Carsharing in Shanghai, China

Analysis of Behavioral Response to Local Survey and Potential Competition

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The rapid motorization of China raises questions about the potential for alternative mobility solutions, such as carsharing (short-term auto use), used in developing megacities such as Shanghai. Demand for motor vehicles is increasing rapidly, but many aspects of urban transportation in Shanghai and in China more broadly separate the city and the center from other urban environments in which carsharing has thrived traditionally. For example, the taxi is much more prominent in the transportation systems of Shanghai and Beijing than in most North American and European cities. Carsharing tends to thrive in environments in which the broad population has experience with driving and automobile ownership. This experience is lacking in Shanghai. To evaluate carsharing's potential in Shanghai, the size and competitiveness of the taxi systems of key carsharing cities in Europe, North America, and Asia were compared. The analysis illustrated core distinctions between Shanghai and other major cities in which carsharing has thrived. To explore further the potential response of Shanghai's citizens to carsharing, a survey was conducted ($N = 271$) of a subpopulation in Shanghai from November 2010 to February 2011. The survey analysis showed that those interested in carsharing were younger, more likely to be educated, had longer commutes, and owned fewer cars than those with no interest in carsharing. This paper concludes with a discussion of this study's implications for the development of a carsharing industry in Shanghai.

Carsharing provides individuals with short-term access to automobiles to complete personal trips within an urban region. In Europe, North America, Australia, and parts of Asia, carsharing has emerged as a means to facilitate temporary access to personal vehicles without ownership costs (*1*). The neighborhood carsharing model, which strategically locates operator-owned or leased vehicles within residential areas of urban environments, has been the most popular approach to date. Typically, third-party operators target large, densely populated areas with high parking costs and robust public transportation networks. Success has been achieved overwhelmingly within traditionally industrialized societies with a history of motorization. Rapidly motorizing economies, such as China, have not experienced major initiatives in carsharing to date.

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China's explosive economic growth has increased the demand for urban automobility. Overall, however, vehicle penetration is still low; China has 46 vehicles per 1,000 people versus the ~800 vehicles per 1,000 people in the United States (*2–5*). Even so, the rapid pace of China's growth portends considerable change with respect to mobility. At the same time, the successful deployment of bikesharing (shared-use, public bicycles) in China and elsewhere has raised new questions about the appropriate paradigm of shared-use vehicle mobility that might evolve in cities, such as Shanghai (*6*).

Several societal distinctions could influence how carsharing might operate and thrive in China. Historically, carsharing has been successful in highly motorized societies. In China, however, carsharing would have to grow in a fundamentally different environment within a population that had not had experienced widespread vehicle ownership or auto access. Thus, if carsharing were to be successful in China, its impact would likely be different in nature than elsewhere. Research in Europe and North America has shown that carsharing lowers vehicular emissions and ownership (*1, 6–17*). Because there are fewer vehicles and miles driven to eliminate, carsharing accelerates auto access in the short term. Nevertheless, China is rapidly building new cities and, in tandem with its built infrastructure, could encourage shared-use vehicle mobility in lieu of personal auto ownership. In the long term, this approach might alter the path of traditional motorization if it were broadly adopted in urban China. Thus China could become a country in which carsharing enabled vastly more individuals to access automobiles for the first time and in turn reduced the need (or desire) for personal auto ownership among people that never had owned a vehicle in the first place.

Another distinction in China is the considerable competition that carsharing would face from the well-established and inexpensive taxi and public transit systems. Carsharing would also face challenges to overcome legal hurdles and to obtain governmental support. In addition, carsharing is a relatively unfamiliar mode to most Chinese citizens. A recent survey in Beijing found that less than 40% of respondents were familiar with carsharing (*15*). Thus initial advertising and educational efforts would likely be needed (as they once were in the United States).

To evaluate the potential customer base of carsharing in Shanghai, researchers conducted a survey of 271 respondents in Shanghai from November 2010 to February 2011. The survey explored the potential response and interest in carsharing among a Shanghai subpopulation. This research also explored exogenous factors in urban regions that could influence the degree to which carsharing might compete with the taxi.

This paper is organized into four sections. First, a review is provided of past carsharing programs in China and related research. Next, the challenges faced by carsharing in China, as distinct from those in

North America and Europe, are examined. Third, the study methodology is introduced. A review of the results is set out in the fourth section. To build on the insights from the analysis, the paper concludes with a discussion of how carsharing may best be designed within China to deliver the goals of efficient automobility and long-term economic sustainability.

LITERATURE REVIEW

Carsharing began in Europe and dates back to the late 1940s. However, it was not until the 1980s that modern carsharing began to take hold in central Europe. The concept was then exported to North America, where it arrived in Canada in the mid-1990s. Since then, carsharing systems have continued to flourish across the continent (*1*).

