

Bike share deployment and strategies in Japan

Draft Discussion Paper

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1. Current condition of cycling in Japan

1.1. Modal share and characteristics of cycling

Bicycles have a great role of economic, effective and eco-friendly modes all over the world. The modal share of bicycles in Osaka is about 25%, and one in Tokyo is about 14%, and that in Japan is much higher than that in many EU countries. On the average in Japan, we have one bicycle per 1.5 people and we can say that Japan is one of the biggest bicycle country. The highest modal share of bicycle is around 25% in Osaka. In Tokyo, there are about 8.4 million bicycles and modal share of bicycle in Tokyo 23 Wards is about 10%, and 18% of rail users access to the station by bicycles (see Figure 1.). The purpose or travel distance by cycling is different among the area, therefore the characteristics are introduced in the case of Tokyo and the whole Japan below.

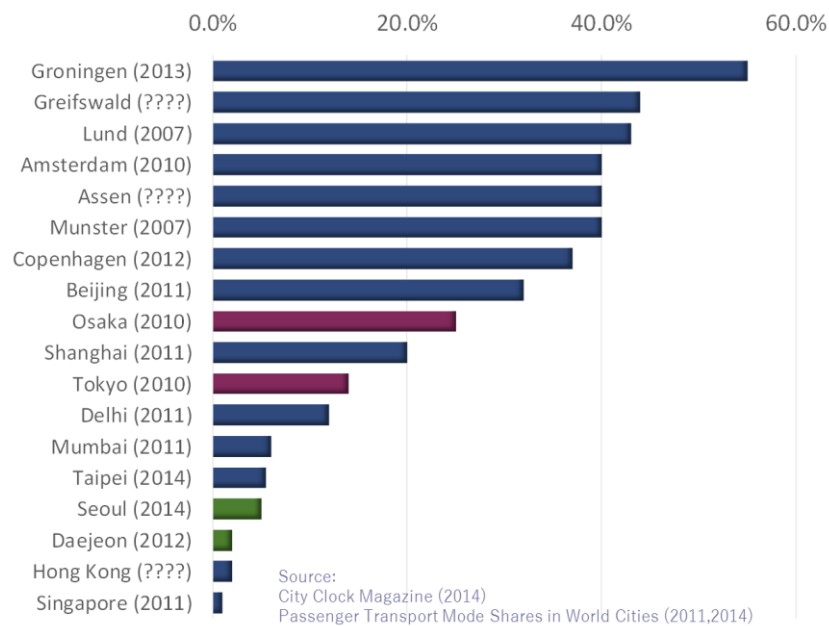


Figure 1. International Comparison of Cycling Modal Share (Suzuki, M, 2016)

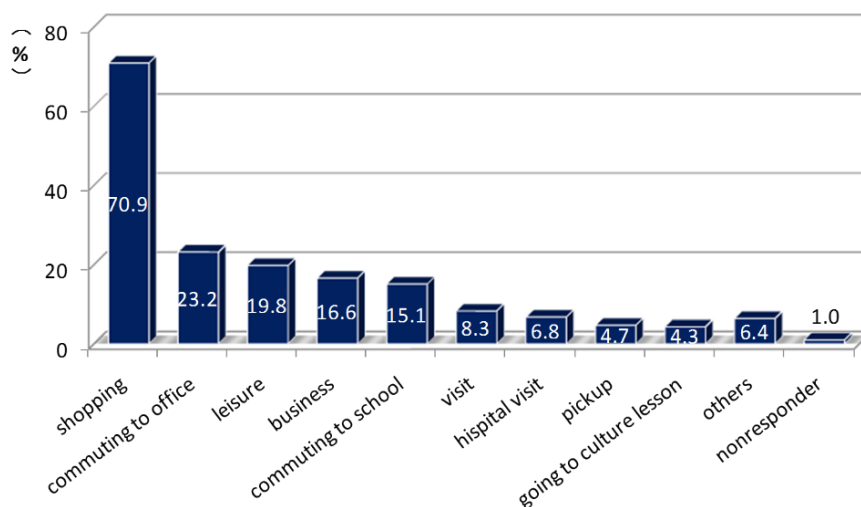


Figure 2. Purpose of Bicycle Use in Japan

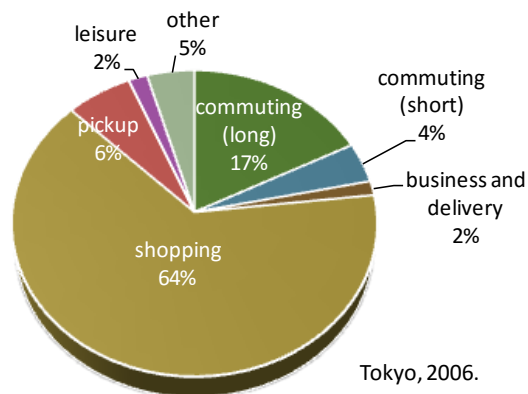


Figure 3. Purpose of Bicycle Use in Tokyo

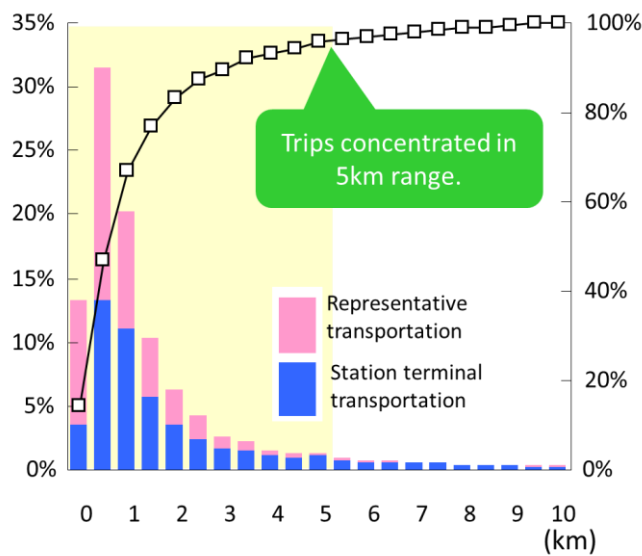
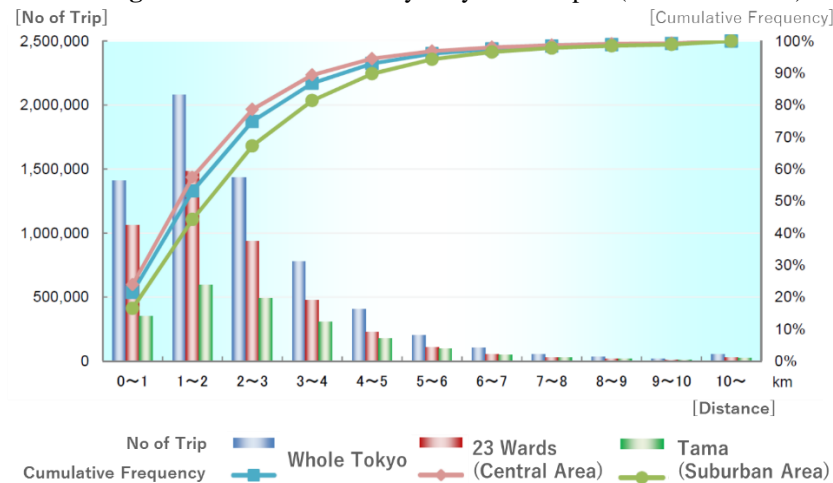


Figure 4. Travel Distance by Bicycles in Japan (Source. MLITT)



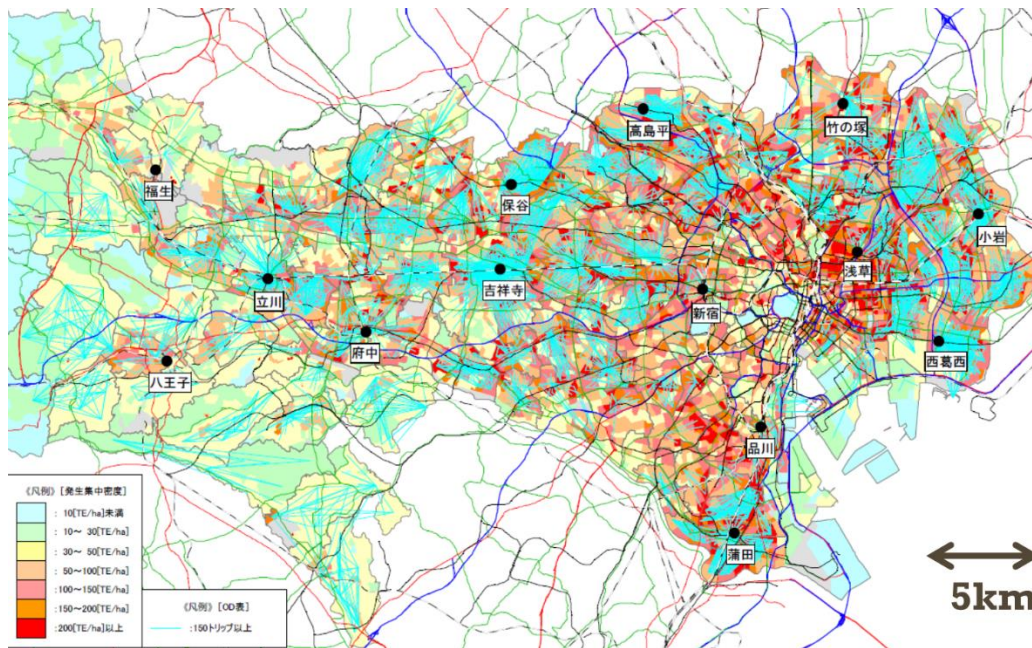


Figure 5. Travel distance and distribution of bicycles in Tokyo (Source: MLITT)

Figure 2 and Figure 3 shows the purpose of cycling in the whole Japan and in Tokyo, respectively. The main purpose of cycling is shopping in their neighborhood. Secondly, people use bicycles for commuting. In the case in Tokyo, people use bicycles for door-to-door (“long” shown in Figure 3) or as an access mode to railway stations (“short” shown in Figure 3).

