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Research on Performance Evaluation Method of Public Transit Routes Based on BCC Model

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Abstract. The fast development of urbanization and development have led to an increase in the difficulties with regards to satisfying the demand of public transport. The quantized evaluation analysis of urban public transport performance is useful to identify its shortcomings and to also enable further optimization of the transport system. This facilitates the improvement of the systems quality of service and provides the means to reduce operating costs. Furthermore, the quantification of the bus lines performance evaluation is crucial in raising the systems operational efficiency and improving the operators level of service. In this study, the data collected from Hangzhou Bus Companys operating income table is evaluated to assess bus performance by Excel and Deap software. The study constructs the conceptual framework that evaluates the performance evaluation of the single bus line, and divides the implementation process of the single bus line service into two stages. Building the Output-BCC (Banker Charnes Cooper) model with DEA method to calculate the operational efficiency and service efficiency, then accesses the Hangzhou bus transport objectively and provides some suggestions.

1. Introduction

Economic development often results in the rapid increase of urbanization and motorization, which raises the difficulties of meeting the demands for public transport. Although the government has already invested considerable human and financial resources in the public transport system, traffic congestion and slow traffic speeds is still evident. This has seriously affected citizens and their convenience. In order to improve the quality of public transport service and reduce operational costs, it is necessary to use an effective method to evaluate bus lines performance. The quantitative analysis of bus lines performance should help identify the current issues and shortcomings of bus lines operation. Further analysis enables the optimization of the systems quality of service, which will in return reduce operating costs and improve the overall operation[1]. Research theories of system performance analysis are quite rich, mostly from empirical perspective, and then provide solutions. The research methods focus mainly on a comprehensive evaluation, or use the analytic hierarchy process to evaluate the bus network [2]. The Hangzhou public transport system is recognized as an input-output system and its effectiveness is evaluated from a system perspective. First, it is necessary to select appropriate indicators. In this study, we have used principle component analysis and factor analysis to select relevant indicators to analyze the data collected from

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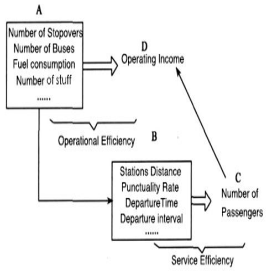

Figure2.1 Conceptual Framework for the single bus line performance evaluation

Figure 1: Figure A Conceptual Framework for the single bus line performance evaluation

the Hangzhou Bus Company.. Each Hangzhou bus line is considered a Decision Making Unit (DMU). Subsequently, the DEA method is used to build an Output-BCC model to evaluate the performance of the bus lines.

2. Performance Evaluation of Bus Routes

2.1. *Performance Evaluation of Single Bus Line*

In this paper, 20 bus lines routinely operated in the public transportation system of Hangzhou Bus Company were selected for operational performance evaluation. We used specific statistical methods to choose the correct indicators in order to receive the results of the systems analysis and evaluation through the DEA (Output-BCC) model. Urban public transport businesses have an operating income and belong to the operational urban public utilities. This indicates that part of it is a commonwealth public service, and the other part belongs to a profit - making enterprise business. =Therefore, combined with the process of bus services, we construct the conceptual framework for a single bus line performance evaluation (Figure 2.1). The single bus line bus service process is ABCD in Figure 2.1. Bus enterprises provide buses, stopovers and other resources to serve passengers, and there are the service indicators (stations distance, punctuality rate, departure time, departure interval). When taking these service indicators as inputs; we then calculate the number of passengers in order to establish the operating income.

2.2. *DEA (Output-BCC) model*

2.2.1. *Data Envelopment Analysis*

Data Envelopment Analysis (DEA) is a nonparametric method used to measure the relative efficiency of a decision making unit (DMU) using mathematical programming and optimization methods. A DMU is an entity that produces outputs and uses up inputs. The basic idea of DEA is to establish a mathematical programming model to evaluate each decision-making unit (DMU). This DMU can be a school, a hospital or a system. DEA has the following advantages: there is no need to preset the function between inputs and outputs; it can handle multiple inputs and multiple outputs problems; combined with appropriate methods (such as Tobit regression) enables the analysis of the external operating environment impact on performance and the situation of multiple limit values [3]. Performance evaluation of bus lines is a typical evaluation problem involving multiple inputs, multiple outputs and an external operating environment. The DEA model provides an efficient solution to this kind of problem.

