Study on Environmental Impacts and Economic Implications of Car-Sharing

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1. Introduction

1.1 The definition of CS

The concept of car-sharing (CS) is referred to using different terms in different countries. In the United Kingdom, the term “car-sharing” refers to the shared use of a single vehicle by multiple parties at the same time, which is otherwise known as carpooling or ridesharing in North American parlance. In British usage, the term “car club” is generally used to refer to the practice of sharing vehicles rather than rides (Table 1.1).

Table 1.1 Terminology used to refer to CS

Feature	North American Usage	British Usage
Vehicles owned by a separate organization and shared between a number of different users, who may use them at different times	Car-sharing	Car clubs
Privately owned vehicles shared for a particular trip	Carpooling, ridesharing	Car-sharing

Source: Millard-Ball, A., Murray, G., Shure, J.T., Fox, C. and Burkhardt, J.: Car-Sharing: Where and How It Succeeds, TCRP Report 108, 2005:Page 2-1

From the viewpoint of a product service system (PSS), and for the purposes of this study, CS is defined as a "car utilization providing service," in which vehicles are owned by a separate organization and shared between a number of different users, who have the option to rent them for different periods of time (typically, by the hour or less). As such, our definition of CS is similar to its North American definition.

1.2 CS from the perspective of urban transport

CS is targeted at people who will use this service for any purpose such as extravagant shopping expeditions, weekend trips to second homes, or visits with friends or family members who live at a distance.
The most significant factor that has spurred CS development is the need to fill the gap among vehicle utilization models of urban transport. The following two figures compare CS to other vehicle utilization models from the standpoints of flexibility, exclusivity, continuous service time, and distance.

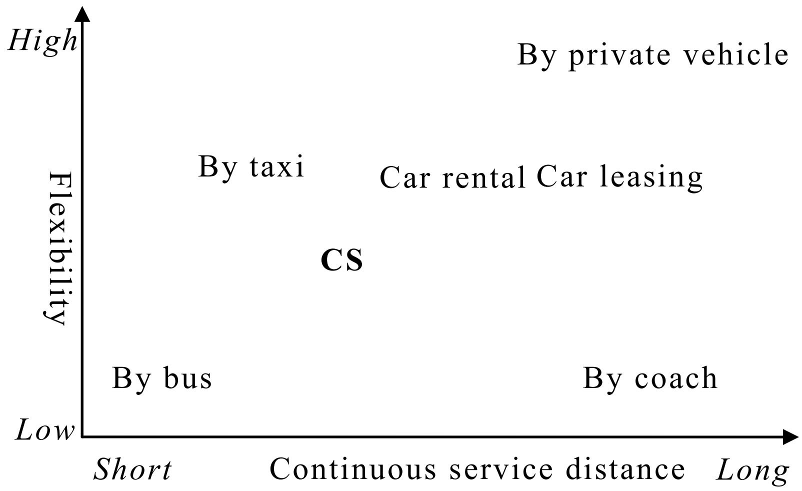

Fig 1.1 Comparison in terms of flexibility and continuous service distance for different modes of urban transport

Source: Author's elaboration

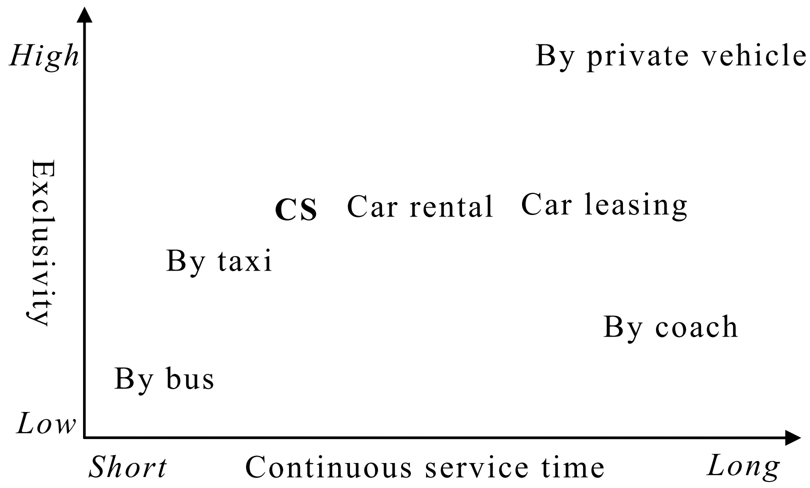

Fig 1.2 Comparison in terms of exclusivity and continuous service distance for different modes of urban transport

