

Analysis on the Application of PPP Mode in Hangzhou City Management

—Take the Infrastructure Construction as an Example

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Abstract

Facing the phenomenon that the increasingly serious shortage of infrastructure causes urban problems, the government will introduce PPP mode to the field of city management, and it achieves good economic and social benefits to promote the sustainable development of PPP mode in city management. Based on the survey of Hangzhou Metro Line 1 and the travelling citizens and the analysis of SPSS data, we can know that the operation management of the later stage is the main reason that affects the sustainable development of PPP mode. Based on this, the paper proposes that in the operation management of the later stage, we should strive to improve the relevant supporting facilities and the quality of services, so as to enhance the public's satisfaction to the project, thereby promoting the sustainable development of PPP mode in city management.

Keywords

PPP Mode, City Management, Infrastructure, Hangzhou Metro

1. Introduction

Traffic congestion, population expansion, housing tension, employment difficulty and environmental degradation are common problems in urban infrastructure derived from the rapid development of urbanization and the extension content of connotation of city management. Because of the particularity of public goods supply, government financial constraints, the shortage of government financial funds and because the supply of urban public services is difficult to keep pace with the increasingly growing demand for infrastructure, it is urgent

for modern urban management to strengthen the construction of infrastructure and promote the harmonious and healthy development of cities. As an effective mode of social capital entering the field of public goods supply, PPP mode stemmed from Britain in the last century and has gained long-term progress in practice development. Since the reform and opening up, China has taken the initiative to integrate itself into the global tide of globalization to learn from and draw lessons from foreign advanced management experience and technology, so China has continuously improved its social and economic level and made remarkable achievements in public-private partnership (PPP). In the tide of economic globalization, as one of the cities that developed abroad earlier, Hangzhou actively explores and uses the PPP mode in the category of city management to ensure the smooth progress of G20 and earn a reputation as a world famous city for Hangzhou; therefore, Hangzhou enters the post era of G20. As a successful example of PPP mode in the field of infrastructure construction, Hangzhou Metro Line 1 has achieved remarkable economic and social benefits and become a model for city management circles to study. However, according to Hangzhou's development goal of building a world famous city, its level of city management is far from enough, and based on reality, it should learn from others to explore new ideas of city management development and promote the construction of the world famous city.

Therefore, take Hangzhou Metro Line 1 as an example, the paper conducts deep analysis of its operation management to have an understanding of the influencing factors of public satisfaction in infrastructure construction under PPP mode and discuss the sustainable development idea of PPP model in city management, thereby ensuring supply of city infrastructure, improving the management level of Hangzhou City and boosting the construction of a world famous city for Hangzhou.

2. PPP Model

PPP model, also known as public-private-partnership model, that is the acronym of Public-Private-Partnership, the "public-private partnership" financing mechanism originated in the United Kingdom refers to the government and private organizations, in order to cooperate in the construction of urban infrastructure projects, or Is to provide some kind of public goods and services based on the concession agreement and to form a kind of partnership relationship with each other and to confirm the rights and obligations of both parties by signing the contract so as to ensure the smooth completion of the cooperation and finally All parties to the cooperation have achieved more favorable results than if they were to act alone. The PPP model transfers part of the government's responsibilities to the social entities (enterprises) through the franchise. The government and the social entities establish a community relationship of "sharing interests, sharing risks and full cooperation." The government's financial burden is lightened and the investments of social entities Risk reduction.

3. Sample Survey

3.1. Current Situation of Hangzhou Metro Line 1

The total mileage of Hangzhou Metro Line 1 is 47.97 km, of which there are 30 stations with a total investment of RMB 22,076,000,000 [1]. It is analyzed from the angle of necessity that the construction of Hangzhou Metro relies heavily on the government and government subsidies are relatively high in terms of capital constitution while it has a relatively general level of operation and the supervision of metros still needs to be strengthened. It is analyzed from feasibility that both the system level and the related laws and regulations are gradually performed, which has created a favorable policy environment for franchising, and the operation foundation of franchising is basically complete with conditions for operation [2], and its current situation of operation is as shown in **Table 1**.

