A user study on station-based EV car sharing in Shanghai

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Summary

There has been a trend in car sharing and especially electric car sharing over the last decade. This study aims at developing knowledge of users and searching market opportunities for the electric car sharing service EVCARD in Shanghai, China. EVCARD originates in the suburban Jiading district and is planning on expanding the business to the centre of Shanghai. Survey methods and tools have been applied in the study to acquire user data. The analysis was designed to answer research questions related to users' attitudes and expectations about the EVCARD service and to provide suggestions for system improvement.

Keywords: Car-sharing, case-study, China, EV (Electric Vehicle), mobility

1   Introduction

Car sharing (US), carpools (EU), or car clubs (UK) all refer to a model of short-term car rental that charges by time of use or sometimes miles driven. It is believed to be an effective measure to alleviate serious congestions in cities and improve quality of life. The economic, environmental and even health benefits brought by car sharing are well explored in earlier literature [1]. With the development of electric motors and battery technology, many have been trying to generate a more environmental-friendly solution by utilizing electric vehicles (EVs) in car sharing, e.g., Autolib (Paris).

The earliest national investment in EVs from the Chinese state came with the 8th Five-year Plan in the 90s. Between 2009 and 2011, Shanghai was assigned as one of the pilot cities to demonstrate New Energy Vehicles under the political framework of the "Ten Cities, Thousand Vehicles" program. Thus, Shanghai city started the governmental promotion of electric vehicles under the local program – EVZONE. In January 2011, Shanghai city was announced as the EV international pilot city and Jiading district was planned to act as the major demonstration platform in Shanghai [2].

EVCARD [3] is a station-based EV car sharing service initiated by Shanghai International Automobile City (SIAC) under the guidance of Jiading District Government, where automobile industry plays a key role in regional development. The goal of EVCARD is to demonstrate EVs through an innovative mobility service platform that encourages accessibility instead of ownership, which is considered a reasonable way to offset the high purchase cost for EVs. All users of this service are entitled to rent a Roewe E50 (Figure 1) with their mobile device, taking the car from a physical station and leave the EV at any of the stations after use. After almost one year testing, EVCARD was officially launched in January 2015. Today, around 300 users are actively using the service with a fleet of at least 150 EVs at 50 different stations. Still, the aim is to expand its service area towards Shanghai centre, in areas such as Jing'an district. More than 400 extra stations and in total 800 EVs are expected to complement the network in the Shanghai metropolitan area at the end of 2015.

This study aims at understanding user needs and identifying potential users for EVCARD, providing the basis for expanding the service area from the suburb to the centre of Shanghai. The literature has

emphasized that knowledge of customers is the fundament to the success of any business [4][5]. EVCARD allows us to examine how electrified mobility services can be operated under current constraints on a highly competitive market, and meanwhile, to learn to avoid potential mistakes when implementing similar services in other cities.

Figure 1: EVCARD station at Shanghai vehicle exhibition centre, Jiading, Shanghai.

1.1 How EVCARD works

The rental process in EVCARD is done through a mobile app or a website. The service requires subscription (currently free of charge). A membership card is required to access the vehicle and only members of EVCARD are eligible to rent the EV. Users can book an available EV nearby from 10 minute to one hour beforehand, and they can leave the vehicle at another station (or within 50 meters from a station if there is no available parking place) after use. To terminate the rental process, users need to checkout from the app and pay the fee online directly after. Users are able to lock the door temporarily by using the membership card, without terminating the rental process.

Subscribers can book an available EV online and pay on the same platform (with Alipal, a virtual wallet used in China, or by credit card) after use. Users need internet access for booking and returning the vehicles and need to possess a physical card as a key to lock and unlock the car door.

