

PERFORMANCE OBJECTIVE-BASED DYNAMIC ADJUSTMENT MODEL TO BALANCE THE STAKEHOLDERS' SATISFACTION IN PPP PROJECTS

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Abstract. Aiming to balance the interests of the principal stakeholders (the private sector, the government and the general public) in Public–Private Partnerships (PPP) projects, the satisfaction of stakeholders were researched thoroughly in this paper. A satisfaction evaluation model was structured based on authors' prior questionnaire survey focusing on the performance objective indicators (POIs) of different stakeholders. The parties' preferred POIs were identified as follows: all three parties emphasize the objectives of construction quality, service quality, cost, time, and lifecycle cost very much. Individually, the private sector prefer the objectives of profit making and government support, the government prefer the objectives of budget saving and risk transfer, and the general public prefer the objectives of toll rate and the facilities' quantities. Furthermore, a satisfaction adjustment model was proposed based on the interrelationships of the adjusting POIs and their impact on the stakeholders' satisfaction by using the feedback loops of System Dynamics (SD). An illustrative case was also introduced, the results of which indicated that the satisfaction evaluation and adjustment model could be well applied to balance the interests of stakeholders and also improve the general performance of the project.

Keywords: public–private partnerships, stakeholder, satisfaction, performance objectives.

Introduction

Due to the enormous demand of capital investment in public infrastructure and for delivery of essential public service, coupled with the need to contain the fiscal deficit, the governments all around the world are in favour of procuring public infrastructures through partnerships with private sector (Iyer, Sagheer 2010). As a popular project delivery model, PPP model is claimed to solve the host government's problem of fiscal shortage, improve efficiency and transfer risk to the project company (Shen *et al.* 2007). PPPs have been practiced widely in different industrial sectors, and evidences can be easily found that the private sector usually have the ability to shorten the time to complete the project, reduce project life-cycle costs, and provide public goods and services with high-quality (Iyer, Sagheer 2010; Jin 2010). Those advantages of PPPs in economic efficiency delivered value for money in the development of infrastructures through the private foundation.

In addition to the efficiency from the collaboration of multiple project participants, the satisfaction of the stakeholders in PPP projects is an important issue for the success of PPP projects (Juan *et al.* 2008).

Project stakeholders are individuals and organizations that are actively involved in the project or whose interests may be affected as a result of project execution or project completion (Project Management Institute 2000). In general, the principal stakeholders of a PPP project are the host government, the private sector partner, and the general public. Although governments are elected to represent people, the benefits pursued by governments and general public are different, which have been identified by authors' prior works (Yuan *et al.* 2009). Thus the general public should be treated as a separate stakeholder.

Zhang (2009) proposed a win–win concession period determination methodology, arguing that the concession period should be long enough to allow the project company to obtain a reasonable return and that the project company has to act in the interest of the host government. Ke *et al.* (2008) hold that a delicate balance had to be in place among the capacity of the project company, government regulatory function, and public satisfaction. A successful PPP project should balance and satisfy the interests of all stakeholders (Ali *et al.* 2006; Ruuska, Teigland 2009; Zhang 2006).

Although a number of methods have been explored in privatization of public infrastructure projects, including asset sale, contracting out, deregulation, build/operate/transfer (BOT), and other types of PPPs (Zhang 2005), it is not sure that those approaches can really satisfy all of the stakeholders, especially for the general public. Aiming to help the stakeholders understand their satisfaction with the project and also provide them a measure to safeguard their interests when their satisfaction is ignored, this paper intends to develop a methodology to balance the satisfaction of stakeholders in a PPP project. Specifically, firstly, how to measure and assess the satisfaction of the three principal stakeholders; secondly, how to balance the satisfaction of stakeholders by aligning their interests if there is a deviation from the balanced level.

Satisfaction can be defined as the consumer's response to the evaluation of the perceived discrepancy between prior expectations (or some other norm of performance) and the actual performance of the product or service as perceived after its consumption (Day 1984; Fornell et al. 1996; Jamali 2007; Yang, Peng 2008). In the case of PPP projects, the prior expectation is studied by the performance objective indicators (POIs), and the actual performance is evaluated through key performance indicators (KPIs). However, the discrepancy between them must be calculated based on the same metrics, so this study is trying to evaluate PPP stakeholders' satisfaction based on the POIs and the KPIs are represented by the POIs through a transformation. Both the POIs and KPIs of PPP projects have been comprehensively studied by the authors' research (Yuan et al. 2009, 2010, 2012).

