Factors Influencing Travel Behaviors in Bikesharing

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Submitted for Presentation at the 91th Annual Meeting of the Transportation Research Board and Publication in the Transportation Research Record Series

November 14, 2011 (revised)

Word Count: 4,751
Text: 4,509 (Abstract: 242)
Figures: 6 x 250 = 1,500
Tables: 4 x 250 = 1,000
Total: 7,251

ABSTRACT

Over 100 cities around the globe currently operate robust, bikesharing systems. While much research in bikesharing is duly taking place, there have been hardly any studies on the factors influencing travel behavior in bikesharing. This study has taken five variables that may significantly influence bikesharing— the floor area of nearby residential and commercial buildings, parks, schools, and subway stations—and performed regression analyses to determine their impact on the frequency of bikesharing usage. In particular, the study separately analyzes conditions which are expected to render different behaviors, including weekdays vs. weekends; precipitation; and departure point and destination. As a result of the analysis, the total area around residential and commercial buildings, parks, schools, and subway stations were shown to have a positive influence on bikesharing usage, although the extent of such influence was shown to vary depending on the model. Commercial buildings were shown to promote public bicycle usage more than residential buildings; and parks were shown to encourage bikesharing usage 3 to 5 times more than schools or subway stations. A difference between weekday and weekend travel behavior was also identified, with the latter seeing twice the amount of bikesharing traffic volume than the former. Rainfall was generally shown to decrease bikesharing usage as is presumed. The results of this study can be used in estimating the appropriate scale of new bikesharing stations at various venues, and are also applicable to building strategies for maximizing the efficiency of bicycle redistribution.

INTRODUCTION

It is widely accepted that today's automobile-centric transportation system suffers not only from inherent problems such as traffic and lack of parking, but also leads to secondary issues such as climate change, due to the combustion of fossil fuel and emission of greenhouse gases. Mitchell et al.[1], meanwhile, view today's transportation system in a different light, saying that the automobiles of the 20th century, as adept as they were at quickly transporting many people across long distances, are not as appropriate for servicing the transportation needs of an individual residing in a city, like many do in the present day. Mitchell et al. also suggest that urban automobiles of the future will be closely associated with environmentalism and smart technology, making driving a truly enjoyable experience. Mitchell et al. present some ideas regarding futuristic automobiles, which are centered on a vehicle sharing system utilizing small electric cars. The proposal essentially calls for smaller, publically shared vehicles as a means of providing short-distance transportation services in the congested urban traffic grid. Although there remain a number of issues that must be addressed to realize such ideas, the proposal by Mitchell et al. is expected to become reality in the future.

Bikesharing has already been implemented in various regions for varying purposes and circumstances. Bikesharing in the context of Mitchell et al.[1] reveals that bikesharing stations at the current level of technology can be a less costly alternative to public electric cars while yielding a similar effect. In South Korea, there are six cities that operate bikesharing stations, starting with Changwon in 2008. Around the world, it is estimated that over 100 cities are operating bikesharing systems[2]. Bicycles are environment friendly, require no artificial source of energy and emit no greenhouse gases. They also take up much less space for movement and parking than automobiles. Furthermore, bikesharing systems would increase the efficiency of utilization as many would share a given amount of resources. With the recent challenges of climate change and energy depletion, bicycle sharing stands out as a highly desirable transportation policy.

However, the actual implementation of bikesharing policy has revealed many limitations. In terms of operations, there have been difficulties associated with maintaining and managing the bicycles. While the most severe problem is theft, such problems are increasingly mitigated thanks to new technology such as GPS equipment. Logistical issues, however, remain a primary concern, with great difficulty in selecting the appropriate size and location of the stations. Redistribution of the bicycles at the stations to optimize supply and demand remains a task driven by trial and error.

In order to maximize the usage of the bikesharing, costs must be lowered, convenience enhanced, and operations made more efficient. While such accomplishment would require significant analysis on the factors affecting bikesharing usage, the lack of data prevents much needed research. Fortunately, the bikesharing systems in Korea have been accumulating data on their operations, which has enabled analysis in bikesharing system.

This study will analyze factors of bikesharing usage based on the data collected in Goyang City. In particular, it will examine various factors that may affect bikesharing usage, such as: certain facilities such as: proximity of schools, parks, and subway stations; the characteristics of land use around the bikesharing stations; and weather conditions.

The rest of the paper is organized as follows: Chapter 2 examines previous research on bikesharing systems and on factors affecting bicycle usage in order to determine the factors affecting bikesharing to be analyzed in this study. Chapter 3 takes a closer look at the characteristics of data used in models. Chapter 4 builds regression models for the volume of usage per station and the factors influencing each station, in order to interpret key findings discovered using the coefficient values of each factor estimated in the model. Lastly, Chapter 5 provides the conclusion of this study.