Source: Author's elaboration

1.3 The development of CS business

1.3.1 History

The earliest CS program can be traced back to 1948, during which year the Sefage program was carried out in a housing cooperative in Zurich, Swizerland. Since this program was implemented, attempts to implement CS were eventually made in motorized countries. Table 1.2 provides the historical overview of the CS pilot programs carried out in motorized countries.

Table 1.2 Historical overview of car-sharing pilot programs carried out in motorized countries

Starting Time	Program name	Country
1948	Sefage	Swizerland
1971	Procotip	France
1973	Witkar	Netherlands
1976	Bilpoolen	Sweden
1977	Green Cars	Britain
1983	Mobility Enterprise, STAR	The U.S.
1997	Community car-sharing	Singapore
1999	Ebina Eco park-and-ride	Japan

Source: Car-Sharing: Where and How It Succeeds and Application of Revenue Management on Dynamic Pricing of Car Sharing.

Although CS originated in Europe between the 1940s and1980s, it did not become popularized until the early 1990s. Similar developments began in Switzerland and Germany in the late-1980s and later spread to 13 other countries across Europe and the British Isles. In the 1990s, CS businesses were also started in North America and Asia. Australia launched three CS initiatives in 2003.

For almost two decades, there has been growing worldwide participation in CS initiatives, with businesses related to CS operating in approximately 600 cities worldwide. Approximately 348,000 individuals shared nearly 11,700 vehicles as a part of organized CS services (with over 60% of these services existing in Europe) in 2006[1]. However, the scope of CS is limited to a metropolis setting, owing to traffic congestion and well-developed public transit, and it has almost no existing market in medium and small-sized cities.

1.3.2 Modes

CS programs have begun to appear in numerous forms throughout the world. From the viewpoint of consumer types, CS is appealing to not only individual consumers but also corporate consumers within a country.

From the viewpoint of its organizational structure, CS can be divided into the following categories: for-profit, non-profit, and cooperative. Among the service items provided, there are services that include only car utilization, while other services include bus discharge and even package services.The vehicle types used in CS programs include saddens, trucks, green gas vehicles, and electric vehicles (EV), among others. Further, the CS business is divided into three primary types of programs from the viewpoint of vehicle location, with a detailed explanation provided for every mode.

1. Neighborhood car-sharing mode

The primary mode of CS programs in Europe consists of neighborhood car-sharing programs. Neighborhood car-sharing programs are mainly for people who want the convenience of using a personal automobile but cannot afford to purchase their own cars or cover related expenses. These programs were created when groups of people bought several vehicles in collaboration and then used these vehicles by sharing. In these grassroot-level programs, successful programs were eventually developed

[1] SusanA. Shaheen, Adam ECohen. Worldwide carsharing growth : an International comparison[J]. Transportation Research. 2006 : 1—1 8

into programs of a multi-node mode.

The typical pattern followed in the neighborhood car-sharing mode is applicable to densely populated urban areas. Within these areas, there are usually some fixed locations dedicated to car-share parking for its members. Members typically need to make a reservation before using the cars, and after confirming the reservation, the cars can be taken and used. After the vehicle has been used, it must be returned to its designated parking space. The cost for using these cars is calculated according to the time and distance covered in each use. The car-sharing organization is also responsible for other expenses such as team-building and maintenance. As such, an organization serves a particular the neighborhood, members are always close by from the car parking space and find it easy to use the car-sharing service. Most of these organizations also charge a monthly registration or deposit fee.

Throughout the world, the neighborhood car-sharing mode has been used in many emerging car-sharing organizations. Parking places are located within residential areas, although, occasionally, parking is provided within the city business districts.

