An Optimal Location Model for a Bicycle Sharing Program: Case Study of the Kaohsiung K-bike System

Shou-Ren HU [a], Chao-Tang LIU [b]

[a] *Department of Transportation and Communication Management Science, National Cheng Kung University, Tainan City, 70101, Taiwan; E-mail: shouren@mail.ncku.edu.tw*
[b] *Traffic Department, Kaohsiung Rapid Transit Corporation, Kaohsiung City, 806, Taiwan; E-mail: estorye@gmail.com*

Abstract: Bicycle Sharing System (BSS) has been considered as one of the effective means for green transport systems. The Kaohsiung Public Bike system (K-bike), a BSS established by the Kaohsiung city government and operated by the Kaohsiung Rapid Transit Corporation (KRTC) has been in operation since 2009. An integrated public transport system should consider their sustainable development and/or operation by providing seamless transport services of different modes. In this study, we develop a local model for the determination of optimal rental stations of the K-bike system where the main objective is to minimize the total system cost. The ultimate goal is to increase the KRTC's ridership by providing transit users with convenient first- and/or last-mile feeder services.

Keywords: Bicycle Sharing System/Program, K-bike, Public Transport, Feeder System

1. INTRODUCTION

The K-bike system is a Bicycle Sharing System (BSS) located in Kaohsiung City, which is also the first BSS formally constructed for both recreation and shuttle purposes in Taiwan. The K-bike system has been operating since March 1st, 2009, with the Kaohsiung city government's subsidy approximately 10 million NTD per year.

In the first stage of operation, the Environment Protection Bureau of the Kaohsiung city government was responsible for operating the K-bike system and totally 20 rental stations and 1,500 bikes were established. In the second stage, the system was increased by 49 rental stations and 4,500 bikes until May 1st, 2009. On August 18th, 2011, the Kaohsiung Rapid Transit Corporation (KRTC) took over operation and maintenance, and extends the system of the current scale up to 78 rental stations and 7,000 bikes. Basically, for different purposes of recreation, commuting and feeder service to the KMRT system, the bike rental stations are usually located near the Kaohsiung MTR stations and popular tourist attractions. Figure 1 shows the locations of the K-bike rental stations.

Figure 1. Rental stations of the K-bike system (in green spot)

As can be found in figure 1, totally 28 rental stations are nearby the metro stations with a walking distance within three minutes; the others are located at some points of interest or school areas. For instance, the rental station named as Sanduo Shopping District station is closed to department stores, whereas the Kaohsiung Municipal Girls' Senior High School station is beside a senior high school.

There is another BSS in Taiwan, the U-Bike system, which initiated its trail run by the Taipei city government and the Giant Corporation with 11 rental stations and 500 bikes in 2008. In 2011, the Taipei city government formally signed a contract with the Giant Corporation for a plan to build 162 rental stations and provide 5,350 bikes before the end of 2014. The average ridership of the U-bike system is approximately 10,000 trips per day with a significant number of connecting trips to the Taipei Rapid Transit Corporation (TRTC) metro system.

Since 2011, the Environment Protection Bureau offers subsidy to the KRTC approximately 10 to 12 million NTD every year to operate the K-bike system, but this government funding support is not guaranteed because the financial plan for promoting green transport mode of the government is not the same each year. Thus, how to operate the K-bike system in a cost-effective and financially sustainable manner is one of the key issues faced by the government offices and the KRTC where cost control would be the main strategy, especially on the system construction stage. The other issue is how to increase usage and create more profit in a long term for both the K-bike system and the KRTC. Thereby, the main purposes of this research are twofold:

(1) to minimize the total cost of the K-bike system, including fixed cost, operating cost, and passenger's travel cost; and
(2) to attract more people to use the K-bike system and transfer to other public transport systems, such as bus and metro, to create more profit and raise the market share of the public transport system in Kaohsiung City.

BSS in the public transport field is usually designated to solve the last-mile transport problem. Accordingly, the rental stations for a BSS are usually located mainly at or closed to metro stations, bus stops, department stores and popular tourist attractions. But, is such location oriented design guaranteed to cover most of travel demands and convenient for transit users? Besides, if it can make more profits for a transit operator is another issue to be investigated. In this research, we will explore these research questions by developing a mathematical programming model to obtain the optimal rental locations for the K-bike system by considering fixed cost, operating cost and passenger's travel cost.