As of October 2010, the carsharing industry was established in 26 countries and comprised 1,250,000 members, who were served by 31,000 vehicles (*18*). Within that population, Asian organizations contributed 77,817 members that shared 4,410 vehicles. By late 2011, there were 35 carsharing operators in Asia: one in Israel and 34 in four East Asian countries (i.e., Japan, Singapore, South Korea, and now China). By comparison, in July 2011, North America had more than 639,000 members, who shared more than 12,600 vehicles (*18*). Researchers that evaluated the industry's growth and its impact on vehicle ownership and emissions found that, in general, carsharing reduced both (*12, 15–17, 19–21*).

Carsharing systems in Asia have evolved separately from those in Europe and North America. In Japan, many early systems were project-based and characterized by advanced technology both in operations and in the use of electric vehicles (*20*). Early business models focused on service to downtown business customers. However, the industry has since evolved toward the neighborhood business model and drastically reduced its emphasis on electric vehicles. The other major center of carsharing in Asia is Singapore. Singapore's carsharing programs were less directed to reduce auto ownership and more oriented to provide access and mobility to residents interested in the use of a vehicle. Early programs in Singapore applied advanced technology and experimented with one-way trips more than with electric vehicles, but, like Japan, Singapore's programs later converged to provide more traditional carsharing services (*8*). Outside of these two countries, carsharing has been slow to take hold in Asia; it was introduced in South Korea only recently.

Although the carsharing industry has struggled to expand its footprint in Asia, bikesharing has flourished in several cities worldwide, and quite prominently in Hangzhou, China. Unlike carsharing, bikesharing more readily permits one-way trips and overcomes last-mile connectivity concerns often associated with public transit. Recent research on bikesharing in Hangzhou found that 30% of respondents used bikesharing in conjunction with a public transportation mode as part of their commute (*22*). By March 2011, the Hangzhou bikesharing system had grown to 60,600 bicycles, with 2,416 fixed stations in eight core districts (*22*). Although bikesharing has been found to benefit the public through the augmentation of public transit, it is subject to large operational costs and has not yet attained economic self-sufficiency (*23*).

Carsharing in its traditional neighborhood form faces several unique barriers that are less relevant to bikesharing. Similar to other Asian cities, urban environments in China have expensive parking costs, and urban highways already are congested with vehicles. Overall, the body of literature devoted to carsharing in China is small. Although recent research in China has focused on neighborhood carsharing operations, analyses of consumer response, or of existing operations, are limited (*24, 25*).

To evaluate how citizens in China might respond to carsharing, Shaheen and Martin explored the concept in Beijing with a survey of 840 respondents in 2006 (*15*). The survey results revealed that more than 25% of respondents were highly interested in carsharing, although only 40% of this group had been familiar with the concept previously. Respondents interested in carsharing were more inclined to take public transit, bicycle, and walk. They also had slightly higher education levels, were less auto-reliant, and had some desire to purchase a vehicle. Only 21% of respondents reported the ability to drive, which indicated that driver education might be critical to the adoption of carsharing. This and other challenges suggest that any carsharing industry that emerges in China may evolve differently than it has in Asia and elsewhere.

CARSHARING CHALLENGES IN CHINA

Despite considerable growth in motorization and demand for auto ownership, only two carsharing operators—EdoAuto in Beijing and Dazhong in Shanghai—existed in China as of 2011. EdoAuto operates in the suburban regions of Beijing and advances a business model similar to the neighborhood carsharing model (*26*). As of July 2011, EdoAuto had 60 members and six vehicles located in four parking lots. The center of the EdoAuto network is about 20 km from the center of Beijing. As a private company, EdoAuto does not operate in a direct relationship with the local government (*26*). The Dazhong system in Shanghai is quite different, and it is currently the closest model that Shanghai has to carsharing at this time. Dazhong offers services that are probably better described as "taxi-sharing," in which the driver is supplied by the company. Consumers make reservations online for trips that may be shared with strangers (*27*). Dazhong is the biggest taxi and car-rental company in Shanghai and possesses almost 20,000 vehicles that operate in the city. The company also is involved in a number of other industries, which include bus transit and real estate development (*27*). Dazhong's entry into carsharing in 2011 was small and experimental, with only four taxi-sharing vehicles (*28*). Nevertheless, Dazhong's approach may represent a practical carsharing business model in China. Through the combination of services with an existing taxi fleet, the company has avoided the need to establish a network of vehicles in urban regions with scarce parking and high land costs.

In this respect, a major challenge that carsharing faces in Chinese cities (particularly in Shanghai) is the prominent role that taxis play within the transportation system. Taxis in Chinese cities have a competitive advantage because of their cost, the mobility they provide, and the limited access to personal vehicles and driving experience in the population. To evaluate this dynamic in more detail, the study reported in this paper included a comparison of existing taxi costs for major cities in Asia, the United States, Europe, and China. In China, taxis have two price tiers, one for day and the other for night, with an average rate per mile that is equivalent to about US$0.8. Some of the more cosmopolitan cities in the United States, such as New York City and Washington, D.C., charge about $2.50 for the initial fare and $2.00 per mile, with a time charge of $0.4 per minute, as well as peak and nighttime surcharges. Table 1 shows Shanghai taxi rates in Central Shanghai versus the suburbs. To illustrate these differences on a normalized scale, Table 2 shows the relative cost of an 8-km, 30-min taxi trip in nine major world cities, alongside Beijing and Shanghai.

