Case Study on Improving the Effectiveness of Public Participation in Public Infrastructure Megaprojects

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Abstract: Public participation is a critical aspect of the success of public infrastructure megaprojects (PIMs), in which ineffectiveness is a constant problem. Although studies have focused on public participation, a method that can measure and improve its effectiveness is lacking. The present study addresses this knowledge gap using a game theory model and social utility equations to measure the effectiveness of public participation in PIMs. Results indicate that the institutional arrangements and social responsibility of PIMs (SR-PIMs) determine stakeholder behaviors, which influence the effectiveness of public participation. The Shanghai Maglev construction project was used as a case study to validate the proposed model and the assumptions of the current study. A conceptual model of governance framework was proposed to enhance the effectiveness of public participation in PIMs. This study contributes to the body of knowledge concerning public participation in PIMs by measuring the effectiveness of such participation and identifying a method to improve it. The policy implication of this study for the PIM global community is that the high effectiveness of public participation entails responsible behaviors among stakeholders. That is, stakeholders should perfect institutional arrangements and cultivate SR-PIMs to reduce game space and expand social effects. **DOI: 10.1061/(ASCE)CO.1943-7862.0001623.** © *2019 American Society of Civil Engineers.*

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Introduction

Over the last few decades, China has built a myriad of public infrastructure megaprojects (PIMs), such as airports, high-speed railway systems, hydropower plants, gas pipelines, expressway networks, and expansive bridges (Flyvbjerg 2011). These PIMs create and sustain employment and benefit consumers through improved quality of service (Flyvbjerg 2014). However, numerous factors detrimental to the delivery and social stability of PIMs have emerged. Stakeholder management is a critical factor in the success of PIMs particularly because public participation in them is becoming increasingly critical and complicated. From 2010 to 2016, 105 (11%) construction projects in Henan Province were aborted because of public participation failure in social stability assessment (Phoenix Weekly 2011).

Studies have shown that PIM public participation remains at a low level in China (Li et al. 2012b; Sun et al. 2016b) despite the country's extensive experience and numerous achievements in PIM construction and operation (Shen et al. 2011). Many developed countries do not consistently achieve high-quality public participation (Cohen et al. 2015). Hence, improving the effectiveness of public participation has become a key challenge in PIM construction. However, limited information is available on the effectiveness of participation (Rosener 1978) and the method to measure it. To reduce this knowledge gap, the present study develops a game theory model to calculate the effectiveness of public participation and determine a method to improve it.

The remainder of this paper is structured as follows. Related literature and methodology are reviewed and introduced. Social utility equations and a game theory model are established to measure the effectiveness of public participation in PIMs. Thereafter, the reasons for the ineffectiveness of public participation are analyzed, while impact mechanisms are revealed. The Shanghai Maglev construction project (SMCP) is adopted as a case study to validate the proposed model and assumptions. Accordingly, a conceptual governance model is proposed. Lastly, this study's conclusion is drawn.

Literature Review

Current Research on Improving Public Participation

Sherry's (1969) paper, "A ladder of citizen participation," was the inception of academic research. The concepts it laid out have been widely applied in PIM decision making worldwide since the 1970s. Developed countries have formulated various methods to achieve public participation (Sanoff 2000; Li et al. 2012a) and identified the best public participation practices (Drazkiewicz et al. 2015). However, current participatory approaches and forms cannot consistently achieve high effectiveness of public participation (Judith and David 2004; Cohen et al. 2015). Public participation is relatively new in developing countries, while its effectiveness remains a matter of debate for academics and practitioners (Xie et al. 2014). Attaining high effectiveness in public participation has consistently drawn the attention of researchers.

Public participation in environmental impact assessment (EIA) has not been executed thoroughly in China, while its effectiveness has been determined not to be ideal in practice (Sun et al. 2016a). Weaknesses in participatory awareness, methods, and participant attitudes (Li et al. 2013; Wang et al. 2016) have led to the

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ineffectiveness of public participation in PIMs (Tang et al. 2008). Accordingly, strengthening legislation (Sun et al. 2016a) and establishing engagement guidelines (Brombal et al. 2017), providing multiway interaction (Judith and David 2004) and training (Yang 2008), and conducting education programs are all necessary to enhance the effectiveness of public participation in EIA. Meanwhile, public participation should be involved throughout the life cycle of PIMs (Sequeira 2003; Li et al. 2012b), while the social impact assessment (SIA) paradigm orientation should shift from project to people.