In PPP projects, stakeholders have very complicated relationships and their interests are highly and mutually influential. This paper has to study interrelationships among different stakeholders' interests so as to balance them. The feedback loops in System Dynamics (SD) can be introduced into the process due to its advantages in addressing problems which are extremely complex, highly dynamic (Thompson, Bank 2010). Actually, the method of SD has been widely used in PPP researches to deal with the problems related to pricing, concession period, and benefit balancing (Xu et al. 2011).

Hence, the remainder of this paper is organized as follows. Section 1 introduces the satisfaction evaluation model. At first, a questionnaire survey focusing on the POIs of three principal stakeholders is introduced; furthermore, satisfaction is evaluated by the identified index of POIs. In Section 2, the satisfaction adjusting model is proposed. Firstly, the satisfaction discrepancy scenarios and the adjusting objectives are discussed; then the interrelationships of the adjusting objectives and stakeholders' satisfaction are studied by the feedback loops, where price, profit and subsidy are proposed as tools to adjust satisfaction; subsequently the calculation procedures to adjust satisfaction are illustrated. After that, in Section 3, a case is applied to illustrate the satisfaction evaluation and adjustment model. Finally some concluding remarks are provided.

1. PPP stakeholders' satisfaction evaluation model

1.1. Questionnaire survey of POIs for PPP projects

1.1.1. Background of questionnaire survey

A structured survey focusing on the POIs was conducted from January to March 2008. A detailed description of the survey questionnaire and results were described by Yuan et al. (2012). In order to identify the relative significance of POIs for different stakeholders, Likert-style rating questions, using a five-point scale, were used to elicit respondents' opinions about the importance of each POI, which have been proved useful in many similar PPP researches (Cheung, Chan 2011; Chan et al. 2009). Generally the level of agreement or disagreement is measured. The scale intervals are interpreted from *Can be ignored or not important*, *Maybe important*, *Important*, *Very important*, to *Most important* (Yuan et al. 2009).

A total of 1083 questionnaires were sent out by email, among which 141 were completed and returned. The effective return rate was 13.02%, which is acceptable for social science research of this nature and scale (Yuan et al. 2012). And the survey respondents' roles and experiences are described by Yuan et al. (2009). The number of respondents from the government, the private sector, the general public and the academic are 12, 31, 52, and 49, respectively. The respondents from the government, the private sector, and the general public are analysed in this paper because they are the principal stakeholders and answer the questions based on their own interests. The opinion of the academics actually is neutral because they answer the questions solely based on their professional knowledge, instead of personal interests.

The identification of POIs is mainly based on the indicators of following topics: (1) CSFs (Li et al. 2005; Tiong et al. 1992); (2) best value contributing factors (BVCFs) (Zhang 2006); (3) the validity and feasibility factors (Salman et al. 2007). The details of POIs identification can refer to Yuan et al. (2009). The public and private sectors should have a common vision of the project under consideration and work in partnership towards shared objectives (Zhang 2006), so this survey thinks that the tripartite share the same POIs. However, the tripartite are sure to have different preference for those POIs, which would be reflected in their responses of the survey by the weights of the factors.

1.1.2. Weighting and ranking

Authors' prior works have ranked the POIs by mean score (Yuan et al. 2009), which is a common technique used to analyze the results obtained by questionnaire surveys (Chan et al. 2009). Based on the means, this paper develops the weights of those POIs and ranks them as Table 1.

The weight of the j^{th} POI for the private sector is denoted by a_j , for the government is denoted by b_j , and for the general public is denoted by c_j , where j denotes the number of POIs and $j \in [1, 15]$. The sampling