TABLE 1 Taxi Rate in Shanghai Metropolitan Area

Taxi Rate in Shanghai	Regular Taxi in Central Shanghai	Regular Taxi in Suburbs
Initial charge	1.76–2.35	1.47
Free kilometers (miles) with basic charge	3 km (1.87 mi)	3 km (1.87 mi)
Rate per kilometer (mile)	\$0.31/km (\$0.56/mi)–\$0.53/km (\$0.85/mi)	\$0.31/km (\$0.56/mi)
Rate over 10 km	\$0.53/km (\$0.85/mi)–\$0.69/km (\$1.11/mi)	\$0.53/km (\$0.85/mi)

NOTE: Comparison of costs for a taxi trip of 8 km within 30 min and a carsharing trip.

Table 2 presents all costs in U.S. dollars and shows that the cost of taxi services in Beijing and Shanghai was nominally lower than elsewhere. When adjusted for median income, however, the ratio between trip cost and household income was similar (i.e., between .02% and .03% across the range of cities). One notable difference between Asian and Western cities was the relative size of the taxi modal share (for all trips). The major Asian cities exhibited taxi modal shares of at least 3%, and up to 8%, whereas most Western cities generally did not exceed 1%. Because taxis can service similar trips to carsharing vehicles, the elevated role that taxis play in China and other Asian cities portends an additional competitive obstacle that is not as prominent in many Western cities. The size of Asia's taxi fleet as compared with that in the West also indicates the larger relative role of taxis. In 2011, more than 65,000 taxis operated in Beijing, and 50,000 operated in Shanghai (*29, 41*). Only Tokyo had nearly as many, whereas Singapore had half as many. New York, arguably one of the most taxi-intensive cities in North America, had only 13,000 (yellow cabs).

The far right column of Table 1 illustrates the approximate ratio of taxi to carsharing cost, where carsharing cost is the approximate hourly cost, and taxi cost is computed for the standardized trip indicated previously. These ratios provide insight into the relative competitiveness of carsharing with taxis. The highest ratios (in which carsharing was relatively more competitive) were found in Europe and North America, whereas Singapore and Tokyo had the lowest ratios. For China, the current prices of EdoAuto and Dazhong were used as proxies, even though these two systems were early models of what carsharing could look like in China. The low ratios in both Chinese cities suggested that carsharing, as priced here, was relatively less competitive with the taxi than in Western cities. The range of ratios provided perspective on hourly carsharing prices that would position carsharing in Beijing and Shanghai competitively with taxis. The median ratio was 1.5, which was reflective of the ratio in a typical American city. If carsharing prices were to match that ratio in China, then a competitive hourly rate would range between US\$2.00 (¥12.9) and US\$2.35 (¥15.15). This rate was close to that offered by EdoAuto (*26*). The company was able to achieve this rate through operation in lower-density areas of the city, where parking was cheaper and fewer taxis operated. However, such prices would be less competitive with those of taxis in city centers, given the high cost to park downtown (e.g., in Shanghai) (*52*). Such costs likely influenced the Dazhong shared-taxi model of carsharing (*27*).

Although the rapid motorization of China may signal an opportunity for carsharing, the reality is that Chinese cities present key obstacles, which include (*a*) high parking costs, (*b*) high traffic congestion, (*c*) limited driving experience, (*d*) well-used taxi systems, and (*e*) little familiarity with carsharing (*15*). To evaluate these macroscopic issues in greater depth, the study reported here explored the response of Shanghai residents to the carsharing concept and evaluated how certain factors influenced interest in carsharing. On the basis of the survey results, the study profiled those interested in carsharing and explored further how the availability of this service might affect vehicle-purchasing behavior.

METHODOLOGY

This discussion of methodology includes three main sections: (*a*) survey design and administration, (*b*) carsharing definition, and (*c*) study limitations.

Survey Design and Administration

The survey was implemented in Shanghai, China, between November 1, 2010, and February 1, 2011. Respondents were chosen randomly from the whole city, according to an address list from previous projects in Shanghai conducted through Tongji University. Each respondent was provided a paper survey, along with the option to take the survey online. A small incentive (i.e., US\$3.00 gift card) was given to respondents that completed the survey. The survey was pretested at Tongji University, 4,000 surveys were mailed, 271 responses were received, and the response rate was approximately 7%.

The survey was divided into several parts. The first section asked basic questions about daily travel, commuting, personal demographics, and household vehicle holdings. In addition, information on work status, employment, age, gender, personal annual income, and education level were collected. The survey also asked stated-preference questions about how respondents might use carsharing for specific trip purposes (e.g., shopping trips, airport journeys, and weekend family travel).