LITERATURE REVIEW

Weather plays the greatest role in bicycle usage. While in Northern Europe one may often see bicycles in use even on rainy days, the same remains a rare sight in North America or Asia. Although the effect of weather on bicycle usage is often taken for granted, there have not been many empirical studies done on such impact of weather. As increasing data on bicycle usage is compiled, analytical research on the impact of weather on bicycle use has been vitalized as of late. The most recent study by Miranda-Moreno et.al [3] analyzed the influence of weather on bicycle traffic in Montreal by setting up loop detectors on five bicycle roads. The study revealed that temperature, humidity, and presence of heavy rainfall impacted bicycle usage in Canada, with precipitation in the morning and three hours before the travel time having a particularly significant influence over bicycle traffic.

Rose [4] also analyzed the impact of weather on bicycle usage in Oregon, Portland and Melbourne, Australia. The study revealed that higher temperatures and less rainfall led to increased bicycle traffic in both cities. However, the coefficients of the temperature variable were 0.3 to 0.6 in one city, and 0.2 in the other, showing that the extent of the effect temperature has on bike travel may differ in each city. In the research regarding bicycle commuting [5], university students became the subjects for an attempt to determine the influence of weather and seasonal changes on bicycle commuting, which turned out to be smaller than expected.

Lewin [6] analyzed the impact of weather and temperature on bicycle usage in two key roads with large bicycle traffic in Boulder, Colorado, over a span of five years. Summer was shown to have the greatest transportation demand for bicycles, while spring and autumn had 2/3 of bicycle traffic compared to the summer, and winter having 1/3 of summer's bike traffic volume. The temperature was shown to have a positive linear relationship with bike usage, peaking and turning around at 90 degrees Fahrenheit.

As both Miranda-Moreno et al.[3] and Rose et al.[4] suggested, there have not been very many studies conducted regarding the impact of weather on bicycle usage because it has often been an intuitive assumption that did not necessitate a great deal of analytical requirements. However, empirical research would be necessary to determine the extent of the impact of weather on bicycle usage, and particularly essential to the efficient operation of 24-hour bikesharing systems.

Shaheen et al.[2] created a comprehensive approach to the bikesharing policy, reviewing the current status of bikesharing in use and their developmental history. The research examined the evolution of bikesharing policy from the first generation to the fourth, along with its social, economic and environmental effects. Based on the history of the operations of bikesharing stations thus far, the study argues that theft, redistribution, information system, insurance, and initial establishment are key factors of vitalizing bikesharing.

Amoruso et. al.[7] proposed a methodology to analyze the efficiency of bikesharing system by calculating an indicator to describe the state of the system. The suggested indicator can be used as one of the measurements to evaluate bikesharing system and to compare different systems.

Froehlich et al.[8] examined the temporal and spatiotemporal pattern of station usage of Barcelona's Bicing, to predict future bicycling station usage behavior. The research suggested four models, including a Bayesian network model, which had the smallest average error, to predict the availability of bicycles at each station.

The most recent study conducted on bikesharing systems, the research by Tang et al.[9], analyzes the impact of bikesharing on travel in Beijing, Shanghai and Hangzhou. The three Chinese cities were the first to implement third-generation bikesharing, with the main users belonging to white collar workers between the ages 20 and 39. The study categorized the system according to the managerial authority, such as 'government-Led Model', 'Manufacturing Company-Led, Government Aid Model', and 'Private Company-Led Model,' in order to analyze the transportation demands for bikesharing.

Morency et al.[10] examined the station usage volume and patterns of Montreal's bikesharing system, and calculated a balancing factor in consideration of the usage rates along with OD patterns between the stations.

Voguel and Mattfeld[11] adopted a nonlinear clearing function in order to model the probability of successful rentals under a certain number of requesting users because a issue observed in bikesharing system is imbalance in the spatial distribution of bikes over time. The imbalance is caused by one-way use and short hiring times of bikes. Therefore, repositioning activities which are followed by travel behaviors in bikesharing were the main focus of the research.

Because third generation bikesharing systems, which is applied recent IT such as smartcard or GPS, were only recently implemented on a large scale, research in bikesharing has been taking place robustly in the most recent years [2]. However, most studies focus on the analysis and effect of the status of bikesharing usage, while there are still no previous studies involving a detailed analysis on the travel behavior affected by each station's characteristics. It is therefore difficult to find literature that includes empirical examinations on how station usage varies depending on the characteristics of the surrounding properties and facilities. Such lack of previous analysis can be attributed to the limitations in data collection. Furthermore, there is virtually no collected data on the characteristics of the surrounding area or facilities, which rendered the analysis thereof virtually impossible until this point. This study thus attempts to exploit data on the usage volume of the bikesharing station in Goyang City in order to build a database on characteristics of land use and facilities surrounding the station, and determine the influence of the characteristics on bikesharing travel behavior.

DATA DESCRIPTIONS

Site Selection

Table 1 indicates that six cities in Korea currently operate bikesharing systems. Among them, Changwon and Goyang are the only cities that fully operate more than 100 stations. As new cities, the two cities possess terrain that is appropriate for bicycles. As a coastal industrial city in the south, Changwon shows a clear volume of bicycle commutes between the residential area and the industrial complex, while travel to other areas is not as active.