Table 1. Questionnaire survey about POIs of PPP projects

No.	POIs	Private sector			Government			General public		
		Weight	SD	Rank	Weight	SD	Rank	Weight	SD	Rank
F ₁	Acceptable quality of project	0.078	0.95	1	0.082	0.83	1	0.083	1.26	1
F ₂	Within budget or saving money in construction	0.072	1.10	3	0.082	0.72	1	0.070	1.09	7
F ₃	Good quality of public service	0.071	1.05	5	0.070	0.90	4	0.076	1.23	2
F ₄	On-time or earlier project completion	0.072	1.32	3	0.069	0.80	6	0.072	1.07	5
F ₅	Solving the problem of public sector budget restraint	0.062	0.99	12	0.077	0.90	3	0.067	1.18	8
F ₆	Provide cheaper and more convenient service for society	0.067	0.99	7	0.067	1.17	6	0.074	1.14	3
F ₇	Satisfying the need for public facilities	0.064	1.07	10	0.067	1.08	8	0.073	1.07	4
F ₈	Life cycle cost reduction	0.074	1.08	2	0.068	1.00	8	0.072	1.09	6
F ₉	Introducing business and profit-generating skills to the public sector	0.066	1.12	6	0.067	1.08	8	0.064	0.98	9
F ₁₀	Transferring risk to enterprises	0.057	1.05	14	0.070	1.08	4	0.051	1.07	15
F ₁₁	Promoting local economic development	0.063	1.04	10	0.062	0.94	11	0.063	0.78	10
F ₁₂	Making profit from public service	0.068	1.21	7	0.057	1.16	12	0.060	1.04	11
F ₁₃	Improving technology level or gaining technology transfer	0.062	1.08	13	0.052	1.30	14	0.060	0.76	11
F ₁₄	Public sector can acquire additional Facilities/ services beyond requirement from enterprises	0.056	1.01	15	0.057	1.24	12	0.056	0.92	14
F ₁₅	Enterprises earn more government sponsorship, guarantees and tax reductions	0.068	1.09	7	0.052	1.07	14	0.059	0.84	13

weights of the factors for three parties (a_j , b_j and c_j) are calculated as:

$$\begin{bmatrix} a_j & b_j & c_j \end{bmatrix}^T = \begin{bmatrix} F_j^e & F_j^g & F_j^p \end{bmatrix}^T \times \begin{bmatrix} 1/\sum_{j=1}^{15} F_j^e & 1/\sum_{j=1}^{15} F_j^g & 1/\sum_{j=1}^{15} F_j^p \end{bmatrix}, \quad (1)$$

where: F_j^e , F_j^g and F_j^p denote the mean value of No j^{th} POI based on the response of the private sector, the government and the general public, respectively.

This paper regards that the POI is preferred if its weight is above the average weight ($1/15 = 0.067$). Therefore, the common preferred POIs for the tripartite are found as follows: F_1 , F_2 , F_3 , F_4 , and F_8 , that explains that the construction quality, budget saving, time saving, good quality of public service and life cycle cost reduction are emphasized by all the stakeholders. The findings are reasonable because they are the traditional objectives for all the projects. On the other hand, different stakeholders have different preferences. For the private sector, the preferred POIs also have F_{12} and F_{15} , which means the project profit and government support. The private sector usually ranks the financial related objectives at the top except for those traditional objectives (Abdel-Aziz 2007). For the government, the preferred POIs also have F_5 , and F_{10} , which indicates that the government should pay much attention to the budget saving, and the risk transfer. As two incentives of the government in PPP projects, budget saving and risk transfer are always im-

portant (Shen *et al.* 2007). For the general public, the preferred POIs also have F_6 and F_7 , which indicates that the general public also attaches importance to the toll rate and the facilities' quantities.

The above findings greatly facilitate the theoretical foundation of the PPP stakeholders' satisfaction evaluation and adjustment model. Firstly, the index of POIs provides metrics to structure the satisfaction evaluation model. Secondly, the difference between stakeholders' preferences for the POIs enables the satisfaction adjustment model. The principle is that appreciation or disappreciation on a stakeholder's individual preferred POIs can accordingly increases or decreases its satisfaction.

1.1.3. Evaluation of PPP stakeholders' satisfaction

The satisfaction level for the private sector (S_e^i), the government (S_g^i) and the general public (S_p^i) in the i^{th} period are the differences between their expected level of POIs and actually realized level of POIs. Therefore, they can be evaluated by Eqns (2) and (3):

$$\begin{bmatrix} S_e^i & S_g^i & S_p^i \end{bmatrix}^T = \sum_{j=1}^{15} \left\{ \begin{bmatrix} a_j & b_j & c_j \end{bmatrix}^T \times \Delta f_j^i \right\}; \quad (2)$$

$$\Delta f_j^i = \frac{f_{aj}^i - f_{pj}^i}{|f_{pj}^i|}, \quad (3)$$

where: $j \in [1, 15]$, a_j , b_j and c_j are index weights for three parties as shown in Table 1; and Δf_j^i is the variations

between planned and actual level of the j^{th} POI (F_j) in the i^{th} period. f_{aj}^i and f_{pj}^i denote the actual and planned level of F_j in the i^{th} period, respectively. The level of POIs (F_j) can be evaluated through transforming into corresponding KPIs (F_j'): project quality (F_1'), construction cost (F_2'), service quality (F_3'), construction time (F_4'), government's investment (F_5'), toll rate (F_6'), quantity of facilities (F_7'), operation cost (F_8'), skills delivered (F_9'), risk transferred (F_{10}'), promotion of local economy (F_{11}'), profit of public service (F_{12}'), technology transfer (F_{13}'), over requirement performance (F_{14}'), and government subsidy (F_{15}') (Yuan et al. 2009).