Carsharing Definition

Respondents were not expected to have any prior exposure to carsharing, so explanatory materials were included to carefully explain the concept. In line with the methodology adopted by Shaheen, each survey was accompanied by an introductory letter and consent form, which gave respondents the option to consent to participate in the research (*53*). In addition, a two-page brochure was included, which clearly described the carsharing concept in both visual and text form. Figure 1 provides a summary of the brochure in English and Chinese versions.

The survey focused on the neighborhood carsharing model, defined earlier in the paper. The information presented in the brochure listed carsharing advantages and disadvantages, including basic operations and cost parameters. The reservation system was shown as a

TABLE 2 Taxi Costs in World Cities (*5, 7, 8; 26–27; 29–50*)

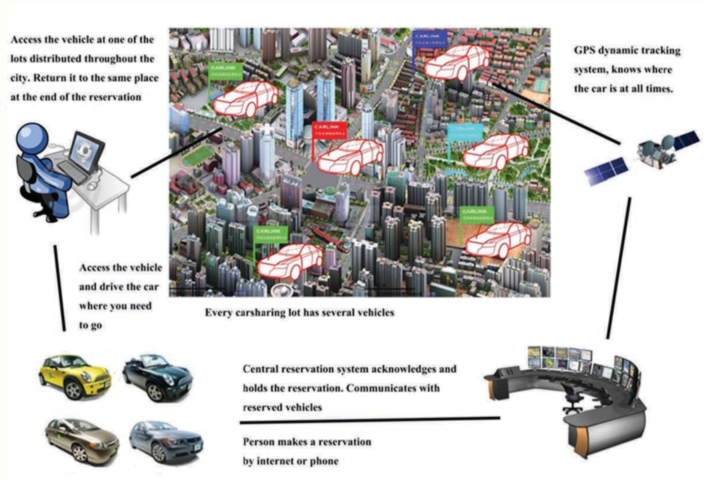
					Taxi							
City	Central City and Metropolitan Area Population (million)[a]	Central City Car Ownership (million)[b]	Population with Driver License (million)[c]	Average Household Income (thousand)	Total Taxi Amount[b]	Taxi Mode Share[b] (%)	Initial Charge and Free Mileage	Regular Rate per Kilometer (mi)[d]	Total Taxi Cost	Typical Carsharing Hourly Cost[e]	Taxi Cost or Income (%)	Taxi Cost or Carsharing Cost
Beijing	**11.71** 19.72	3.74 (32.0%)	4.75	13,432	66,646	**8.1**	$1.50 3 km	**$0.31/km** ($0.5/mi)	3.06	**2.50**[f]	0.023	**1.22**
Shanghai	**9.76** 23.02	1.03 (10.5%)	2.58	14,029	53,199	**5.3**	$1.76 3 km	**$0.35/km** ($0.56/mi)	3.51	**4.00**[f]	0.025	**0.88**
Singapore	**5.07** 5.07	0.61 (12.0%)	4.03	75,597	25,176	**5.3**	$2.10 1 km	**$0.5/km** ($0.8/mi)	5.60	**15.00**	0.007	**0.37**
Washington, D.C.	**0.60** 5.58	0.36 (60.0%)	0.43	59,290	6,800	**~0.3**	$4.00 0.27 km	**$0.94/km** ($1.5/mi)	11.25	**7.50**	0.019	**1.50**
Chicago, Illinois	**2.69** 9.46	1.19 (44.3%)	1.83	45,734	6,999	**~0.3**	$2.25 0 km	**$1.13/km** ($1.8/mi)	11.25	**7.50**	0.025	**1.50**
New York	**8.17** 18.97	3.86 (47.3%)	5.67	55,980	13,087	**~2.5**[g]	$2.50 0 km	**$1.25/km** ($2/mi)	12.50	**8.50**	0.022	**1.47**
San Francisco, California	**0.80** 4.34	0.35 (43.4%)	0.62	55,221	1,381	**~0.1**	$3.10 0.27 km	**$1.41/km** ($2.25/mi)	13.97	**7.50**	0.025	**1.86**
Paris	**2.19** 11.84	0.32 (14.8%)	1.56	58,000	14,900	**~1.0**	$3.00 0 km	**$1.5/km** ($2.4/mi)	15.00	**7.00**	0.026	**2.14**
London	**7.82** 13.90	1.88 (24.0%)	5.49	59,800	16,210	**~0.5**	$4.40 0 km	**$1.38/km** ($2.2/mi)	15.40	**6.40**	0.026	**2.41**
Berlin	**3.45** 4.43	1.43 (41.8%)	2.48	67,500	7,000	**~1.0**	$4.50 0 km	**$2.19/km** ($3.5/mi)	22.00	**7.50**	0.033	**2.93**
Tokyo	**13.01** 35.68	2.71 (20.8%)	10.41	58,000	60,000	**3.1**	$3.10 2 km	**$3/km** ($4.8/mi)	25.10	**20.00**	0.043	**1.26**