2.2.2. *Output-BCC model*

When considering the performance evaluation of bus lines, each bus line is expressed as a DMU and a BCC model is built based on Variable Returns to Scale (VRS), that is when not all DMUs are run in the best scale, the calculation of technical efficiency will be affected by scale efficiency, but the VRS can make the technical efficiency be unaffected by scale efficiency [4][5][6]. Therefore, the output-BCC model is: j the

$$
\begin{aligned}
&Max \quad \mu && (1)\\
&s.t. \quad x_{i0} \geq \sum_{j=0}^{n} x_{ij}\lambda_j \qquad i = 1,2,\mathrm{L}\ ,m && (2)\\
&\qquad y_{r0}\mu \leq \sum_{j=0}^{n} y_{rj}\lambda_j \qquad r = 1,2,\mathrm{L}\ ,s && (3)\\
&\qquad \sum_{j=1}^{n} \lambda_j = 1 && (4)\\
&\qquad \lambda_j \geq 0, \qquad j = 1,2,\mathrm{L}\ ,n && (5)
\end{aligned}
\quad (2.1)
$$

Figure 2: Figure A Conceptual Framework for the single bus line performance evaluation

number of the decision making unit(DMU) j ?1,2,L ,n ; ithe number of inputs i ?1,2,L ,m ; r the number of outputs r ?1,2,L ,s ; xij the amount of input i from the DMUj ; yrj the amount of output r from the DMUj ; ?i the non-negative weight of the DMUj ; ?optimal output level ; Due to the model need to be solved n times (once per DMU), DMU0 represents any Decision Making Unit (DMU) to be evaluated. And in this model, DMU0 represents any bus line. For any given DMU0, the model tries to create the most efficient virtual Decision Making Unit (DMU) whose efficiency is based on the linear combination of all Decision Making Units(DMUs). The objective function (1) maximizes the output level of the virtual decision unit; the constraint condition (2) ensures the maximum input value does not exceed the observed input; the constraint condition (3) ensures the output level is at least the same as that of the DMU; constraint condition (4) guarantees the DEA model meets the VRS mode; the last constraint (5) is the non-negative constraint. If the optimal solution ¿ 1.0, so there is a virtual DMU and its operational efficiency is higher than DMU0, and DMU0 is not technical efficiency. The greater the value of is, the less effective DMU0 is. The relative efficiency of DMU0 is 1 / . When the BCC model is used to evaluate the operational performance of multiple DMUs city bus lines, the validity of the results is as follows: When the pure technical efficiency is 1, this means that the unit is technically efficient, that is, the operation output efficiency of this bus line is optimal; When the scale efficiency is 1, the units scale efficiency , that is, the input of bus lines is exact (neither too large nor too small), Hangzhou public transport scale returns are in the best state of the same critical point from increasing to decreasing; When the unit's bus operating efficiency satisfies both the technical efficiency and the scale efficiency, the unit is a DEA valid unit; When only one of the two is satisfied, the unit is a weak DEA valid unit; When neither is satisfied, the unit is a non-DEA valid unit. The DEA valid unit is better than the weak DEA valid unit in bus operating performance, and the weak DEA valid unit is better than the non-DEA valid unit [7][8].

3. Establishment of Indicator System

3.1. *Selection of Indicators*

Each bus line is selected as a Decision Making Unit (DMU) in this paper. According to the operation and management practice of bus lines [9], the operation of bus lines may have variable returns to scale. Generally, the input indicators of bus lines are usually easier to control than the output indicators [10]; therefore, use the input-oriented BCC (Banker Charnes Cooper) model that allows variable returns to scale (VRS).

3.2. *Input and Output Variable Selection*

After doing analysis and research, the data will be unified in the same dimension, then all the data is normalized to receive the following indicators:

Considering the different types of the inputs and outputs, the public bus system can be divided into two parts; the passengers and also the public transport enterprises. For bus enterprises, the main goal

Bus NO.	Number of Stations	Waiting Time	Punctuality Rate	Total Kilometers	Number of passengers/ year	Days of running(fr om new)	Number of bus shifts
K20	28	9	0.78	1227643	4548346	7949	13485
K355	20	12	0.8	1152008	3226049	7946	11745
K21	22	8	0.81	1686674	5381954	9573	17353
K325	21	12	0.75	1627946	5196922	10437	15137
K198	13	10	0.63	1725218	5736825	10458	16252
K8	24	8	0.76	1747372	7969449	10949	18948
K207	12	9	0.67	175235	247733	923	1921
K29	12	8	0.78	676770	2517379	4193	7317
K44	16	10	0.79	768419	2801736	4591	7514
K517	17	8	0.69	553683	984057	3853	6614