2 Research Process

To understand user needs and identifying potential users for EVCARD, user input have been collected. A timeline of the research process can be found in Figure 2. User data acquisition is done mainly through a questionnaire. For questionnaire design, local interviews were carried out beforehand in the sample districts as pre-tests − Jiading and Jing'an, selected based on their suburban and urban characteristics. The interviews, including phone interviews and face-to-face interviews, have been executed with help from the EVCARD's operator. Before the official launch, a pilot study was executed to ensure the feasibility of the questionnaire.
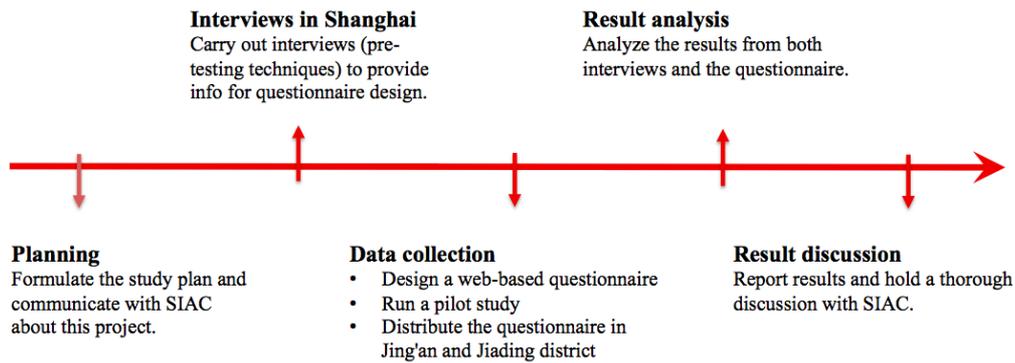
Figure 2: Timeline of the research process.

2.1 Pre-testing techniques

Pre-tests allow designers to detect and mitigate specification errors, operationalization errors and measurement errors [6]. Interviews were used as pre-testing techniques for the questionnaire. The pre-testing interview aims at gathering local background information, especially those concerning emotions and attitudes, in order to provide information for questionnaire design. Detailed data, especially the ones related to emotions and attitudes, have been acquired through the 21 interviewed participants in Shanghai.

2.1.1 Pre-testing technique I for questionnaire design: phone interview

Phone interview data were used to acquire background knowledge, for example, user experience of the current EVCARD service. Interviews took place at EVCARD's call centre and all respondents were contacted and interviewed on the phone by one interviewer speaking Chinese Mandarin. Respondents were selected from the information provided by the EVCARD operator on basis of their age, career, gender and frequency of use. The selection was based on the sociological assumption that people with similar social background tend to develop similar experience after testing a new service or technology [7][8]. All six respondents were registered in Jiading district, where the EVCARD service has been available since January 2015. Respondents were welcomed to leave free comments as they wish at the end of the interview. Respondents were rewarded with four-hour free driving time.

During the phone interview, all respondents were asked about their experience with vehicles in general and with the EVCARD service in particular, and how they valued the service. In total, 15 questions were posted to the respondents through the phone interview. All respondents contacted agreed to participate in the interview. In average, the interview took around 20 minutes including time for explaining ambiguous terms and presenting the procedure. Information of the respondents can be found in Table 1.

Table 1: Respondent info (include their use frequency).

No.	Gender	Occupation	Use frequency within 3 months (times)	Interview time (minutes)
1	Male	Master student	6	36
2	Male	Accountant	15	15
3	Male	PhD student	14	20
4	Female	Engineer	17	15
5	Male	Doctor	11	15
6	Male	Salesman	11	15

2.1.2 Pre-testing technique II for questionnaire design: face-to-face interview

In order to understand how EVCARD is generally perceived, face-to-face interviews targeted people who are eligible for the service, i.e. possess a driving license and show up in the EVCARD's service zone. Respondents were randomly selected from one university campus and also commercial areas (e.g. shopping malls) in each sample district. Fifteen people were successively interviewed for about 5-10 minutes.

Response rate at Jiading district is much higher than in Jing'an district. Nevertheless, all response rates were over 50%.

2.1.3   Pilot study for questionnaire assessment

The purpose of a pilot study is to assess the feasibility a questionnaire. It is a quantitative pre-testing technique that is implemented on a relatively smaller scale and aims at discovering "practical problems" concerning interviewers and respondents, length of the questionnaire, and examining key variables.

Five respondents, two internal contacts and three random persons, were involved in the pilot study before launching the questionnaire officially.

2.2   Questionnaire design

The questionnaire was directed to the respondents in sample districts, with or without knowledge of EVs or EVCARD. The goal of the questionnaire was to find out how the EVCARD service and the EV technology were perceived in different geographical areas to provide information on system design by considering user needs, attitudes and resources. The questionnaire was web-based, accessible with mobile devices or stationary computer.

An introduction of the research project and a description of the station-based free-floating EV sharing were presented in the very beginning of the questionnaire. Respondents were welcomed to leave comments for all the questions. In total, 28 questions were included in the questionnaire and approximately 15 minutes were required to complete it. Five themes were included in the questionnaire: demographics, current travel pattern, interests in using EVCARD and value creation (for example, saving time or obtaining a sense of personal gratification), and resource and payment method.