[a]Top cell is population within the city limits; bottom cell is the metropolitan region; data from city websites or within country statistical agencies.
[b]Transportation data from city websites, accessed in 2011. American cities derived from travel survey data provided by local Metropolitan Planning Organizations.
[c]Beijing and Shanghai Statistics 2010; the residents who lived in the other cities were required to have driver licenses when they were 18 years old.
[d]Taxi rates from taxi provider websites, 2011.
[e]Zipcar, 2011; Paris, Berlin, Tokyo, Singapore Carsharing, 2011.
[f]EdoAuto offered the carsharing vehicle for $2.50/h + gasoline, Dazhong sought to launch carsharing service at approximately $4.
[g]Includes only yellow cabs and not car services or black cars.

Brochure of Carsharing Survey in Shanghai, English Version

Details:

1. Carsharing could serve as a replacement for car-ownership, removing the cost of owning a car, with no need to buy a second car.
2. No deposit needed, online and phone reservations are possible. The system provides detailed information on vehicle access and location.
3. Pick up a car by walking to the carsharing parking lots, make your trip and return the vehicle back to the original place.
4. Make sure the care is clean when you finish. There is no smoking, and no pets, report if you have accidents or damage, return on time.
5. Carsharing can be cost-effective for non-work trips, but is too expensive for commuting. Trips generally need to be planned, as you may not be able to reserve and use a vehicle with little advance warning.



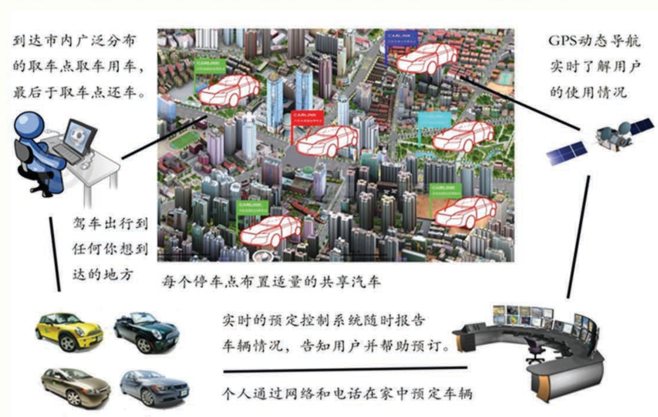
Rates and Costs

1. The rate of carsharing is estimated to be ￥28/h, with an additional mileage charge of￥1/km.
2. With a membership fee of ￥500/year, you could reserve and drive a carsharing vehicle anytime, with different vehicle types to choose.
3. No other insurance fee, no need to pay gasoline, maintenance and clean your car, and you could save ￥6000/year on these.

Brochure of Carsharing Survey in Shanghai, Chinese Version

你可以

1. 为您提供中频度的汽车准拥有服务，免去购车的巨额成本。可以满足家庭第二辆用车需求而无需再行购买。
2. 汽车共享的收费标准预计在28元每小时，外加每公里1元的油费。
3. 每年仅需支付500元的会员费，就可以随时预定和取用不同类型的汽车。
4. 无需另行购买保险，无需为加油，保养，维护和清洗车辆烦恼。相对自行购车，每年仅停车和维护费用即可节约6000元。
5. 仅需会员卡与密码，无需每次缴纳订金。即可随时通过信息全面的网络和电话预定车辆。



但是你需要注意的是：

1. 到指定的汽车共享停车点取车、用车、但出行后需还车至原取车点。
2. 保持车内清洁卫生，车内不准吸烟，不准带宠物，如遇事物或损伤须报告，及时还车。
3. 汽车共享适合于非上下班出行，若用于通勤费用较高。行程需提前安排，若无预留时间，用车难以保证。

FIGURE 1 Summary of information in brochure included with survey.

graphic, and respondents were instructed how to reserve and access a carsharing vehicle (Figure 1).

Study Limitations

Because the neighborhood carsharing model is still a new concept in China and public exposure to it is limited, the survey could only explore stated responses to the concept. In addition, the study evaluated a respondent's preference for carsharing without consideration of variations in service level. The design attempted to counter nonresponse bias through the inclusion of a gift card incentive. As mentioned earlier, the overall response rate was 7%, which was low by traditional standards but reflective of recent survey response rates achieved in Shanghai (*54*). Given budget limitations, respondents were asked to take the survey only once. Several dynamics could have introduced some selection bias into the data. For example, the head of household typically completed mail surveys and was likely to have the highest education in the household. It was also possible that a survey focused on carsharing might have appealed only to a subset of potential respondents. Finally, the survey responses were stated, rather than revealed, preference, and thus indicative of how people thought that they would respond to the service. As a result of these dynamics, the results more likely reflected the views of potential early adopters, who constituted a subset of the Shanghai population, and were less generalizable to other regions in China.