Figure 3: Table3.1 Normalization Index

Item	Decision Making Unit (DMU)	Input Variable			Output variable
Operational Efficiency	Single Bus Line	Number of stations	Fuel Consumption	Number of bus shifts/day	Daily Operating Income
Service Efficiency	Single Bus Line	Waiting Time	Days of running	Punctuality Rate	Number of Daily Passengers

Figure 4: Table3.1 Normalization Index

is to minimize input costs and maximize operating income [11]. Therefore, the input indicators of bus enterprises are the number of stations, fuel consumption and the number of staff per bus line. The consumers of bus services are the passengers, in their case, the bus lines effectiveness is measured in terms of the shortest waiting time. Service efficiency indicators correspond to punctuality rate, waiting time, which also corresponds with the intermediate outputs of the bus enterprises. Furthermore, the calculation of service efficiency assumes that factors such as vehicle types and line service types (full range, range vehicles, etc.) are not taken into account, the input indicators reflect the public transport services provided by bus enterprises. The output indicators reflect the aims of the two stages during the service process. For enterprises, the goal is to maximize the business interests which is the income; therefore, the output indicator is the operating income [11]. For governments, the goal of service efficiency is to service as many passengers as possible [12], in this case the output indicator is the number of passengers. Given the above, the indicators selected in this paper correspond to the ones listed in the following table:

4. Performance Evaluation Model of Hangzhou Bus Routes

Numerical experiments are performed in two different software environments for different purposes, by Microsoft Office Excel 10.0 and DEAP 2.0 respectively. Since Microsoft Office series is the most popular office-software, the related data is often stored in Excel tables. The BCC model built in Excel will be convenient to use, however, fewer results are provided using this method in comparison the using DEAP 2.0.

4.1. An Empirical Research of BCC Model Based on EXCEL

4.1.1. Operating Efficiency and Service Efficiency Evaluation Model Based on EXCEL

The output-oriented BCC linear programming model is implemented using EXCEL software. Prior to resolving the BCC model, it is of significant importance to use Excel as a method of building a solution model

Operational Efficiency Evaluation		Input			Output				
		Number of Stations	Daily Bus shifts	Total Kilometers	Daily Income	Weight (λ)	Line Evaluated	Optimal output(μ)	1/μ
DMU	K20	22.00	36.95	3363.41	12945.02	0	1	1.112107562	0.899193598
	K355	20.00	32.18	3156.19	877.33	0			
	K21	22.00	47.54	4621.02	18671.66	0			
	K325	21.00	41.47	4460.13	16316.90	0.875			
	K198	13.00	44.53	4726.62	15925.77	0			
	K8	24.00	51.91	4787.32	18612.68	0			
	K207	12.00	5.26	480.10	951.75	0.125			
	K29	12.00	20.05	1854.16	5819.24	0			
	K44	16.00	20.59	2105.26	6955.72	0			
	K517	17.00	18.12	1516.94	5039.31	0			
						1	=	1	
		Number of Stations	Daily Bus Shifts	Total Kilometers	Daily Income				
	Virtual Unit	20	17	37	14396.25525				
		<=	<=	<=	>=				
		22	18	37	14396.25525				
					12945.02055				

Figure 5: Table3.1 Evaluation Model of Operational Efficiency

Service Efficiency Evaluation		Input			Output				
		Waiting Time	Days of running	Punctuality Rate	Daily Passengers	Weight (λ)	Line Evaluated	Optimal Output(μ)	1/μ
DMU	K20	9.00	21.78	0.78	12461.22	0		1.096717632	0.911811729
	K355	12.00	21.77	0.80	8838.49	0			
	K21	8.00	26.23	0.81	14745.08	0			
	K325	12.00	28.59	0.75	14238.14	0			
	K198	10.00	28.65	0.63	15717.33	0			
	K8	8.00	30.00	0.76	21834.11	0.365848793			
	K207	9.00	2.53	0.67	678.72	0.634151207			
	K29	8.00	11.49	0.78	6896.93	0			
	K44	10.00	12.58	0.79	7675.99	0	1		
	K517	8.00	10.56	0.69	2696.05	0			
						1	=	1	
		Waiting Time	Days of running	Punctuality Rate	Daily Passengers				
	Virtual Unit	9	13	1	8418.392647				
		<=	<=	<=	>=				
		10	13	1	8418.392647				
					7675.989151				

Figure 6: Table3.2 Evaluation Model of Service Efficiency

with decision variables (indicators), constraints, and objective functions. Firstly, the linear programming model is specified according to the output-oriented BCC model (Output-BCC).