In contrast, Goyang is a satellite city of Seoul, with a population of 950,000 and only 30km away from the metropolitan area. It features a subway connection to Seoul, artificial lake and park, an international exhibition hall named KINTEX, along with other diverse facilities and land uses. This study has thus selected Goyang as its subject location in order to determine the impact of nearby land use on bicycle stations.

The transportation network of Goyang is characterized by a central road lying across a two-way, 8-lane road in the heart of the city. Line 3 of the subway sits along the central road. The bicycle path extends 165km [12]. The 1,034,000 ㎡ artificial lake in the southern part of the city also features a 5km bicycle path. In terms of land use, shopping centers, commercial buildings and offices are focused around the subway station. As it was designed as a satellite city to Seoul, Goyang features a great number of high-density apartment blocks. The average amount of precipitation in 2009 amounted to 1,426mm. The average temperature in 2009 was 11.0℃[13].

TABLE 1 Bikesharing Systems in South Korea

City	Area (km2)	Population (in 1000's)	Name	No. of Bicycles	No. of Stations	Starting Year
Changwon	292.72	500	Nubija	3,000	163	2008
Goyang	267.31	940	Fifteen	3,000	125	2010
Daejeon	539.86	1,500	Tashu	200	22	2009
Suncheon	905.15	270	Onnuri	100	11	2009
Seoul	605.33	10,310	Seoul Bike	400	43	2010
Busan	765.94	3,560	U-Bike	300	15	2010

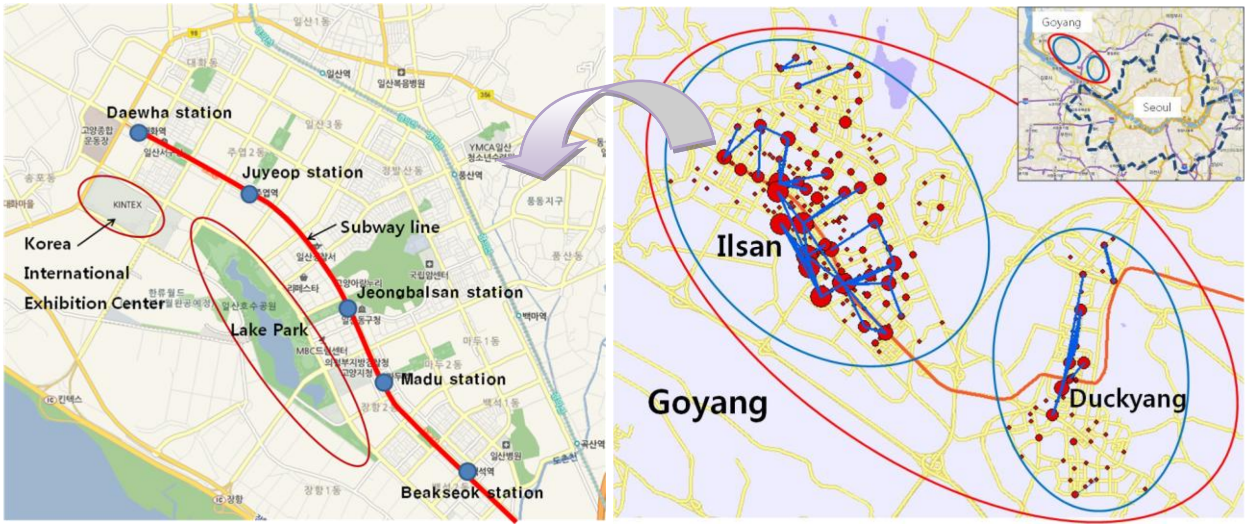

FIGURE 1 Site Map of Ilsan-gu, Goyang city

Fifteen Data

Dubbed "Fifteen," the bikesharing system of Goyang city was established in June 2010 [14]. Fifteen indicates the average speed of bike, 15km/h. Since then, it has expanded its fleet to around 3,000 bicycles as of July 2011. It is operated by a special purpose company, Ecobike, comprised of four institutions: Goyang City, Hanhwa S&C, Samchuly Bicycle, and Innodesign.

Fifteen is open to the entire public for an annual fee of 60,000 KRW ($60 USD). The first 40 minutes are free, with 500 KRW ($0.50 cents) per additional 30 minutes. Non-members may use the bikes upon authenticating their identity with their personal mobile phones. Non-members are charged 1,000 KRW ($1 USD) for the first 40 minutes, and 1,000KRW ($1 USD) per additional 30 minutes thereafter.

This study used the data from June to September 2010 for Fifteen's service usage. Analyzed data excludes incomplete records that lack return stations or travel time, and travel time under one minute. Structure of the Fifteen data set is shown in Table 2.

