the average age of Uber's vehicle fleet in Stockholm. Source: data from Uber.

<sup>70</sup> Copenhagen Economics based on data from Uber and Motorbranschens Riksförbund (2015).

<sup>71</sup> We do not have sufficient information to quantify this effect.

**Table 6.2 Cost of emissions**

	Pollutant (SEK/kg)						
	CO	CO <sub>2</sub>	HC/VOC	NO <sub>x</sub>	PM <sub>M</sub> (fuel)	PM <sub>M</sub> (wear)	SO <sub>2</sub>
Local average	-	-	45	-	7,697	-	225
Regional	-	-	40	80	-	-	27
Global	-	3.5	-	-	-	-	-

Note: Local effects can vary significantly between from the outer areas of Greater Stockholm to the Stockholm city centre.

Source: Trafikverket (2015b).

Emissions of particulate matter only have local impact, as particles do not move far from where they are emitted. For this reason, local harm varies depending on where the emissions occur: more people are exposed to particles emitted in central Stockholm than on the city outskirts. Other pollutants have more wide-ranging effects. Carbon dioxide spreads in the atmosphere and contributes to climate change that affects the entire planet.

Not including the effect from a peer-to-peer car fleet being younger than the current one, we find that reduced emissions due the lower traffic volumes have a value of about SEK 200 million, cf. Table 6.3. Most of it is a global cost savings related to carbon dioxide. The lower traffic volumes would reduce carbon dioxide emissions annually by around 49,000 tons at a value of up to SEK 171 million. The value of the local and regional cost savings is around SEK 30 million.

**Table 6.3 Economic value of emissions reductions from introducing peer-to-peer transport in Stockholm**

	CO	CO <sub>2</sub>	HC/VOC	NO <sub>x</sub>	PMM (fuel)	SO <sub>2</sub>	Total
Reduction (tons)	654	48,856	110	88	1.7	0.2	-
Local value (MSEK)			5.3		14	0.2	
Regional value (MSEK)			4.4	7		0.1	
Global value (MSEK)		171					
<b>Total</b>		<b>171</b>	<b>9.7</b>	<b>7</b>	<b>14</b>	<b>0.07</b>	<b>202</b>

Source: Copenhagen Economics.

### Effects on land-use

Parking lots on urban streets make use of valuable urban space. On average, cars spend 96 per cent of the time parked<sup>72</sup>, and as much as 30 per cent of city-centre traffic is trying to find a parking space at any given time.<sup>73</sup> A more efficient utilisation of the vehicle pool through the introduction of peer-to-peer transport frees up space that can be used for other purposes such as bike or bus lanes.

<sup>72</sup> Gullberg (2015).

<sup>73</sup> Roland Berger Strategy Consultants (2014).

The introduction of a well-functioning peer-to-peer transport service reduces the number of active cars in private ownership by up to 18,000 vehicles, and the number of cars in Stockholm altogether by 45,000. This corresponds to a decline in the number of private vehicles by around 5 per cent. While we do not know the total area reserved for parking in Greater Stockholm, road side parking space in the city of Stockholm occupies 2.5 million square metres, or 1.3 per cent of the total area of Stockholm.<sup>74</sup> This corresponds approximately to the size of *Östermalm*, a central area of Stockholm.<sup>75</sup>

If we assume that the reduction of the number of cars translates into an equal reduction in the demand for parking space, a 5 per cent reduction in parking space means that an area corresponding to 63 km bike lanes (two metres wide) could be freed up in Stockholm City.

The reduced need for parking will also lower the costs of snow mowing and street cleaning in Nordic capitals. Snow moving, for example, can carry significant costs. Stockholm City alone uses between SEK 150 and 300 million per year, depending on the might of winter. In streets where parking space is converted into bike lanes, Stockholm City can plough in a single working procedure, and save a second weekly ploughing in the pre-defined period where use of parking spaces is disallowed.

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<sup>74</sup> The entire area of Stockholm City is 187 million square meters.

<sup>75</sup> Gullberg (2015).

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