2. Station car-sharing mode

A second type of CS mode is the station car-sharing mode. This mode has been used in many countries, but it is most popular in the United States. The earliest and most popular station car-sharing model consists of fleet vehicles parked at the city railway station, thereby providing a link between the workplace and home as a commuting traffic tool. Promoters of these systems use railway transportation and believe that this program will reduce the demand for parking while increasing public transport use. Although it is not a typical CR mode, the station CS mode is often used to improve public transport efficiency. Therefore, this mode is characterized by a relatively low person/vehicle ratio at many stations.

The station CS mode is heavily based on the use of electric or hybrid vehicles in several large United States cities. The main reasons for choosing electric vehicles (EV)s are as follows: EVs do not require a complex fuel transportation systems; they represent a reduction in gasoline-burning engine systems and related maintenance, (with the number of motor parts to be reduced from 10000 with fuel-burning engines to 1500 of two-seater EVs); and, of course, the EV produces less air, noise, and water pollution than gasoline-burning vehicles. While an EV is being charged at the station, it is also possible to perform its cleaning, maintenance, and scheduling.

3. Multi-node car-sharing mode

Compared with the two previously described car-sharing modes, the multi-node car-sharing mode is more accessible. This mode involves the use of cars parked at a number of car parks, allowing users to drive the cars from one active site (node) to another active site (node) without having to return the car back to its original location. This mode can be widely applied to large tourist centers and is also ideal for recreation and corporate settings or university campuses. For example, a tourist who arrives in a city by plane or train is able to drive to a hotel by borrowing a sharing car. The tourist is then able to drive the same car to go shopping or to another tourist destination.

A primary difference between the multi-node and traditional car-sharing models is the two-way drop-off/pick-up formula of traditional models. With the multi-node mode, most uses involve a one-way journey. One of the problems associated with the one-way trip mode is an uneven distribution of vehicles between sites. To balance this distribution, some vehicles may have to be transported manually back to origin sites by non-users.

1.3.3 Barriers to developing CS business

The following factors are identified as barriers or potential issues in developing CS businesses. (in ` Car-sharing: Where and How It Succeed`(2005)).

- Finding a partner
- Understanding car-sharing
- Lack of data
- Financial barriers
- Regulatory obstacles
- Parking provision
- Serving low-income participants
- Geographic and cultural barriers

It is also mentioned in (Author, date) that the support of government and other stakeholders, such as automobile manufacturers and public transit operators, is necessary when considering the ways to overcome most of these barriers.

As the first step to win the support of these entities, a quantitative analysis of the savings expected to arise from the development of a local CS program should be developed. This analysis should assess local economic and environmental conditions and needs. Hence, research from environmental impact assessments and the economic implications of CS programs are discussed next.

2. Assessment of environmental impacts of CS

2.1 Potential environmental benefits from CS

According to the related references, the potential environmental benefits associated with CS programs are summarized in Figure 2.1.

