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Collaborative governance in the sharing economy. A case of free-floating bicycle sharing with visualized analysis

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Abstract: A business model of sharing economy has rapidly developed. It is predicted to profoundly influence the society. However, because imperfect management might ruin its operation and future growth, the sharing economy model is rife with conflicts and paradox in terms of logic, boundary, and influence. Taking the Free-floating bicycle sharing (FFBS) as an example, although it is becoming more and more popular in many big cities, the service has led to many problems, including road congestion, parking disorder, and mismanagement of bicycle information. As a result, its sustainable development is severely affected. In this study, we used FFBS as a case study to investigate the relations among government, companies and users. We interviewed varies stakeholders and discussed their different perspectives of collaborative governance. It showed that the parking location, usage frequency, number of parked bicycles, and bicycle health status could be used as indicators to monitor the service situations. We also identified that the wanton occupancy of public space was the major problem of FFBS. To address these issues, we developed a real-time information management platform with information visualization, aimed to help the government, the company, and the users to gather the bicycle information and coordinate their sharing usage. This platform could promote the sustainability of FFBS system and foster the development of other forms of sharing economy in the future.

Keywords: Sharing economy, Bicycle-sharing, Coordinated management, Sustainable design, Visualized analysis

1. Introduction

The development of information technology and shrinking of natural resources has prompted the emergence of collaborative consumption (Botsman and Rogers, 2010) and drove the society to connect via the Internet so as to improve efficiency. Consequently, sharing economy becomes a hot topic in many domains globally. In recent days, sharing-based business activities and consumption practices have emerged continually, such as product service systems, co-creation, consumer
participation, collaborative consumption, and business sharing systems (Belk, 2010). Compared with purchasing and possession of products, consumers more expect to acquire services and pay for temporary acquisition, but ownership is no longer the ultimate reflection of the desire to consume (Chen, 2009). This business form has covered transportation (e.g. cars, ships), space (e.g. short rent, living space), and labor (e.g. part-time). For instance, Airbnb has thoroughly changed the way of accommodation, and has surpassed some leading international hotels such as Marriott International, expanding its market to the whole world.

The current sharing economy activities are common in two aspects. Firstly, they depend on Internet platforms (especially after the emergence of Web2.0), which allow users’ broad participation and thus generate relations among users (Carroll and Romano, 2011). So far, the birth of Web 3.0 makes sharing economy more convenient and intelligent, and provides users more-equal platforms. Secondly, the key to sharing is the consumption or services through temporary possession of non-ownership rather than ownership possession. Along with the rapid expansion of sharing economy, the networking and temporality have caused negative effects on sustainable development, such as the lack of product identification sense (Bardhi and Eckhardt, 2012), interest inequality and ownership polarization (Richardson, 2015; Ma et al., 2018), which have attracted attention from researchers in recent years (Davidson and Infranca, 2016). An ecological closed-loop is needed by sharing economy to balance the interests among governmental administrators, company managers, and users.

During the development of sharing economy, interventions from different forces would cause structural tension, which cannot be solved by any single participant and should be relieved through the cooperation of all stakeholders. In research on collaborative management, though researchers have proposed a dynamic evolution framework of governments–companies–society cooperation during the sharing economy (Yuge Ma, 2018), no operable design tools are available for collaborative management. In this study, targeting at free-floating bicycle sharing (FFBS), we explored urgent management problems behind this rapidly-developing business mode, and presented a collaborative management method with information visualization. Firstly, we investigated the negative effects of sharing economy (represented by FFBS) on the society. Then we synthesized major problems appearing during FFBS management. After clarification of major negative effects and influence factors of FFBS, we tried to build bridges among companies, governments and customers. Given the contradictory of sharing economy, we proposed a visualized solution in the case of FFBS. Finally, we discussed how information visualization could contribute to sharing economy and summarized the cons and pros of this method.