2. BACKGROUND INFORMATION

Reducing CO_2 emission is becoming a trend of the whole world; how to raise public transport system's market share and decrease private vehicle usage are crucial for a sustainable transport system development. In Taiwan, Mass Rapid Transit (MRT) and bus systems are two main transport modes which are usually used to resolve traffic congestion and air pollution problems.

The Taipei MRT is the first MRT system in Taiwan, and it was officially operated by the TRTC on March 28th, 1996. Until now, the system totally has six MRT lines and 102 stations. In addition, the bus system in the metropolitan Taipei area which provides approximately 300 lines serves as the main feeder system of the Taipei MRT system. The Taipei MRT averagely serves 1.78 million ridership a day, the market share of the public transport in Taipei City is 37.7 % in 2011 (versus 23.8% in 1996). Figure 2 shows the market shares of the public transport systems in Taipei City, Kaohsiung City and the overall in Taiwan in past few years.

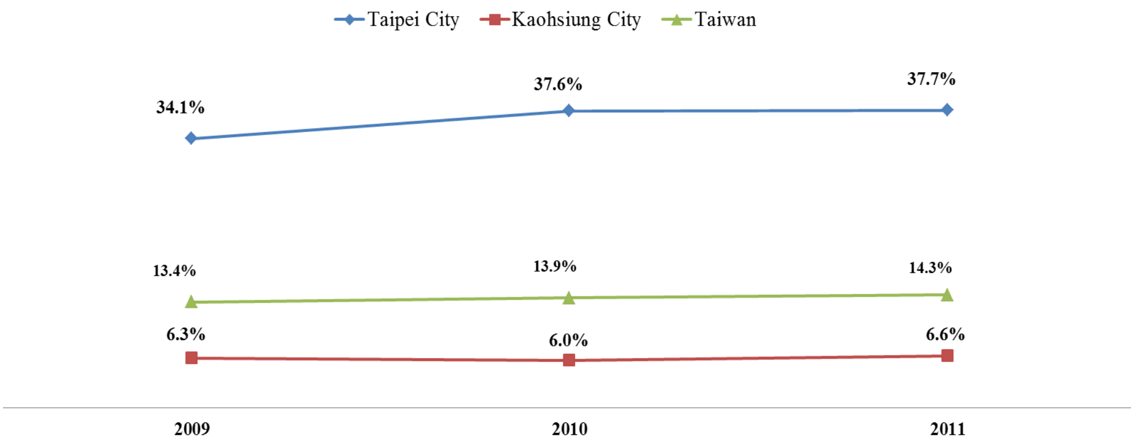

Figure 2. Market share of the public transport in Taipei City, Kaohsiung City in Taiwan

As shown in figure 2, providing MRT system and combining other public transport modes can significantly change people transport behaviors and achieve the goal of reducing vehicle emissions and increase public transport system's market share. In Kaohsiung City, the Kaohsiung MRT, the second MRT system in Taiwan, was completed in 2007, and formally operated by the KRTC in March 9, 2008, with totally 2 lines and 38 stations. In order to encourage people to use the Kaohsiung MRT, the Kaohsiung city government also provides 22 bus lines connecting to the main MRT stations. But, the market share of the public transport in Kaohsiung City hasn't been increased obviously in past ten years.

Due to different social and economic developments and travelers' behaviors, there is a significantly different growing path of the public transport systems in Taipei City and Kaohsiung City. The main reason for the low usage of the Kaohsiung MRT system is that the network hasn't stretched enough to change travelers' daily commuting behaviors. Especially for motor scooter which is much cheaper and convenient for commuting purpose than the public transport system has been intensively used in this city. According to the Ministry of Transportation and Communication, Kaohsiung City holds the second position on private vehicle ownership; total registered motor scooters and passenger cars are on the verge of 3.1 million with a total population of 2.78 million. Although the MRT system has been established, it has hardly a significant influence on local citizens' mode choice behaviors. For a green transport in the future, the Kaohsiung city government still continues to plan several public transport related projects, including railway underground construction, bus transfer post and bike sharing program. Figure 3 shows the Kaohsiung city government's expectation on market share of the public transport systems in 2016.