SURVEY RESULTS

This section discusses (*a*) survey respondent demographics relative to the current Shanghai population, (*b*) potential carsharing impacts on vehicle sales and planned purchases, and (*c*) results of the ordinal regression model to further understand carsharing interest among the survey population.

Respondent Demographics

Respondents exhibited a wide distribution of demographic characteristics. The subjects were divided into subgroups characterized by their expressed interest in carsharing. At the end of the survey, respondents were asked: "On a scale of 1 to 10, where 1 is 'definitely not' and 10 is 'definitely,' please indicate how likely it is that you would join carsharing, if it were available to you?" Respondents whose ratings were 6 or greater were considered to be "interested" in carsharing (144 of the sample), and respondents whose answers ranged between 1 and 5 on the rating scale were considered "not interested" in carsharing (127 of the sample). This division was relevant to understand how different people reacted to the carsharing concept. Table 3 illustrates a breakdown of key demographic variables of these subgroups, along with the overall sample.

TABLE 3 Demographic and Socioeconomic Attributes of Survey Respondents

Attribute	Interested ($6 \leq$ Preference ≤ 10 $N = 144$)(%)	Not Interested (Preference ≤ 5 $N = 127$)(%)	Whole Sample ($N = 271$)(%)
Income			
Less than ¥10,000 (US$1,540)	0	2	1
¥10,000–¥20,000 (US$1,540–US$3,080)	1	0	1
¥20,000–¥30,000 (US$3,080–US$4,620)	3	2	3
¥30,000–¥40,000 (US$4,620–US$6,160)	4	3	4
¥40,000–¥50,000 (US$6,160–US$7,700)	13	13	13
¥50,000–¥70,000 (US$7,700–US$10,780)	22	14	18
¥70,000–¥100,000 (US$10,780–US$15,400)	15	20	17
¥100,000–¥150,000 (US$15,400–US$23,100)	18	16	17
¥150,000–¥300,000 (US$23,100–US$46,200)	16	18	17
More than ¥300,000 (US$46,200)	8	13	10
Education			
Primary school	1	0	0
Middle school	3	6	4
High school	15	15	15
Technical or vocational college	15	24	19
University or college (undergraduate)	4	5	4
University or college (graduated)	41	35	38
Graduate/professional	21	16	18
Age			
Younger than 21	0	0	0
21–23	4	2	3
24–26	11	12	11
27–30	22	16	19
31–35	31	20	25
36–40	15	16	15
41–45	10	10	10
46–50	4	9	6
51–55	2	9	6
56–60	1	2	2
Older than 60	0	4	2
Household car ownership			
0	50	43	47
1	43	46	45
2	6	8	7
3	1	2	1
4	0	1	0
More than 4	0	0	0
Commute mode			
No commute	13	15	14
Taxi	8	3	6
Car	23	29	26
Bus	19	14	17
Metro	27	24	25
Cycling	6	6	6
Walking	6	9	7

Although population data in China are improving, they still are not as comprehensive as the U.S. Census (i.e., full distributions of key population parameters are not published). Still, population statistics are produced in statistical yearbooks for cities and for the nation, which provide benchmarks for comparative analysis with the sample. In terms of income, the sample and population corresponded reasonably well. The average household income for Shanghai residents was ¥92,170 (US$14,029), whereas the median income category of the sample was ¥70,000 to ¥100,000 (US$10,780 to US$15,400) (*41*). Variation in within-sample income existed among the subgroups defined by carsharing interest. A Mann–Whitney test to evaluate the differences in the household-income distributions between the subgroups did not find a statistically significant difference, however ($p = .165$).

The distribution of educational attainment indicated that the sample was more educated than the Shanghai population. Only 24% of Shanghai residents had an undergraduate education or higher, whereas 23% attended high school, and the remainder had a middle school education or lower (*55*). Within the survey sample, 56% of respondents ($n = 153$) had an undergraduate degree or higher. The differences between the subgroup distributions were nearly (but not) significant ($p = .086$), with the distribution of those interested in carsharing skewed toward higher education levels.

Within the Shanghai population that was 18 years of age or older, 27% were 18 to 34, 49% were 35 to 59, and the remaining 23% were older than 60 (*41*). In general, the sample was younger than the population: 59% ($n = 160$) were between the ages of 21 to 35. Furthermore, the difference in the mean age in the subgroups of those not interested (~38) and interested (~34) was statistically significant ($p = .000$), which suggested that younger people might be more interested in carsharing.