Figure 4 and Figure 5 shows the travel distance of cycling in the whole Japan and in Tokyo, respectively. Trips by bicycles concentrated within 5km range, especially within 2km trips. In the case in Tokyo, cyclists are concentrated around the specific railway stations.

These graphs show that cycling is a mode of daily travel in short distance.

1.2. Rules and Accidents during cycling

One of the reasons why we have so many bicycles is said that bikers are permitted to ride bicycles on sidewalks in Japan.

According to the Road Traffic Act, bicycles are classified as “light vehicles” and cyclists are required to bicycle on driveways. (Road Traffic Act; Article 17 Clause 1) However, the number of bicycle fatalities in traffic accidents increased rapidly, even before the spread of automobiles. At the peak around 1960, there were approximately 1,800 deaths every year for a period of more than 10 years. This was equivalent to a little less than 20% of all fatalities by traffic accidents at that time.

As a result, people began to bicycle on sidewalks illegally for their own safety. Because of this increase, Kanagawa Prefectural police allowed the use of bicycles on sidewalks experimentally in Yokohama and Kawasaki cities in June, 1970. From that time, the fatalities of cyclists had begun to decrease. During that time, it was intended to develop bikeways as well as sidewalks along roadways. However, due to space restrictions, it has been difficult to develop even just sidewalks along new and existing roadways. While the large number of bicycle accidents was a serious problem, the construction of pedestrian sidewalks was a priority. Therefore, bicycle facilities were not developed at that time. In consideration of this situation, the Road Traffic Act allowed people to bicycle on sidewalks legally in December, 1978. At that time, the number of fatalities in cycling had decreased to about 1,000 a year. It may be said that the revision of the Road Traffic Act had accepted the fact that many people bicycle on sidewalks. This revision was taken to take an immediate step to reduce the number of bicycle accidents, but this policy continues up to the present. The rule allowing people to bicycle on sidewalks is very rare, and that “it is only Japan among the developed countries that allow bicycles on sidewalks.”

The concept of bicycle facilities in Japan is regulated in the Road Traffic Act. First, “people must operate a vehicle on a roadway when it is separated from a sidewalk or a side strip (Road Traffic Act; Article 17)”. Because a bicycle is a type of vehicle, people must bicycle on the roadway. Second, “when a bikeway is developed, people must ride a bicycle or a tricycle on it (Road Traffic Act; Article 63 Clause 3, there is an exception)”. And third, “A person can bicycle on a sidewalk when it is permitted legally (Road Traffic Act; Article 63 Clause 4)”.

In one law of the Road Traffic Act, three policies for bicycle facilities are determined –roadways, bikeways, and sidewalks. People are required to bicycle on roadways or bikeways in principle, and are permitted to bicycle on sidewalks partially. However, in reality, most of the people bicycle on the sidewalks everywhere. In the first place, there are not many people that know of the requirement to bicycle on roadways in principle. According to a questionnaire conducted in Tokyo in 2003, there are more people that believe they must bicycle on sidewalks as the general rule (45%) than people that know the rule (27%).

Furthermore, on sidewalks, people must bicycle on the half side neighboring the roadway slowly (around 4-5km/h), and pedestrians should be given priority. However, in reality people often honk to get pedestrians out of the way. It sounds safe that bicycle is on the sidewalk, but it’s not true. According to safety, the number of all traffic accidents and ones between bicycles and pedestrian last 10 years. The number of all traffic accidents is coming down, but the number of accidents between bicycles and pedestrians has increased. It’s a dangerous situation not only for pedestrians, but also for cyclists themselves. Figure 3 shows the relationship between bicycles possession and the death toll. It seems that the Japanese situation, cycling on sidewalks is safer than the other countries where people bicycle on roadway, but as you can see the reverse is true. Because of them, we can say that bicycling on sidewalks is not always safe.

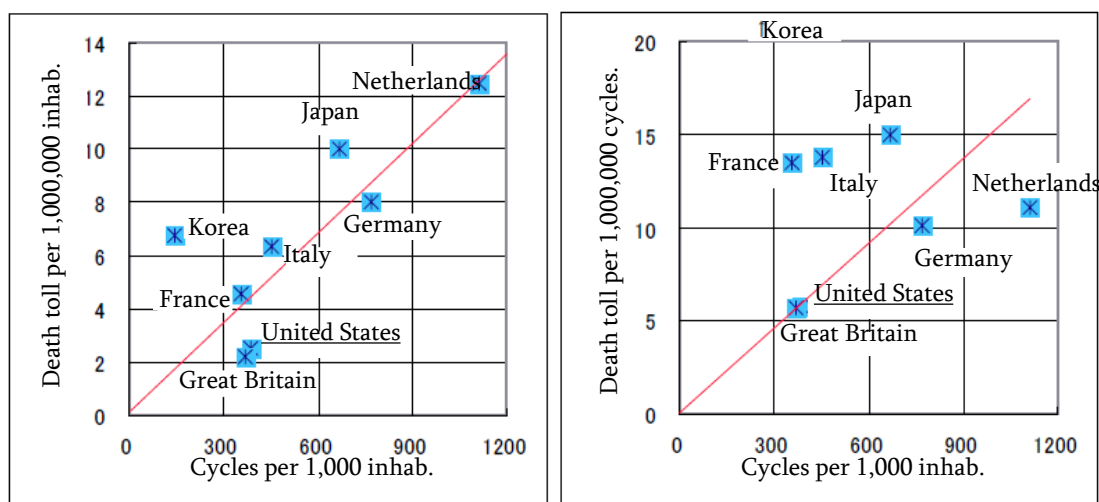


Figure 6. International Comparison of Death Toll during Cycling (Source: JSTE, 2008)

In accord with the situation, the guideline for development of safe and comfortable bicycle facilities published by the MLITT (Ministry of Land, Infrastructure, Transport and Tourism) and the National Police Agency was published in November, 2012 (and revised 2016). This guideline defines only 3 types of bicycle facilities: “bicycle path” (two-way bicycle tracks on the both sides of a road), “bicycle lane” (a one-way bicycle lane on the left side of a roadway), and “local discretionary lanes or pictographs” (a sign for clarifying cycling space on a roadway). And it also mentions about the planning process of bicycle network. There are the 6 conditions to be selected routes of bicycle network:

- 1) Roads connecting the landmarks (stations, bicycle-parking areas, sightseeing spots, public facilities, and so on),
- 2) Roads where the many accidents with cyclists occur,
- 3) Roads where cyclists should be used,
- 4) Roads around the place where a landmark is planned to be located,
- 5) Roads where bicycle facilities are already developed, and

6) Roads which is necessary to connect the network.

Now the bicycle network plans have been designed in the several municipalities and the bicycle facilities start to be developed. Therefore, in the current situation, the bicycle facilities have been developed intermittently, especially at midblocks. One of the reasons is that there is no numerical standard of bicycle facilities at intersections.



Figure 7. Various types of bicycle facilities in Tokyo

1.3 Current situation of public bicycle systems in Japan

There are 100 cities where public bicycle systems (included as pilot programs) are available in Japan, as of October 2016. The number of ports, port distribution, and the rate of rotations are shown in Table 1. There are only 22 cities where the number of ports is over 10 (and the maximum is 44) in Japan. It shows that the scale of public bicycle systems in Japan is smaller than that in the other countries.

“Guideline for developing bicycle parking facilities” published by MLITT mentions about the promotion or spread of public bicycle systems. The reason why the guideline about bicycle parking mentions about public bicycle is that there are many cities which the save of bicycle parking lots or illegal bicycle parking motivate to start rental bicycle system many years ago. However, nowadays, many cities install the public bicycles for the improvement of the transport network, connected with public transport stations (questionnaire survey by MLITT in 2016, shown in Figure 8.).

