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ABSTRACT

The rapid motorization of China raises questions about the potential of alternative mobility solutions, such as carsharing (short-term auto use), in developing mega cities like Shanghai. While motor vehicle demand is increasing rapidly, there are many aspects of urban transportation in Shanghai (and China more broadly) that separate it from the urban environments in which carsharing has traditionally thrived. For example, the taxi plays a much more prominent role in the transportation systems of Shanghai and Beijing than it does in most North American and European cities. Carsharing has also normally thrived in environments in which the broader population has experience with both driving and automobile ownership. This is currently lacking in Shanghai. To evaluate carsharing's potential in Shanghai, the authors comparatively analyze the size and competitiveness of the taxi systems of key carsharing cities in Europe, North America, and Asia and highlight some core distinctions between Shanghai and other major cities where carsharing has thrived. To further explore the potential response of citizens to carsharing, the authors conducted a survey (N=271) of a subpopulation in Shanghai from November 2010 to February 2011. The survey analysis shows that those interested in carsharing are younger, more likely to be educated, have longer commutes, and own fewer cars than those not interested in carsharing. Following the survey analysis, the authors conclude with a discussion of the implications of these results for the development of a carsharing industry in Shanghai.

KEY WORDS: Carsharing, Shanghai, China, taxi, business model, stated-preference survey

INTRODUCTION

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 of facilitating 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. Third-party operators in this market, typically target large, densely populated areas with high parking costs and robust public transportation networks. However, this success has been overwhelmingly achieved within traditionally industrialized societies that were previously motorized. Rapidly motorizing economies, such as China, have not experienced major initiatives in carsharing to date.

China's explosive economic growth has increased the demand for urban automobility. But overall vehicle penetration is still low, as China has 46 vehicles per 1,000 people versus the ~800 vehicles per 1,000 people in the United States (U.S.) (2, 3, 4). Even so, the rapid pace of China's growth portends considerable mobility changes. At the same time, the successful deployment of bikesharing (shared-use public bicycles) in China and elsewhere has raised new

questions regarding the appropriate paradigm of shared-use vehicle mobility that might evolve in cities, such as Shanghai *(6)*.

There are several societal distinctions that could influence how carsharing might operate and thrive in China. Because carsharing has historically been successful in highly motorized societies, carsharing in China would have to grow in a fundamentally different environment within a population that has largely not had previous vehicle ownership or auto access. Thus, if carsharing were to be successful in China, its impact would likely be different in nature. Previous carsharing research in Europe and North America has shown that it lowers vehicular emissions and ownership *(1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18).* Since there are fewer vehicles and miles driven to eliminate, carsharing could *accelerate* auto access in the short term. Nevertheless, China is in the process of rapidly building new cities and as part of their built infrastructure could encourage shared-use vehicle mobility in lieu of personal auto ownership. In the long term, this may alter the path of traditional motorization, if it were broadly adopted in urban China. Thus, China could be a country in which carsharing enables vastly more individuals to access automobiles for the first time and in turn reduces the need (or desire) for personal auto ownership among people who never owned a vehicle previously.

Another distinction of carsharing development in China is the considerable competition it would face from taxi and public transit systems that are well established and inexpensive. Carsharing would also face challenges in overcoming legal hurdles and obtaining governmental support. In addition, carsharing is a relatively unfamiliar mode to a majority of Chinese citizens. A recent survey in Beijing found that less than 40% of respondents were familiar with carsharing *(16)*. Thus, initial advertising and educational efforts would likely be needed (as they were in the U.S.).

To evaluate the potential customer base of carsharing in Shanghai, researchers implemented 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 may compete with the taxi.

This paper is organized into four sections. First, the authors provide a review 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 authors introduce the study methodology, which is followed by a review of the results in the fourth section. Finally, building on the insights from the analysis, the authors conclude with a discussion of how carsharing may best be designed within China to achieve the goals of delivering 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 within central Europe. The concept was then exported to North America, arriving in Canada in the mid-1990s. Since then, carsharing systems have continued to flourish across the continent *(1)*.

As of October 2010, the worldwide carsharing industry was established in 26 countries and comprised of 1,250,000 members served by 31,000 vehicles *(19)*. Within that population, Asian organizations contributed 77,817 members sharing 4,410 vehicles. By late 2011, there were 35 carsharing operators across Asia: one in Israel and 34 operating in four East Asian countries including Japan, Singapore, South Korea, and now China. By comparison, in July

2011, North America had more than 639,000 members sharing over 12,600 vehicles *(19)*. Previous research has evaluated the industry growth and its impacts on vehicle ownership and emissions, with the general finding that carsharing reduces both *(12, 16, 16, 18, 20, 21*, *22)*.