As can be seen from **Table 1**, the Company's Metro Line 1 was opened and put into trial operation in November 2012, and it is backbone of the rail transit network with the length of 47.47 km. The trial operation has been completed in November 2014. In 2016, Hangzhou Metro Line 1 (including Xiasha extension) achieved 198,771,300 times of passenger volume, 7,231,200 kilometers of total mileage of operation, 99.97% of punctuality rate of trains and 99.99% of fulfilled rate of run chart. From January to March 2017, it achieved RMB 143,000,000 of ticket revenue and 99.99% of punctuality rate.

3.2. Acquisition of Research Data

In recent years, China's infrastructure construction has been developed and improved, and production and living conditions of residents have been significantly improved. However, are residents satisfied with the existing infrastructure? What are the factors influencing satisfaction? These questions should be important contents that government departments should know when carrying out infrastructure construction. With the above analysis, we have a preliminary understanding of Metro Line 1-representative of infrastructure in Hangzhou City and its operation. In order to further understand the application of PPP mode in Hangzhou infrastructure, the paper adopts the survey method of random sampling in the range of Hangzhou City to investigate and study the public's satisfaction to Metro Line 1.

9,188,000 research objects are involved in the paper, and the number of sample elements is determined according to the Scheaffer equation:

$$N^* = \frac{N}{(N-1)\delta^2 + 1} \quad (1)$$

In the above formula, N^* is the number of sample elements, and N is the research object, and in other words, the total population in the old district is investigated. δ is sampling error, and we set it to 0.06, and then we draw the number of sampling elements in the old residential district is 277. The survey uses the combination of questionnaires and structured interviews, and the main

Table 1. The operation of Hangzhou Metro Line 1.

Program	2012	2013	2014	2015	2016	2017 (first season)
Operation mileage (Ten thousand kilometers)	34.20	437	598.60	615.71	723.12	168.09
Number of stations	30	31	31	34	34	34
Number of trains(columns)	Plan 48 Actual22	Plan 48 Actual 32	Plan 48 Actual 36	Plan 48 Actual 38	Plan 48 Actual 44	Plan 48 Actual 44
The annual passenger volume (Ten thousand)	561.30	9237	14,437.84	17,666.54	19,877.13	4973.12
Average daily passenger volume (Ten thousand)	14.90	25.30	39.56	48.40	54.32	54.71
Ticket revenue (billion)	0.22	3.24	4.94	5.41	6.04	1.43
Average Fare (yuan)	3.96	3.79	3.82	3.33	3.27	3.30
Schedule Rate (%)	99.67	99.89	99.88	99.96	99.97	99.99
Operating chart cashing rate (%)	99.94	99.94	99.97	99.98	99.99	99.99

Data from: Track rating report on Hangzhou Metro Refco Group Ltd.

contents of questionnaires include the overall satisfaction of residents to Metro Line 1, various supporting facilities in Metro Line 1, security check and other services, basic information and other relevant contents(See appendix for details). The research obtains 282 valid questionnaires, which meet the need for investigation.

Table 2 shows that interviewees' gender, age and other social attribute structures are more reasonable. Female interviewees are 19.8% more than male interviewees; ages mainly concentrate in the range from 18 to 35, which accounts for 86.9% of the total sample, and with mental maturity, interviewees have the ability to think independently and identify; interviewees with above college degree account for 81.2% in the total interviewees, which show that interviewees have higher level of knowledge and they have the basic ability to identify and judge contents of questionnaires; interviewees cover different occupations, and they are mainly personnel in companies. Therefore, we can believe that the survey shows different perceptions of different groups on Hangzhou Metro Line 1 from different genders, different ages, different knowledge structures and different industries to lay a better mass base for the study of this paper.

4. Analysis on Sample Data

As an example of infrastructure construction, Hangzhou Metro Line 1 has become the focus of Zhejiang province and even the whole country since the beginning of construction because of its investment quota and construction mode.

Table 2. Respondents basic information.