Table 1. International comparison in usage of public bicycle system (Source: MLITT, 2017)

	No. of Bikes	No. of Ports	Rate of Rotation (times/bike·day)
Taipei	7363	225	7.1
London	11000	744	2.5
Barcelona	6000	420	7.8
Paris	23900	1800	10.0
New York	6142	469	4.9
Montreal	5200	460	6.8
Japan (ave.)	171	10	0.7

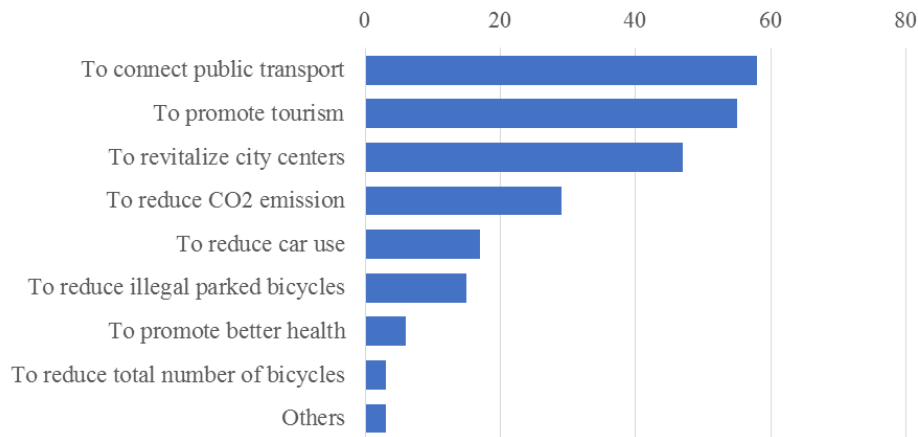


Figure 8. Purposes of installing public bicycle systems (N=87, multiple answers)

2. Worldwide public bicycle-sharing projects and users

2.1. Operators

Extant scholarly research has discussed various models in the development and provision of PBSPs (Shaheen et al., 2010). DeMaio (2009) reported a large spectrum of current bicycle-sharing providers. These include local governments, transportation agencies, nonprofit organizations (NPOs), advertising companies, and private companies. Each type of provider will be briefly introduced in the following paragraphs.

A number of local governments operate PBSPs in the areas they serve. In this prototype model, the local government sponsors the initiative and retains control over it as its primary operator. In some cases, public transportation is being managed by professional agencies. In Germany, for example, a national railway provider operates a car-sharing service alongside a public bicycle-sharing service. Similarly, in Canada, the parking authority of Montréal City provides both municipally funded on-street and off-street parking as well as a public bicycle-sharing service. In both cases, the organizations extended their traditional transportation services to include a bicycle-sharing initiative to holistically promote integrated public mobility (DeMaio, 2009).

Two possibilities can potentially be attributed to the emergence of a nonprofit public bicycle-sharing initiative: in the first model, an existing organization decides to incorporate a bicycle-sharing service into its current programs, whereas in the second model, an organization is created with the specific intention of operating the bicycle-sharing service. According to DeMaio (2009), Shaheen (2012), and a report produced by the city of Minneapolis (2008), nonprofit models generally contribute a number of benefits to the localities they serve. For example, a nonprofit corporation can raise the capital required for initial equipment purchases through public subsidies and private sponsorships. Because of this capability, nonprofit corporations are well positioned to operate public bicycle-sharing initiatives at a relatively lower cost.

In an advertising-company-initiated model, an advertising company offers to develop and manage a PBSP in a given locality in exchange for the rights to use public space to display revenue-generating advertisements on billboards, bus shelters, and kiosks. This type of arrangement can be more convenient, feasible, and cost-effective for local governments, especially if they do not have the financial capability to roll out a public bicycle-sharing service to their citizens (DeMaio, 2009).

In the private company model, a private business provides the service with limited or no government involvement. Although this model is similar to the advertising company model, it differs in two key ways. First, there exists no contract related to on-street advertising between the private company and the government. Second, the private company that funds the project retains all revenue that is generated from its operation (DeMaio, 2009). Therefore, a private company serves as both owner and operator of the PBSP, although in some cases, it is possible for a local government to own a project while a private company operates it.

Previous research suggests that relatively larger PBSP systems (i.e., those with 50 or more stations) generally attract greater government involvement, whereas small to medium-sized PBSPs (approximately 2 to 50 stations) tend to be operated by NPOs (Toole Design Group and the Pedestrian and Bicycle Information Center, 2012). Shu, Chou, Liu,

Teo, and Wang (2010), however, contend that many of these small-scale schemes have been implemented without adequate evidence to support their technical viability or economic feasibility, leading ultimately to their failure.

According to DeMaio (2009), there is no one model that is ideal for all localities. In fact, the size of a locale is one of the most critical factors for determining the appropriate management model. For example, advertising companies most typically provide PBSPs in larger cities, because cities have the greatest amount of advertising space and the largest captive audience and therefore provide the greatest potential for generating advertising and product revenue. Whereas large-scale PBSPs have been fully implemented in Paris, Barcelona, Lyon, and London, small-scale programs have begun to emerge in other countries such as Japan. Although the different operation models feature different characteristics and capabilities, there are a number of trends among extant projects. For example, public bicycle-sharing initiatives that are operated under the advertising contract model tend to be large-scale. This is likely a result of their need to cover a wide area in order for advertising campaigns to be effective.

In contrast, nonprofit models tend to be small-scale. Because it is difficult to pay large initial costs, nonprofit organizations often require financial support from a local community. These trends are illustrated in Table 2, which outlines the number of bicycles and docking stations by country and city.

Table 2. Examples of the business scales of PBSPs

City (Since)	Number of bicycles	Number of docking stations	Operators
Paris, France (2007)	23,900	1,751	Advertising company
Barcelona, Spain (2007)	6,000	420	Advertising company
London, U.K. (2010)	11,945	772	Transport agency
Lyon, France (2005)	4,000	343	Advertising company
Toyama, Japan (2010)	150	15	Local government, Advertising company, Private company
Kitakyushu, Japan (2010)	246	21	Nonprofit organization

Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan (2010), DeMaio (2009), and Shaheen (2012), and each website.

Japanese cities accommodate only small-scale PBSPs, but they display high proportions of private bicycle use (Ministry of Land, Infrastructure, Transport, and Tourism [MLIT] 2010). The implementation of PBSPs in Japan has incurred a number of challenges, including difficulty in securing funds for their implementation and determining the most appropriate business models for their operation. These problems stem partly from a lack of continuous operators and from limited terms of operation and budget. There is, therefore, an urgent need to address the lack of continuity in the operation of PBSPs in Japan. In particular, it is indispensable to continue managing programs that are relatively small-scale, but strategically placed for easy accessibility. At the same time, project evaluation requires cost-benefit and profitability analyses to ensure the sustainable operation of PBSPs. The Bicycling Popularization Association of Japan (2010) has calculated the initial and ongoing operational costs for small-scale PBSPs in Japan. They determined that the cost for Yokohama City in Japan was 5,000,000 yen (54,348 USD) per docking station. This figure includes expenses for patrol personnel, bicycle transportation, bicycle equipment repairs, system usage, member administration, electricity and communication charges, and business administration. Each of these expenses (which vary in relation to the number of a location's installed docking stations) is required as part of the operational cost of a PBSP (see Table 3).

In one medium-scale PBSP, the city of Minneapolis (2008) determined its total facility costs, which were derived from 1,000 bicycles, 50 solar-powered kiosks, 1,500 kiosk bicycle stands, 394 kiosk platforms, and 15,950 sheets of system cards, to be 3,200,475 USD. The city details and itemizes its operating costs, which primarily comprise annual costs related to personnel expenses (265,064 USD), maintenance car and equipment loans (22,764 USD), and maintenance contract fees (248,616 USD). In addition to these expenses, the program in Minneapolis also costs an additional 31,150 USD for other maintenance expenses and 212,444 USD for overhead costs such as communications and office rent.