Asian carsharing systems have evolved somewhat separately from Europe and North America. In Japan, many early systems were project based and characterized by advanced technology in both operations and electric vehicle (EV) use *(21)*. Early business models were focused on servicing downtown business customers. However, the industry has since evolved towards the neighborhood business model and drastically reduced its emphasis on EVs. As the other major center of Asian carsharing, Singaporean carsharing programs were less directed at reducing auto ownership and more oriented towards providing access and mobility to residents interested in using a vehicle. As in Japan, early programs in Singapore applied advanced technology and experimented with one-way trips more than EVs, but they have also converged towards providing more traditional carsharing services *(*8*)*. Outside of these two countries, carsharing has been slower to take hold in Asia, with only a recent introduction in South Korea.

While carsharing has struggled to expand its footprint in Asia, bikesharing has flourished in several cities worldwide, and quite prominently in Hangzhou, China. Unlike carsharing, bikesharing is more readily capable of permitting one-way trips and overcoming 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 be beneficial to the public by augmenting 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 not as relevant to bikesharing. Similar to other Asian cities, urban environments in China have expensive parking costs, and urban highways are already congested with existing vehicles. Overall, the body of literature devoted to carsharing in China is still small. While recent research in China has focused on neighborhood carsharing operations, there has been very limited analysis of consumer response or existing operations *(24, 25)*.

To evaluate how citizens in China might respond to carsharing, Shaheen and Martin (2010) explored the concept in Beijing with a survey of 840 respondents in 2006. The survey results found that over 25% of respondents were highly interested in carsharing, although only 40% of this group was previously familiar with the concept. Respondents who were 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. Interestingly, only 21% of respondents reported the ability to drive, indicating that driver education may be critical to future carsharing adoption *(16)*. These and other challenges suggest that any carsharing industry that emerges in China may evolve differently from those in Asia and elsewhere.

CARSHARING CHALLENGES IN CHINA

In spite of the considerable growth in motorization and demand for auto ownership, in 2011 there existed only two carsharing operators in China—EdoAuto and Dazhong—which are located in Beijing and Shanghai, respectively. EdoAuto operates in the suburban regions of Beijing, advancing a business model that is very 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 kilometers (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 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. To make a trip with Dazhong, consumers make reservations online, which can be shared by strangers *(27)*. As the biggest taxi and car-rental company in Shanghai, the company has almost 20,000 vehicles operating in Shanghai and is involved in a number of other industries including bus transit and real estate development *(27)*. Dazhong's entry into carsharing in 2011 was small and experimental with only four "taxi-sharing" vehicles operating in Shanghai *(28)*. Nevertheless, Dazhong's approach may represent a more practical carsharing business model in China, by combining services with an existing taxi fleet, it avoids the need to establish a network of vehicles in urban regions with very scarce parking and high land costs.

In this respect, a major challenge facing carsharing in Chinese cities (particularly Shanghai) is the prominent role that taxis play within the transportation system. Taxis in Chinese cities have a competitive advantage due to costs, the mobility they provide, and limited personal vehicle access and driving experience in the population. To evaluate this dynamic in more detail, the authors compared existing taxi costs for major cities in Asia, the U.S., Europe, and China. In China, taxis have two different pricing tiers that are distinguished by day and night, with an average rate per mile of about US$0.8. In comparison, some of the more cosmopolitan cities in the U.S., such as New York City and Washington D.C., charge about US$2.50 for the initial fare and US$2.00/mile, with a time charge of US$0.4/min, as well as peak and nighttime surcharges. To illustrate these differences on a normalized scale, Table 1 shows the relative cost of taking an 8 km, 30-minute taxi trip in nine major world cities, alongside Beijing and Shanghai.