TABLE 2 Fifteen data

date	member id	Departure time	Departure station	Lot number	Arrival time	Arrival station	Lot number	Riding time (min)	Riding distance (meter)
2010-07-25	K****	2010-07-25 12:57:43	STA11	7	2010-07-25 13:01:10	STA29	15	00:04	366
2010-07-25	G****	2010-07-25 15:46:36	STA29	22	2010-07-25 15:59:56	STA85	10	00:13	1,382
2010-07-25	Y****	2010-07-25 22:47:45	STA21	7	2010-07-25 23:16:37	STA61	7	00:29	3,440
2010-07-25	W****	2010-07-25 15:58:26	STA18	3	2010-07-25 16:12:44	STA49	6	00:14	1,587
…	…	…	…	…	…	…	…	…	…

As Figure 2 illustrates, out of the stations with the largest traffic flow, the stations located near the Lake Park and the subway stations showed higher usage patterns than others. This highlights how nearby land use such as the Lake Park or the subway station have significant impact over bikesharing usage. Public transportation points near the subway, travel between and residential areas, and travel to the Lake Park area showed the largest volume of traffic. In particular, the Lake Park area showed a large number of departures and arrivals, as well as great volume of traffic to points surrounding the lake. Note that Figure 2 shows selected stations with frequent usage.

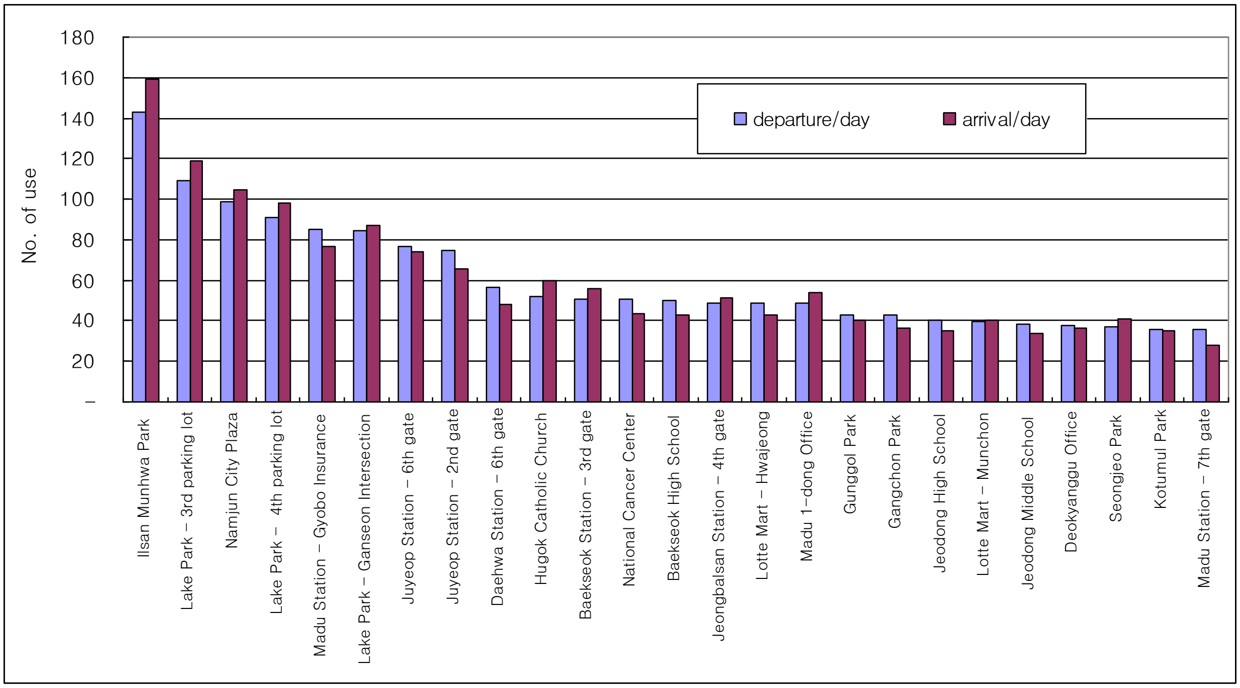

FIGURE 2 Fifteen: Daily Uses per Station

Figure 3 shows that Saturdays (15.9%) and Sundays (12.5%) had similar amounts of users to weekdays, which is believed to be attributed to the increased leisure activities at the Lake Park on the weekends. The mode travel time was shown to be 15 minutes at 50.2%, followed by 15 to 30 minutes at 26%. Although this may reflect the fact that the first 40 minutes are free, short-distance travel clearly takes up most of the bikesharing usage. As for the hours of usage, 18:00 to 21:00 took up 23.8% of total bike usage, while 06:00 to 09:00 saw relatively low usage at 8.6%. Furthermore, 15:00 to midnight saw 61.1% of bikesharing travel, proving that bikesharing are most often used in the afternoon and evening for commuting back home from school or work, or for shopping and leisure activities.