Nearly 10 million people live in Shanghai, and 1 million private vehicles are registered there. It is suspected that Shanghai also has a sizable population of vehicles that are registered elsewhere in China but driven within city boundaries because of the large, regional variation in licensing costs. People register a vehicle in one region but park it in another. Thus the 10% ratio of vehicles to people listed in Table 1 is considered a lower bound. If each vehicle was owned or leased by a separate household, then an upper bound on the household auto-ownership rate would be approximately 30%, given the average household size of 2.8 in Shanghai (*41*). The sample showed that 53% ($n = 144$) of the households owned a car, which was more than the population average. About 86% of the sample ($n = 234$) commuted to an employment site. The remaining 14% ($n = 37$) were homemakers or unemployed. Although the sample was relatively automobile-adapted, there was no statistical distinction across subgroups in vehicle ownership ($p = .488$). As Table 1 shows, 26% of Shanghai residents had a driver's license, whereas in this sample the proportion was 60% ($n = 163$). Thus one clear dimension of survey bias was auto ownership and driving experience, which departed significantly from the ownership and experience of the general population.

Vehicle Sales and Planned Purchases

In North America, carsharing has been found to reduce the need for personal auto ownership. To evaluate how Chinese carsharing members might alter vehicle ownership, respondents were asked directly: "If you joined carsharing, do you think that you would sell any vehicle that you currently own?" Only 11.1% of the respondents that owned a vehicle in their household stated that they would dispense with their automobile (16 of 144) if they joined a carsharing program. This proportion was the same among those households interested in carsharing (8 of 72). This proportion was smaller than it was in research done in Europe and North America, which repeatedly found that nearly 25% of carsharing members gave up a vehicle (*10, 11, 13*).

The present study reported here also explored whether the availability of carsharing might change expected vehicle purchase plans over the next 5 years. Respondents were asked: "If you joined carsharing, do you think that you would still buy a car?" Within the entire sample, 32% ($n = 87$) of respondents were interested both in carsharing and in planning a vehicle purchase within 5 years. Of those respondents, 51% ($n = 44$) stated that they thought that they would give up their purchase plans if they joined carsharing, which supported the idea that carsharing might be more effectual in China because it obviated household vehicle purchases.

Ordinal Regression Model: Carsharing Interest

The study evaluated interest in carsharing with an ordinal regression model. A key advantage of ordinal regression is that the most influential variables can be isolated, which controls for the influence of other variables. Table 4 presents the model estimation, with interest in carsharing as the dependent variable. The question had a 10-point response scale. However, it was rescaled to 5—two responses were placed in each ordinal category—to reduce the number of threshold variables (intercepts). For example, responses of 1 and 2 were rescaled to 1, while responses of 9 and 10 were rescaled to 5.

Ordinal regression models have three main components: (*a*) threshold coefficients, (*b*) covariate coefficients, and (*c*) factor coefficients. The threshold coefficients are the constants that are estimated on the individual logits, which pertain to each ordinal response of the dependent variable. The covariates are ordinal or interval variables that exhibit a definable scale. Factors are variables that in general are categorical. Positive coefficients for covariates and factors indicated that the variable increased interest in carsharing.

The covariates included seven: household income, education, age, commute trip time, and three attitudinal questions. Household income was statistically significant and negative, which indicated that, when all else was equal, higher income reduced interest in carsharing. The age coefficient had the same effect. Although age and income often were correlated, age was not significant by itself. As education rose, so did the appeal of carsharing. This last result was consistent with findings in carsharing research done in North America and Europe, which found that most members had a bachelor's degree or higher (*9, 11, 13*). In addition, a study in Beijing found that those interested in carsharing were relatively more educated than those that were not interested (*15*). Finally, the length of time it took to commute to work had a positive influence on the interest in carsharing.

The survey in this present study asked respondents attitudinal questions to evaluate their opinions on climate change and energy security, as well as their concerns and preferences with respect to their use of carsharing. Respondents were asked on a 4-point Likert scale whether or not they believed "energy security" was more important than "climate change." The negative coefficient indicated that respondents that believed China's energy security was more important than climate change were less likely to be interested in carsharing. This effect, however, was weak because the coefficient was not significant. The model found that an individual with a high concern for personal driving safety also was less likely to be interested in carsharing. The final covariate pertained to the importance of carsharing-vehicle proximity to public transit. Respondents that considered close proximity important also were more interested in carsharing.

TABLE 4 Ordinal Regression Parameter Estimates to Predict Carsharing Interest Among Survey Respondents

Variable	Coefficient Estimate	Standard Error	Probability
Threshold			
Carsharing preference = 1.00	−1.828	0.595	.002
Carsharing preference = 2.00	−1.233	0.587	.036
Carsharing preference = 3.00	0.089	0.581	.878
Carsharing preference = 4.00	0.853	0.582	.143
Demographic			
Household income $10,000	−0.024	0.008	.003
Education	0.095	0.053	.074
Age	−0.011	0.008	.173
Commute single trip time	0.006	0.003	.085
Attitude			
Energy security versus global warming in China	−0.123	0.083	.139
Worry about getting into an accident when driving	−0.255	0.086	.003
Carsharing lots near transit stations and stops	0.148	0.031	0
Factor			
Major shopping mode = taxi	−0.957	0.568	.092
Major shopping mode = private car	0.206	0.186	.267
Major shopping mode = bus	0.247	0.232	.288
Major shopping mode = metro	0.568	0.238	.017
Major shopping mode = bike	0.287	0.237	.227
Major shopping mode = walk	0[a]	na	na
Car purchase plan = within 1 year	−0.26	0.263	.322
Car purchase plan = within 1–3 years	−0.204	0.196	.298
Car purchase plan = within 3–5 years	−0.551	0.203	.007
Car purchase plan = within 5–10 years	−0.459	0.253	.07
Car purchase plan = no plan within 10 years	0[a]	na	na