For attitude questions, studies showed that the acquiescence bias, meaning that respondents tend to appear polite or agreeable during interviews, was commonly found in survey studies [9][10]. To minimize this kind of bias, unipolar numeric labels were applied to quantify user attitudes towards the EVCARD. According to [11], unipolar numeric labels can be avoided adding on extra acquiescence bias because bipolar numeric labels usually lead to more positive response distribution.

2.3   Questionnaire data collection

The questionnaire data collection was completed locally in Shanghai by a third party. Five hundred valid responses, 250 from each sample district, were expected from the design. Ten places, mostly transport hubs, activity centres, hospitals and shopping malls, were selected to collect data in each district. Before the official launch, a pilot test was conducted to validate the web-based questionnaire for two days with 15 answers.

The official data collection was performed during a weekend, from 2015-04-11 to 2015-04-13. Eventually, 497 valid responds were available for the analysis. Data was first analysed with simple descriptive statistics and diagrams with different interest groups and geographical groups, followed by statistical analysis to cluster the potential users group.

3   Methods

3.1   Qualitative analysis

As mentioned above, the data from the interviews aims at providing the background of the current status of the EVCARD and to provide information for questionnaire design. All interview data was managed with simple coding and information was extracted from the responses. Textual analysis that involves information retrieval, studying work frequency distributions, pattern recognition, tagging/annotation, and

information attraction was applied together with cross-comparison to analyse the notes after the interviews [12].

3.2 Statistical analysis

The statistical tool IBM SPSS® was used for the statistical analysis in this study. Descriptive statistics and frequencies are the statistical methods employed for obtaining the overall view of questionnaire results. In order to identify the potential user group for the EVCARD, clustering was applied to categorise the group with similar characteristics from the data. This method can capture the structure nature of data and thus is considered as a useful tool for marketing research [13]. It is a good start for data summarization and compression, allowing a more efficient process to find the nearest neighbours who possess similar features [14]. Overall, clustering is a simple method to group data based on resemblance.

Cluster analysis was carried out first with principle component analysis to obtain the explanatory factors. Then the hierarchical cluster (Ward's methods) was applied to identify the number of grouping [15]. Eventually, ten groups were obtained and processed further with k-means clustering.

3.3 Cross-reference and comparison

Information extracted from interview data was cross-referenced with findings obtained from the questionnaire to ensure consistency, and moreover, discover the underlined features or details that cannot be retrieved directly from the results.

4 Results and discussion

Same as for the interviews, more males than females, especially young males, responded during the questionnaire data collection period. Most of respondents had never heard of EVCARD before the survey; however, most of them held a positive attitude. Over 38% expressed interests to the EVCARD and 35% of respondents held neutral opinion. Results from the two districts are not far from each other. Users expressed that convenience of use, for example easy booking, was the most important criterion for new customers to start using the service. This feature was considered even more crucial than economic benefits.

4.1 Mobility needs and transport mode substitute

The analysis results from the survey with 497 respondents suggested that people were in general keen to test-drive EVs and try the flexible rental service. No significant difference was observed between the two sample districts regarding user perceptions and expectations towards EVCARD; however, a difference in mobility patterns existed. Jing'an district locates at the centre of Shanghai. With good subway connection and undesirable driving conditions, car use was found in general less interesting than public transport. On the contrary, with a history of vehicle industry and limited public transport alternative, driving is part of the life of residents in Jiading district. Mobility in Jiading was found much more dependent on private vehicles than in Jing'an. Today, most of the respondents required short-term return (less than 40km one-way) in their daily transport, implying that they travel inside the city and potentially to many different places nearby.