Table 3. Estimated costs of public bicycle-sharing programs in Japan (in 10,000 yen)

Number of installed docking stations	4	8	12	16	20	24	28
Initial cost	2,000	4,000	6,000	8,000	10,000	12,000	14,000
Patrol personnel expenses	300	300	300	300	300	300	300
Bicycle transportation costs	180	260	340	420	500	580	660
Bicycle equipment repair fees	180	260	340	420	500	580	660
System usage fees	120	240	360	480	500	720	840
Member administration fees	300	300	300	300	300	300	300
Electricity and communication charges	24	48	72	96	120	144	168
Business administration expenses	166	211	257	302	333	394	439
Total	1,270	1,619	1,969	2,318	2,553	3,018	3,367

Source: Bicycling Popularization Association of Japan (2010); and Nakamura and Abe (2014a)

The Metropolitan Washington [District of Columbia] Council of Governments (MWCOC; 2010) has calculated the costs of PBSPs according to their respective sizes. Specifically, the MWCOC calculated operating costs by defining initial maintenance costs, additional maintenance costs, equipment costs, and operating costs for programs of four size classifications: extra-small (XS), small (S), medium (M), and large (L). Similarly, Alta Planning + Design (2011, 2012a, 2012b), which consults on and develops PBSPs, has conducted feasibility studies in various cities to illustrate the programs' cost structures and the benefits that can be expected from the programs' implementations. In order to comprehensively explore the benefits associated with a PBSP, MWCOC (2010) performed a cost-benefit analysis focusing on several of the benefits outlined above. These

Table 4. Percentage of transportation modes replaced by shared bicycles

	Public transportation	Walking	Private motorized vehicle	Bicycle	Taxi	No travel
Paris	65	20	8	—	5	0
Barcelona	51	26	10	—	—	—
Lyon	50	37	7	4	0	2
London	34	21	6	6	—	23
Yokohama	39	40	9	3	5	3
Hiroshima	53	35	4	1	6	1
Nagoya	51	45	2	0.5	1	—
Kitakyushu	33	33	20	6	5	3
Average	46	32	8	4	5	5

Source: MLIT Japan (2010); MWCOC (2010); and Nakamura and Abe (2014a)

benefits included reductions in transportation expenses for users, travel time, emissions of material that is harmful to the environment, medical expenses, and traffic accidents as well as improvements in access and mobility. Because of their establishment in the literature, the authors consider these benefits in this paper as well. Table 4 reports the percentage of transportation modes that are replaced by shared bicycles. These data were used in the cost-benefit analysis performed by the MWCOC (2010) and are similarly adopted in this study as well.

2.2. Association between Public Bicycle-Sharing Operation and Private Bicycle Parking Management

In general, the primary alternative to private vehicles for personal transportation is public transport. In this vein, PBSPs can facilitate access to public transportation facilities, which can then serve as places from which individuals can travel to work, school, or their homes. Given the facility with which a bicycle-sharing initiative could promote the use of public transport, a strong synergy effect is expected between the two systems. Because

public transportation stations can be accessed from home by private bicycles, the use of public bicycles to travel from home to public transportation facilities is likely to be low (Transport Canada, 2009). However, because few people are likely to take their private bicycles with them on public transportation or to keep a second bicycle at their destinations, the use of public bicycles for travel between public transportation stations and work or school is likely to be substantial. Given this, public transportation stations in areas where many commuters arrive on their way to work or school are likely to be the optimal sites for achieving synergy with PBSPs (Transport Canada, 2009).

In places where private bicycle use is popular (e.g., Japanese cities), if parking areas around public transportation stations are insufficient, bicycles are often illegally parked on sidewalks or roads. As such, it is critical to decrease illegal private bicycle parking prior to the introduction of a PBSP. Although public transport agencies that attract private bicycle parking should bear the responsibility for addressing the problem, it may be more effective to aggregate parking areas by establishing and managing an appropriate private bicycle parking facility with public-private partnership. This is especially true for small-scale areas adjacent to public transport stations, where there are many illegally parked bicycles. Further, it is a public responsibility to provide appropriate private bicycle parking spaces and address related matters. Therefore, local authorities must also participate in the implementation of effective parking measures.

Private bicycle parking is one of the key issues associated with the integration of private bicycle use and public transportation. To this end, local governments in Europe and Japan have focused on providing extensive private bicycle parking at rail stations (Buehler and Pucher, 2009). For instance, ample private bicycle parking is provided at Tokyo metro and rail stations, where 704,000 bikes are parked daily (Harden, 2008). Similarly, over 350,000 bike racks are provided at train stations in the Netherlands (Martens, 2007). In addition to calculating the extent to which private bicycle parking is available in the Netherlands, Martens (2007) explored its effects; he found that private bicycle parking availability in the Netherlands was positively associated with public transport use and private bicycle use, especially for travel between private homes and suburban rail stations (access trips). Martens (2007) indicated that the success of the Dutch PBSP (OV-Fiets) was largely contingent on inexpensive, short-term bicycle rentals for trips from major train stations to final destinations (egress trips).

2.3. Public Bicycle-Sharing Projects and Users in Japan

In Japan, bicycle-sharing pilot projects have been carried out in many cities and areas such as Kitakyushu City, Setagaya Ward (Tokyo), Sapporo City, Hiroshima City, Nagoya City, Hanshin Area, Chigasaki City, Okayama City, Sendai City, and Kanazawa City. In addition to organizing characteristics of each pilot project, the Ministry of Land, Infrastructure and Transport (MLIT) (2010) summarized the characteristics through questionnaire surveys administered for users. Summaries of some of the projects are shown in Table 4 and Figures 1 and 2. The pilot projects in Japan used from 50 to 300 bicycles, quite smaller in scale than the approximately 20,000 bicycles of Paris and the 6,000 bicycles of London. The utilization rates per bicycle per day were 0.22 at the lowest and almost 6 at the highest. The purposes of usage were very different for each case. However, excluding Nagoya and Sendai, the bicycles were generally used for sightseeing. In Sendai and Nagoya, many of them were used for shopping. On the other hand, excluding Nagoya and Sendai, there were not many business uses. Especially in the Nagoya case, in addition to its relatively big scale, the pilot project coupled with the area where the project was carried out allowed for unique characteristics such as arrangements for high-density bicycle access ports established in vacant stores in local shopping areas as well as other features. Based on the traffic conversion ratios shown in Figure 2, conversions from public transportation such as buses and trains were generally large. There were not many conversions from cars, which had been expected to have good environmental and health effects.

According to MLIT official materials, as of 2015, more than 70 cities officially introduced not pilot projects, but full-scale PBSPs (see Figure 3-6). Especially, in Tokyo, the number of PBSPs has been growing rapidly.

Table 4. Overview of bicycle-sharing pilot projects in Japan.

	Hiroshima	Nagoya	Okayama	Sendai	Kanazawa
Project Duration	Nov.–Dec. 2009	Oct.–Dec. 2009	Sep. 2011 –Mar. 2012	Nov. 2010	Aug.–Oct. 2009
Number of ports	11	30	7	10	10
Number of bicycles	110	300	100	100	100
Average daily usage	74.3	1647	22	596.1	354.5
Utilization rates per bicycle per day	0.68	5.49	0.22	5.96	3.54

Source: Nakamura and Abe (2014b) and MLIT (2010)

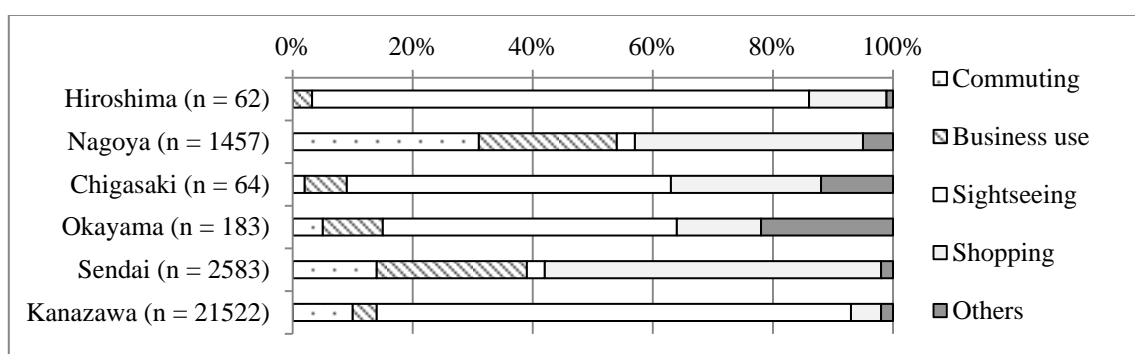


Figure 8. Uses of shared bicycles

Source: Nakamura and Abe (2014b) and MLIT (2010)

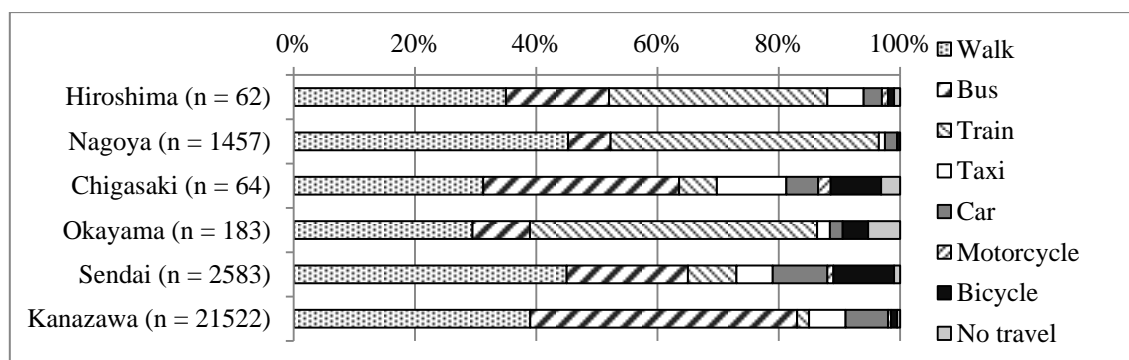


Figure 9. Changes in users' transportation modes

Source: Nakamura and Abe (2014b) and MLIT (2010)