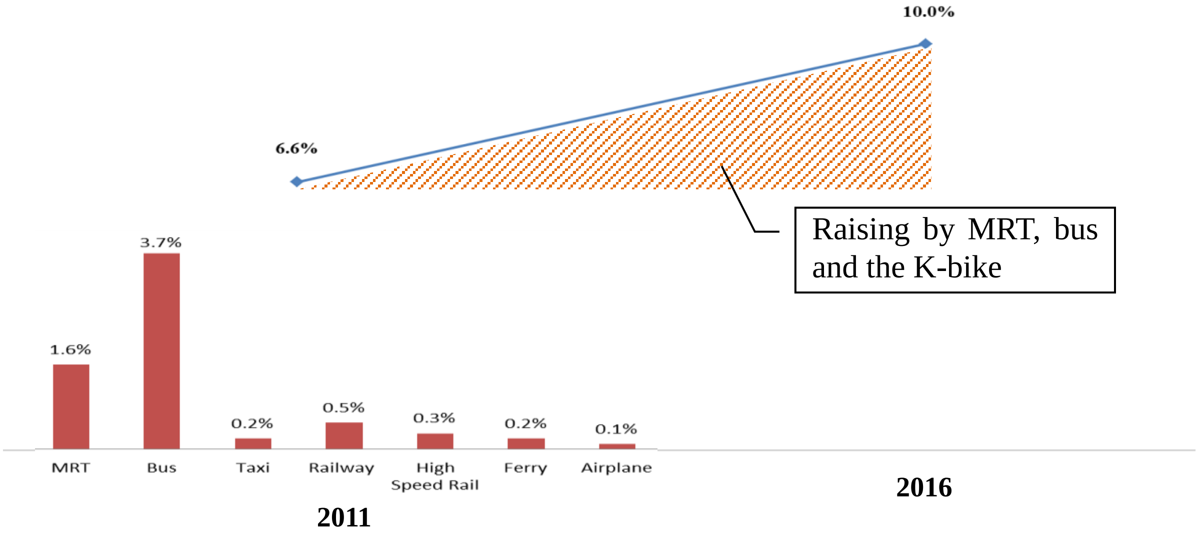

Figure 3. Kaohsiung Public transport systems' market share in 2016

The K-bike system is born to solve shuttle demand problem and provide another green and cheap choice for the citizen with commuting need. As indicated in figure 3, in the near future, we hope that the Kaohsiung MRT, bus system and the K-bike system will fill the triangle area under a mutual benefit basis of the allied public transport systems. To achieve the above goal, the location of a rental station is the key issue of the K-bike system, because if the user spends less time for riding and transferring to the other transport modes easily, it can attract more people to use the bike-sharing system. In turn, more profit can be earned and the public transport system's ridership and/or market share can be significantly raised.

3. PROBLEM STATEMENT AND LITERATURE REVIEW

The main purpose of this research is to develop a location model to promote the usage of the K-bike system where users' location choices and travelling behaviors, and local area's characteristics are the key factors needed to be considered. Marten (2007) described that the BSS is a developing experience in the Dutch, thus they advocated setting the BSS rental stations near bus stops and train stations as a bike-and-ride mode can increase bike usage and transfer to public transport systems directly. Lin *et al*. (2011) considered the BSS rental station as a transfer post, they used a mathematical programming approach to find the best locations for work related trips.

Besides, some articles pointed out other issues. For instance, a comfortable environment and well-suited rental process would make people like to use the BSS. Buehler (2012) investigated the BSS in Washington D.C. area by adding some facilities into a bike rental station, such as bicycle parking, cyclist shower and free car parking lot. Using the logistic regression method, the empirical study result indicated that the cyclist shower and free car parking are highly related to bicycle commuting. Pucher *et al*. (2011) reviewed trends in cycling levels, safety, and policies in the USA and Canada in the past two decades. They described the successful experience of nine case study cities and found those great innovations for the other city which would like to develop a similar system. Börjesson *et al*. (2012) suggested that the bicycle system should be viewed as a competitive mode for traveling, because its travel time saving is higher than that of alternative modes.