By developing quantitative methods, a fuzzy approach (Li et al. 2013) and a structural stakeholder model (Yu and Leung 2018) have been used to evaluate the satisfaction of stakeholders in public participation. Moreover, questionnaires and a statistical method have been used to gauge stakeholder perceptions of public participation in PIMs in China and to identify the extent of and obstacles to public participation (Xie et al. 2014). Yang (2008) analyzed the history and development of public participation in EIA and proposed several methods and indices for evaluating and improving its effectiveness (Brombal et al. 2017). The aforementioned factors have contributed to improving public participation. However, an approach that can measure the effectiveness of public participation is still needed.

Game Theory Applied to Stakeholder Relationships

Stakeholder relationships can be a delicate game, in which every move has an impact on benefits or outcomes (Lawrence and Sorbarikor 2016) and conflict management is difficult. Myerson (1991) defines game theory as the study of mathematical models of conflict and cooperation between intelligent rational decision makers, and it is a good decision-making approach in stakeholder conflicts. To balance economic and environmental concerns in water management, game theory has been employed to convert the stakeholder payoff in all strategies into a multiobjective game theory model and identify and analyze resolutions for assistance in decisions (Raquel et al. 2007; Lee 2012). Game theory also aids in explaining the incentives of stakeholders' behavioral strategies and their payoffs in decisions involving land-use planning (Hui and Bao 2013) and property development (Samsura et al. 2010). Therefore, the present study uses game theory to measure the effectiveness (and achieve high effectiveness) of public participation in PIMs by computing the payoffs of stakeholders during public participation.

Research Methodology

The present study aims to improve the effectiveness of public participation by measuring the payoffs of key stakeholders (players). The fundamental assumption is that the effectiveness of public participation is determined by the behaviors of key stakeholders. Two propositions are based on this assumption. Social utility equations and a game theory model were used to calculate the social utility of stakeholders and d values. The best public participation situation and impact mechanism were determined via a result analysis. SMCP was adopted as a case study to validate the proposed model and assumptions. Therefore, a conceptual governance model was proposed to improve the effectiveness of public participation in PIMs. The research methodology is shown in Fig. 1.

Social utility was introduced to measure the effectiveness of public participation and was found to positively correlate with it. Thus, good public participation should bring high satisfaction (utility) to society.

Measuring the Social Utility of Public Participation in PIMs

Social Utility Equations

In economics, utility refers to buyers' satisfaction with the goods they purchase. Analogously, under different rules or prerequisites, stakeholders adopt different behaviors to maximize their interests during public participation, while their payoff can be computed as a social utility (Bolton and Ockenfels 2005). Gilchrist and Allouche (2005) calculated the total cost of a construction project as follows:

$$\text{Total cost} = \text{construction costs} + \text{social costs} \tag{1}$$

The social utility of a PIM is the investment (total cost) to buy the social and engineering services of a particular megaproject by satisfying all stakeholders. In this process, the construction cost will generate the value of a PIM itself. Social cost aims to generate social effect value, which is the social service component of a PIM, such as accelerating economic development. Irresponsible behaviors among stakeholders increase social cost and lower social effect value. Therefore, social utility comprises the PIM and social effect values. Eq. (1) may be converted into Eq. (2) to compute the social utility of a single stakeholder in PIM public participation

$$\text{Social utility} = \text{PIM value} + \text{social effect value} \tag{2}$$

After computing the social utility of every stakeholder, the total social utility of public participation in a PIM can be calculated as follows:

$$\text{Total social utility} = V_1 + V_2 + \ldots + V_n \tag{3}$$

where V_n = social utility of the nth stakeholder.

Game Theory Model

Freeman (1984, p. 40) defined stakeholders as individuals "who can affect or [are] affected by the achievement of the firm's objectives." This study selected governments, the organization (Maglev Construction Ltd. here), the public, and local communities as stakeholders who directly influence the effectiveness of public

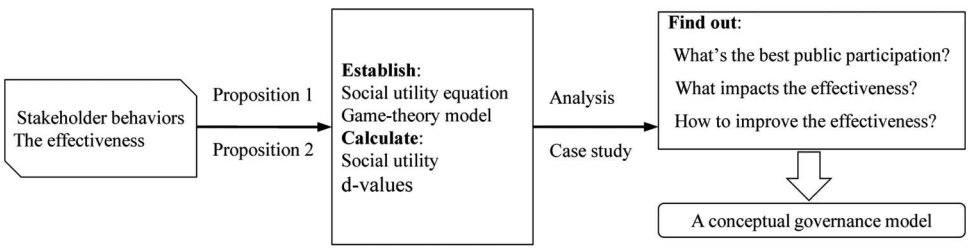

Fig. 1. Research methodology.