TABLE 1 Taxi Costs in World Cities (Cost of 8 km for 30 minutes)

Taxi Rate in Shanghai Metropolitan												
Taxi Rate in Shanghai				**Regular Taxi in Central Shanghai**					**Regular Taxi in the Suburban**			
Initial Charge				1.76			2.35		1.47			
Free Kilometers (Miles) with Basic Charge				3 km (1.87 miles)			3 km (1.87 miles)		3 km (1.87 miles)			
Rate per Kilometer (Mile)				\$0.31/km (\$0.56/mile)			\$0.53/km (\$0.85/mile)		\$0.31/km (\$0.56/mile)			
Rate over 10km				\$0.53/km (\$0.85/mile)			\$0.69/km (\$1.11/mile)		\$0.53/km (\$0.85/mile)			
Comparison of Costs between a Taxi Trip of 8 kilometers within 30 minutes and a Carsharing Trip												
City	**Central City (c) and Metropolitan Area Population (million)[1]**	**Central City Car-Ownership (million)[2]**	**Population with Driver License (million)[3]**	**Average household Income (thousand)**	**Taxi**					**Typical Carsharing Hourly Cost[5]**	**Taxi Cost / income**	**Taxi Cost / Carsharing cost**
					Total Taxi Amount[2]	**Taxi Mode Share[2]**	**Initial Charge and Free Mileag**	**Regular Rate per Mileage (Mile)[4]**	**Total Taxi Cost**			
Beijing	**11.71**	3.74	4.75	13,432	66,646	**8.1%**	\$1.50	**\$0.31/km**	3.06	**2.50[6]**	0.023%	**1.22**
	19.72	(32.0%)					3km	(\$0.5/mile)				
Shanghai	**9.76**	1.03	2.58	14,029	53,199	**5.3%**	\$1.76	**\$0.35/km**	3.51	**4.00[6]**	0.025%	**0.88**
	23.02	(10.5%)					3km	(\$0.56/mile				
Singapore	**5.07**	0.61	4.03	75,597	25,176	**5.3%**	\$2.10	**\$0.5/km**	5.60	**15.00**	0.007%	**0.37**
	5.07	(12.0%)					1km	(\$0.8/mile)				
Washington DC	**0.60**	0.36	0.43	59,290	6,800	**~0.3%**	\$4.00	**\$0.94/km**	11.25	**7.50**	0.019%	**1.50**
	5.58	(60.0%)					0.27km	(\$1.5/mile)				
Chicago	**2.69**	1.19	1.83	45,734	6,999	**~0.3%**	\$2.25	**\$1.13/km**	11.25	**7.50**	0.025%	**1.50**
	9.46	(44.3%)					0km	(\$1.8/mile)				
New York	**8.17**	3.86	5.67	55,980	13,087	**~2.5%[7]**	\$2.50	**\$1.25/km**	12.50	**8.50**	0.022%	**1.47**
	18.97	(47.3%)					0km	(\$2/mile)				
San Francisco	**0.80**	0.35	0.62	55,221	1,381	**~0.1%**	\$3.10	**\$1.41/km**	13.97	**7.50**	0.025%	**1.86**
	4.34	(43.4%)					0.27km	(\$2.25/mile				
Paris	**2.19**	0.32	1.56	58,000	14,900	**~1.0%**	\$3.00	**\$1.5/km**	15.00	**7.00**	0.026%	**2.14**
	11.84	(14.8%)					0km	(\$2.4/mile)				
London	**7.82**	1.88	5.49	59,800	16,210	**~0.5%**	\$4.40	**\$1.38/km**	15.40	**6.40**	0.026%	**2.41**
	13.90	(24.0%)					0km	(\$2.2/mile)				
Berlin	**3.45**	1.43	2.48	67,500	7,000	**~1.0%**	\$4.50	**\$2.19/km**	22.00	**7.50**	0.033%	**2.93**
	4.43	(41.8%)					0km	(\$3.5/mile)				
Tokyo	**13.01**	2.71	10.41	58,000	60,000	**3.1%**	\$3.10	**\$3/km**	25.10	**20.00**	0.043%	**1.26**
	35.68	(20.8%)					2km	(\$4.8/mile)				

Source: (5, 7, 8, 26, 27, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50)

1. Top cell is population within the city limits, bottom cell is the metropolitan region. Data from city websites or within country statistical agencies

2. Transportation data from city websites, accessed in 2011. American cities derived from travel survey data provided by local MPOs.

3. Beijing and Shanghai Statistics 2010, the residents living in the other cities are required to have driver license when they are 18 years old.