2. Theoretical research

2.1 Sharing Economy

Sharing economy is considered as a subversive economic mode revolution. Specifically, the commodity or service consumption is achieved through the online renting, sharing or exchange of resources organized by manufacturers or service providers. The sharing process does not involve ownership transfer (Botsman and Rogers, 2010; Belk, 2014). In this way, transaction costs are reduced so as to increase the efficiency and commodity utilization rate, break the monopoly of suppliers, and to excite market competition. The sharing economy mode can be localized into three basic cores, including acquired economy, platform economy, and community economy (Acquier, 2017). Acquired economy is defined as the measures to optimize any capital (material resource or skill) that is not fully utilized (Acquier, 2017). It usually depends on an organization (e.g. FFBS, Zipcar)
that possesses and manages the highly concentrated capitals, or relies on disperse ownerships (e.g. Airbnb). FFBS is a typical case of capital centralized acquired economy. In this study, we focused on FFBS to study the social problems faced during the development of sharing economy.

2.2 Collaborative governance during acquiring economy

Acquier (2017) summarized the promises of acquiring economy to socioeconomic and the environment, and found the acquiring economy was also affected by tensions and paradoxes, and suffered from moral risks, information asymmetry, and the generation of extra unsustainable consumption. The rapid development of sharing economy is closely related with the fast and agile governance. Future public institutions should rapidly adapt to environmental changes (Ganapati, S., & Reddick, C. G., 2018). Lack of responsibility to the shared products, the negative effects due to improper operations, and weak social control, are the causes of the wanton use of shared products (Bardhi and Eckhardt, 2012). The users of resources will never spontaneously maintain these resources (Ostrom and Elinor, 2009). Thus the cost of resource recovery and maintenance are extremely high that the company can not afford. The company will usually ignore bicycle management, which leave the responsibility to the government to provide solutions.

Local governments have realized the importance in supervision and management of sharing economy, and their attitudes have changed from the complete welcome to open hostility. Companies are forced to handle supervision and management restrictions through business adjustment (Davidson and Infranca, 2016). However, as key roles of problem coordinator, governments usually reinforce management by raising the entry barriers such as restricting areas and number of bicycles, which are delayed to some extent and reduce the enthusiasm of FFBS businesses (Sebastian and Christopgh, 2018). According to the above reasons, unilateral governance of sharing economy by governments is largely limited in practice and can not flexibly adapt to the varying markets. Therefore, we consider that guidance of user self-maintenance, possession of definite input and collaborative management by companies, will positively contribute to creating a sharing economy closed-loop.

2.3 Manage information visualization

In recent years, many traffic management studies based on information visualization have been conducted. At the level of data analysis, visualization methods such as choice-of-location graph, wait/move strategic tree and visual analysis of route diversity, can offer drivers travel route guidance and evaluation (Liu H et al., 2011; Gao Y et al., 2012). At the level of behaviour analysis, methods including latent dirichlet allocation (LDA), visual analytic of taxi topics (VATT) and topological modes of road traffic (TMRT), have been used to analyse traffic route contexts so as to help with traffic management (Chu D et al., 2014; Anwar A et al., 2014; Wang F et al., 2014). Clearly, traffic data visualization has been actively applied to aid traffic management. However, in the field of bicycle management, the existing studies mostly focus on the public bicycles with fixed parking lots (Austwick et al., 2013; Du F et al., 2015; Oliveira G N et al., 2016), but rarely on FFBS.

Comparing with the visualized analysis of vehicle traffic data, current studies on public bicycles are mostly focused at the visual level and lack of higher-dimensional discussion. By using visualization techniques, statistic methods, and space and network analytics, Austwick et al. constructed an urban exploration bicycle sharing system from five dimensions, and thereby characterized the geographical locations of different cities and found out the similarity among systems. Guilherme et al. introduced the interactive visualization system into bicycle sharing, conducted 10-month visualization analysis with New York Citi Bicycle, and validated that the visualization system could better help decision-
makers to understand commuting dynamics and conquer governance problems. These achievements suggest the visualization of bicycle sharing can be an efficient tool for governance and decision-making, but these studies present no deeper discussion about the solutions to concrete problems.