2. PPP stakeholders' satisfaction adjustment model

PPP projects have long concession period, in which the satisfaction of parties are sure to fluctuate up and down. It is possible to set criteria that the satisfaction of three parties should be equal in all situations. In such case, the "balance" of satisfaction of stakeholders becomes an essential provision and will have the same significance on contract validity as the essential provisions described in the law. The stakeholders are supposed to cooperate harmoniously without worrying about unfair treatment, and that is likely to increase general performance of the project (Sharma et al. 2010). In order to testify this assumption, a mechanism is designed as follows: all stakeholders have equal planned level of satisfaction at the contract stage; after that, periodic supervisions are conducted to examine the satisfaction of the stakeholders in construction and operation period; and then the adjustments will be taken in the next period once one party's satisfaction is found to be lower than the other parties' satisfaction.

2.1. Satisfaction discrepancies and adjusting POIs

The satisfaction discrepancies, which indicate the gap between the stakeholders' actual satisfaction and balanced level, are evaluated by Eqns (4) and (5):

$$[D_e^i \ D_g^i \ D_p^i]^T = [S^i - S_e^i \ S^i - S_g^i \ S^i - S_p^i]^T; \quad (4)$$

$$S^i = \frac{S_e^i + S_g^i + S_p^i}{3}, \quad (5)$$

where: D_e^i , D_g^i and D_p^i are satisfaction discrepancies of private sector, governments and general public in the i^{th} period, respectively; S^i is the average satisfaction of three parties in the i^{th} period; S_e^i , S_g^i and S_p^i are the satisfaction for private sector, governments and general public in the i^{th} period, respectively.

It should be noticed that satisfaction discrepancies in the construction period could be too huge to be adjusted off in the following period. That's because construction cost overruns and time delays could significantly influence the satisfaction of stakeholders, but limited measures can be taken to adjust the satisfaction in construction period. Hence, this study distributes the satisfaction discrepancies in the construction period into the

operation period by a straight line method, as shown in Eqn (6):

$$[\Delta D_e \ \Delta D_g \ \Delta D_p]^T = \frac{1}{T_o} \left[\sum_1^{i=T_c} D_e^i \ \sum_1^{i=T_c} D_g^i \ \sum_1^{i=T_c} D_p^i \right]^T, \quad (6)$$

where: ΔD_e , ΔD_g and ΔD_p are the amortization of satisfaction discrepancy for private sector, government and general public in construction period, respectively; T_o is the duration of operation period; T_c is the duration of construction period; D_e^i , D_g^i and D_p^i are the satisfaction discrepancy of private sector, government and general public in the i^{th} period, respectively.

The regular situations of satisfaction discrepancies are discussed as Table 2. The " $D^i < 0$ " and " $D^i > 0$ " indicates that the party's satisfaction is over and below average satisfaction, respectively. If " $D^i < 0$ ", the stakeholder's individual preferred POIs should be depreciated in the next period to adjust off its satisfaction; otherwise, they should be appreciated. The individual preferred POIs have been found for the private sector (F_{12} , F_{15}), the government (F_5 , F_{10}), and the general public (F_6 , F_7) through the questionnaire survey. Therefore, they can be served as adjusting POIs. Table 2 shows the adjusting POIs for regular situations. For example, the situation of $D_p^i > 0$, $D_g^i < 0$ and $D_e^i < 0$ indicates that the satisfaction of the public is below the average level, at the same time, the satisfaction of the government and private sector are both above the average level. In this case, the best way to balance off those discrepancies is to appreciate the individual preferred POIs of the gen-

Table 2. Regular satisfaction discrepancies and proposed adjusting objectives in PPPs

Discrepancies	Public's adjusting objectives	Private sector's adjusting objectives	Government's adjusting objectives
$D_p^i > 0$	$\frac{D_g^i < 0, D_e^i > 0}{D_e^i > 0}$	F_6, F_7	-
	$\frac{D_g^i > 0, D_e^i > 0}{D_e^i > 0}$	F_6, F_7	F_5, F_{10}
	$\frac{D_g^i < 0, D_e^i > 0}{D_e^i > 0}$	F_6, F_7	F_{12}, F_{15}
$D_e^i > 0$	$\frac{D_g^i < 0, D_p^i < 0}{D_p^i < 0}$	-	F_{12}, F_{15}
	$\frac{D_g^i > 0, D_p^i < 0}{D_p^i < 0}$	-	F_{12}, F_{15}
	$\frac{D_g^i < 0, D_p^i > 0}{D_p^i > 0}$	F_6, F_7	F_{12}, F_{15}
$D_g^i > 0$	$\frac{D_e^i > 0, D_p^i < 0}{D_p^i < 0}$	-	F_5, F_{10}
	$\frac{D_e^i > 0, D_p^i < 0}{D_p^i < 0}$	-	F_{12}, F_{15}
	$\frac{D_e^i < 0, D_p^i > 0}{D_p^i > 0}$	F_6, F_7	-