4. Taxi rates from taxi provider websites, 2011.

5. Zipcar, 2011, Paris, Berlin, Tokyo, Singapore Carsharing, 2011;

6. Edoauto offered the carsharing vehicle for \$2.5/hour+gasoline, Dazhong sought to to launch carsharing service at around \$4;

7. Includes only yellow cabs, not car services or black cars.

Table 1 presents all costs in US dollars and shows that the cost of taxi services in Beijing and Shanghai are nominally lower, but when adjusting for median income, the ratio for trip cost /

household income is similar, between .02% to .03% across the range of cities. One notable difference between Asian and western cities is the relative size of the taxi modal share (for all trips). The major Asian cities exhibit taxi modal shares of at least 3% up to 8%, whereas most western cities generally do 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 the taxi fleet in Asia versus the west also emphasizes the larger relative role of taxis. In 2011, Beijing had over 65,000 taxis, and Shanghai had 50,000 *(29, 40)*. Only Tokyo had nearly as many, while Singapore claimed half as much. 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 above. These ratios provide insight on the relative competitiveness of carsharing with taxis. The highest ratios (where carsharing is relatively more competitive) are found in Europe and North America, while Singapore and Tokyo have the lowest ratios. For China, the current prices of EdoAuto and Dazhong are used as a proxy, even though these two systems are early models of what carsharing could look like in China. The low ratios in both Chinese cities suggest that carsharing, as priced here, is relatively less competitive with the taxi than in western cities. The range of ratios provides perspective on hourly carsharing prices that would position carsharing in Beijing and Shanghai competitively with taxis. The median ratio is 1.5, which is reflective of a typical American city. If carsharing prices were to match that ratio in China, then a competitive hourly rate would range between US$2 (¥12.9) and US$2.35 (¥15.15). This rate is close to that offered by EdoAuto *(26)*, which is able to achieve this rate by operating in lower density areas of the city where parking is cheaper and there are fewer taxis. However, such prices would be less competitive with taxis in the central cities, given the high parking costs in downtowns, such as Shanghai *(51)*. Such costs likely influenced the Dazhong shared-taxi model of carsharing *(27)*.

Thus, while the rapid motorization of China might signal an opportunity for carsharing, a reality is that Chinese cities are characterized by key obstacles including: 1) high parking costs, 2) high existing traffic congestion, 3) limited driving experience, 4) well-used taxi systems, and 5) low carsharing familiarity (*16*). To evaluate these macroscopic issues in greater depth, the authors explore the response of Shanghai residents to the carsharing concept and evaluate how certain factors influence carsharing interest. Based on the survey results, the authors profile those interested in carsharing and further explore how the availability of this service might impact vehicle-purchasing behavior.

METHODOLOGY

In this section, the authors provide a methodological discussion, including three main sections: 1) survey design and administration, 2) carsharing definition, and 3) study limitations.

Survey Design and Administration

Researchers implemented the survey 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 gift card) was provided to complete the survey. The survey was pre-tested at Tongji and a total of 4,000 surveys were mailed, 271 responses were received with a response rate of approximately 7%.

The authors divided the survey into several parts. The first section asked basic questions about daily travel, commuting, personal demographics, and household vehicle holdings. In addition, 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, including shopping trips, airport journeys, and weekend family travel.

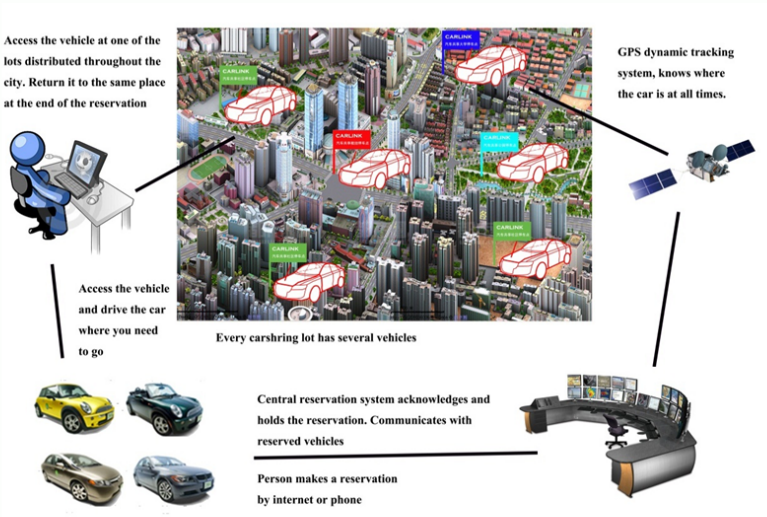
Carsharing Definition

Respondents were not expected to have any prior carsharing exposure, so explanatory materials were included to carefully explain the concept. Following 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 *(52)*. In addition, a two-page brochure was included, which clearly described the carsharing concept in both visual and text form. A condensed summary of the information presented in the brochure in Chinese is given with a translation in Figure 1.