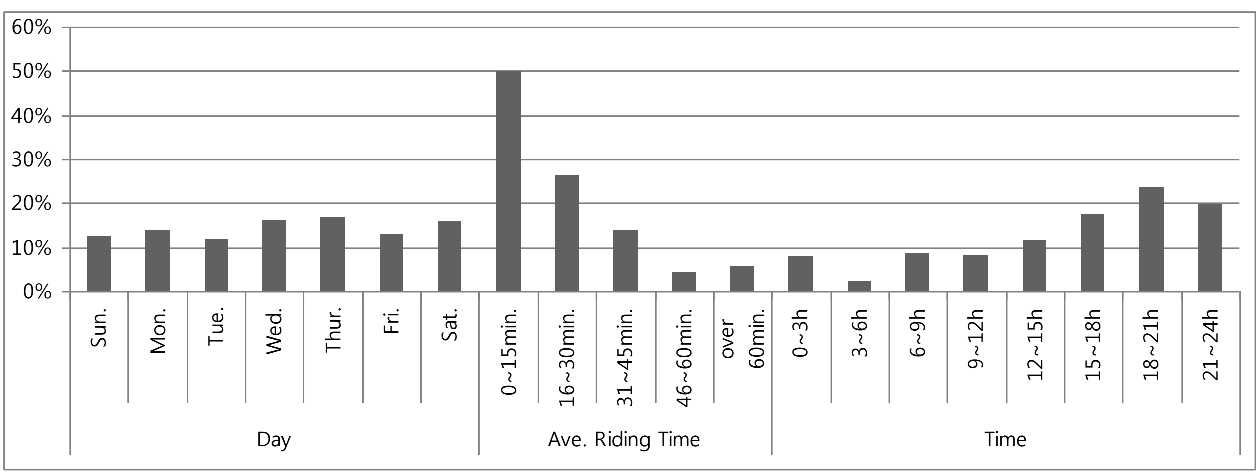

FIGURE 3 Fifteen: Ratio of Usage by Day, Riding Time, and Time Zone (%)

Regarding the impact of precipitation, daily usage on rainy days has been compared with non-rainy days. While average rides for dry days on weekdays stood at 3,767 trips, rainy days showed lower usage at 1,904, merely 50% of the usage in dry days. For the weekends, it was shown to be at a level similar to that of weekdays, with 4,592 trips on dry days and 2,136 on rainy days.

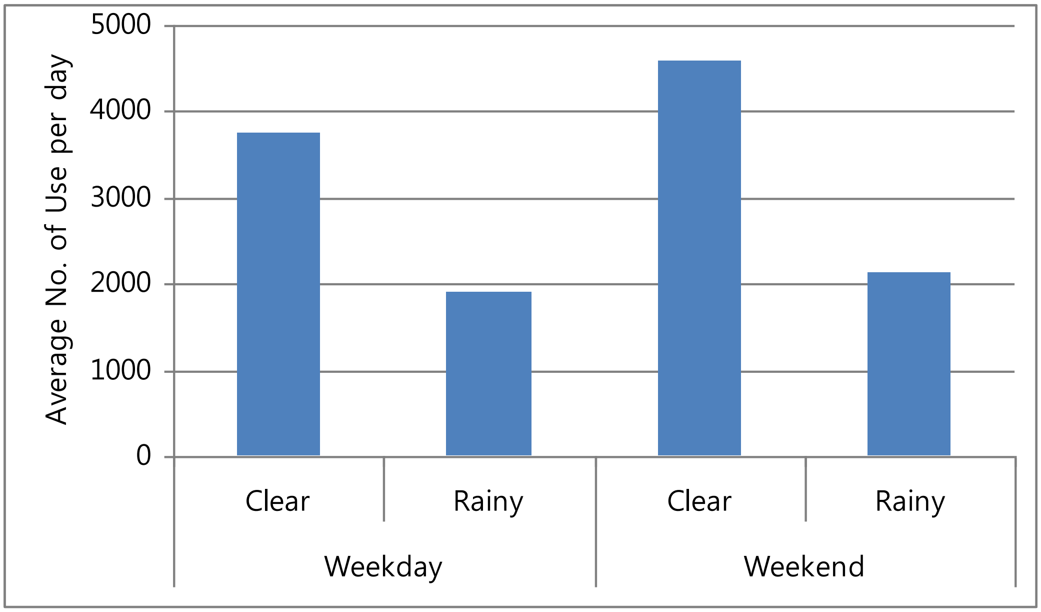

FIGURE 4 Average Daily Uses Depending on Precipitation

ANALYSIS OF RESULTS

Model Estimation

Factors influencing the use of public bike are various, including socio economic condition, geographic location, cultural trait, land-use and transportation system, and climate condition. The site of this study is a New Town located in Goyang city, which was developed in 1990s. New Town is geographically even, planned similarly throughout the area, and remote from the rest parts of the Goyang city having little inter-regional bike traffic.