Compared with fixed-pile public bicycles, FFBS has a larger market supply and is obviously more influential to the traffic environment. Relations among different stakeholders are more complicated. Decision making of any party will affect other parties. Visualization as an effective tool to support data-driven decision-making, could provide an efficient management method to these urgent issues raised by FFBS.

3. Case study

3.1 Background
FFBS is a pile-free bicycle renting service and is different from other public bicycle services in two aspects. 1) FFBS bicycles can be parked at any place of a city and are free from the restraint or restriction by piles (Yuge Ma, 2018), which relieve the burden of registration. 2) Each bicycle is equipped with a built-in chip, an LBS system, a power system and a theft deterrent device, which facilitate long-term data monitoring and gathering. Users can search and pay on mobile phones to use bicycles. FFBS users started to explosively grow in China since 2016, and rose to nearly 16 million by July 2017. However, within short time, it was such an outbreak that it fully embodied the pros & cons of the emerging mode of acquiring economy.

FFBS promotes exercises among residents, saves time, improves air quality and accelerates urban economic development (Adrian Bauman, 2017). Apparently, this free use mode is also limited by the difficulty of management. When the numbers of bicycles continually increase due to business competition and lack of management, many problems emerge, such as the occupancy of public space by bicycles, improper maintenance of bicycles, and non-standardized recovery management (Sebastian and Christopgh,2018). While promises are fulfilled, the management disadvantages of acquiring economy also emerged. The excessive investments within short time and the excessive competition will lead to the ‘supply exceeding demand’ and finally lead to severe unbalance.

Regarding these problems of sharing economy, researchers have put forward new organization frameworks from the perspective of management. But these management frameworks are mostly limited to theoretical guidance, and consequently, no suitable management tools are available for the execution of strategies. Here we first identify the conflicts affecting the sustainable development of sharing economy, and then design real-time information platforms for stakeholders, so as to promote the collaborative management of sharing economy.

3.2 Data acquisition
We collected data using two methods from two resources, literature data acquisition and interviews with stakeholders. There are many studies on FFBS management reporting interviews of companies and governments. Following established interviewing protocols, we interviewed over 20 FFBS users, administrators from different level of governments, different levels of managers in companies, and other stakeholders such as local residents in this area. The data collection and user interviews were focused on four problems about the collaborative management by stakeholders:

1) As for FFBS, what problems have interfered with the normal social orders, and how these problems have negatively affected citizens, enterprises and governments?
2) When the social and environmental impacts of FFBS have emerged, what has been done by different stakeholders to regulate a balance, and what are the results?

3) Is collaborative management necessary for FFBS? Who should be responsible? What benefits will be achieved?

4) During the collaborative management of FFBS, what challenges have been faced by different stakeholders? What coordination is needed to achieve collaborative management?

To ensure the integrity and objectivity of data, we also acquired relevant data from FFBS website, news reports, and interviews with stakeholders, so as to obtain a more macroscopic perspective. Relevant open policies and data from governments were also important sources for the governance of FFBS.

4. Information visualization as a tool of collaborative management

4.1 FFBS collaborative management mode

As for this flourishing business mode, the lack of supervision, management and regulation has led to many social problems that obsess all stakeholders. This raises all kinds of problems including the worse user experience, the higher maintenance costs by the company, and the experience shortage of governments in adopting mandatory measures. For instance, the costs of moving 22000 illegal FFBS bicycles in July 2017 in Hangzhou was over ¥220000 RMB; each illegal FFBS bicycle in Nanjing was punished with 50 RMB penalty and 15 RMB clearance costs. The companies lose big revenue from the punishment. However, due to crucial competition and humble profit, they still cannot solve the messy bicycle-stacking problem since they do not have enough human resources. Long time ago, companies, governments and researchers have realized the importance of collaborative management of FFBS-related problems.