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.



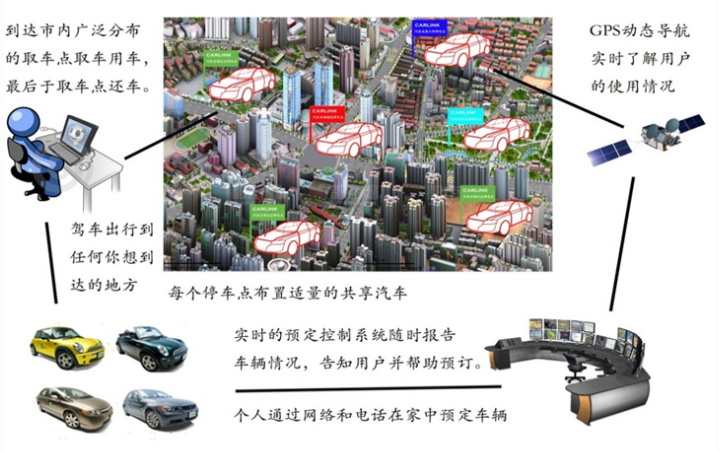
Rates and Costs

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 you 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 Presented in Brochure Included with Survey

The survey focused on the neighborhood carsharing model, which was defined earlier. The information presented in the brochure listed carsharing advantages and disadvantages,

including basic operations and cost parameters. The reservation system is shown as a graphic, instructing respondents how to reserve and access a carsharing vehicle.

Study Limitations

Because the neighborhood carsharing model is still a new concept in China with limited public exposure, the survey can only explore the stated response to the concept. In addition, the study evaluated a respondent's preference to carsharing without considering variations in the service level. The design attempted to counter non-response bias through the inclusion of a gift card incentive. As mentioned earlier, the overall response rate was 7%, which is low by traditional standards, but reflective of recent survey response rates achieved in Shanghai (*53*). Due to budget limitations, respondents were only queried once to take the survey. Several dynamics could have introduced some selection bias into the data. For example, the head of household typically completes mail surveys, and these respondents are more likely to have the highest education in the household. It is also possible that a survey focused on carsharing may have only appealed to a subset of potential respondents. Finally, the survey responses are stated, not revealed preference, and thus indicative of how people think that they would respond to the service. Due to these dynamics, the results are likely more representative of potential early adopters that comprise a subset of the Shanghai population and less generalizable to other regions in China.

SURVEY RESULTS

In this section, the authors discuss: 1) survey respondent demographics relative to the current Shanghai population, 2) potential carsharing impacts on vehicle sales and planned purchases, and 3) 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 that were 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?" The authors considered respondents with answers of 6 or greater to be "Interested" in carsharing (144 of the sample), and respondents with answers between 1 and 5 to be "Not Interested" in carsharing (127 of the sample). This division is relevant for understanding how different people reacted to the carsharing concept. Table 2 illustrates a breakdown of key demographic variables of these subgroups, along with the overall sample.

TABLE 2 Demographic and Socioeconomic Attributes of Survey Respondents

	Interested 6<=Preference<=10	NOT Interested Preference<=5	Whole Sample
Income	N = 144	N = 127	N = 271
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	N = 144	N = 127	N = 271
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	N = 144	N = 127	N = 271
Less 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%
More than 60	0%	4%	2%
Household Car Ownership	N = 144	N = 127	N = 271
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	N = 144	N = 127	N = 271
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%

While population data in China are improving, they are still not as comprehensive as the U.S. Census, in that 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 correspond reasonably well. The average household income for Shanghai residents is ¥92,170 (US$14,029) whereas the median income category of the sample was ¥70,000 – ¥100,000 (US$10,780 –US $15,400) (*40*). While there is also within-sample income variation among the subgroups defined by carsharing interest, a Mann-Whitney test evaluating the differences in the household-income distributions between the subgroups did not find a statistically significant difference (p=0.165).