In order to determine the impact of land use and facilities surrounding bikesharing stations on the travel behavior of bikesharing, because characteristics and densities of facilities cause to use more bicycles, variables representing land use and facilities were set as independent variables, while daily usage per station has been set as dependent variables for this regression model (1):

$$bikeusage = a + b_1 \cdot residence + b_2 \cdot commercial + b_3 \cdot park + b_4 \cdot school + b_5 \cdot subway \quad (1)$$

where, bikeusage: daily usage of bikesharing at each station (usage/day),
residence: square area of residential buildings (1,000 ㎡),
commercial: square area of commercial buildings (1,000 ㎡),
park: park dummy,
school: school dummy,
subway: subway dummy.

Gross square areas of residential and commercial buildings were used as variables representing the characteristics of land use. The greater the number of residential and commercial buildings around the bikesharing stations the greater traffic and arrivals, and is therefore expected to increase the usage of bikesharing system. To examine current land use, existing facilities, and the use of public transport within a 300m radius of Fifteen stations, we used a buffer analysis function of ArcGIS. To prevent a double counting error which can be caused within a less than 300m inter-Fifteen distances, we create thiessen polygons other than a 300m buffer.

In order to determine the impact of characteristics of nearby facilities, the presence of schools, parks, and subway stations around the bikesharing stations have been set as dummy variables. Since students are likely to make frequent usage of bicycles, the school dummy variable is expected to have a positive impact on bikesharing usage.

Note that spatial random effects are not considered to capture unobserved effects because research site is believed as uniform as referred above. Therefore, Ordinary Least Square (OLS) estimation was performed.

The Lake Park in Goyang has a robust network of bicycle paths and enjoys a considerable volume of leisure traffic. As confirmed by the data analysis, the Lake Park area is shown to attract a large volume of bikesharing rides, particularly on the weekends. As subways are significantly linked to bicycles as a means of transportation, bicycle stations around the subway stops were also shown to have frequent usage.

FIGURE 5 Bikesharing Stations in Analysis Site(Ilsan new-city in Goyang)(left) and its Analysis Buffer(right)

In order to determine the specific impact of weather on bicycle usage, four models were created with varying categories for weather and weekday or weekend (dry weekday, dry weekend, rainy weekday, and rainy weekend). 1682, 547, 782, and 519 instances of data were used for each category, respectively, to a total of 3,530 entries. The total number of the entries, or 3,530, was collected from 29 Fifteen stations during 122 days, and 8 entries considered as errors were excluded.

The reason for having separate categories for weekdays and weekends is because weekdays and weekends show different travel patterns that can in turn have different impacts on bicycle usage. Precipitation is another key factor to bicycle usage; this study set 2 mm as the standard amount of rainfall when categorizing the models for precipitation, as rainfall of less than 2 mm was shown to have a relatively insignificant effect on bicycle usage according to the usage data. Despite that bikesharing behavior differs at winder season, temperature and snowfall were not taking into account for the analysis as winter season's usage data was not available.

Furthermore, traffic at each station varies depending on departures and arrivals. Thus the four models were further categorized into eight models that account for departures versus arrivals.

Data for rainfall was taken from information provided by Weather I Inc., a meteorological information institute registered under the Korea Meteorological Administration [15]. Values for the independent and dummy variables (land use, and presence of schools, parks or subway stations) were set for each bicycle station using the Gyeonggi Province real estate information [16] and the ArcGIS (ver. 9.3) application. Coefficient values for the regression model were estimated using the statistics program STATA (ver. 10.0) [17, 18].

The variable statistics used for the multiple regression analysis models is shown in Table 3.

TABLE 3 Basic Statistics of the Variables Used in the Model

				Mean	Standard Deviation	Min.	Max.
Dependent Variables	Departures (instance/ day)	Total		53.92	34.56	1	338
		Weekday	<2mm	59.95	33.11	1	215
			≧2mm	45.54	29.82	3	204
		Weekend	<2mm	62.84	40.53	11	338
			≧2mm	37.64	30.55	1	180
	Arrivals (instance/ day)	Total		46.99	30.98	0	304
		Weekday	<2mm	52.72	29.76	6	235
			≧2mm	39.62	25.97	1	177
		Weekend	<2mm	53.36	36.92	7	304
			≧2mm	32.80	27.93	0	184
Independent Variables	Land use	Residential Sq Area (1,000 ㎡)		252.84	329.24	27.98	1438.94
		Commercial Sq Area (1,000 ㎡)		90.76	158.26	2.02	778.88
	Facility	Park(dummy)		0(none): 3,408(96.5%), 1(present): 122(3.5%)			
		School(dummy)		0(none): 488(13.8%), 1(present): 3,042(86.2%)			
	Public Transport.	Subway (dummy)		0(none): 2,920(82.7%), 1(present): 610(17.3%)			

Findings

Table 4 and Table 5 display the coefficient values for the eight models built in the aforementioned steps. The analysis shows that more active use of land surrounding the location and the presence of schools, parks, or subway stations are correlated with increased usage of bikesharing usage.