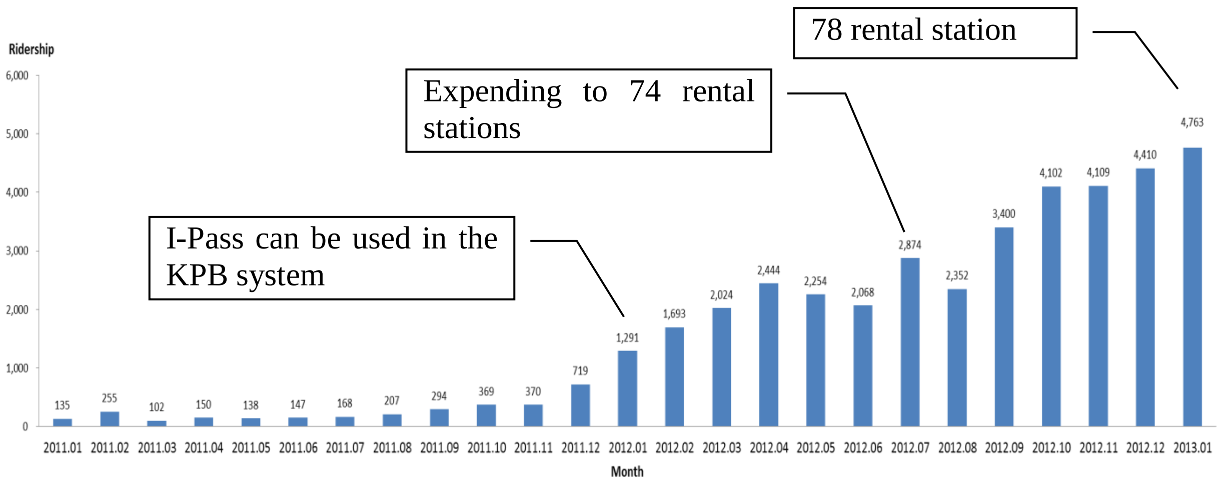

Figure 4. Average daily ridership of the KPB system

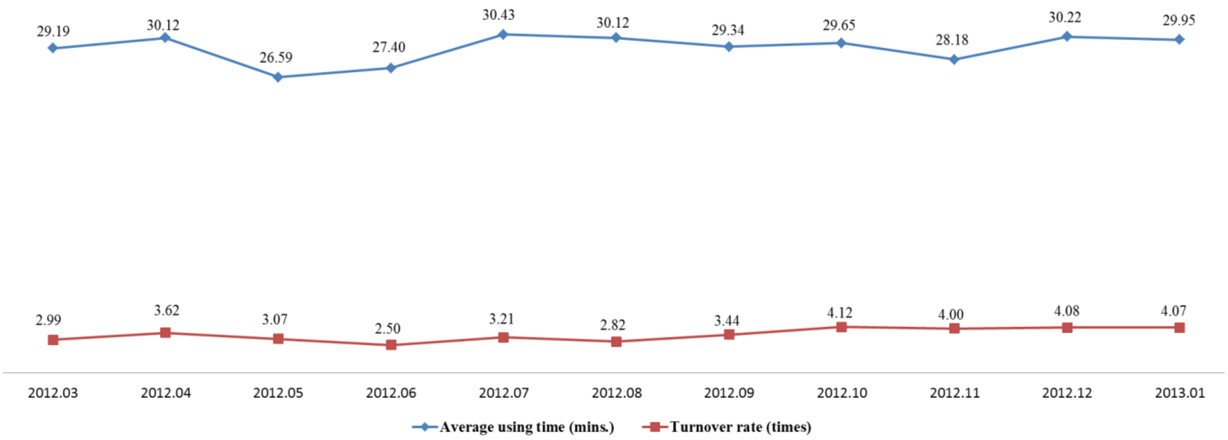

Figure 5. Average using time and turnover rate of the KPB system

As can be seen in figure 4, according to the historical data, the K-bike system's ridership has been incrementally increased in the past two years. Because the number of the rental stations of the K-bike system expands from 49 units to 74 units. Another reason is, when he or she uses the I-PASS card issued by the KRTC in the K-bike system, they don't pay any charge in the first hour and pay $10 NTD every 30 minutes thereafter the first hour. This strategy promotes people to use the K-bike. But, there is a contradiction in the free strategy, as shown in figure 5, the average riding time per user is less than 35 minutes. There is the same situation in the U-Bike system; 80% of the daily ridership finished their journey in 30minutes, which means that the KRTC can't earn profit from the K-bike system. Furthermore, the transfer market share of the K-bike system to the Kaohsiung MRT system, or vice versa is less than 10%. It means that only 210 passengers are transferring between these two systems per day. Under this situation, it is very difficult to achieve sustainability for the K-bike system without the subsidy from the Kaohsiung city government.

Thereby, how to attract more potential users to use the K-bike system is the main problem we need to solve in this research. In order to achieve this goal, we propose a bike rental location method by considering related cost items and aiming to minimize the total cost for both the operator and the passenger.

4. MODEL CONSTRUCTION

4.1 Model Structure

The model structure of the present research consists of several parts, describe below:

1. Collecting the relative cost items: we collect the real costs of the K-bike system from the KRTC and incorporate them into the proposed model. Basically the cost structure includes three parts: one is the fixed cost consisting of rental station cost and bicycle inventory costs; another is the operating cost consisting of manpower cost and maintenance cost; the other is the passenger's travel cost, we measure the riding time depending on trip distance and traffic conditions.
2. Establishing a cost-oriented model: we use the linear programming method to establish a formulation to minimize the total cost.
3. Sensitivity analysis: we vary some cost item values to investigate what would be the key factors that have an effect on the system performance.