One of the perspectives to assess the market potential of EVCARD is from its substitutes. The station-based free-floating EV sharing service allows flexible mobility inside and also between districts, which is comparable to a combination of public transport and private cars. From the survey, most respondents thought that EVCARD could substitute E-scooters or motorcycles (26%) and private cars (21%). Up to 12% of respondents saw subway as an alternative mode for the EVCARD service (Figure 3). Illegal taxis, or "black taxis", were also seen as one of the substitutes for EVCARD, especially in the suburban areas of Shanghai where fewer taxis are around. These results can lead to the conclusion that realistically it is not yet possible for EVCARD to replace people's primary transport mode, i.e. commuting to work. Secondary trips, for example business trips or grocery shopping, done with the previously mentioned transport modes would be easier accomplished by the EVCARD. However, commuting was what people wish to achieve with EVCARD service in the end (Figure 4).
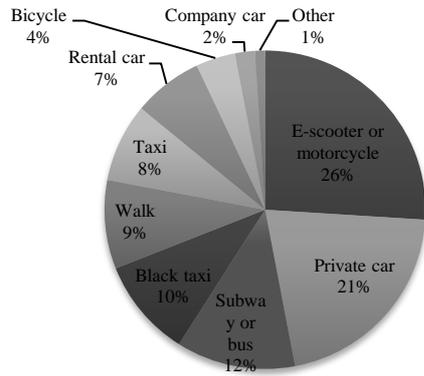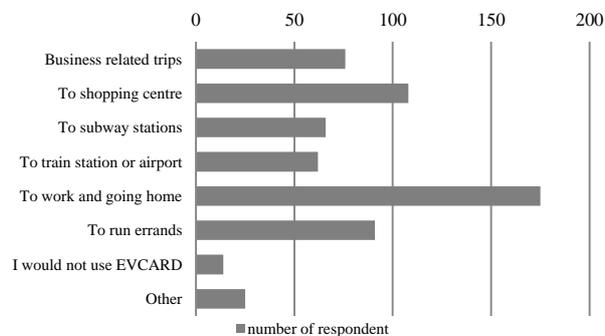
Figure 3: Substitutes for EVCARD.

Figure 4: Purpose of using EVCARD.

4.2 User needs and requirements

To design a salient and user-friendly service, the survey also offered some valuable insights considering the preferred features. In order to locate the stations with a good distance in between, respondents were asked about the longest distance that they would consider walking instead of taking a motorized vehicle. Results showed that a distance of 500 meters is what people are willing to walk to a station (Table 2). A distance longer than 2 km was linked with motorized vehicle use, according to the survey results. Consequently, locating stations more than 2 km from residential or commercial areas would not be recommended because it could hinder accessibility.

Table 2: Survey results of the choice of transport mode.

Time to walk to an available EV	
Options	Response Percentage
More than 10 minutes	12%
5 – 10 minutes	60%
Less than 5 minute	25%
I cannot answer	3%
Transport mode use for a 2-km trip (under good weather condition)	
Motorized vehicle	40%
Bicycle	36%
Walk	21%
Other	3%

The potential for EV car sharing service is substantial, especially under the Central Government's policy support. However, the competition in the passenger transport sector is enormous. Taxis and other car rental services are the major competitors for EVCARD. Most of the current users expressed content with the price levels, which was cheaper than using a taxi for a trip longer than 5 km and more expensive than renting the same model of EV at a car rental place. However, since the average trip length in Shanghai is about 6.3 km [16], it implies that EVCARD should achieve a high use rate of each vehicle, and at the same time, offering a more flexible service than car rental to retain its competitiveness on the market. The majority of respondents agreed with the hourly charge model; however, today's revenue stream cannot support the business in the long-term without support from other finance sources.

4.3 Potential user characteristics

The potential user characteristics were identified through cluster analysis method based on the assumption that all original data are correct. After obtaining 10 groups from cluster analysis, several groups of characteristic combinations were extracted. The results suggested that 14.4% of the respondents belong to the potential user group. The following features of user were found in the potential user group: age between 18 and 40 years old, employed, driving more than 3 times per week and trust the technology (i.e. willing to drive it every day). The result is in line with findings from earlier studies. Young generations are more sensitive to environment issues and green products and find it easier to accept changes [17]. This explains why young professionals appeared to be keener to take part in EVCARD. Since familiarity can be taken as the knowledge and affective evaluations of a product or a service [18], it is reasonable that people who are prone to driving are more likely to become a user of EVCARD.

Other common characteristics found in both potential users and all respondents were the desire for easy access to station, straightforward booking and payment system. Besides, the current pricing model was preferred by both groups of respondents.

Differences between sampled areas were minor regardless the diverse urban characteristics of the two districts. On basis of these characteristics and the fact that EVCARD starts in Jiading, one would expect that Jiading residents should have a better knowledge and more interest in EV sharing referencing [19]. However, the results suggested otherwise. It can be interpreted that people in general do not receive enough information about EVCARD, implying that the marketing strategy may need to be revised.

4.4 Challenges of EVCARD

An overview of the general perception of EV car sharing was outlined via the phone and face-to-face interviews. Many challenges were identified: one example being that users rarely charge the vehicle (Figure 1). This is partly for lack of knowledge and partly for lack of incentives. The operator has difficulty to include charging in the return process because the reserved parking places are often occupied due to a lack of parking spaces. Currently users are allowed to park close to a station (5-10 meters) if all spots are taken.