From the operational efficiency evaluation model, the input indicators are the number of bus stations, the number of daily bus shifts and the main vehicle kilometers travelled. The output indicator resembles the average daily operating income used.. From the bus enterprises perspective, the number of virtual units optimized by linear programming, adjust with practical problems (e.g. integers-only solutions), then we can evaluate the bus line objectively.

From the service efficiency evaluation model, the input indicators are the waiting time, the number of running buses and the punctuality rate. The output indicator is the average daily income. In order to analyze the service efficiency from the passengers perspective; the optimal number by linear programmings requires to be adjusted with practical problems such as integers only solutions. Accordingly, the service satisfaction for the bus line can be evaluated impartially. According to the operational efficiency evaluation model, the evaluated lines perform the assignment and operation. When one of the lines is assigned to 1, then we calculate the operating efficiency of the line results, and so on to run 10 times to get the operational efficiency results of all lines. According to this, in order to get the service efficiency results in the same way; we must set one of the lines assigned to 1 and get the weight respectively, then calculate the service efficiency results. When comparing operational efficiency and service efficiency, there is usually a positive correlation between operational efficiency and service efficiency for the whole bus system. However, bus lines with good operational efficiency do not necessarily have great service efficiency, and vice versa. The results of 10 bus lines are analyzed as follows:

From the table we can retrieve the efficiency evaluation of these 10 bus lines: (1) The operational efficiency and service efficiency of bus lines K198, K8, K207, K29 are good. K198 and K8 run through the city north and south, serving an important commercial area; K207 and K29 are the main lines of the Wulin trading area, serving a large population flow in the downtown shopping district. The four lines used in the

Item	Operational Efficiency		Service Efficiency	
Bus Line	Optimal Output(μ)	1/ μ	Optimal Output(μ)	1/ μ
K20	1.11210	0.899194	1.2441	0.8037
K355	12.1231	0.082487	1.7534	0.5703
K21	1	1	1.2744	0.7846
K325	1	1	1.4422	0.6933
K198	1	1	1	1
K8	1	1	1	1
K207	1	1	1	1
K29	1	1	1	1
K44	1.0716	0.9331	1.09671	0.9118
K517	1.2395	0.806	1	1

Figure 7: Table3.3 Analyzed Results of BCC Performance Evaluation Model Based on Excel

previous adjustment of the public transport network system can be retained. . (2) The operational efficiency of Bus line K517 is poor, but the service efficiency is good. Bus line K517 starts at Hangzhou Qianjiang New Town (The Second Changhua Building station) runs through the Wulin shopping district and finalizes at the Midu Bridge. The main reason for the low operational efficiency is that the operational organization of lines does not match the demand of the residents. If passengers preferences of bus lines were taken into consideration, bus line K517 can remain and be efficient. After further investigation and analysis of the commuting behavior of the communities and the passenger flow characteristics of the bus stations, the operation efficiency could be improved by increasing the intervals between departure and implementing interval vehicles amongst other solutions. The bus line K517 runs through two important main roads in Hangzhou, the line length is too long and the number of intermediate bus stations is too high, resulting in low running speed, low punctuality rate and low operating efficiency. To optimize the bus network, it could reduce its function, optimize the bus shifts and adjust the distribution of the intermediate bus stops. (3) The operating efficiency and service efficiency of bus lines K20, K355, K44 is low mainly due to the link on bus line 20 between the railway station and the pottery market. The demand on the first half of the line is high, but the population density of the second half is small and also the number of passengers. In addition, certain parts in the downtown section of Bus line 20 coincide with bus lines that have good operational efficiency and service efficiency. Bus line 355 is the loop line. Bus line 44 runs between South Bus Station and Zhaohui Fifth Community. Both bus lines 355 and 44 link several residential areas and most non-peak passengers are elderly. In order to optimize the bus network to work efficiently, the adjustments should take into account the previous notes. It should be noted that this study only selected certain sections of the Hangzhou bus market and have not classified bus lines using other attributes. When carrying out a broader efficiency evaluation of the bus lines, additional attributes ought to include: set line length, service type and line level as the standard and perform the cluster analysis. The change should enable the generation of more reasonable results.