Figure 10. Toyota PBSP near LRT station



Figure 11. Osaka PBSP near bicycle parking station



Figure 12. Okayama PBSP near on-road bicycle parking lots



Figure 13. Yokohama PBSP near car parking lots

2.4. The Kitakyushu Nonprofit Organization-led Public Bicycle-sharing Project

In Japan, a nonprofit organization-led public bicycle-sharing project has been operating in Kitakyushu City. This study focuses the Kitakyushu public bicycle-sharing project. Kitakyushu City is a government-designated city located at the Northeast tip of the Kyushu region and an international city with more than 970,000 people in Fukuoka prefecture, borders on the main island of Japan. Kitakyushu City has seven wards and Kokura station in Kokura-kita ward is the main rail hub of the city. Kitakyushu public bicycle-sharing service is mainly provided around the Kokura station area. There is another service area near Yahata station in Yahata-Higashi ward.

2.4.1. Cooperation and Diversification of Activities for Sustainable Operation

Sequentially since 2003, the nonprofit organization that operates the Kitakyushu public bicycle-sharing project has carried out the sightseeing bicycle rental business using electric-assisted bicycles, bicycle and motorcycle parking lots around the urban area stations, and car-sharing and specified manager businesses in the Kitakyushu City Traffic Park, which operates traffic education projects. Through these businesses, the nonprofit organization has gained experience in cooperating with the municipal government. The public bicycle-sharing project was realized as a result of repeated discussions with the municipal government about the bicycle-related problems that had been recognized through the above experiences as means of regional vitalization. The nonprofit organization carried out all the facility construction and has been responsible for maintenance and operations; however, the organization has been assisted by the municipal and national governments at many points. For example, it utilized national government subsidies for the initial costs and received support for promotional activities from the Kitakyushu municipal government; public officers now use the project for their official business.

For the nonprofit organization, the project is a business that achieves its mission of making a regional contribution as a nonprofit organization. In other words, its primary purpose is not to maximize the profit of the public bicycle-sharing project. The organization attaches importance to continuously managing and operating the project. Therefore, it also reinvests part of the profits from its related businesses back into the bicycle-sharing project. The related businesses are mainly the following: as a countermeasure against illegal bicycle parking, organizing bicycle parking lots (hardware-related measure); traffic safety education and improvement of the bicycle-use environment through bicycle-related events (software-related measure); and rental of electric bicycles for sightseeing. These activities mutually complement the nonprofit organization's businesses and finances. The organization also contributes to the area in various ways. For example, it accepts student volunteers and interns from the area, employs aged people as traffic safety instructors, actively participates in community-building activities using the public bicycle-sharing project, and carries out community vitalization using the "eco point" (local community currency) membership card system, in which 10% of the usage fee is returned to the user as eco points, in addition to other activities.

2.4.2. Operating Staff of the Kitakyushu Project

In addition to full-time staff members who are engaged in strategy drafting, office work, and general affairs, there are full-time staff members for traffic safety guides and vastly experienced part-time staff members (aged people in the area). They actually patrol the public bicycle-sharing project's bicycle parking lots and perform traffic safety guidance, beautification of the facilities, and equipment checks, in addition to providing immediate response in emergencies. The nonprofit organization staff members are engaged in other bicycle, transportation, and related environmentally friendly businesses in addition to the public bicycle-sharing project, and they can flexibly react to users. For example, staff members appropriately offer flexible support for new users. If users do not understand how to use the system, staff will lease the bicycles without using the system or will explain the system. For excursionists who want to obtain local information (such as sightseeing information), staff members give them the information. Regardless of their employment status (full-time or part-time), the staff also actively participates in events hosted by the local municipality or other related organizations for regional vitalization, environmental beautification, and other activities. As mentioned above, operating staff are closely involved with the management, operation, users, and moreover, the local community where the public bicycle-sharing project operates; together, the staff makes efforts for the business. This operating method is a major characteristic of the Kitakyushu public bicycle-sharing project.

2.4.3. System and Spatial Management Strategy

In Kitakyushu City, there are 10 ports and 116 electric-assisted bicycles in total, and 7 ports are located in the downtown district near Kokura station as of 2010. Only electric-assisted bicycles are used for the project. The keys and batteries for the electric bicycles are managed with a system of lockers with touch panels (Figure 14).



Figure 14. The Kitakyushu public bicycle-sharing system with bicycle parking lots

The ports downtown are expected to be used for daily life by local area residents, including public officers. Therefore, they are installed in front of public transportation stations and public facilities. The longest distance between the ports is 2.2 km, so that users can move from one port to the next nearest one within 10 minutes or so. As mentioned above, the public bicycle-sharing program is a part of bicycle-use promotion and community building projects done by the nonprofit organization with public private partnerships. Therefore, public bicycle-sharing ports were introduced to connect between the city center (shopping area), public facilities, and hub train stations spatially (Figure 15). The average amount of usage was drawn in Figure 16. The use of the public bicycle-sharing project is apparently contributing to connect between the city center (shopping area), public facilities, and hub train stations.

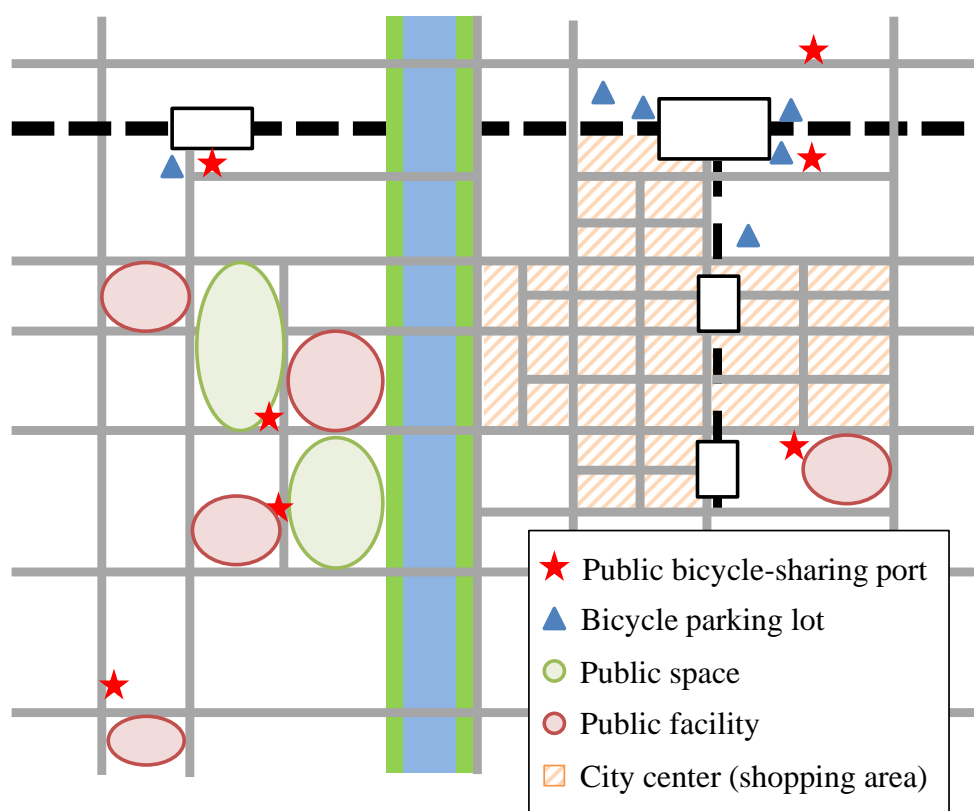


Figure 15. Spatial concept for public-bicycle sharing service

Source: Nakamura and Abe (2014b)