In this research, we set the ridership basic pattern as shown in figure 6, including four parts, MRT station (original), rental station R*i*, rental station S *j* and building (destination).

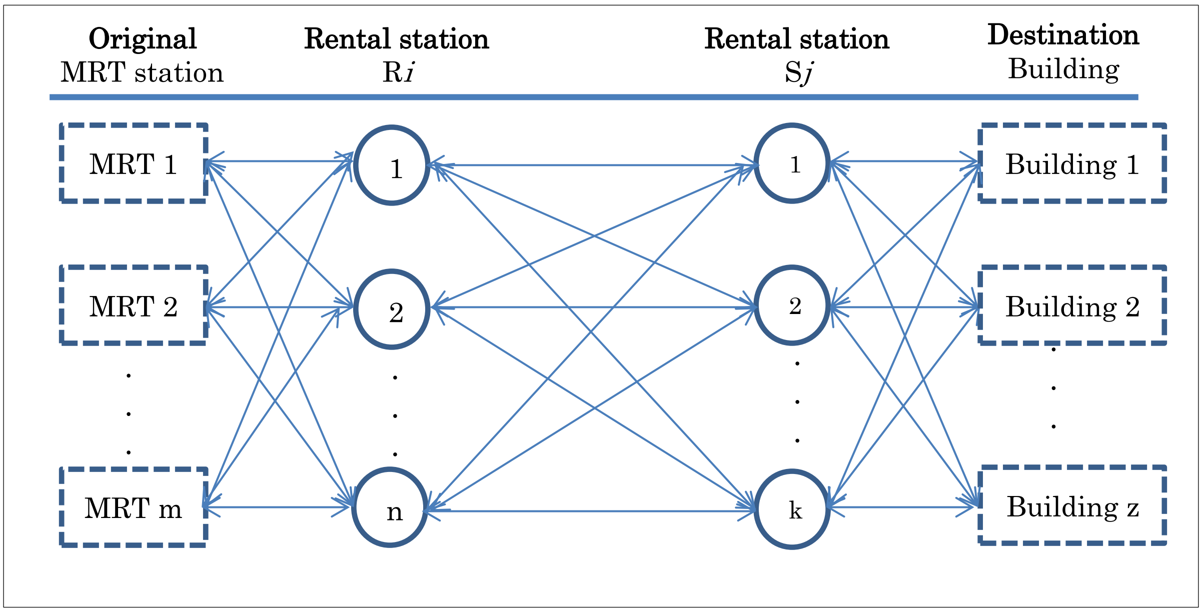

Figure 6. Ridership pattern and location of the infrastructure

4.2 Model Formulation

The location model for the bike rental stations is formulated as liner program as following.

Minimize:

$$\left\{\sum_{i=1}^{n}\sum_{j=1}^{k}(Ri+Sj)*(Cr+B*Cb)\right\} \tag{1}$$

$$+\left\{H\left(\sum_{i=1}^{n}\sum_{j=1}^{k}(Ri+Sj)\right)*Hf*Ch+\sum_{i=1}^{n}\sum_{j=1}^{k}(Ri+Sj)*(Cm+Bd*Cb)\right\}$$

$$
+\left\{ \begin{array}{c} \sum_{O=1}^{m}\sum_{i=1}^{n} Doi * Ct * Tod \sum_{i=1}^{n}\sum_{j=1}^{k} Ri * Sj \\ + \sum_{i=1}^{n}\sum_{j=1}^{k} Dij * Ct * Tod \sum_{i=1}^{n} \sum_{j=1}^{k} Ri * Sj + \sum_{j=1}^{k}\sum_{d=1}^{z} Djd * Ct * Tod \sum_{i=1}^{n}\sum_{j=1}^{k} Ri * Sj \end{array} \right\}
$$