4.1.2. Optimization Project of Operational Efficiency and Service Effectiveness Evaluation Results

Using operational efficiency, based on the BCC model optimization results produces the set of outputs shown in the following Table 3.4. The results indicate it is necessary to adjust the number of bus stops and the number of buses to coordinate the number of bus shifts. As a result the opportunity to save resources, make full use of the vehicles and accordingly achieve a high operating efficiency.

From the service point of view, the optimization results are as follows:

Firstly, due to the inefficient service system; it is necessary to improve the punctuality rate of five bus lines. . Increasing the punctuality rate to 75% or more would lead to the whole service efficiencys improvement. The following action is to optimize the waiting time. Keeping the average waiting time of non-peak and peak time to 8 minutes at most, it is possible to achieve optimal results.

Item		Operational Efficiency	
Virtual Unit	Number of Stations	Number of Buses	Number of Daily Shifts
K20	20	18	37
K355	19	7	31
K44	16	16	21
K517	15	9	18

Figure 8: Table3.4 Analyzed Results of BCC Performance Evaluation Model Based on Excel

Item	Service Efficiency		
Bus Line	Waiting Time	Days of Running	Punctuality Rate
K20	8.299222	22	0.73307
K355	8.299521	22	0.733043
K21	8	26	0.764073
K325	8.135015	29	0.75
K44	8.634151	13	0.702926

Figure 9: Table 3.5 Analyzed Results of BCC Performance Evaluation Model Based on Excel

4.2. *Evaluation of BCC Model Based on DEAP Software*

4.2.1. *BCC Model Based on DEAP Software*

In this case, the performance evaluation model of 10 bus lines in Hangzhou based on output-BCC model was built. The modelling platform used was DEAP2.1 software. The evaluation model is built on applying operational efficiency and service efficient to Hangzhou bus lines.

4.2.2. *Result Analysis*

When the BCC model is used to evaluate the operational performance of multiple DMUs city bus lines, the results are assessed in the following way: if the pure technical efficiency is 1, the unit satisfies technical efficiency, that is the operation output efficiency of this bus line is optimal; if the scale efficiency is 1, the

```
Input orientated DEA

Scale assumption: VRS

Slacks calculated using multi-stage method

EFFICIENCY SUMMARY:

 firm  crste  vrste  scale

   1   0.953  0.976  0.976 irs
   2   0.070  0.600  0.117 irs
   3   1.000  1.000  1.000  -
   4   1.000  1.000  1.000  -
   5   1.000  1.000  1.000  -
   6   0.962  0.962  1.000  -
   7   0.491  1.000  0.491 irs
   8   0.777  1.000  0.777 irs
   9   0.845  0.936  0.903 irs
  10   0.822  0.946  0.869 irs

mean   0.792  0.942  0.813

Note: crste = technical efficiency from CRS DEA
      vrste = technical efficiency from VRS DEA
      scale = scale efficiency = crste/vrste
```

Figure 10: Figure 4.1 The Result of Operational Efficiency

```
Input orientated DEA
Scale assumption: VRS
Slacks calculated using multi-stage method

EFFICIENCY SUMMARY:
 firm  crste  vrste  scale

   1  0.778  0.919  0.847 irs
   2  0.552  0.809  0.682 irs
   3  0.779  1.000  0.779 irs
   4  0.675  0.870  0.775 irs
   5  0.868  1.000  0.868 irs
   6  1.000  1.000  1.000  -
   7  0.311  1.000  0.311 irs
   8  0.862  1.000  0.862 irs
   9  0.811  0.918  0.884 irs
  10  0.337  1.000  0.337 irs

mean  0.697  0.952  0.735

Note: crste = technical efficiency from CRS DEA
      vrste = technical efficiency from VRS DEA
      scale = scale efficiency = crste/vrste
```

Figure 11: Figure 4.2 The Result of Service Efficiency

unit is scale efficiency, that is, the input of bus lines is exact (neither too high nor too small), Hangzhou public transport scales profit is at its best state of the equal point of increasing to decreasing; if both the technical and scale efficiency are satisfied, the unit is a DEA valid unit; if only one of the two is satisfied, the unit is a weak DEA valid unit; if neither is satisfied, the unit is a non-DEA valid unit. A DEA valid unit is better than a weak DEA valid unit when evaluating bus operating performance. Also a weak DEA valid unit is therefore better than a non-DEA valid unit.