TABLE 4 Results of the Regression Models for Departure

Precipitation		<2mm				>=2mm			
Day		Weekday		Weekend		Weekday		Weekend	
		Coef.	VIF	Coef.	VIF	Coef.	VIF	Coef.	VIF
Land Use	Residential (1,000 ㎡)	0.010***	1.08	0.009***	1.08	0.008***	1.08	0.007**	1.08
	Commercial (1,000 ㎡)	0.148***	2.07	0.153***	2.07	0.110***	2.07	0.104***	2.07
Facility	Park (dummy)	97.551***	1.59	177.588***	1.59	68.255***	1.59	94.800***	1.59
	School (dummy)	27.006***	2.33	32.153***	2.33	25.093***	2.33	22.031***	2.33
Public Transport.	Subway (dummy)	27.184***	1.26	25.814***	1.26	20.495***	1.26	13.768***	1.26
cons.		12.828		8.239		5.989		1.824	
Num of obs.		1682		547		782		519	
Prob>F		0.0000		0.0000		0.0000		0.0000	
R_squared		0.6683		0.7386		0.4211		0.4228	
Adj R-squared		0.6673		0.7362		0.4174		0.4172	

Note: Significant at *** = 1%; ** = 5%; * = 10%

For weekdays without rain, the coefficient value of residential buildings' square area was shown to be 0.010 at the significance level of 1%, while square area of commercial buildings yielded a coefficient value of 0.148 at the significance level of 1%. The coefficient values suggest that commercial land use leads to bikesharing rides 14.8 times that of residential areas.

Dummy variables to represent the characteristics of nearby facilities (i.e. presence of schools, parks, and subway stations) were shown to have both a qualitative and quantitative correlation with the volume of usage of bikesharing stations. Coefficient value of the school variable was shown to be 27 at the significance level of 1%, suggesting that 27 rides occur at stations near schools. The park variable was analyzed to have 98 rides at significant level of 1%, which suggests that parks have four times more effect than schools do on promoting bikesharing usage. The subway variable showed a similar degree of impact, with 27 rides at significance level of 1%.

Weekday and weekend usage of bikesharing were shown to have different patterns. Stations near parks and schools show an increase in bikesharing traffic volume on the weekends. While traffic at stations near parks stand at 98 rides on the weekends, it nearly doubles on the weekends to 178 rides. This can be attributed to an increase in leisure activities at the parks on the weekends. Weekend increase in rides at stations near schools is assessed to be due to visits to schools for social activities, leisure, and exercise on the weekends. While gross residential area and subway station were shown to have less bicycle traffic on the weekends, commercial gross area shows greater traffic on the weekends than weekdays; the difference, however, is not significant.

Rainfall is analyzed to decrease the amount of bicycle rides regardless of weekdays or weekends, but more so during the latter. Stations near schools seemed less affected by rain on weekdays, with 27 rides on dry days to 25 rides on rainy days; this can be interpreted as students being captive riders, having to ride their bicycles to school regardless of the weather. Usage around parks and subways is seen to be affected heavily by rainfall, particularly on the weekends.

Stations near parks are shown to cause 98 rides on dry weekdays and 178 rides on weekends, displaying a significantly positive impact on bikesharing rides (Figure 6). Although stations near parks are shown to have decreased visits on rainy days, they still enjoy 68 and 95 rides on weekdays and weekends, respectively; parks are therefore analyzed to have 3 to 5 times the positive effect schools or subways have on bikesharing usage. Although schools and subways were also shown to cause bikesharing usage, their impact on weekdays and weekends did not significantly differ.