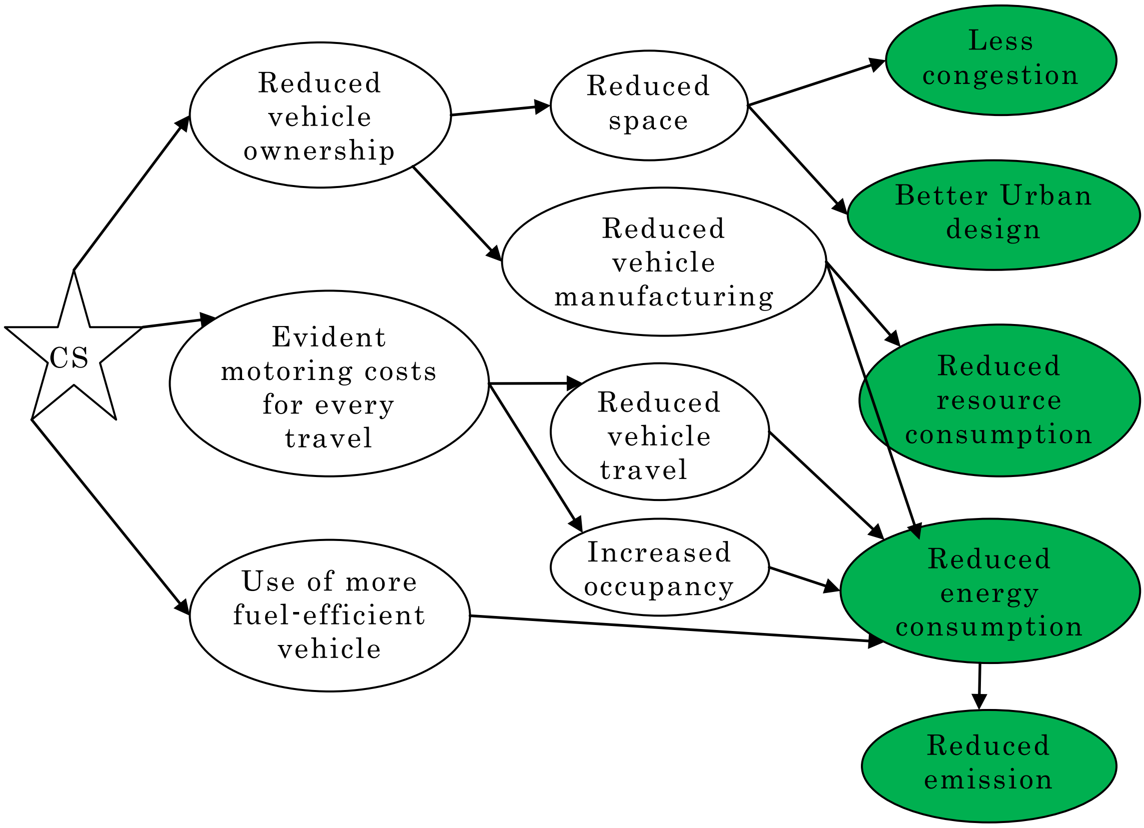

Fig 2.1 Potential environmental benefits from CS

Source: Author's elaboration based on related references

2.2 Empirical research related to the environmental impacts of CS

The existing published assessments developed to study environmental impacts and advantages of CS programs are generally based on empirical research obtained from cross-sectional or longitudinal surveys. These studies have frequently involved asking participants to provide information about their daily commuting habits. Table 2.1 provides a representative example.

Table 2.1 Representative empirical researches related to CS

Location	Survey method	Time frame	Vehicle type	Participant	Indicator	Reference
Europe						
Switzerland	Cross-sectional surveys	1998	Unknown	511 CS members (carless, car owner, (substituter, second car driver)) and 340 potential members who understand CS well	Gasoline consumption CO_2 emission	Energie, 2000; Muheim, 1998
Leiden, Netherlands	Cross-sectional surveys	1999	Unknown	337 CS adopters (carless, car owner, (substituter, second car driver)) and 807 non-adopters	CO_2, CFC-11, SO_2, PO_4 emission Airborne heavy metal carcinogens Winter smog Summer smog nuclear radiation Solid matter Parking space	Changing Consumer Behaviors through Eco-efficient Services An empirical study on Car Sharing in the Netherlands (Rens Meijkamp, 2000)
North America						
San Francisco, U.S.A.	Longitudinal survey (daily transportation)	2001.3~2003.4	48 Volkswagen, Beatle	462 members and 54 nonmembers	CO_2 emission, Gasoline consumption CO_2 emission	Second-Year Travel Demand and Car Ownership Impacts (Robert Cervero, 2004)