	Classification	Frequency	Scale
Gender	Male	113	40.1%
	Female	169	59.9%
Age	Below18	3	1.1%
	18 - 25	165	58.5%
	26 - 35	80	28.4%
	36 - 45	16	5.7%
	Up 46	18	6.4%
Educational Status	High school or Below	53	18.8%
	Junior College and Undergraduate	193	68.4%
	Master or Above	36	12.8%
Occupation	Company Employee	132	46.8%
	Civil servants	31	11%
	Businessman	13	4.6%
	Retiree	6	2.1%
	Student	64	22.7%
	Others	36	12.8%

On the basis of the failed PPP case of the Hangzhou Bay Bridge, the Hangzhou municipal government actively learned from the experience of successful cases at home and abroad and worked with Hong Kong Railway Group to set up the operation management of Hangzhou Metro Line 1 that Hangzhou-Hong Kong Company is responsible for, thereby achieving good economic and social benefits. However, we can know that from the field social practice survey, the public has mixed opinions on Hangzhou Metro Line 1, which to a certain extent, affects the satisfaction of city infrastructure construction under PPP mode and is not conducive to promoting the management level in Hangzhou city. Based on the survey data, the paper selects related influencing factors to explore PPP mode embedded infrastructure construction ideas through data analysis, thereby ensuring its application in the field of city management and promoting transformation and upgrade of city management. The following analysis is as follows:

4.1. Non-Parametric Test

In order to further explore the current operation situation of PPP mode in Hangzhou City infrastructure, the public's evaluation on Hangzhou Metro Line 1 is used to show its influencing factors, including station settings, supporting facilities, service level of security check and other personnel and the docking level of off-station service. Satisfaction score of Metro Line 1 is set to five indicators of 5, 4, 3, 2 and 1, and the Kruskal-Wallis test in multiple independent sample tests is used to test whether there are significant differences in station settings,

supporting facilities, service level of security check and other personnel and the docking level of off-station service based on different score perceptions. By the Kruskal-Wallis test, the significant P-values are less than 0.05 (as show in **Table 3**), which shows that there are significant differences between the six groups affecting the overall satisfaction score of Metro Line 1, so it is worthy to conduct further research.

4.2. Analysis on Multiple Linear Regression

4.2.1. Multiple Linear Regression Theory

The multiple linear regression model is a linear regression model with multiple explanatory variables, which is used to reveal the linear relationship between the explained variable and other explanatory variables [3]. The mathematical model of the multiple linear regression is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \varepsilon \quad (2)$$

Equation (2) is a p linear regression model, in which there are p explanatory variables. It shows that the variation of the explained variable y can be explained by two parts: the first part is the linear variation party caused by the change x of p explanatory variables, which is $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p$; the second part is the change y caused by other random factors, and in other words, $\varepsilon, \beta_0, \beta_1 \cdots \beta_p$ are the unknown number in the model, which are called regression constant and partial regression coefficient respectively. ε is called random error and random variable [4].

4.2.2. Equation Establishment Process

In order to study the factors affecting the operation management of Hangzhou Metro Line 1, the overall evaluation data of 282 metro passengers in Hangzhou on Metro Line 1 were collected and the multivariate linear regression method was used for analysis. Here, the explained variable is the score of Metro Line 1 (y), and the explanatory variable (x) is the satisfaction of station supporting facilities (such as the proportion of shops, advertisements, toilets and waiting seats), construction mode (PPP mode), station personnel service (personnel excerpt for security check), station settings, docking procedures with services outside a station (such as buses, parking lots, public bicycles, shopping centers and

Table 3. Kruskal-Wallis test.