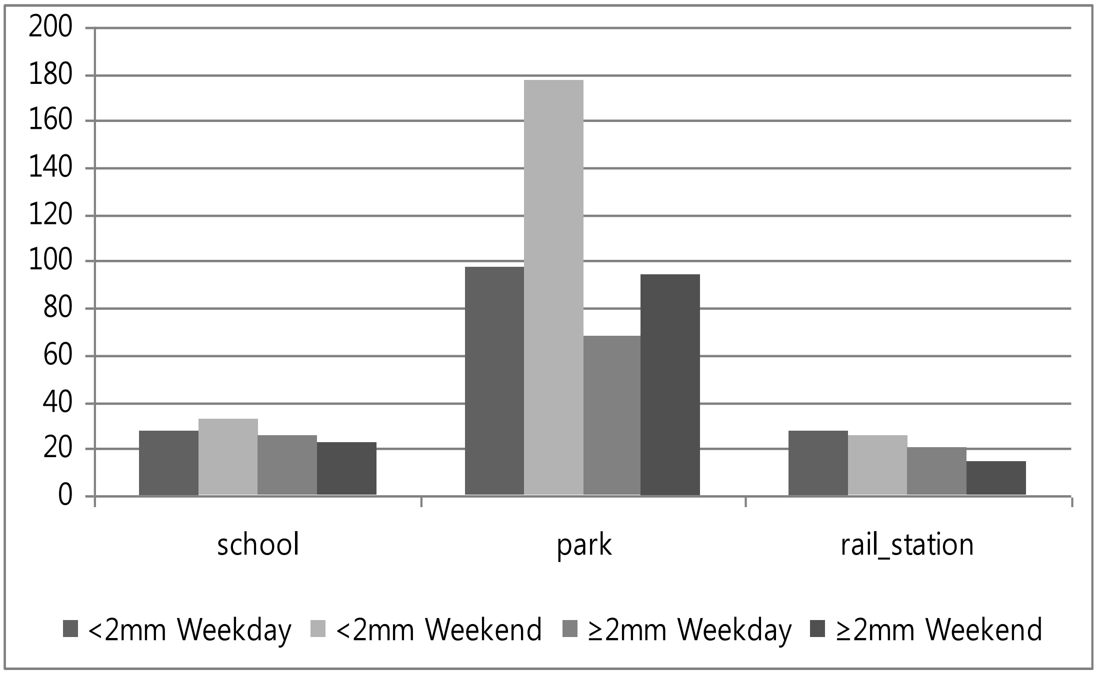

FIGURE 6 Coefficients for Variables Representing Parks, Schools, and Subway in Each Model

Station arrivals were also analyzed for four instances categorized as dry weekdays and weekends, and rainy weekdays and weekends. The school variable was shown to have 50% more departures than arrivals. This is assessed to be the result of students taking the family vehicle, shuttle, or a bus to school, while using a bicycle after the school day has finished. In addition, students may have varying destinations after school, which may include home, academies, or leisure venues. The subway variable was shown to have similar results, as the final destinations may vary after using the subway. However, stations near park areas, where traffic is mostly leisure-oriented, are shown to have nearly equal amounts of arrivals and departures.

As for variables on land use, residential gross area was shown to have more impact on arrival than departure. This can be construed in the same context as how schools and subways cause more departures than arrivals. Commercial gross areas, on the other hand, showed similar levels of departure and arrival. Meanwhile, arrivals during rainy weekends or weekdays showed similar patterns as those of departures, revealing that the weather has no particular effect on determining arrivals or departures.

TABLE 5 Results of the Regression Models for Arrival

Precipitation		<2mm				>=2mm			
Day		Weekday		Weekend		Weekday		Weekend	
		Coef.	VIF	Coef.	VIF	Coef.	VIF	Coef.	VIF
Land use	Residential (1,000 ㎡)	0.015***	1.08	0.015***	1.08	0.013***	1.08	0.011***	1.08
	Commercial (1,000 ㎡)	0.133***	2.07	0.132***	2.07	0.093***	2.07	0.089***	2.07
Facility	School (dummy)	18.031***	2.33	21.978***	2.33	16.848***	2.33	15.691***	2.33
	Park (dummy)	93.695***	1.59	171.015***	1.59	65.282***	1.59	92.756***	1.59
Public Transport.	Subway (dummy)	18.950***	1.26	16.990***	1.26	14.897***	1.26	9.694***	1.26
cons.		14.849		9.657		8.566		3.502	
Num of obs.		1682		547		782		519	
Prob>F		0.0000		0.0000		0.0000		0.0000	
R_squared		0.6853		0.7763		0.4235		0.4400	
Adj R-squared		0.6844		0.7742		0.4198		0.4346	

Note: Significant at *** = 1%; ** = 5%; * = 10%

CONCLUSION

Recently, bikesharing systems have been actively implemented all around the world. Although this trend has led to a variety of research on public bicycle systems, there have been no previous studies on the factors influencing the travel behavior using public bicycles. This study has analyzed the impact of land use and facility factors that are speculated to have significant influence over bikesharing usage. The factors are gross area of residential buildings around the station; gross area of nearby commercial buildings; and parks, schools, and subway stations near the bikesharing stations. In addition, eight models were categorized according to factors that were also expected to yield different riding patterns: weekends and weekdays; rainy and non-rainy days; and arrivals to and departures from the bike stations.

As a result, land use factors (the gross area of nearby residential and commercial buildings) and facilities (parks, schools, and subway stations) were shown to have positive impact on bikesharing usage. However, the extent of their impact varied depending on certain variables and models. For non-rainy weekdays, commercial areas were shown to cause rides 15 times more than residential areas; and parks were shown to cause 3 to 5 times more rides than subway stations and schools. Parks, which are frequented mostly by traffic for the purpose of leisure, were shown to enjoy about twice the amount of traffic on the weekends than weekdays. As expected, bicycle usage was shown to decrease on rainy days overall.

This study is meaningful in that it has empirically analyzed the extent of the impact various factors have on the travel behavior of bikesharing users. When establishing bikesharing systems, the appropriate scale of each station must be calculated in consideration of nearby land use and facilities. In terms of operating bikesharing, an efficient redistribution strategy is also essential. This study may be used as a foundational reference in estimating the scale of new stations and building redistribution strategies for bikesharing stations. Afterwards, comprehensive analysis should be done in consideration of socio economic indicators, climate conditions, and the time of day.

ACKNOWLEDGEMENTS

The authors thank Ecobike for sharing data sets for use in this study.

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