Continue

Asia						
Toyota City, Japan	Cross-sectional surveys	2001.10	9 compact EVs	118 CS members	CO, NO_x emission, Electric consumption	
Fukuoka City, Japan	Longitudinal survey	2003.11~ 2004.9	24 EVs and Green gas vehicles	330 CS members(260 individual members, about 70 corporate members)	CO_2 emission	Report on CS Business in Fukuoka City (NPO Car sharing network, 2005)
Osaka City, Japan	Cross-sectional surveys and Longitudinal survey	1999.12~ 2001.3	24 electric trucks	Corporate member (321 samples)	CO_2, NO_x emission	Tests on Cooperative Use of Electric vans for City Logistics (Shichi TAKEUCHI,etc.,2005)
Beijing, China	Cross-sectional surveys (intercept survey and follow-up in-depth interview	2005.9~2006.7	—	447 carless and 172 car owners	CO_2, CFC-11, SO_2, PO_4 emission airborne heavy metal, carcinogens, winter smog, summer smog, nuclear radiation	The Economic and Ecological Efficiency of Car Sharing Service and the Feasibility to Implement the Service in Beijing (XIA Kai-xuan, 2006)

Source: Author's elaboration

It has been found that there is remarkable consistency among the majority of empirical researches conducted; in other words, these reports show that CS is found to reduce emissions and gasoline consumption. While the extent of these benefits has not been established, the benefits of CS programs are likely to be as significant due to local circumstances—both geographic and based on the nature of the car-sharing program—as due to research design.

2.3 Shortcomings of existing related research

2.3.1 Reliability of survey results

Much of the existing empirical research on the environmental impacts of CS is conducted by operators themselves or by other advocates having a strong interest in promoting CS programs. Sample sizes are often small, and in-depth research is often conducted early in the program's history. This means that the behavior of early adopters may not reflect those of members in later years. Many studies (particularly those conducted by operators themselves) are not published in full, with only a summary "fact sheet" released. This makes a thorough analysis of their data impossible. Meanwhile, many car-sharing members are themselves evangelists for the concept: a particular problem where the survey methodology relies on respondents to predict how they would have behaved in the absence of the car-sharing program (should they have owned a car, for example). For these reasons, many of the assessment results are disappointing in quality.

2.3.2 Estimation range

According to Figure 2.1, there are five environmental benefits associated with CS programs. However, with the exception of quantitative analyses on

congestion and urban design benefits, an estimation as to how resources and energy reduction efforts have been impacted by these programs is not found in any of the empirical studies. Environmental benefits from the use of more fuel-efficient vehicles are also not discussed in some of the studies.
Additionally, environmental impacts associated CS system infrastructure itself (such as increased car station and public transit), as well as the management of CS department operations, are not mentioned in any the studies assessed here.

2.3.3 Estimation method

Nearly all of the related researches calculate decreases in gasoline consumption and emission reductions associated the implementation of CS programs. Vehicle travel growth associated with increased mobility for low-income households has not been subtracted from the calculated reductions. In another words, net impacts on vehicle travel are not accurately calculated in many of the existing studies. Environmental impacts associated with using another type of conveyance (aside from cars) which substitute for vehicles are also not calculated.

Thus, the implication life cycle of all the empirical researches discussed here is short, ranging from a few months to two or three years. The estimation that considers the service time of CS is not found in these studies. In summary, there is no research conducted from a life cycle point of view.

Finally, major environmental assessments of CS do not consider the intensity of CS service and or include a needs satisfaction survey of the CS's target population. Only the following studies discuss these factors: `Changing Consumer Behaviors through Eco-efficient Services an Empirical Study on Car Sharing in the Netherlands (Rens Meijkamp, 2000)` and `The Economic and Ecological Efficiency of Car Sharing Service and the Feasibility to Implement the Service in Beijing (XIA Kai-xuan, 2006)`.

However, in the interest of ecological efficiency and Product Service System life cycle, a sustainable business needs to meet consumer needs for service while minimizing environmental impacts. Therefore, we believe that both service intensity[1] and needs satisfaction assessments should be included into data when conducting comprehensive environmental assessments of CS.

3. Analysis on economic implications of CS

The development of CS programs is considered to be one of the greatest threats to economic development associated with car ownership, as the growth of CS programs leads to the total revenue reduction for the automobile sale industry. Hence, as an analysis on economic implications of CS, the operating rates discussed here involve comparisons among car selling and car-sharing profits.