Subject to:

$$R_i + S_j \geq 2 \quad (2)$$

$$\sum_{i=1}^{n} R_i \geq 1 \quad (3)$$

$$\sum_{i=1}^{k} S_j \geq 1 \quad (4)$$

$$R_i = \{0,1\} \quad (5)$$

$$S_j = \{0,1\} \quad (6)$$

where,

m, *n*, *k*, *z*: represent the number of MRT stations (original), rental stations (R*i*, near MRT), rental stations (S*j*, near the building) and buildings (destination);
R*i*/S*j*: 1, means rental station *i* is chosen; 0, otherwise;
C*r*: cost of constructing a rental station, NTD;
B: number of bicycles in a rental station;
C*b*: bicycle unit cost, NTD;
H (R*i*+S*j*): number of staffs for operating the overall system;
H*f*: manpower factor;
C*h*: staff's cost per year, NTD;
C*m*: maintenance cost for a rental station per year, NTD;
B*d*: number of damaged or stolen bicycles;
D*oi*: travel time from a MRT station to rental station *i*, including the time required for renting the bicycle, minute;
D*ij*: travel time from rental station *i* to rental station *j*, minute;
D*jd*: travel time from rental station *j* to a building, including the time required for returning the bicycle, minute;
C*t*: passenger's value of time, NTD/ per minute;
T*od*: yearly ridership from a MRT station to a building, number of trips;

There are three components in equation 1. The first part is the fixed cost. When we construct a rental station, there are two cost items: 1) cost of constructing a rental station (C*r*), and 2) cost of purchasing bicycles (C*r* multiplied by B). The second part is the operating cost, including manpower resource cost (H (R*i* + S*j*)), maintenance cost (C*m*) and cost associated with stolen or malfunction (B*d*). Due to shift arrangement, we need to consider staff's off-duty period, so H*f* is adding into the manpower function for adjusting. The third part is a passenger's travel cost, including walking cost (C*oi*, C*jd*) and riding cost (C*ij*).

5. EMPIRICAL STUDY

5.1 Data assumption

We propose a small network located in the central Kaohsiung city to be a case in the empirical study. Figure 7 shows the network and candidates of rental stations.

Figure 7. Neighboring network of the MRT R8 station

: R*i*, rental station near the R8 MRT station (R1, R2)

: S*j*, rental station near the destinations (S1, S2, S3)

: MRT R8 station (origin of the trips)

: building (destination of the trips)

In this case study, the rental stations near the MRT R8 station had been constructed, so in the research, we would consider different scenarios (e.g. R*i* are given or not). We use the proposed model to find the best location of R*i* and S*j*. The relative parameters are shown in table 1. Basically they are set depending on the real operating data obtained from the KRTC.

Table 1. Parameter settings and assumption

Parameters	value
C*r*	$600,000 NTD (per station)
B	15 vehicles (per station)
C*b*	$5,344 NTD (per vehicle)
H (R*i*+S*j*)	H1: 3 persons (if the number of stations is less than10) H2: 6 persons (if the number of stations is between 10 and 20)
H*f*	1.552
C*h*	$567,624 NTD (one person, per year)
C*m*	$36,575 NTD (one station, per year)
B*d*	50 vehicles
D*oi*	R8 MRT to R1: 3 minutes R8 MRT to R2: 4 minutes
D*ij*	R1 to S1: 1.5 minutes R1 to S2: 1.5 minutes R1 to S3: 1.8 minutes R2 to S1: 1 minutes R2 to S2: 2 minutes R2 to S3: 1.8 minutes
D*jd*	S1 to building 1: 4 minutes S1 to building 2: 8 minutes S2 to building 1: 5 minutes S2 to building 2: 4 minutes S3 to building 1: 8 minutes S3 to building 2: 5 minutes
C*t*	$4.43 NTD (one person, per minute)
Tod	M to B1/ B1 to M: 27,235 (trips, per year) M to B2/ B2 to M: 27,235 (trips, per year)

5.2 Results

Scenario 1

In the real situation, two rental stations had been constructed near the MRT R8 station. Thereby, we assume R1 and R2 are known. We use Lingo mathematical programming solver to solve this problem. As a result, the total cost of scenario 1 is $7,169,219 NTD and S2 is chosen to construct the rental station.

Scenario 2

In this scenario, we assume all R*i* and S*j* are unknown. The total cost of scenario 2 is $6,266,788 NTD and R1, S2 are chosen to construct appropriate rental stations.

According to the results found in scenarios 1 and 2, scenario 2 saves cost comparing to that of scenario 1 in the total cost item, even it just sets up a rental station closed to MRT R8 station. Each cost item comparisons are shown in table 2.