1) Overall efficiency As both pure technical efficiency and scale efficiency of bus lines K21, K325 and K198 are 1, these three DMUs satisfy technical efficiency and scale efficiency. The operational efficiency of these three bus lines is DEA valid, which means they have the best scale and best production conditions. Bus line 21 runs between the City Train Station and the West Lake Stadium, although the time interval is 6 to 8 minutes between bus shifts and the operational investment is quite high, it connects two terminals and runs through Qianjiang New City and Caihe community where the population flow is large, therefore a match between the input and output is identified.t. Bus line 325 runs from Qianjiang New City to Jiubao, and has a large population flow, although the investment scale is not as high as Bus line 21, it meets the needs of the passengers because the repetition rate of bus lines (share the same certain routes with other bus lines) in these areas is relatively high. However, the investment of Bus line 198 is relatively small, but it is relatively an individualized bus line (This bus line rarely share the same routes with other bus lines) which starts from Zhijiang Road to Northern City, the overall operational efficiency is great. 2) Pure technical efficiency The Pure technical efficiency is used to measure whether the bus companies have maximized the output of all public transport inputs. A higher value indicates a higher resource utilization. From the figure, the pure technical efficiency of Bus lines K21, K325, K198, K207, K29 is 1, which means it has reached the best production efficiency, but it is overall invalid because of its scale ineffectiveness. But the scale returns are increasing so it can reach DEA valid by increasing appropriate investment. 3) Scale efficiency In the figure, there are five bus lines with a pure technical efficiency under 1, but as the input of the non-DEA valid unit is not the smallest; there is no causal relationship between the absolute number of inputs and the performance of operational efficiency. Increasing outputs is not the best solution to resolve this issue . It can be seen from the table that only five lines (K355, K207, K29, K44, K517) are in the state of increasing scale returns in the non-DEA valid units, and should increase inputs appropriately to reach the best production. The five bus lines remaining are enough to reduce inputs.. Subsequently, we will introduce the Factor Analysis to analyze the indicator in order to reduce scale investment and discover the main indicator of ineffective scale.

5. Conclusion and suggestions

Based on the objective of routine bus performance evaluation, this paper describes the conceptual framework for single bus line performance evaluation, and uses the DEA method to build Output-BCC method. From the perspective of bus companies and passengers, the evaluation of the operational efficiency and service efficiency of urban bus lines provides a quantitative basis for the recent optimization and adjustment for bus route planning and a reference for the construction of an urban public transport subsidy mechanism [13]. It not only evaluates the rationality of existing bus transportation [14], but also provides a reference and a basis for urban public transport system optimization. This has significant theoretical value and is therefore of importance to governments, public transportation enterprises and passengers. According to Hangzhou's urban planning program, Hangzhou is expanding. Urban areas and distances are increasing; therefore, it becomes necessary to develop public transport in the city. =To solve the existing problems in the Hangzhou bus operation, it is necessary to reduce travel time and guarantee citizens rights by improving the capacity of urban roads. And when necessary, the government have to increase the construction of urban roads and improve the urban construction structure. Meanwhile, ensuring bus punctuality to avoid delays is important. To reduce the pressure of peak hours, it is necessary to shorten the departure time intervals and increase the number of operating buses during peak hours. This can be achieved by improving the construction investment and using an effective and reasonable method to solve the public transport funds. Implementing the bus priority strategy in the traffic management, would allow public transport the highest priority right of way at the appropriate time thereby improving efficiency. According to the results of the assessment and references [15], the suggestions are as follows: (1) Setting bus lanes: design and establish bus lanes in areas subject to higher traffic flow and also where there is intense traffic congestion. (2) Improvement of Buses: by improving the dynamic performance of public buses and minimizing delays; reducing the height of to facilitate the boarding/leaving of buses by the passengers thereby improving the duration of the trips; Change the number and location of bus doors; Improve the IC card system and its position. (3) The Optimization of Intersection: Adjust the signal period and give priority to the flow and operation of buses at the intersection when setting the signal distribution system. (4) Use actuated signal for buses: When the traffic flow is high at intersections, use actuated signal to represent an ordinary lane is changed to a bus lane. (5) The improvement of bus stations: The station density and distance should be appropriate according to the location and passenger flows much as possible, using harbor type docking stations rather than other types in order to reduce the impact of parking buses on the traffic.

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