3.1 The calculation formula for the CS marginal operation rate

The CS pricing system of ORIX Auto Corporation is chosen here to represent pricing models and the average CS fee level in Japan. According to the ORIX CS fee structure, the following equation can be used to calculate the marginal operating rate.

$$\mathrm{VR} \times \mathrm{AP} = \mathrm{UF} \times \mathrm{OR} \times \mathrm{ST} + \mathrm{BF} \times \mathrm{MN}$$

Therefore,

$$\mathrm{OR} = (\mathrm{VR} \times \mathrm{AP} - \mathrm{BF} \times \mathrm{MN}) \div (\mathrm{UF} \times \mathrm{ST}), \qquad (1)$$

where

OR — Operating rate

[1] Service/product quantity. For CS, it is usually the number of CS members/number of CS vehicles

VR — Private vehicle reduction contributed by one CS vehicle

AP — Average price of private vehicle

UF — CS utilization fee

ST —Service time of CS vehicle

BF — CS basic fee

MN — Member number for one CS vehicle

It should be pointed out that CS vehicles of the ORIX Auto Corporation are generally sold as a secondhand vehicle through public bids or to individuals through retail shops.

UF ofa CS vehicleis calculated for a per-month fixed fee (UFm), per-hour fee (UFt), and per-kilometer fee (UFd) in the current CS pricing system of ORIX Auto Corporation.

In order to transform UFm, UFt, and UFd into a single unit, we use the average speed (AS) of a CS vehicle. The calculation formula for the CS utilization fee can be expressed as follows.

$$UF = UFm \div (30 \times 24) + UFt + UFd \times AS \quad (2)$$

By substituting (2) into equation (1), we have the equation:

$$OR = (VR \times AP - BF \times MN) \div ((UFm/720 + UFt + UFd \times AS) \times ST) \quad (3)$$

3.2 The value of parameters

The Private Vehicle Reduction contributed by a single CS vehicle in Japan can be estimated according to the impact assessments conducted in Europe and the U.S. Due to differing local circumstances, the value varies (See Table 3.1), and hence, the estimated value is not precise but is given by a certain range.

The average price of private vehicles is represented by the average price of passenger vehicles specifically in Japan. The member number of one CS vehicle is calculated by determining the total car-sharing vehicles and members in Japan. The average speed of a CS vehicle is represented by the national average tourism speed in a densely inhabited tourist district of Japan. The average service time of CS vehicle is represented by the average service time of a passenger vehicle in Japan. The CS basic fee, UFm, UFt, and UFd have been acquired from plan A of ORIX Auto Corporation's CS rate-table, which is the most popular choice. The details of the data values and data sources are as follows.

Table 3.1 Impacts on Vehicle Ownership after 2000

Reference	Region	Given-up a Vehicle	Members Per CS Vehicle	Private Vehicles Replaced per CS Vehicle*
Hope (2001)[2]	Edinburgh	32%	16	5.1
Holm & Eberstein (2002)[3]	Dresden	10%	35	3.5
Smart Moves (2003)[4]	England	37%	15	4.5
Rydén & Morin (2005)[5]	Bremen	34%	19	6.5
Rydén & Morin (2005)[6]	Belgium	21%	18	3.8
European Average		**22%**	**20**	**4.7**

[2] Hope, Steven (2001). *Monitoring and Evaluation of the Edinburgh City Car Club*. Scottish Executive Central Research Unit. Accessed March 29, 2004 at www. scotland.gov.uk/cru/ kd01/ blue/carclub-04.asp.

[3] Holm, Birger and Eberstein, Frank Müller (2002). "Car-Sharing and PT. The Dresden Model." Public Transport International, June 2002, pp 18-22.

[4] SmartMoves(2003). "*Using cars to reduce car use in local transport planning.* "Carplus Thestudio 32 The Calls, Leeds LS2 7EW

[5] Rydén, Christian and Morin, Emma (2005). MOSES Environmental Assessment Report. Accessed February 1, 2005 at: 213.170.188.3/moses/Downloads/reports/ del_6.pdf.

[6] Rydén, Christian and Morin, Emma (2005). MOSES Environmental Assessment Report. Accessed February 1, 2005 at: 213.170.188.3/moses/Downloads/reports/ del_6.pdf.