‘Why I’m ceaselessly finding investors is because I have no definite profiting mode. I expect others give me money and let me survive, let me run faster than others. Then we can find the profiting mode together.’
- Wang Xiaofeng, CEO of Mobicycle, 2016 First Financial Annual Meeting, December 2016

‘We find the migration of shared bicycles is obviously tide-like: during the morning rush hours, the shared bicycles surge from communities to office buildings; during the afternoon rush hours, the shared bicycles recede from office buildings to communities. If bicycles are devoted to both communities and office buildings, the parking sources at these two areas will be complementary, which facilitates the green travel of residents during the rush hours.’
- Wu Haiyan, party secretary at Qingfeng community, Hangzhou Net, October 2018

‘As for concrete practices, the management of shared bicycles should be based on marketization and be cooperatively handled by governments, enterprises, communities and citizens through active dredging, reasonable guidance and innovation.’
- Tang Xiaotian, professor from Shanghai University of Political Science and Law, Xinhua Net, January 2017

So far, the governments mainly adopt measures of bicycle total number restriction, electronic fences, and Bluetooth spikes to standardize FFBS management. But these measures will greatly hurt users’ experience since they mostly focused on restricting users or bikes. Clearly, though governments and
enterprises have started to use obliged measures, they are not fully adapted and suitable to the varying market environment.

‘Technology progress can facilitate management, but when parking sites are insufficient, the restriction of parking sites will hinder the riding experience, which makes the sharing bicycles meaningless.’

- Shang Chongsheng, distinguished professor at City Safety and Social Management Research Center, Wuhan University, Hubei Daily, October 2018

‘Regarding the social and environmental effects of sharing bicycles, users can hardly make any change, because convenience was the first impression of FFBS to them. This vicious situation can be relieved only by the collaborative adjustment by governments and enterprises according to user demands.’

- Yang Xiaozhou, FFBS user in Shanghai, September 2018

As for this vicious cycle of FFBS, the main problems to be solved include the blind competition among companies, the lack of restraint on users, and the lag of governmental policies. For the four key stakeholders of shared bicycle including FFBS company, government, society, and user, we illustrated relations among them as the left graph in Figure 1. Effective tools of collaborative management are needed to make timely adjustment and restraints according to the varying markets under the sharing economy environment. We proposed to build bridges among stakeholders (green connections in right graph in Figure 1) by means of key information sharing. Through bicycle information sharing from online platforms and the coordinated offline user restraints, we can present to the stakeholders the dynamics of sharing economy in an open and transparent way. Through the information sharing platform, governments and companies can have conversation and negotiations can be conducted between the reconstruction/expansion of public space and the regulation of FFBS number. Compared with the strategic competitive investments by companies, the real numbers usually reflect the user demands and thus more complied with the rules of marketing, which give companies a more macroscopic perspective to investigate the environmental effects of FFBS. While monitoring the numbers of FFBS, governments can also think if more public space should be opened to users, and can use quantitative data to precisely plan the locations, areas and forms. When benefiting from the convenience of sharing, users will willingly follow the guidance (restrictions) from the company and government (e.g. electronic fences, Bluetooth spikes), which will solve some irresponsible bicycle use habits (Fig. 1).

![Figure 1. Collaborative Governance(CG) tools change the relationship between stakeholders](image)

As for the new sharing economy collaborative management, due to the nature of visualization that it can help people quickly get insight from a large amount of data, we consider that designers can
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Contribute to constructing collaborative management platforms utilizing visualization to help make data-driven decision making. The main social effects of FFBS were clarified through literature review and user interviews. We can use design thinking to summarize them into corresponding indicators. We identified key parameters to quantify the abstract problems (Fig. 2). Previous research on traffic information was focused on the recording of travel routes, and the travelling rules of citizens reflected by the superposition of travel routes. As for the FFBS collaborative management, the abundant key information about the effects on social orders can be acquired only from the time of unlock, time of lock and GPS as well as different algorithms. Since each GPS corresponds to the bicycle information, it is possible to analyse the majority of commuting behaviours through the shortest path fitting. Through aggregation and statistical analysis, concise information can be synthesized from the large amount of data, which can greatly reduce the load of data acquisition.