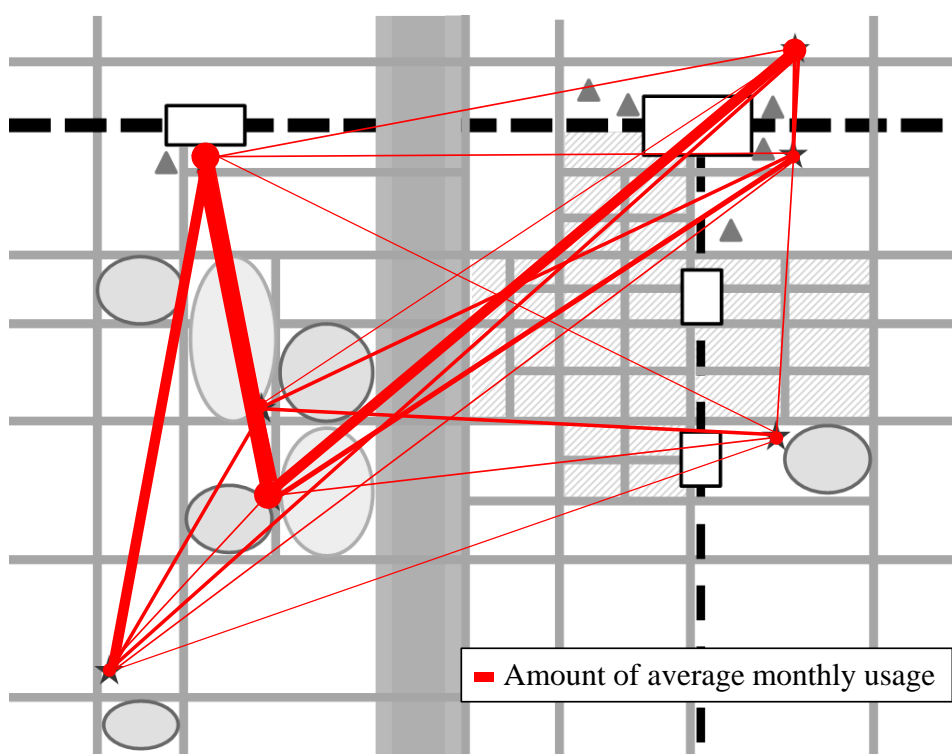


Figure 16. The spatial amount of average monthly usage

Source: Nakamura and Abe (2014b)

2.4.4. Users of the Kitakyushu Project

To use the project, users need to become registered members. Members pay 525 yen monthly as the base charge. The fee is 105 yen per hour for actual usage, and the maximum charge per day is 525 yen. Aside from the hourly charge, users can choose a monthly payment system. By paying 5,250 yen, they can use the project as many times as they like during a month. In addition, assuming there might be non-registered tourists or temporary business-use users, the project offers a 1-day user system for non-registered members. By paying 500 yen, people can use the bicycles as many times as they want during a day. If users want to use both the car-sharing and public bicycle-sharing services, they must pay the initiation fee for the car sharing and the bicycle usage fee as well. However, the payment method and the system are synthetic so that both can be easily used.

As of December 31, 2011, the public bicycle-sharing project had reached 18 registered corporation members (604 persons) and 261 individuals registered members, for 865 registered members total, demonstrating an upward trend. The daily mean usage count varied depending on the month. The total amount of daily usage was generally 50 to 80 times. The utilization rates per bicycle per day were 0.43–0.69. The results are similar to those of the Hiroshima City project, as are the sizes of the two projects. The Kitakyushu municipal government officers' official business use of the public bicycle-sharing project is included in the corporate member use. To promote low-carbon community building, public officers took the initiative in using the project. They had used it since September 2010. The number of registered members was 38 sections, for 366 persons in total, accounting for approximately 40% of the total.

2.5. Sharing service of Electrically Motorized Personal Travel Modes

In Japan, where personal travel modes have diversified remarkably, the introduction of ULVs, electric-assisted bicycles, electric scooters, and electric four-wheel carts via rental businesses in some tourism areas is one of the current strategies to popularize these new transportation modes for short distances. Figure 17 evaluates motility—specifically, characteristics such as whether the modes are road transport vehicles or not, whether they are facility and walkway operable, and extent of the rated outputs. The vehicles used in this study are considered to be typical electrically powered vehicles (i.e., they do not require gasoline or diesel fuel), though each has unique characteristics.





	<div style="display: flex; justify-content: space-between; align-items: center;"> ← Sidewalk Road → </div>			
	 Electric cart	 Electric-assisted bicycle	 Electric scooter	 ULV
Rated output (Electric)	—	230 - 250W	0.6kW or less	More than 1kW
Engine displacement	—	—	50cc or less	-660cc or less

Figure 17. Characteristics of Personal Travel Modes for Short Distances

Source: Nakamura and Abe (2016), and MLIT (2012)

It is assumed that, in the future, diversifying personal travel modes for short distances will be more socially recognized, that public pilot projects for popularization will be done in various tourism areas, and that rental business will be a key part of this effort. In addition to the low environmental impact of the above four modes of personal transport, part of the motivation for focusing on these particular modes lies in the fact that it is necessary

to recharge them. Because an electric recharging system has to be available, users of these vehicles must anticipate the amount of time that they can run before needing to be recharged. Therefore, it is an advantage to users to rent these vehicles because the businesses generally take care of any cost associated with recharging.

Personal transportation modes that target personal use and short distances are becoming increasingly miniaturized and motorized. For example, electric-assisted bicycles save effort and offer multi-purpose optimization. This trend in miniaturization has extended to car designs. Ultra-lightweight vehicles (ULVs) have been developed that offer a halfway point between bicycles and cars. Reviews of the safety of these vehicles and efforts to improve the social popularity of these ULVs are currently underway.

EV and bicycle sharing services are widespread in Paris, Barcelona, Lyon, and London. There are some interesting business cases regarding this sharing service in Japan. People in Yokohama City share electric-assisted bicycles and ULVs. A service called “Ha:mo” exists in Toyota City, in which ULVs, electric scooters, electric-assisted bicycles and eco-friendly cars are shared in the same system (Figures 18 and 19). The sharing of new personal transportation modes has been carried out in Kitakyushu City (Figure 20). A nonprofit organization (NPO) has pursued a public transportation sharing pilot project in this case. These services have been successful thus far, and the electric-assisted bicycle sharing system provides unique benefits with regard to the management’s and users’ satisfaction and behavior (Nakamura and Abe 2014a, 2014b).

Various ideas are incorporated in Kitakyushu’s electric-assisted bicycles sharing service. For example, this bicycle sharing service has various operating staff. Some full-time staff members supervise the project, strategize, and conduct office and general affairs. Traffic safety guidance staff members engage in work related to traffic safety. Part-time staff members have extensive experience in job sharing, operating the bicycle sharing service, patrolling the bicycle parking business, conducting safety trainings, and managing facilities and equipment. All the staff members participate in events hosted by the city or related organizations to revitalize or beautify the city.

A battery is also shared within the community in this system. In the event of a disaster, the battery provides power for bicycles and electricity. The system also offers a car-sharing service. Kitakyushu City was approved as the nation’s first special zone for car and bicycle sharing. An NPO became the main operator of this service. Using the same system, the NPO also offers a community sharing ULV service. These sharing services are part of a project designed to introduce ULVs into a particular community and to customize sharing services for sightseeing, safety patrol, and shopping assistance.



Figure 18. Toyota PBSP with ULV



Figure 19. Toyota PBSP with electric scooter



Figure 20. Kitakyushu PBSP with ULV

3. Largest public bicycles system in Japan, case in Tokyo

Originally, the public bicycle systems started in each ward independently, but the mutual operation (as field trial) between 4 Wards in central Tokyo started in April, 2016. There are 1,760 bikes and 153 ports as of May 2016. And then, 2 wards (pink and yellow points shown in Figure 21) also joined it, so there are 2,580 bikes and 240 ports in the central area in Tokyo as of January, 2017. Each local government choose the public bicycle operating company independently, but under the conditions that the network could be spread, so finally, the same company operates the system in the 6 wards. Compared with the map shown in Figure 5, they have little trips by bikes before the public bike service started. However, after the mutual operation started, the number of