Robert (2000)[7]	Montreal, QC	21%	17	3.5
Robert (2000)[8]	Quebec City, QC	29%	17	4.7
Katzev, Brook & Nice (2000)[9]	Portland, OR	26%	13	3.5
Zipcar (2001)[10]	Boston, MA and Washington, DC	15%	20	3.0
Jensen (2001)[11]	Vancouver, BC	28%	18	5.0
City CarShare (2002)[12]	San Francisco Bay Area, CA	20%	25	5.0
Cervero & Tsai (2003) [13]	San Francisco, CA	24%	25	6.0
Robert Cervero, (2004)[14]	San Francisco, CA	33%	24	7.0
AutoShare, email	Toronto, ON	15%	22	3.3
Communato (2004)[15]	Quebec (4 cities)	32%	20	6.4
Lane (2005)[16]	Philadelphia,	21%	23	4.7

[7] Robert, Benoît (2000). Potentiel de l'auto-partage dans le cadre d'une politique de gestion de la demande en transport. Paper presented at Forum de l'AQTR, gaz à effet de serre: transport et développement, Kyoto: une opportunité d'affaires?, Montréal, February 7 2000.

[8] Robert, Benoît (2000). Potentiel de l'auto-partage dans le cadre d'une politique de gestion de la demande en transport. Paper presented at Forum de l'AQTR, gaz à effet de serre: transport et développement, Kyoto: une opportunité d'affaires?, Montréal, February 7 2000.

[9] Katzev, Richard; Brook, David; and Nice, Matthew (2000). "The Effects of Car Sharing on Travel Behavior: Analysis of CarSharing Portland's First Year," World Transport Policy & Practice, 7(1): 22-26.

[10] Zipcar (2001). Factsheet on Zipcar service.

[11] Jensen, Nicole (2001), The Co-operative Auto Network Social and Environmental Report 2000-01. Vancouver: Co-operative Auto Network.

[12] City CarShare (2002). City CarShare Vehicle Ownership Survey.

[13] Cervero, Robert and Tsai, Yu-Hsin (2003). San Francisco City CarShare: Travel Demand Trends and Second-Year Impacts. University of California at Berkeley, Institute of Urban and Regional Development. Working Paper 2003-05.

[14] Robert Cervero(2004)Second-Year Travel Demand and Car Ownership Impacts'. TRB 2004 Annual Meeting

[15] Communauto (2004). Résultats du Sondage 2004. Accessed June 21, 2005 at: www.communauto.com/sondage04_resultats0.html

[16] Lane, Clayton (2005). PhillyCarShare: First-Year Social and Mobility Impacts of Car Sharing in Philadelphia. Paper presented at Transportation Research Board

	PA			
North American Average		**20%**	**24**	**5.2**
Combined Average		**21%**	**23**	**4.7**

Data source: Author's elaboration from various literatures shown in footnotes.

Note:* Excluding impacts of forgone purchases. Many surveys do not distinguish between respondents who have relinquished car because they were using CS or some other means of transport. Where available, the data in the table refer to those who have given it up because of CS.

Table 3.2 Values of parameters for CS marginal operating rate calculation

Parameter	Value
VR	3~7 vehicles [1]
AP	2,082,116 Yen[2]
BF	6250 Yen
MN	18.7[3]
ST	126 months[4]
AS	21 km/h[5]
UFm	2000 Yen per month
UFt	800 Yen per hour
UFd	15 Yen per kilometer

Data source: [1] "3" is the minimum value and "7" is maximum value according to Table 3.1;[2] The data from「時間価値原単位および走行経費原単位（平成 20 年価格）の算出方法」(Ministry of Land, infrastructure, transport and tourism, 2008);[3] The total number of car-sharing vehicles and the number of car-sharing members in Japan has reached 3911 and 73224 by January, 2011 according to the survey conducted by The Foundation for Promoting Personal Mobility and Ecological Transportation (ASAHI newspaper(evening),2011/2/21);[4] The data is from「平成 22 年版わが国の自動車保有動向」(Automobile inspection & registration Information Association, 2010);[5] The data is from 「平成 17 年度道路交通センサス」(Ministry of Land, infrastructure, transport and tourism, 2005)