Table 2. Comparison of the cost contents (Scenarios 1 and 2)

	Fixed cost (NTD)	Operating cost (NTD)	Passenger's travel cost (NTD)	Total cost (NTD)	Chosen rental stations
Scenario 1 (A)	2,040,480	2,763,950	2,364,789	7,169,219	R1/R2/S2
Scenario 2 (B)	1,360,320	2,723,586	2,182,882	6,266,788	R1/S2
Cost reduced rate (B-A)/A, %	-33.33%	-1.46%	-7.69%	**-12.59%**	-

According to the results in table 2, in scenario 2 we can save 33% of the fixed cost, it's obvious if we construct two rental stations near the MRT R8 station, it's inefficient. In the operating cost item, since the network scale of this case is small, there is not significantly variation in this cost item. Because the manpower resource cost is the same that all needs three staffs to operate the system in these two scenarios, and a slight difference on the maintenance cost and vehicle cost. Passenger's travel cost includes walking cost and riding cost. In scenario 2, even only one rental station (R1) can be used to rent bike to their destinations, the route between R1-S2 is a shorter path for riders than the other paths.

5.3 Sensitivity analysis

Scenario 3

As stated in the previous study, providing convenient infrastructures around the bicycle rental station would attract more people to use the BSS. Thereby, in scenario 3 we set C*r* to be $1,000,000 NTD where extra $400,000 NTD is to construct relative infrastructures. Table 3 shows the result and comparison.

Table 3. Comparison of the cost contents (Scenario3)

	Fixed cost (NTD)	Operating cost (NTD)	Passenger's travel cost (NTD)	Total cost (NTD)	Chosen rental station
Scenario 1 (A)	2,040,480	2,763,950	2,364,789	7,169,219	R1/R2/S2
Scenario 2 (B)	1,360,320	2,723,586	2,182,882	6,266,788	R1/S2
Scenario 3 (C)	2,160,320	2,723,586	2,182,882	7,066,788	R1/S2
Cost reduced rate (C-B)/B, %	58.81%	0.00%	0.00%	**12.77%**	-
Cost reduced rate (C-A)/A, %	5.87%	-1.46%	-7.69%	**-1.43%**	-

Comparing the result of scenario 3 to that of scenario 2, if we add some convenient infrastructures around the rental station, the fixed cost increases by 58.81%, and the total cost also raises by 12.77%. Comparing the result of scenario 3 to that of scenario 1, the fixed cost only increases by 5.87%, the operating cost and passenger's travel cost decrease by 1.46% and 7.69% respectively, the total cost is slightly reduced. According to the empirical study results, if we can remove one rental station nearby the MRT R8 station, and use this constructing monetary resource to establish convenient infrastructures around the rental station, the overall system still spends less cost but has high potentials to attract more passengers in this local area.

Scenario 4

In Kaohsiung City, the traffic condition is very tough for passengers to ride bike easily along the road. Accordingly, in scenario 4, we modify D_{ij} by route-specific traffic conditions where 1.5 minutes is needed to pass a traffic light on the route. The result is shown in table 4.

Table 4. Comparison of the cost contents (Scenario4)

D*ij** (consider traffic condition)	R1 to S1: 6 minutes (pass 3 traffic lights) R1 to S2: 7.5 minutes (pass 4 traffic lights) R1 to S3: 7.8 minutes (pass 4 traffic lights) R2 to S1: 2.5 minutes (pass 1 traffic lights) R2 to S2: 6.5 minutes (pass 3 traffic lights) R2 to S3: 6.3 minutes (pass 3 traffic lights)				
	Fixed cost (NTD)	Operating cost (NTD)	Passenger's travel cost (NTD)	Total cost (NTD)	Chosen rental station
Scenario 2 (B)	1,360,320	2,723,586	2,182,882	6,266,788	R1/S2
Scenario 4 (D)	1,360,320	2,723,586	3,031,781	7,115,687	R2/S1
Cost reduced rate (D-B)/B, %	0.00%	0.00%	38.89%	**13.55%**	-

Referring to the result shown in table 4, if we consider traffic conditions into the model, the passenger's travel cost increases obviously, and the candidate rental stations have changed. Looking at D*ij**, the route of R2-S1 has the shortest travel time than others, so if the fixed cost and operating cost remain the same, especially in a small network, the model would proceed the result rely on passenger's travel cost significantly.

6. CONCLUSION AND FUTURE WORK

6.1 Conclusion

In this research, we aim to reduce total cost of the K-bike system and offer a better bike rental location for a passenger. In the proposed model, we consider fixed cost, operating cost and passenger's travel cost into the model. Based on the results revealed in the case study by setting different test scenarios, some conclusions are described below.