eral public, for example, “provide cheaper and more convenient service for society (F_6)” and “satisfying the need for public facilities (F_7)”. Thus the private sector should charge lower price and improve the service quality, meanwhile, government should provide more funding in public facilities. In this way, the public’s satisfaction increases because of lower charge, better service quality and more public facilities.

However, the proposed adjusting POIs could be conflicted with each other. For example, when $D_p^i > 0$, $D_g^i > 0$ and $D_e^i < 0$, the proposed way is to appreciate “provide cheaper and more convenient service for society (F_6)” or “satisfying the need for public facilities (F_7)” to increase S_p^i , at the same time, improving “solving the problem of public sector budget restraint (F_5)” or “transferring risk to private sector (F_{10})” to increase S_g^i , but F_7 is conflicted with F_5 because the investment in public facilities could cause government’s funding shortage. In this case, the only applicable way is to improve F_6 and F_{10} at the same time. Hence, it is necessary to figure out whether those adjusting POIs can influence each other and how could they influence the satisfaction of three parties.

2.2. Interrelationships of adjusting POIs and stakeholders’ satisfaction

The feedback loops in System Dynamics can be introduced to analyse the interrelationships of adjusting POIs and stakeholders’ satisfaction. The feedback loops are where a change in one variable affects other variables over time, which in turn affects the original variable, and so on. There are two kinds of feedback loops: reinforcing or balancing. Reinforcing loops are associated with exponential increases/decreases; and balancing loops are associated with reaching a plateau (Thompson, Bank 2010). The feedback loops of adjusting POIs are shown in Figure 1.

The adjusting POIs influence each other through the feedback loops. There are four balancing loops in Figure 1: B1, “solving the problem of public sector budget restraint (F_5)” has positive influence on “satisfying the need for public facilities (F_7)”, but the latter has negative influence in return because the investment in public facilities could cause government’s budget restraint.

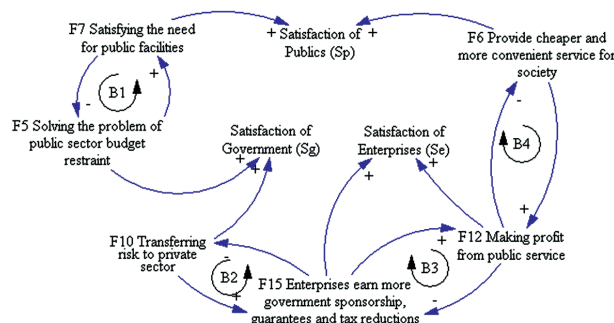


Fig. 1. Interrelationships of adjusting POIs and stakeholders’ satisfaction

Hence there could come to a balance of public facilities investment and government budget restraint; B2, “transferring risk to private sector (F_{10})” has positive influence on “private sector earn more government sponsorship, guarantees and tax reductions (F_{15})”, but the latter has negative influence in return. If the government transfer more risk to private sector, they should provide more sponsorship, guarantees and tax reductions as risk premium. Therefore, there could be a balance of risk transfer to private sector and government sponsorship, guarantees and tax reductions; B3 and B4, “private sector earn more government sponsorship, guarantees and tax reductions (F_{15})” and “provide cheaper and more convenient service for society (F_6)” both have positive influence on “making profit from public service (F_{12})”, but the latter has negative influence on both of them in return.

On the other hand, the adjusting POIs also influence the satisfaction of the three parties. That’s because the satisfaction of the three parties is influenced by their individual preferred POIs, at the same time, the individual preferred POIs are connected with each other through feedback loops. Specifically, the satisfaction of the government is significantly influenced by “solving the problem of public sector budget restraint (F_5)” and “transferring risk to private sector (F_{10})”, where F_5 and F_{10} are involved in the feedback loops “B1” and “B2”, respectively. For the general public, the satisfaction is influenced by “provide cheaper and more convenient service for society (F_6)” and “satisfying the need for public facilities (F_7)”, where F_6 and F_7 are involved in the feedback loops “B4” and “B1”, respectively. And regarding the private sector, the satisfaction is influenced by “making profit from public service (F_{12})” and “private sector earn more government sponsorship, guarantees and tax reductions (F_{15})”, where F_{12} is involved in the feedback loops “B3” and “B4” and F_{15} is involved in the feedback loops “B2” and “B3”.