**Figure 2. Design deduction from social problems to figurative parameters**

### 4.2 Information Communication through Visualization

The evaluation of FFBS parking health can be focused on the four aspects: parking locations, amount of bicycles parked at each location, use frequency and bicycle health in the region (figure 3). The data of four dimensions can be presented through visual presentation. Indicators such as bicycle parking position, number of parking bicycles, use of frequency, and bicycle health status were comprehensively displayed from the perspectives of position, area and colour.

The bicycle parking status in a certain region could be preliminarily determined by combining the bicycle number, use frequency to make a index we called bicycle saturation index. Ideally, the use frequency and bicycle number should be balanced in most cases. Figure 4c shows the two axes of bicycle saturation indices. Horizontal axis (N) is the number of bicycles. Vertical axis (F) means frequency of usage. When the use frequency was high but the number of bicycles was low (top left corner of Figure 4c), this location may need to supply more bicycles. When the use frequency was low but the number of bicycles was large, then this location may need to reduce bicycles (bottom right corner of Figure 4c). When the number of bicycles exceeded the saturation index in this region but the use frequency was still high, governors should adjust the traffic plans in this region (top right corner of Figure 4).

We used a map based visualization show bicycle distributions in an area. Due to the GPS positioning error of ~ 3 m and the large volume of bicycles, to make the data cleaner and better organized, we divided areas into a grid of 3mx3m and counted the number of bicycles within each grid cells. Bicycles in a 3mx3m cell are aggregated and presented as a circular disc. The area of the disc corresponds to the number of bicycles in the cell, while the frequency of bicycle use in the cell was represented by the hue of colours from yellow to orange to indicate low to high usage. By looking at the size and color of the discs in the area, managers and administrators can easily make corresponding decision to supply or reduce bicycles in the area. To closely examine each individual
bicycle within the cell, we designed a three-dimensional mode with stacks of discs located on the map. Users could check the parking time of each bicycles in a region. One disc represents one bicycle, and the yellow colour of the pie indicates short parking time and the bicycle is under good state. As the parking time was prolonged, the colour was darkened, the pie moved upwards, and finally the long-time idle bicycle shifted to the top. If there are some bicycles not been used for a long time but other bicycles have been used frequently, it typically means that these bicycles were broken, or locked by individuals. If a whole pile of bicycles were in idle for a long time, it means these bicycles were placed in a devious corner that not much people could use them. (Figure 5)

Figure 3. FFBS Venn diagram and four important indicators of vehicle parking

Figure 4. Data visualization design deduction and judgment basis
Figure 5 Each disc in the unit area represents a bicycle. The difference between the sampling time of the bicycle and the final GPS data acquisition time is the parking time.

In this visual management system, determinants that would have influence on the bike-sharing economy have been converted to graphics and colours. According to the real-time data and trend of variations, more information about the bicycle sharing system would be acquired so that users, companies and government can be benefited: user would avoid choosing long abandon bicycles.
which might be in poor condition and be aware of the availability of the parking space; companies could be more conscious of potential stress in different area and match up with the government to decide whether they should adjust the numbers of bicycles or expand the space; as a regulator, the government could control the location and number of bicycle for all companies. These data can also be analysed in depth, for instance, the trend of variations could be summarized to prevent potential menace.

5. Conclusions

In this work, a design of visual management tool was introduced to support FFBS collaborative governance. Data asymmetry among stakeholders including governments and companies are decomposed and quantified into insightful information and thereby became an important medium for communication of problems. The introduction of information visualization into FFBS management could connect the governments, companies and social phenomena.

Aimed at supporting the challenges brought up by sharing economy, our solution provided three innovations to benefit stakeholders at different stages. Firstly, the management tool offers new media for social collaborative innovation, and designers could use simple quantification methods to form a sustainable closed-loop among governments, companies, and consumers. Secondly, information visualization becomes a gauge of responsibility quantification in the complex governance systems, and solves the problem of responsibility unknown due to responsibility intersection in collaborative innovation, thereby promoting the internal coordination of organizations. Thirdly, visualized collaborative innovation tools not only help companies and governments to solve governance problems within short time, but the consumer behavioural habits and trends fed back by data also create conditions for the future developing and governance directions of companies and governments and for the sustainable utilization of resources.

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