The distribution of educational attainment indicates that the sample was more educated than the Shanghai population. Only 24% of Shanghai residents have an undergraduate education or higher, whereas 23% attended high school, while the remainder holds a middle school education or lower (*54*). 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=0.086), with the distribution of those interested in carsharing skewed towards higher education levels.

Within the Shanghai population that is 18 years of age or older, 27% are between the ages of 18 to 34, 49% of the population are between the ages 35 to 59, and the remaining 23% are older than 60 *(40)*. The sample is generally younger than the population, as 59% (n=160) were between the ages of 21 to 35. Furthermore, the difference in the mean age of the not interested (~38) and interested (~34) subgroups was statistically significant (p=0.000), suggesting that younger people may be more interested in carsharing.

There are nearly 10 million people living in Shanghai with one million registered private vehicles. But Shanghai is also suspected of having a sizable vehicle population that is registered elsewhere in China, but driven within city boundaries. This is due to the large difference in licensing costs between regions. People will have a vehicle licensed in one region but park it in another. Hence, the 10% ratio of vehicles to people listed in Table 1 is considered to be 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 (*40*). The sample showed that 53% (n=144) of the households owned a car, which is 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 is relatively automobile-adapted, there is no statistical distinction across subgroups in vehicle ownership (p=0.488). Also shown in Table 1, 26% of Shanghai residents have a driver's license, whereas in this sample the proportion was 60% (n=163). Hence, one clear dimension of survey bias was auto ownership and driving experience, which departed significantly from the general population.

Potential Carsharing Impacts on Vehicles 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 who owned a vehicle in their household stated that they would dispense of their automobile (16 of 144), if they joined carsharing. This proportion was the same among those households interested in carsharing, (8 of 72).

Interestingly, this proportion is smaller than past research in Europe and North America, which has repeatedly found that nearly 25% of carsharing members give up a vehicle *(10, 11, 13).*

The authors also explored whether carsharing availability might change expected vehicle purchase plans over the next five 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 both interested in carsharing and planned a vehicle purchase within five years. Among those respondents, 51% (n=44) stated that they thought that they would give up their purchase plans if they joined carsharing, thus supporting the idea that carsharing may be more effectual in China by obviating household vehicle purchases.

Ordinal Regression Model: Carsharing Interest

The authors evaluated carsharing interest using an ordinal regression model. A key advantage of using ordinal regression is that the most influential variables can be isolated, controlling for the influence of other variables. Table 3 presents the model estimation, with carsharing interest as the dependent variable. The question had a 10-point response scale; however, the authors rescaled it to five categories—placing two responses into each ordinal category—to reduce the number of threshold variables (intercepts). For example, the responses of one and two were rescaled to one, while the responses of nine and ten were rescaled to five.

TABLE 3 Ordinal Regression Parameter Estimates for Predicting Carsharing Interest among Survey Respondents

Variable		Coefficient Estimate	Standard Error	Probability
Threshold	[Carsharing Preference = 1.00]	-1.828	0.595	0.002
	[Carsharing Preference = 2.00]	-1.233	0.587	0.036
	[Carsharing Preference = 3.00]	0.089	0.581	0.878
	[Carsharing Preference = 4.00]	0.853	0.582	0.143
Demographic	Household Income ($10,000)	-0.024	0.008	0.003
	Education	0.095	0.053	0.074
	Age	-0.011	0.008	0.173
	Commute Single Trip Time	0.006	0.003	0.085
Attitude	"Energy security" VS "Global warming" in China.	-0.123	0.083	0.139
	Worry about getting into an accident when drive.	-0.255	0.086	0.003
	Carsharing lots near transit stations and stops.	0.148	0.031	0
Factor	[Major Shopping Mode = Taxi]	-0.957	0.568	0.092
	[Major Shopping Mode = Private Car]	0.206	0.186	0.267
	[Major Shopping Mode = Bus]	0.247	0.232	0.288
	[Major Shopping Mode = Metro]	0.568	0.238	0.017
	[Major Shopping Mode = Bike]	0.287	0.237	0.227
	[Major Shopping Mode = Walk]	0[a]	.	.
	[Car Purchase Plan = Within 1 year;]	-0.26	0.263	0.322
	[Car Purchase Plan = Within 1-3 years;]	-0.204	0.196	0.298
	[Car Purchase Plan = Within 3-5 years;]	-0.551	0.203	0.007
	[Car Purchase Plan = Within 5-10 years;]	-0.459	0.253	0.07
	[Car Purchase Plan = No plan Within 10 years;]	0[a]	.	.