Many respondents pointed out in the interview a problem of incorrect driving range in the app. They complained about the difficulties of trip planning that originated from the untrustworthy EV range. This technical flaw increases the risk of getting stuck on the road with an empty battery, which eventually contributes to a significant cost for EVCARD to rescue the EV and a surge of range anxiety from the user side [20]. At the current stage, the amount of user does not allow EVs to flow properly within the EVCARD system. As a result, extra personnel are required to relocate and charge the vehicles in good time to guarantee access of EVs to all their customers.

The lack of parking lots or land in general, appears to be a common problem in dense cities such as Shanghai. Even for reserved parking, it is somehow socially acceptable for an unauthorized person to occupy it when empty. This phenomenon deters the deployment of station-based free-floating EV sharing

because it demands extra time or/and cost for parking if all the reserved places are taken. The incentive of guaranteed parking disappears and thus discourages the use. One solution might be building a designated parking house that only allows access of EVs from the EV sharing service, as in Mini-bus project in Hangzhou [21]. In any case, expanding the EV sharing system towards city centre is always difficult due to the scarcity of land. It is then common to ask for support from the authority, for example, the municipality.

Additionally, several other minor technical problems related to the mobile app were also mentioned in the interviews. Yet, these are less severe comparing to the range- and parking-related complications (Figure 5).
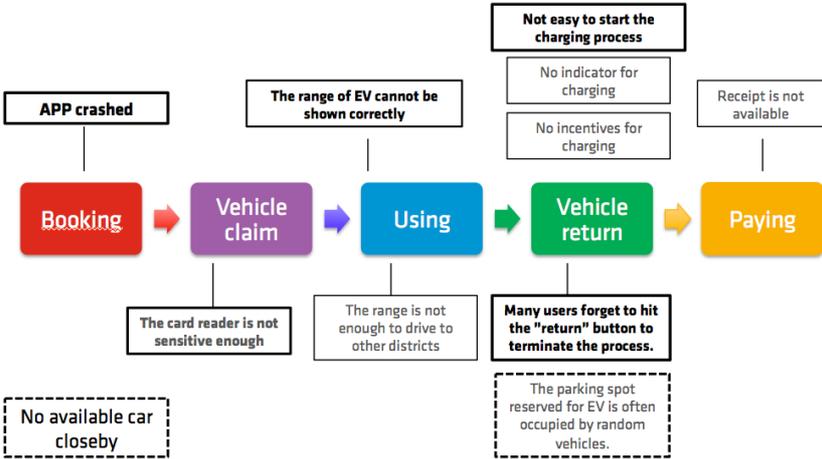

Figure 5: Challenges for EVCARD (solid lines: technical limits; dot lines: other limits).

5   Conclusions

The station-based free-floating EV sharing service is believed to be one of the solutions to complement last-miles and resolve problems such as congestion and pollution in megacities. In China, several cities have recently initiated demonstrations of similar services, e.g. Mini-bus in Hangzhou and GreenGo in Beijing. However, for a successful operation, a thorough knowledge of different customer needs is necessary. A number of examples of entrepreneur failures can be explained by ignorance or misinterpretation of customer needs [4]. EVCARD has a potential to scale up; nevertheless, a solid business model should be settled to generate good revenue streams. At the current stage, EVCARD can only replace or complement certain transport modes and for secondary trips.

The potential user group is characterized by employed young to middle-aged individuals, who are relatively familiar to driving and comfortable with EVs. The majority of people in this group own at least one car in the household. Nevertheless, a number of respondents expressed confusion towards EVCARD's use process, implying that better communication should help the public to know more about and start using the EV sharing service. Considering the fact that no difference was found in the respondent's answers in Jiading and in Jing'an when it comes to the publicity of EVCARD, the strategy team may consider revising the marketing and communication strategy for expanding. Besides, according to the respondents, simple access was the most important feature for EVCARD. This implies that the booking, renting, returning and payment step should be as easy as possible for the user.

The current price model is deemed competitive on the market based on the survey results; however, it is not sustainable economically. New business models are needed to allow EVCARD to grow organically. Since free-floating EV sharing is still a new service in China, more research is expected before a balanced business model can be settled.

There is still possibility to improve the service quality of EVCARD. For example, extra work is required in software and hardware development regarding to the IT platform and the rental system, marketing strategy and customer communication.