	Test Statistic ^{a,b}					
	Station infrastructure settings	Service of staff	Security check	Station settings	The docking level of off-station service	Supporting facilities
Chi-square	58.879	55.851	69.158	47.937	46.594	61.268
df	4	4	4	4	4	4
Asymp. Sig	0.000	0.000	0.000	0.000	0.000	0.000

a: Kruskal Wallis test; b: Grouping variables: Please rate the overall satisfaction of Hangzhou Metro Line 1 (Full score is 5).

scenic spots), station infrastructure setting (such as ticket machine, inquiry equipment and other electronic devices you need) and security check. In this paper, the backward screening strategy is used to make SPSS automatically complete the selection of explanatory variables, observe the changes in each step of the test and carry out residual analysis and detection of abnormal points

As shown in **Table 4**, the backward screening strategy is used to complete the establishment of the regression equation with five steps, and the final model is the sixth model. From the process of equation establishment, with the continuous decrease of explanatory variables, the fitting degree of the equation decreases slightly, which not only explains the characteristics of the judgment coefficient, but also shows that the establishment of the regression equation should pay attention to examine whether explanatory variables contribute to explained variables rather than blindly taking the pursuit of high fitting degree as the sole goal [5]. The variables that are eliminated in the equation are station setting, construction mode, service of station personnel and docking degree with the service outside a station. If the significance level α is 0.05, we can see that the probability P-values of partial F test of these eliminated variables are greater than the significance level, so the original hypothesis in the test can't be rejected, and without significant difference between the partial regression coefficients of these variables and without significant contribution to the linear interpretation of the explained variables, they should be kept in the equation [6]. The variables which are kept in the equation at last are station supporting facilities, basic station infrastructure settings as well as works of station security check and security personnel. The test value of the DW equation is 2.046, and the residual error has a certain degree of positive autocorrelation.

4.2.3. Test of Linear Relationship among Variables

The fifth model in **Table 5** is the final equation. If the significant level α is 0.05, because the probability P-value of its significance test of regression coefficients is less than the significant level, the linear relationship between the explanatory variable and the explained variable is significant and it is proper to establish the linear model.

Table 4. Multiple linear regression analysis results (a).

Mode Summary ^f										
model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.598 ^a	0.357	0.341	0.628	0.357	210.755	7	274	0.000	-
2	0.598 ^b	0.357	0.343	0.627	0.000	0.001	1	274	0.977	-
3	0.598 ^c	0.357	0.345	0.625	0.000	0.050	1	275	0.824	-
4	0.597 ^d	0.357	0.348	0.624	0.000	0.098	1	276	0.755	-
5	0.597 ^e	0.356	0.349	0.624	0.000	0.202	1	277	0.653	2.046

f: Dependent Variable: Metro Line 1 scoring (Full score is 5).

Table 5. Multiple linear regression analysis results (b).

		Anova ^f				
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	60.001	7	8.572	21.755	0.000 ^a
	Residual	107.956	274	0.394	-	-
	Total	167.957	281	-	-	-
2	Regression	60.001	6	10.000	25.474	0.000 ^b
	Residual	107.957	275	0.393	-	-
	Total	167.957	281	-	-	-
3	Regression	59.981	5	11.996	30.664	0.000 ^c
	Residual	107.976	276	0.391	-	-
	Total	167.957	281	-	-	-
4	Regression	59.943	4	14.986	38.430	0.000 ^d
	Residual	108.014	277	0.390	-	-
	Total	167.957	281	-	-	--
5	Regression	59.864	3	19.955	51.320	0.000 ^e
	Residual	108.093	278	0.389	-	-
	Total	167.957	281	-	-	-

f: Dependent Variable: Metro Line 1 scoring (Full score is 5).

4.2.4. Partial Regression Coefficient and Significance Test of Each Variable in the Model

Table 6 shows the partial regression coefficients and the significance test of partial regression coefficients of each explanatory variable in each model. If the significant level α is 0.05, the above four models are not available because there are insignificant explanatory variables in regression coefficients. The fifth model is the final equation, and the probability P-value of its significance test of regression coefficients is less than the significant level α , so the linear relationship between the explained variables and the basic station infrastructure settings, station security check and its security personnel work and station supporting facilities is significant and it is reasonable to keep it in the model. The final regression equation leaves three explanatory variables, and the equation is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \quad (3)$$

After the change of correlation coefficients, the multiple regression model in model 4 is used as the regression model:

$$y = 0.381 + 0.263x_1 + 0.255x_2 + 0.174x_3 \quad (4)$$

We can know by using the multiple linear regression equation:

1) The three variables of satisfaction of basic station settings, security check and station supporting facilities are positively affecting the score of Hangzhou Metro Line 1, and in other words, the three variables affect the public's satisfaction to Hangzhou Metro Line 1.