Based on the above analysis, it can be found that the satisfaction of three parties can be monitored systematically through the adjusting POIs. This study select three adjusting POIs, including “provide cheaper and more convenient service for society (F_6)”, “making profit from public service (F_{12})” and “private sector earn more government sponsorship, guarantees and tax reductions (F_{15})”, to structure the satisfaction adjustment model because they are convenient to be transformed into executive KPIs, i.e. price, profit and subsidy, respectively. The procedures of developing the satisfaction adjustment model are illustrated in the following section.

2.3. Satisfaction adjustment procedures

This model is based on hypothesis of a fair contract which means the satisfaction of private sector, public sector and general public are equal when the construction period starts. Moreover, the satisfaction balance will be kept throughout the concession if the project progresses well as the agreement. As discussed in the satisfaction evalu-

ation model, the satisfaction of the three parties in the i^{th} period can be examined by Eqns (2) and (3). As a result, the satisfaction discrepancies in operational period are calculated by Eqns (4) and (5), and in construction period are calculated by Eqn (6). The satisfaction discrepancies in the i^{th} period to be adjusted off are assessed as $D_e^i + \Delta D_e$, $D_g^i + \Delta D_g$ and $D_p^i + \Delta D_p$. Then the satisfaction adjustment model can be used to adjust off the satisfaction discrepancies through the selected adjusting POIs (F_6 , F_{12} and F_{15}) in the $i+1^{th}$ period, as shown in Eqn (7):

$$\begin{bmatrix} \Delta f_6^{i+1} & \Delta f_{12}^{i+1} & \Delta f_{15}^{i+1} \end{bmatrix} = \begin{bmatrix} a_6 & b_6 & c_6 \\ a_{12} & b_{12} & c_{12} \\ a_{15} & b_{15} & c_{15} \end{bmatrix} \times \begin{bmatrix} D_e^i + \Delta D_e & D_g^i + \Delta D_g & D_p^i + \Delta D_p \end{bmatrix}^T, \quad (7)$$

where: Δf_6^{i+1} , Δf_{12}^{i+1} and Δf_{15}^{i+1} are the adjustments of F_6 , F_{12} and F_{15} in the $i+1^{th}$ period; a_j , b_j and c_j are the weights of the three parties for the POIs, which are indicated in Table 1. The selected adjusting POIs should be transformed into executive KPIs, so the adjustments are also transformed as Eqn (8):

$$\begin{cases} P_a^{i+1} = P^{i+1} - P^{i+1} \Delta f_6^{i+1} \\ I_a^{i+1} = I^{i+1} + I^{i+1} \Delta f_{12}^{i+1} \\ U_a^{i+1} = U^{i+1} + U^{i+1} \Delta f_{15}^{i+1} \end{cases}; \quad (8)$$

$$\begin{bmatrix} S_e^i & S_g^i & S_p^i \end{bmatrix}^T = \begin{bmatrix} 0.078 & 0.082 & 0.071 \\ 0.072 & 0.082 & 0.070 \\ 0.071 & 0.070 & 0.076 \end{bmatrix}^T \times \begin{bmatrix} \Delta f_1^i & \Delta f_2^i & \Delta f_3^i \end{bmatrix}; \quad (9)$$

$$\begin{bmatrix} \Delta D_e & \Delta D_g & \Delta D_p \end{bmatrix}^T = \begin{bmatrix} -0.25 & -0.27 & -0.23 \end{bmatrix}^T; \quad (10)$$

$$\begin{bmatrix} \Delta f_6^{i+1} & \Delta f_{12}^{i+1} & \Delta f_{15}^{i+1} \end{bmatrix} = \begin{bmatrix} 0.067 & 0.069 & 0.074 \\ 0.067 & 0.057 & 0.060 \\ 0.067 & 0.052 & 0.059 \end{bmatrix} \times \begin{bmatrix} D_e^i - 0.25 & D_g^i - 0.27 & D_p^i - 0.23 \end{bmatrix}^T, \quad (11)$$

where: p_a^{i+1} , I_a^{i+1} and U_a^{i+1} are the actual price, profits and subsidies in the $i+1^{th}$ period; P^{i+1} , I^{i+1} and U^{i+1} are the planned price, profits and subsidies in the $i+1^{th}$ period, which should be stated in the financial base case. After these adjustments, the satisfaction discrepancies in the i^{th} period are balanced off.