EVCARD is an interesting case worth investigating because it explicitly depicts the difficulties of enabling a station-based EV car sharing service in a highly populated and extended city – Shanghai.

Acknowledgments

References

[1]   J.L. Kent, *Carsharing as active transport: What are the potential health benefits*, Journal of Transport & Health, ISSN 2214-1405, 1(2013), 54-62.

[2]   EVZONE, http://www.evzonechina.com/en/about/default.aspx , accessed on 2016-02-01

[3]   EVCARD, http://www.evcardchina.com/, accessed on 2015-10-27

[4]   N. Furr, P. Ahlstrom, *Nail it and scale it: the entrepreneur's guide to creating and managing breakthrough innovation*, ISBN 0-98372-360-5, 2011.

[5]   A. Osterwalder, Y. Pigneur, *Business Model Generation*, ISBN 0-47087-641-7, Wiley, 2010.

[6]   R. Tourangeau et Al., *Sources of Errors in a Survey on Sexual Behaviour*, Journal of Official Statistics, 13, 4(1997), 341-365.

[7]   A. G. Rosati, B. Hare, *Decision making across social contexts: competition increases preferences for risk in chimpanzees and bonobos*, Animal Behaviour, 2012. http://dx.doi.org/10.1016/j.anbehav.2012.07.010

[8]   M.A., Lamanna, A. Riedmann, A. Strahm. Marriage, families, and relationships: making choices in a diverse society. GENGAGE Learning Custom Publishing. ISBN 1111301549, 2010.

[9]   H. Schuman, S. Press, *Questions and answers in attitude surveys: experiments on question form, wording and context*. New York: Academic Press, 1981.

[10]   P.J. Ferrando, U. Lorenzo-Seva, E. Chico, *Unrestricted factor analytic procedures for assessing acquiescent responding in balanced, theoretically unidimensional personality scales*, Multivariate Behavioral Research, 38, 3(2003), 353-374.

[11]   N.C. Schaeffer, S. Presser, *The science of asking questions*. Annual Review of Sociology, 29 (2003), 65-88.

[12]   P. Gill, K. Stewart, E. Treasure, B. Chadwick, Methods of data collection in qualitative research: interviews and focus groups, British Dental Journal, 204 (2008), 291-295.

[13]   G. Punj, D.W. Stewart, *Cluster analysis in marketing research: review and suggestions for application*, Journal of Marketing Research, 20, 2 (1983). 134-148

[14]   Tan Pang-Ning, Steinbach, M., Kumar, V. (2006). Introduction to Data Mining, Chapter 8: Basic concepts and algorithms. pp. 489.

[15]   C.C. Aggarwal, C.K. Reddy, *Data Clustering: Algorithms and Applications*, Chapman and Hall/CRC, 2013.

[16]   Shanghai Maritime University, *Cost analysis for public transport in Shanghai*. Shanghai Maritime University, Shanghai, China, 2010. (In Chinese)

[17]   M. Kanchanapibul, E. Lacka, X. Wang, H.K. Chan, *An empirical investigation of green purchase behaviour among the young generation*, Journal of Cleaner Production, 66 (2014), 528-536, ISSN 0959-6526, http://dx.doi.org/10.1016/j.jclepro.2013.10.062.

[18]   N. Luhmann, *Familiarity, confidence, trust: problems and alternatives. Trust: Making and Breaking Cooperative Relations*, Department of Sociology, University of Oxford, 94-107, Chapter 6, 2000.

[19]   B. Vilhelmson, *The use of the car: Mobility dependencies of urban everyday life.* In T. Gärling and L. Steg (Eds.) Threats from Car Traffic to the Quality of Urban Life: Problems, Causes and Solutions. Oxford: Elsevier, 2007, 145-164

[20]   M. Nilsson, *Electric vehicles: An interview study investigating the phenomenon of range anxiety*. Public deliverable Task (5000) ELVIRE project (www.elvire.eu), 2011. Accessed on 2016-03-24 at http://e-mobility-nsr.eu/fileadmin/user_upload/downloads/info-pool/report_result_interview_elvire.pdf.

[21]   H. Zeng, *Car-sharing grows in China as an alternative to vehicle ownership*. The City Fix, 2014. Accessed on 2015-08-11 at http://thecityfix.com/blog/car-sharing-china-alternate-vehicle-ownership-car-congestion-peer-to-peer-growing-government-support-heshuang-zeng/.

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