3.3 The calculation result of the CS marginal operation rate

By substituting the values in Table 3.2 into equation (3), the CS marginal operating rate in Japan is estimated to fall within the range of 6% to 14.3%.More specifically, when one CS vehicle can replace 3 private vehicles, the total revenue reduction estimated by the use of the CS vehicle is inaccurate if that vehicle operates for 77 minutes (about 1.3 hours) every day. In the scenario where one CS vehicle replaces 7 private vehicles, the total revenue reduction estimated by the use of that CS vehicle is inaccurate if that vehicle operates for 206 minutes (about 3.4 hours) every day.
Hence, it can be deduced that when CS vehicles are operated for no less than 3 hours and 30 minutes, the automobile manufacturer can increase sales by running a CS business instead of selling cars. However, it should be pointed out that the future discounting has not been taken into account the calculation in this paper. If taking it into account, the results may be somewhat different.

References

English

City CarShare (2002). *City CarShare Vehicle Ownership Survey*.

Cervero, Robert and Tsai, Yu-Hsin (2003). *San Francisco City CarShare: Travel Demand Trends and Second-Year Impacts*. University of California at Berkeley, Institute of Urban and Regional Development. Working Paper 2003-05.

Communauto (2004). *Résultats du Sondage 2004.* Accessed June 21, 2005 at: www.communauto.com/sondage04_resultats0.html

Holm, Birger and Eberstein, Frank Müller (2002). “Car-Sharing and PT. The

Dresden Model." *Public Transport International*, June 2002, pp 18-22.

Hope, Steven (2001). *Monitoring and Evaluation of the Edinburgh City Car Club*.
Scottish Executive Central Research Unit. Accessed March 29, 2004 at www.
scotland.gov.uk/cru/ kd01/ blue/carclub-04.asp.

Jensen, Nicole (2001), *The Co-operative Auto Network Social and Environmental*
Report 2000-01. Vancouver: Co-operative Auto Network.

Katzev, Richard; Brook, David; and Nice, Matthew (2000). "The Effects of Car Sharing on Travel Behavior: Analysis of CarSharing Portland's First Year," *World Transport Policy & Practice,* 7(1): 22-26.

Lane, Clayton (2005). *PhillyCarShare: First-Year Social and Mobility Impacts of*
Car Sharing in Philadelphia. Paper presented at Transportation Research Board
84th Annual Meeting, Washington, DC, January 9-13, 2005

Robert, Benoît (2000). *Potentiel de l'auto-partage dans le cadre d'une politique*
de gestion de la demande en transport. Paper presented at Forum de l'AQTR,
gaz à effet de serre: transport et développement, Kyoto: une opportunité d'affaires?, Montréal, February 7 2000.

Robert Cervero(2004)Second-Year Travel Demand and Car Ownership Impacts'. *TRB 2004 Annual Meeting*

Rydén, Christian and Morin, Emma (2005). *MOSES Environmental Assessment*
Report. Accessed February 1, 2005 at:
213.170.188.3/moses/Downloads/reports/
del_6.pdf.

SmartMoves(2003). "*Using cars to reduce car use in local transport planning.* "Carplus Thestudio 32 The Calls, Leeds LS2 7EW

SusanA. Shaheen, Adam ECohen. Worldwide carsharing growth : an International comparison[J]. Transportation Research. 2006 : 1—1 8

Zipcar (2001). Factsheet on Zipcar service.

Japanese

平成 17 年度道路交通センサス, Ministry of Land, infrastructure, transport and tourism, 2005

時間価値原単位および走行経費原単位（平成 20 年価格）の算出方法, Ministry of Land, infrastructure, transport and tourism, 2008

平成 22 年版わが国の自動車保有動向, Automobile inspection & registration Information Association, 2010 国土交通省自動車交通局監修：自動車検査登録情報協会編集 2010/10