NOTE: Summary statistics: number of cases = 271; link function: complementary log–log; model fitting information (−2 log likelihood) = 762.831 (0.000); test of parallel lines, $p = .624$; prediction attitude accuracy = 196/271 = 72.3%. na = not applicable.
[a]This parameter is set to zero because it is redundant.

Two categorical factors were included in the model. Respondents were asked to identify the primary mode that they used to shop. The most significant responses were metro and taxi, which suggested that people that used the metro as their primary shopping mode had a higher likelihood of interest in carsharing, whereas those that identified taxis as their primary mode had less interest. The model also included vehicle purchase plans. Compared with people with no vehicle purchase plan, those with long-term purchase plans were found to be relatively less interested in carsharing. This finding suggested that a near-term plan to purchase a vehicle was not a large deterrent to the exploration of carsharing.

To evaluate the validity of any ordinal regression model, a "test of parallel lines" is required. This test evaluates whether the influence of covariates and factors is appropriately specified by a single coefficient, or if multiple coefficients for each ordinal response are required. The analyst does not want to reject a null hypothesis, which was the case for this model ($p = .642$). The nonrejection of the parallel lines test confirms that the complementary log–log link function is the appropriate specification, and a single coefficient value is sufficient to explain its effect for all of the ordinal values of the dependent variable.

CONCLUSIONS

Overall, the survey results suggested that a subpopulation of Shanghai residents had an interest in carsharing but also that the interest was governed by several key factors. Interest in carsharing rose with education level and fell with age, a common pair of attributes shared by carsharing members across the globe. At the same time, interest in carsharing declined with higher household income. Other aspects that drove interest in carsharing included travel patterns and vehicle purchase plans. Those respondents that used the metro predominantly to shop were more likely to be interested in carsharing, whereas those that used taxis were less likely to express interest. Furthermore, a small share (11%) of households that owned a vehicle stated that they would be willing to shed one, if carsharing were made available. Those that planned to purchase a vehicle in the near term (within 1 to 3 years) received the carsharing concept better.

These results, together with the broader, macroeconomic circumstances discussed earlier, did not indicate that carsharing would unequivocally take hold in large Chinese cities were it made available, at least on the basis of the neighborhood model used in North America and Europe. Rather, the results reinforced the perception that neighborhood carsharing might face several challenges to the attainment of a broad customer base and the rapid membership growth experienced in the United States. The taxi, which plays a small role in U.S. transportation systems, is a far more important component of urban mobility in China. Taxis are able to supply automobility to a population that does not have much driving experience. With abundant taxis and rapidly developing public transit networks, it is not immediately evident that widespread driving experience even is needed. Furthermore, land use and parking costs are high in Chinese cities, and thus the economics generally are stacked against a business model that needs to deploy a large number of vehicles throughout a high-density, urban environment. Finally, Chinese urban highways are highly congested with traffic, even with comparatively low vehicle ownership rates. It is unclear for how long China's existing infrastructure can manage additional growth. For these and other reasons, the model of carsharing that might emerge in China could look quite different from neighborhood carsharing in Europe and North America. Although carsharing was originally envisioned to get people out of privately owned vehicles, carsharing in China would most likely get more people into them.

Certain designs of the neighborhood model might be implemented to overcome these obstacles, however. Carsharing vehicles might be more readily deployed within parking garages accessible to residents of large apartment buildings. This "closed" or "semi-open" neighborhood model would restrict vehicle use to those with access to the building. China is at a unique point in its industrial development; it is building cities rapidly at a time when carsharing exists. Throughout history, new cities have had the advantage (or, in some cases, the disadvantage) to form around the prevailing transportation technology of the age, and carsharing may be more appropriately established in China through integration with new infrastructure. In such a case, carsharing could reduce the need for personal vehicles. Unlike elsewhere, however, the reduced need in China might express itself in fewer vehicles acquired in the first place, rather than through more vehicles ultimately shed. In established Chinese cities, the business model that emerges may offer more value added through shared-mobility services, such as ridesharing, as opposed to shared vehicles.

Thus it is probable that some form of carsharing will emerge in China. It is not clear, however, that to copy the neighborhood model, which has spread across Europe and North America, would be the most successful approach. Rather, China, with its unique status as a large but still-emerging economy, may need to develop a unique style of carsharing that satiates the increasing demand for vehicle ownership and mobility even as it complements existing transportation system constraints.

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