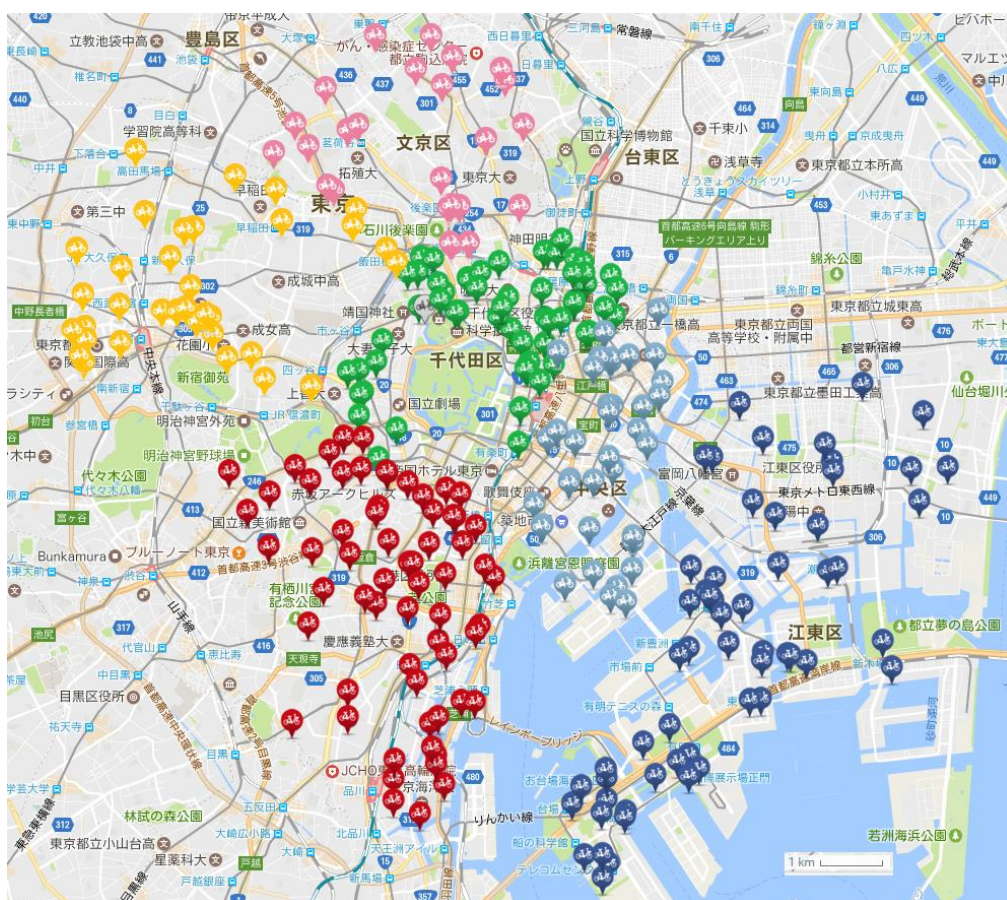


Figure 21. Map of port distribution in Tokyo (mutual operation by 6 wards)

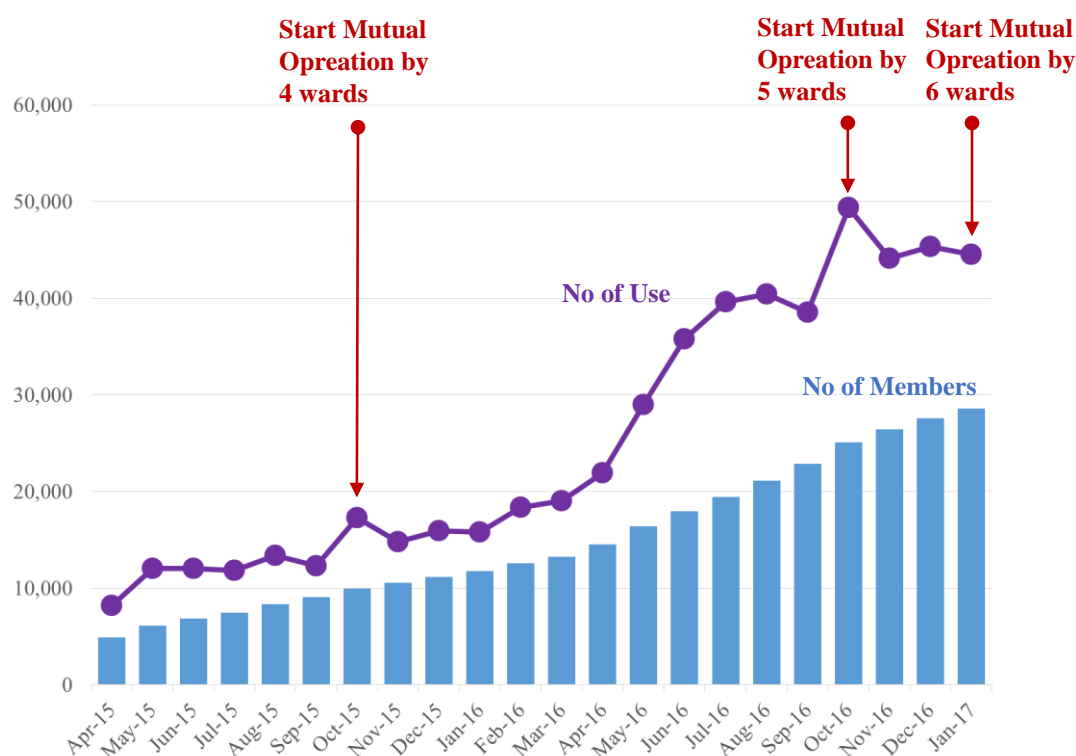


Figure 22. Time trend of number of members and use in Tokyo (Source: Minato ward)

users have increased dramatically, especially single trip users. Moreover, the number of usages has increased around 2.85 times in comparison with before and after the mutual operation (Figure 22).

On the other hand, even though the mutual operation started, over 80% of trips are in each ward. Actually, the highest-used ports are in front of large apartment and the nearest railway station. It means that public bikes are also used same as the regular bicycles (an access mode in short distance).

In the case of Tokyo, it can conclude that the monthly membership who use public bicycles steadily contribute the number of usage, and the single trip membership who use public bicycles flexibly contribute the number of users.

4. Tips for future development of public bicycle-sharing projects

4.1. Scale and Services of public bicycle systems

Public bicycle systems have spread steadily, but scales are small and number of bicycles or ports are not enough in the most cases. Because of limited budget, the most of local cities plan the install that gradually; start with very small number of bicycles and ports. However, according to the data of international comparison with 16 cities without Japan (Figure 23-25, survey conducted by ITDP, and arranged by author), the level of service of public bicycle systems is affected strongly by the density of bicycles or ports than by the number of that. It means that the number of bicycles and ports should be increased in Japanese cities, especially, the urban area with dense population.

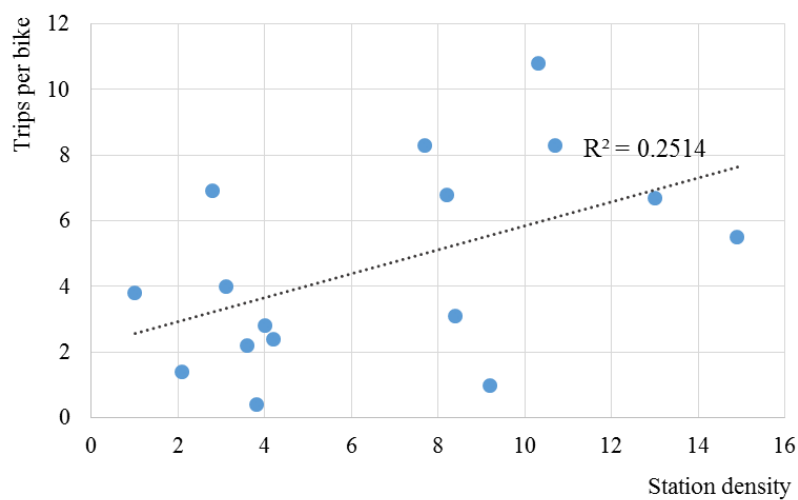


Figure 23. International comparison between station density and trips per bike

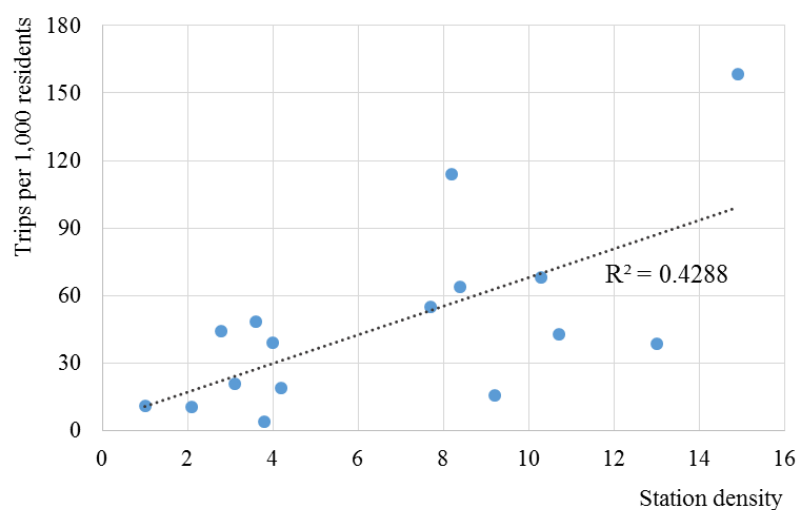


Figure 24. International comparison between station density and trips per 1,000 residents

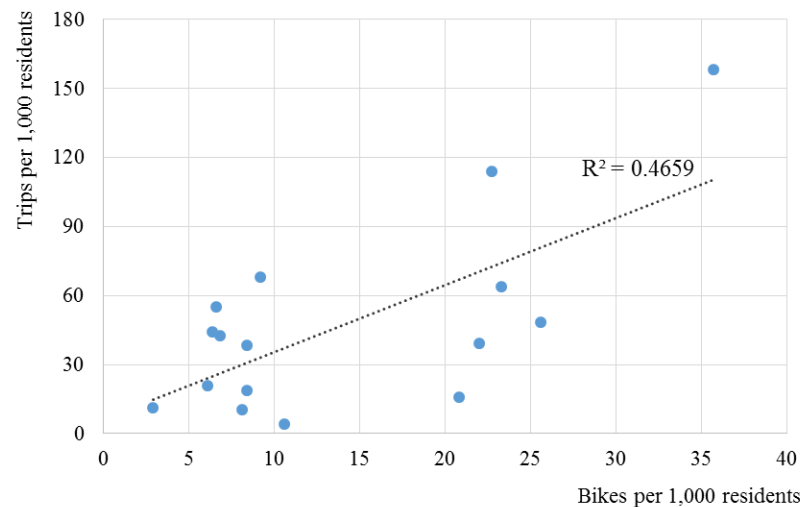


Figure 25. International comparison between bikes per 1,000 residents and trips per 1,000 residents

In terms of connectivity with public transport, the improvement of that is expected to the both effects: increase of steady users and single trip users. Monthly or yearly membership users increase if there are ports near their residences and the nearest station, and then their steady usage contributes income. Single trip membership users increase if they can find the port easily, for example, they get off a public transport. That is, the connectivity with public transport is most important to promote the all types of users.