3. An illustrative case

3.1. Brief introduction

To illustrate the quantitative discussion, a hypothetical case is designed as shown in Appendix 1. It can be assumed that a private investor is tendering for a BOT toll bridge named as Dong-Fang Bridge (Shen *et al.* 2007; Wu *et al.* 2012). It is estimated that a total investment

of \$120 million is needed. The project started in 2000, and the economic life of the project will finish in 2030. Parameters are listed in Appendix 1. The planned quality of public services is set fixed throughout the concession ($H_p^i = 80$). In this case, deviations of the most important POIs (F_1 , F_2 , and F_3) are examined yearly.

3.2. The analysis on the case

Firstly, the satisfaction of three parties is calculated by Eqns (2) and (3). The weights of factors for F_1 , F_2 , and F_3 are available from Table 1. Eqn (9) calculates the satisfaction of three parties in this case. Δf_1^i , Δf_2^i and Δf_3^i are actual deviations, and the values of S_e^i , S_g^i and S_p^i are then calculated, as shown in Appendix 1.

After that, the satisfaction discrepancies are evaluated as follows: in the operation period, the satisfaction for private sector, government and general public in this case are calculated as $\begin{bmatrix} D_e^i & D_g^i & D_p^i \end{bmatrix}^T$ by Eqns (4) and (5); in the construction period, three parties' satisfactions are all negative and the government has the biggest losses of satisfaction. Therefore, the satisfaction in construction period should be distributed straightly into each operation year by Eqn (6). The average amortization of satisfaction for private sector, government and general public are calculated as Eqn (10). Furthermore, these discrepancies can be adjusted off in the $i+1^{th}$ period by Eqn (7). The selected adjusting POIs are F_6 , F_{12} and F_{15} , and the weights of factors are available in Table 1. Then, the adjustments are calculated as Eqn (11). Finally, these adjustments of POIs are transformed into executive KPIs (price, profit and subsidy) by Eqn (8) and the results are shown in Appendix 1.

3.3. The discussion on the case study

By the case study, the proposed satisfaction evaluation and adjustment model can be well used to balance the benefits of government, private sector, and general public. After the application of the model, a comparison between the planned and actual performance results is conducted as Figure 2.

The actual costs of this project overran the planned budgets significantly in the construction period, but fluctuated around the planned budgets throughout the operation period; the actual subsidies basically equalled the planned subsidies except slightly decrease at the end of the operation period; the actual profits for service delivery were similar to that planned at the financial base case, but in 2009, the actual profit increased rapidly and exceeded the planned profit. From then on, the actual profits were higher than the planned profits, even though there was a dive to be close the planned profit in 2016.

As far as the NPV been concerned, the total profit of the private sector increased by \$18.2 million, the total subsidy decreased by \$1.4 million, and the total cost increased by \$8.8 million. The satisfaction was adjusted when the model was applied. The profit of public service increased, and the subsidies from the government were

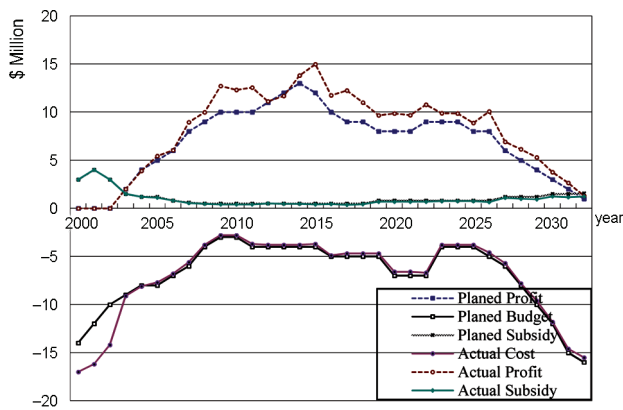


Fig. 2. Comparison between planned and actual performance

lower than that planned although the costs overran the budget.

The satisfaction of three parties were kept in high level and balanced throughout the concession. As shown in Appendix 1, three parties' satisfaction were negative in the first two operation years, however, all of them were positive and also equally with each other in the reminding years of concession.

This case study indicated that keeping the satisfaction of all participants at the same level was an effective approach for improving the performance of PPP projects. The result of the case study proved that the satisfaction evaluation and adjustment model was appropriate and worthwhile to be applied for PPP projects. Moreover, the result of the case study strongly supported the previous studies which were focusing on the "fairness" issues of public infrastructure projects, like some scholars designed pricing mechanism based on both efficiency and fairness objectives, or examined the fairness effects of congestion pricing policy for infrastructure projects (Eliasson, Mattsson 2006; Juan *et al.* 2008).