Table 6. Multiple linear regression analysis results (c).

Model	Coefficients ^a			t	Sig.	
	Unstandardized Coefficients		standardized Coefficients			
	B	Std. Error	Beta			
1	(Constant)	0.386	0.190	-	2.032	0.043
	Construction Mode	-0.009	0.040	-0.011	-0.217	0.828
	Basic station Settings	0.266	0.071	0.261	3.732	0.000
	Station personnel Service	-0.026	0.081	-0.026	-0.319	0.750
	Security Check	0.267	0.070	0.295	3.791	0.000
	Station Settings	-0.002	0.063	-0.002	-0.029	0.977
	Docking Procedures with Services Outside a Station	0.034	0.070	0.032	0.487	0.627
	Station supporting Facilities	0.161	0.066	0.163	2.459	0.015
2	(Constant)	0.386	0.189	-	2.035	0.043
	Construction Mode	-0.009	0.039	-0.011	-0.223	0.824
	Basic station Settings	0.266	0.070	0.261	3.804	0.000
	Station personnel Service	-0.026	0.081	-0.026	-0.323	0.747
	Security Check	0.266	0.068	0.295	3.896	0.000
	Docking Procedures with Services Outside a Station	0.034	0.068	0.032	0.495	0.621
	Station supporting Facilities	0.161	0.065	0.163	2.464	0.014
3	(Constant)	0.361	0.155	-	2.335	0.020
	Basic station Settings	0.264	0.069	0.258	3.817	0.000
	Station personnel Service	-0.025	0.081	-0.025	-0.313	0.755
	Security Check	0.266	0.068	0.294	3.897	0.000
	Docking Procedures with Services outside a Station	0.033	0.068	0.031	0.488	0.626
	Station supporting Facilities	0.161	0.065	0.163	2.466	0.014
4	(Constant)	0.358	0.154	-	2.323	0.021
	Basic station Settings	0.256	0.064	0.250	4.002	.000
	Security Check	0.254	0.056	0.281	4.533	.000
	Docking Procedures with Services outside a Station	0.030	0.067	0.028	0.450	0.653
	Station supporting Facilities	0.161	0.065	0.163	2.475	0.014
5	(Constant)	0.381	0.145	-	2.618	0.009
	Basic station Settings	0.263	0.062	0.257	4.249	0.000
	Security Check	0.255	0.056	0.282	4.579	0.000
	Station supporting Facilities	0.174	0.059	0.176	2.937	0.004

a: Dependent Variable: Metro Line 1 scoring (Full score is 5).

2) The influencing degree of the satisfaction of basic station settings (x_1) on Metro Line 1: under the condition that the satisfaction of security check (x_2)

and station supporting facilities (x_3) are unchanged, when the satisfaction of basic station settings (x_1) increases (or declines) one unit, the score of Metro Line 1 increases (or declines) 0.263 units averagely.

3) The influencing degree of the satisfaction of security check (x_2) on Metro Line 1: under the condition that the satisfaction of basic station settings (x_1) and station supporting facilities (x_3) are unchanged, when the satisfaction of security check (x_2) increases (or declines) one unit, the score of Metro Line 1 increases (or declines) 0.255 units averagely.

4) The influencing degree of the satisfaction of station supporting facilities (x_3) on Metro Line 1: under the condition that the satisfaction of basic station settings (x_1) and security check (x_2) are unchanged, when the satisfaction of station supporting facilities (x_3) increases (or declines) one unit, the score of Metro Line 1 increases (or declines) 0.174 units averagely.