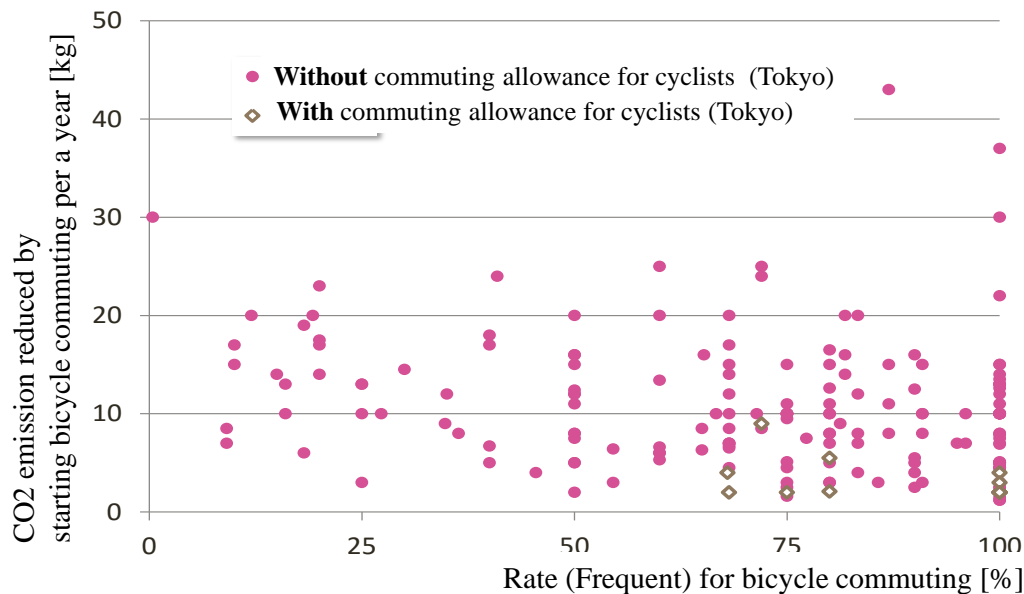


Figure 26. CO2 emission reduction by commuting by bicycle (Suzuki, M. 2013)

How should we do for the environment with a public bicycle system? For reference, we showed one survey data. In recent years, some companies start the financial support for bike commuters because cycling is eco-friendly and good for commuters. But at once the commuting allowance system serves to commuters, they are required to ride bicycles as frequented as possible, even in rainy day, or with heavy baggage. Therefore, commuters have to transfer only a part of their way to bicycle. As the results, cyclists with commuting allowance reduce the less CO2 emission

than the longer distance and lower frequent cyclists (Figure 26). It means that cycling with longer distance, even low frequency contribute effectively to CO2 emission reduction. For the environment, price system or other service of public bicycle system should be considered in order to use longer distance.

4.2. The hybrid management model with private bicycle parking lots near public transport station

A city's introduction of a PBSP is closely related with the increased use of public transportation and private bicycle parking near public transport stations. Although projects related to private bicycle parking area management and public bicycle sharing are separate from one another, they can be intrinsically linked to promote bicycle use and reduce the incidence of illegally parked bicycles. In this section, the authors propose a new method for developing a public bicycle-sharing initiative that integrates bicycle-sharing stations with private bicycle parking areas. To introduce this kind of model, the authors propose the following strategic steps:

1. Promote active and appropriate private bicycle use;
2. Monitor and manage private bicycle parking areas to reduce the incidence of illegally parked bicycles around public transport stations and other public places; and
3. Develop and introduce a PBSP integrated with private bicycle parking area management.

A hybrid model that achieved these goals would offer a number of positive outcomes. First, the incorporation of an organized private bicycle parking area into the project would reduce the incidence of illegal parking, thus removing a key obstacle for the introduction of a PBSP. Second, the operating income collected from private bicycle parking charges, membership fees, and public bicycle-sharing usage fees could be used to pay for initial costs and management expenses. Third, an integrated membership system could allow for the parking of personal bicycles at public transport stations and the sharing of public bicycles after travel via bus, train, or rail. Fourth, if illegal private bicycle parking is to be eliminated, operation staff members who regularly patrol and remove illegally parked bikes are required. By integrating the operation of public bicycle sharing and private bicycle parking area management, the staff could simultaneously observe, patrol, and manage both. Similarly, staff members who are appropriately trained could provide traffic safety guidance and information related to proper bicycle use.

Some cities have already begun to experience some success with this type of management model. For example, Setagaya Ward in Tokyo has introduced a small-scale PBSP that has been integrated with private bicycle parking area management and bicycle rental services near the train stations. Setagaya Ward provides bicycle-parking areas in front of public transport stations and promotes the use of electrically assisted bicycles in public bicycle-sharing and bicycle rental services. Similarly, Kitakyushu City in Fukuoka Prefecture introduced a relatively small-scale PBSP that is operated by a nonprofit organization. The management strategy of integrating public bicycle-sharing operations and private bicycle parking management has three key elements: a) host traffic safety education classes and cycling tours to promote the safe use of private bicycles, b) management of private bicycle parking areas in front of public transport stations to promote public transportation and reduce illegal private bicycle parking, and c) provision of a mobility-sharing service for local community building and excursions. And furthermore, private bicycle parking is also one of the key issues associated with the integration of private bicycle use and public transportation. Bicycle-use is more important in urban transport system and in Figure 14, bicycle-use is playing an important role as both access and egress trip modes. As access trip mode, people can use your private bicycle from your home to some public transport station, and near the station, people park their bicycle and ride a public transport. After using the public transport, people can use multi-transport modes such as shared electric-assisted bicycle, electric cart, or ULV accordance with their each demand to their destination.

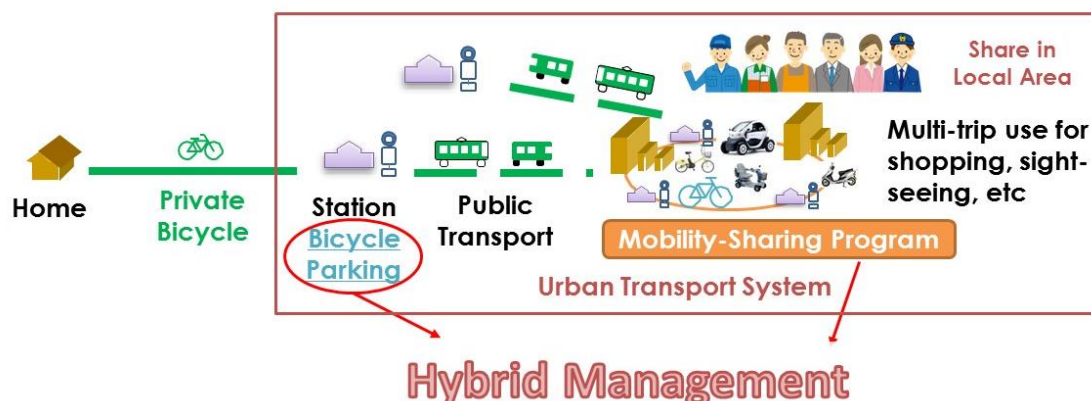


Figure 27. Concept of hybrid management model with private bicycle parking lots near public transport station

The hybrid model, however, does not fit all situations for PBSP management. There are some limitations and issues to be discussed. The hybrid model would not be suited for all communities and cities around the world. In Japan and some European countries, there are still similar management models as seen in this paper, but in other cities throughout the world, there is space to provide a sufficient supply of well-designed bicycle parking racks not only near transit stations but also in the city centers. In these cases, illegal parking is not a problem. The hybrid model suits areas where there is demand to park bicycles near transit stations and the areas' centers in order to connect personal travel modes with public transport or inner cities while at the same time illegal bicycle parking is a problem because of insufficient space for bicycle parking. In such areas, demand for a PBSP is expected.

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