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 = 0.624.
a. This parameter is set to zero because it is redundant.
Prediction Attitude Acuracy = 196/271 = 72.3%.

Ordinal regression models have three main components: 1) threshold coefficients, 2) covariate coefficients, and 3) factor coefficients. The threshold coefficients are the constants that are estimated on the individual logits, pertaining to each ordinal response of the dependent variable. The covariates are ordinal or interval variables that exhibit a definable scale. Factors are variables that are generally categorical. Positive coefficients for covariates and factors indicate that the variable increases carsharing interest.

There are seven covariates including: household income, education, age, commute trip time, and three attitudinal questions. Household income was statistically significant and negative, indicating that all else equal, higher income reduces carsharing interest. The same effect is given by the age coefficient. Although age and income are often correlated, age was not significant by itself. As education rises, so does carsharing appeal. This last result is consistent with carsharing research in the North America and Europe, which has found that the majority of members had a bachelor's degree or higher *(9, 11, 13)*. In addition, a previous study in Beijing found that those interested in carsharing were relatively more educated than those not interested *(16)*. Finally, the length of commute time to work positively influenced carsharing interest.

The authors asked respondents attitudinal questions to evaluate their opinions on climate change and energy security, as well as their concerns and preferences regarding carsharing use. Respondents were asked on a four-point Likert scale whether they felt that "energy security" was more important than "climate change." The negative coefficient indicated that respondents believing China's energy security was more important than climate change were less likely to be interested in carsharing. This effect, however, is weak as the coefficient is not significant. The model also found that an individual with a high concern for personal driving safety was also 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 of carsharing vehicles to public transit important were also found to be more interested in carsharing.

Two categorical factors were also included in the model. Respondents were asked to identify the primary mode that they used for shopping. The most significant responses were metro and taxis, suggesting that those using the metro as their primary shopping mode had a higher likelihood of carsharing interest, whereas those identifying taxis as their primary mode had less interest. The model also included vehicle purchase plans. Relative to people with no vehicle purchase plan, those with long-term purchase plans were found to be relatively less interested in carsharing. This suggests that having near-term vehicle purchase plans is not a large deterrent to exploring 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 are 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 is the case for this model ($p=0.642$). The non-rejection 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.

CONCLUSION

Overall, the survey results suggest that a subpopulation of Shanghai residents have an interest in carsharing, but that interest is governed by several key factors. Namely, carsharing interest rises with education level and falls with age, a common pair of attributes for carsharing members across the globe. At the same time, it declines with higher household income. Other aspects that drive carsharing interest include travel patterns and vehicle purchase plans. Those who predominantly shopped using the metro were more likely to be interested in carsharing, whereas those that used taxis were less likely to express interest. Furthermore, a very 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 one to three years) received the carsharing concept better.

These results, in combination with the broader macroeconomic circumstances discussed earlier do not indicate that carsharing, as the neighborhood model is operated in North America and Europe, would unequivocally take hold in large Chinese cities were it made available. Rather, the results reinforce the perspective that neighborhood carsharing may face several challenges in attaining a broad customer base or rapid membership growth as experienced in the U.S. The taxi, which plays a very 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 pubic transit networks, it is not immediately evident whether widespread driving experience is even needed. Furthermore, land use and parking costs are high in Chinese cities, and thus the economics are generally stacked against a business model that needs to deploy a large amount 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 may emerge in China could look quite different from neighborhood carsharing in Europe and North America. While carsharing was originally envisioned to get people out of privately-owned vehicles, carsharing in China would most likely get more people into them.

But certain designs of the neighborhood model might overcome these obstacles. Carsharing vehicles might be more readily deployed within parking garages accessible to residents of large apartment buildings. This "closed" or "semi-open" neighborhood model places restrictions on who uses the vehicle to those with access to the building. China is at a unique point in its industrial development in that it is rapidly building cities at a time when carsharing exists. Throughout history, new cities have had the advantage (or in some cases disadvantage) of forming 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, but more in the form of vehicles never acquired than 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.

Hence, it is probable that some form of carsharing will emerge in China. But it is not clear that copying the neighborhood model, which has spread across Europe and North America, would be the most successful. Rather, China with its unique status as a large but still emerging economy may need to form a unique style of carsharing that satiates the increasing demand for vehicle ownership and mobility, while at the same time complementing its existing transportation system constraints.

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