5. Tentative Suggestion

Through observing sample elements and analyzing relevant data, the relationship between explanatory variables and explained variables has been clearly defined. The overall satisfaction evaluation of basic station settings, security check and station supporting facilities on Hangzhou Metro Line 1 is the most obvious one; although other explanatory variables have an unobvious impact, they can't be ignored and should be considered from the same perspective. We should be free from any bias to promote the sustainable development of Hangzhou Metro Line 1. Based on this, in the case of comprehensive assessment of other factors, this paper believes that the late operation management of PPP project has a significant effect on the sustainable development of PPP mode in city management. Therefore, the PPP project in city management should pay attention to supporting facilities and work and service quality in the late stage to strive to improve the public's satisfaction to the project, thereby ensuring the benign application of PPP mode in city management.

1) Establish and improve an effective staff management system

Scientific and effective management system is the precondition for subway operation and management in PPP mode. Specifically, you can try from the following aspects: First, Improve staff supervision and evaluation mechanism. Second, Effective implementation of reward and punishment mechanism. Finally, Implementation of employee care policy.

2) Effectively improve the effectiveness of public participation

First, cultivate public awareness of public participation in public decision-making. Second, Establish and improve the information disclosure system. Third, Set up a variety of information disclosure platform.

3) Standardize the planning and construction of PPP projects

The first planning, post-construction, and then within the framework of the established management, has become a natural model. This paper proposes to reverse the thinking of the three major fields in the space-time sequence, to invert

and to put the management in front. The adjusted sequence is “management, planning → management, construction → management”.

4) Clarify the functional roles of the government and the private sector

The construction of the PPP project is jointly completed by the government and the private sector. A successful PPP project is inseparable from the government and the private sector's sincere cooperation, including the early planning and design, mid-term construction, post-operational management. It is necessary for the government and the private sector to clarify the roles of self-serving functions, give full play to their respective duties and promote the healthy and orderly development of PPP projects.

5) Gradually improve the relevant laws and regulations policy

First, develop guidelines for industry indicators. Second, the municipalities and districts can formulate PPP policies and regulations that are suitable for their own characteristics, exert the advantages of local legislative powers and safeguard the sound development of local PPP projects legally. Finally, establish and improve the supervision and management of PPP project and feedback system.

6. Conclusion

Taking Hangzhou Metro Line 1 as an example, this paper discusses the practical application of PPP project. From the perspective of perfecting the infrastructure, it improves the urban management level of Hangzhou and further promotes the integration of PPP mode and urban management. However, the research object selected in this paper is too single to universal applicability, the other areas of PPP mode of use, pending further study.

Fund Projects

Science and technology innovation plan of college students in Zhejiang and new talent assistance project: research of application of PPP mode in Hangzhou city law enforcement management (2017R412047).

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Appendix

1) Gender

- A. male B. female

2) Age

- A. below 18 B. 18 - 25 C. 26 - 35 D. 36 - 45 E. beyond 45

3) What's your occupation

- A. company employee B. civil servants C. businessman
D. student E retiree F. others

4) What's your educational background

- A. High school or bellow B. Undergraduate C. Master or above

5) Do you know the construction mode of Hangzhou Metro Line 1(PPP)?

- A. Yes, absolutely B. Yes C. Yes, but a little D. I don't know
E. Not at all

6) Do you think that the Hangzhou Metro Station infrastructure settings is perfect?(Please indicate how much the current charity-related policy of our company is perfect on a scale of 1 to 5 with "1" meaning "not at all" and "5" meaning "very perfect")

- A. 5 B. 4 C. 3 D. 2 E. 1

7) Do you think that the service of staff in Hangzhou Metro Station is perfect?

- A. 5 B. 4 C. 3 D. 2 E. 1

8) Do you think that the security check in Hangzhou Metro Station is perfect?

- A. 5 B. 4 C. 3 D. 2 E. 1

9) Do you think that the station settings is perfect?

- A. 5 B. 4 C. 3 D. 2 E. 1

10) Do you think that the docking level of off-station service at Hangzhou Metro Station is perfect?

- A. 5 B. 4 C. 3 D. 2 E. 1

11) Do you think that supporting facilities with Hangzhou Metro Station is perfect?

- A. 5 B. 4 C. 3 D. 2 E. 1

12) Overall, do you think that the Hangzhou Metro Station is perfect?

- A. 5 B. 4 C. 3 D. 2 E. 1