1. Reconstruct existed rental station: according to the result shown in table 2, it's obviously if we reduce one rental station that near the MRT station, the overall system not only reduces the fixed cost but also maintain a certain level of service for passenger. In the real situation of Kaohsiung City, there are many MRT stations with numbers of bike rental stations. Although it is much convenient for passenger to use the K-bike system, but there is not necessary to construct more than one rental station which is closed to a MRT station, especially the fixed cost is relatively high ($600,000 NTD).
2. Add convenient infrastructures: from a passenger's perspective, if there are more useful facilities around the rental station, it will attract them to adopt the K-bike system. According to the result shown in table 3, if we can remove one station and use the constructing money to build free parking lot or shower equipment, the overall system cost is still reducing 1.43% and it will have a high opportunity to attract more potential users. But maintenance and management for those facilities are other issues we need to consider. It would also have spending we should incorporate into the model.
3. Traffic condition: in Kaohsiung City, traffic is very tough for walking and riding bike,

there are 3.1 million private vehicles, including cars and scooters. In scenario 4 we consider the route traffic situations, and the result shown in table 4 indicates that it brings a significant efficiency on choosing the candidate rental stations. Basically in scenario 1, we only consider the length of each route and turn into a time-base cost item, so the model will search the shortest way to construct to the rental station. Nevertheless, in a real situation, there is not only the distance between a pair of trip origin and destination needing to be considered, but also the traffic condition should be also accounted for; even the route pavement or traffic flow condition can influence the rental station choice result.

6.2 Future work

In the case study, there are some factors that were not specifically considered, and they will be incorporated into a later research.

1. Land price: in the K-bike system, if a rental station is to construct, the government will use their authority to levy the land. Thereby, in this case study we didn't set up a land price notation into formulation. But if a BSS is not supported by the government, the land price will be a key factor of the model, especially if the system is operating in the central area of a city, it that would be a key concern. Because the land price which is significantly higher than the construction cost might decide the location.
2. Budget: for K-bike system, the subsidy provided by the government is to support the system operating that makes the KRTC can operates the system without considering the revenue received from the K-bike system. In this case, since we used a small scale of network, the total cost is limited to a restricted range, not beyond the budget scale (10 million NTD). But if we consider the overall area of Kaohsiung City to build rental stations, the maximum budget needs to be considered into the model and it would become the upper bound of the proposed model.
3. O-D pair: for the ridership for each pair (MRT to R*i*, R*i* to S*j* and S*j* to building), we equally assumed 10% of MRT ridership in this case study. In reality, passenger will not all go to the same rental station or take the same route for their destinations. In addition, off-line situation needs to be taken care of. We need to simulate O-D pairs depending on real situations in order to increase the creditability of empirical study results.
4. Change of rental stations on passenger volume: in the future research, we could analyze the change of O-D pairs and their corresponding volume due to modifying the location of rental stations and users' rental station choice behaviors.

REFERENCES

Buehler, R. (2012) Determinants of bicycle commuting in the Washington, DC region: The role of bicycle parking, cyclist showers, and free car parking at work. *Transportation Research Part D 17*, 525-531.

Börjesson, M., Eliasson, J. (2012) The value of time and external benefits in bicycle appraisal. *Transportation Part A 46*, 673-683.

Fishman E., Washington S., Haworth N., Barriers and facilitators to public bicycle scheme use: A qualitative approach. *Transportation Research Part F 15*, 686-698.

Lin, J.R., Yang, T.H. (2011) Strategic design of public bicycle systems with service level constraints. *Transportation Research Part E 47*, 284-294.

Martens, K., (2004) The bicycle as a feedering mode: experience from three European countries. *Transportation Research Part D 9*, 281-294

Marten, K. (2007) Promoting bike-and-ride: The Dutch experience. *Transportation Research Part A 41*, 326-338

Pucher, J., Buehler R., Seinen, M. (2011) Bicycling renaissance in North American? An update and re-appraisal of cycling trends and policies. *Transportation Research Part A 45*, 451-475.

Wang, Y.W. (2007) An optimal location choice model for recreation-oriented scooter recharge stations. *Transportation Research Part D* 12, 231-237.

Romero, J.P., Ibeas, A., Moura, J.L., Benavente, J., Alonso, B. (2012) A simulation-optimization approach to design efficient systems of bike-sharing, Paper presented at 15th meeting of the EURO Working Group on Transportation, Spain, September 10-13.

Liu, Z., Jia, X., Cheng, W. (2012) Solving the last mile problem: Ensure the success of public bicycle system in Beijing, Paper presented at the 8th International Conference on Traffic and Transportation Studies, Changsha, China, August 1-3.