Conclusions

In this paper, a satisfaction evaluation model and a satisfaction adjustment model were proposed for the three principal stakeholders in PPP projects. In order to improve the overall satisfaction and address the problems related to the "balance" of satisfaction for PPP stakeholders, three contributions were offered to the knowledge base in the context of PPPs as followed.

The satisfaction evaluation model is structured based on the POIs of PPP projects. Most of previous studies about the satisfaction in construction industry focus on the government (Jamali 2007; Yang, Peng 2008), but the improvement in this paper considers three principal stakeholders (the government, the private sector, and the general public). Moreover, this model enables comparative study of stakeholders' satisfaction. The questionnaire survey of POIs found that the three principal stakeholders in PPP projects have different preference on POIs, and the stakeholders' satisfaction could be adjusted through their individual preferred POIs.

With the application of satisfaction evaluation model, the satisfaction discrepancies amongst the stakeholders can be detected, and the satisfaction adjustment model can be used. The satisfaction adjustment model is able to balance off the satisfaction discrepancies through the adjusting POIs. The feedback loops of the adjusting POIs connected the satisfaction of three parties, and then can perform as a proposed satisfaction adjustment mechanism. The adjusting POIs can be transformed into executive KPIs, such as price, subsidy and profit. This approach is a liable way to guarantee "fairness" for stakeholders in PPPs.

The illustrative case found that the application of the satisfaction evaluation and adjustment models can improve the general performance of PPP projects. In the case study, the original objective was to ensure "balance" of satisfaction of stakeholders in the whole concession, but the results indicated that the performance was improved significantly. Even though this is only a numerical simulation of the model, the achievement in performance improvement encouraged the scholars and practitioners to put focus on the "fairness" issues.

Despite of aforementioned contributions, there are some disadvantages should be improved in future. First of all, the POIs for satisfaction evaluation are based on general PPP projects, but the POIs for different types of PPP projects need to be studied individually because of their distinct differences between sectors. Besides, even though the effectiveness has been testified by the illustrative case, the proposed approach is necessary to be examined by a real project.

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Appendix 1

Case study of Dong-Fang Bridge (I , U and C , \$Million; P , \$)

Year	P_p^i	I_p^i	C_p^i	U_p^i	Q_p^i	Q_p^i	H_a^i	C_a^i	S_e^i	S_g^i	S_p^i	P_a^i	I_a^i	U_a^i
2000	–	–	–14	3	100	100	–	–17	–1.54	–1.76	–1.50	–	–	3
2001	–	–	–12	4	100	100	–	–16.2	–2.52	–2.87	–2.45	–	–	4
2002	–	–	–10	3	100	100	–	–14.2	–3.02	–3.44	–2.94	–	–	3
2003	10.8	2	–9	1.5	95	98	75	–9.1	–0.28	–0.28	–0.33	10.7	2.2	1.40
2004	10.8	4	–8	1.2	95	96	80	–8.1	–0.01	–0.02	–0.01	10.64	3.91	1.20
2005	10.8	5	–8	1.2	95	94	85	–7.7	0.63	0.66	0.66	10.97	5.43	1.11
2006	10.8	6	–7	0.8	95	92	90	–6.8	0.85	0.86	0.93	10.93	6.04	0.80
2007	10.8	8	–6	0.6	90	90	100	–5.6	2.26	2.32	2.37	11.13	8.95	0.54
2008	12.0	9	–4	0.5	90	88	100	–3.8	1.96	2.00	2.09	12.65	9.99	0.47
2009	12.0	10	–3	0.5	90	86	100	–2.8	1.91	1.96	2.05	12.94	12.71	0.40
2010	12.0	10	–3	0.5	90	84	100	–2.8	1.74	1.78	1.89	12.81	12.32	0.41
2011	12.0	10	–4	0.5	85	82	100	–3.7	2.04	2.10	2.17	13.00	12.55	0.41
2012	12.0	11	–4	0.5	85	80	100	–3.8	1.68	1.70	1.83	12.29	11.12	0.50
.....														
2031	4.8	2	–15	1.5	70	66	100	–14.6	1.52	1.53	1.68	5.22	2.64	1.15
2032	4.8	1	–16	1.55	70	64	100	–15.5	1.33	1.33	1.51	5.23	1.30	1.23
NPV		119	–129	23				–137					137	21

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