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participation in PIMs. Governments and the public represent public interests, while the organization pursues profit and local communities protect private interests.

Governments own and initiate the construction of PIMs, evaluate and approve various PIM documents, and enforce laws. The organization is designated by governments to be in charge of PIMs, including financing, management, construction, and operation, as well as public participation. The organization represents or has contractual relationship with governments to deliver the service of PIMs (Zeng et al. 2015). Thus, these two institutions have a common interest and in building PIMs. Governments have administrative and final decision-making powers, thereby possibly influencing the behaviors of organizations when negotiating with local communities or the public to reduce conflicts and resistance (Liu et al. 2016). However, local communities mistrust governments when conflicts of interest exists between them (Botetzagias and Karamichas 2009; Thomas 2013; Sun et al. 2016a) and when local community behaviors are unpredictable. Therefore, we draw the following proposition based on the preceding discussion.

Proposition 1: Governments can directly influence the organization's behaviors, while both sides are consistent in the payoff and pose slight influence on the behaviors of local communities.

The public comprises external experts, residents, mass media, nongovernment organizations (NGOs), and interested individuals (Li et al. 2012b), and may have no direct interest in PIMs. Local communities are the residents in the vicinity of construction sites affected directly by PIMs. These communities are burdened by the adverse impact of PIMs. Thus, they are directly involved in terms of direct conflict of interest in PIM construction and often seek compensation for or influence over decisions to cover their losses. Therefore, local communities are different from the public in terms of positions of interest.

The public's awareness influences the behaviors of local communities (Wang et al. 2016). The construction of PIMs often causes social conflicts between local communities and organizations or governments (Sun et al. 2016a). The public consistently sympathizes with or supports local communities in various ways in these conflicts. For example, NGOs and external experts offer professional knowledge and skill training. Therefore, the public can influence the behaviors of local communities because they have common goals, such as social responsibility and justice. However, the public cannot influence the behaviors of organizations because they have no direct-interest or subordinate relationship, which explains why the public's input should not always be adopted. Therefore, we present the following proposition.

Proposition 2: The public can guide and influence local communities, while both sides are consistent in the payoff and cannot influence the behaviors of the organization.

Propositions 1 and 2 indicate that governments and the public use the same strategies toward the organization and local communities, respectively, when conflicts of interest exist in public participation. Therefore, a game theory model can be established to calculate the social utility of public participation, in which the key players are the organization and local communities. The players' payoffs are determined by the behaviors they adopt.

The organization and local communities are assumed to obtain payoff (α_1, α_2) when they adopt responsible behaviors. However, they can adopt irresponsible behaviors to transfer the loss to the other side and obtain additional payoff (μ). The organization adopts irresponsible behaviors to obtain additional payoff (μ) if local communities adopt responsible behaviors and assume the burden of loss (μ). The payoffs for the organization and local communities are $(\alpha_1 + \mu)$ and $(\alpha_2 - \mu)$, respectively. Analogously, local communities adopt irresponsible behaviors to obtain additional payoff (μ) if the organization adopts responsible behaviors and assumes the burden of loss (μ). The payoffs for the organization and local communities are $(\alpha_1 - \mu)$ and $(\alpha_2 + \mu)$, respectively. The organization and local communities suffer losses μ_1 and μ_2, respectively, when they adopt irresponsible behaviors in conflicts. Such losses increase as conflicts escalate. The payoffs of the organization and local communities are $(\alpha_1 - \mu_1)$ and $(\alpha_2 - \mu_2)$, respectively. Table 1 provides the payoff matrix of game theory.

Table 1. Payoff matrix of local communities and the organization

	Local communities strategy	
Organization strategy	Responsible behaviors	Irresponsible behaviors
Responsible behaviors	(α_1, α_2)	$(\alpha_1 - \mu, \alpha_2 + \mu)$
Irresponsible behaviors	$(\alpha_1 + \mu, \alpha_2 - \mu)$	$(\alpha_1 - \mu_1, \alpha_2 - \mu_2)$

In accordance with Propositions 1 and 2, consistent social effect payoff exists between governments and the organization, as well as the public and local communities, γ_{1i} and γ_{2j} representing their respective linearly dependent coefficients, γ_{1i} and $\gamma_{2j} \in (0, 1]$. Assume the value of a PIM as c delivery to governments. The value is inverse to the irresponsible behaviors of the organization. The public has no direct PIM value. The "Notations" section defines the symbols and variables used here.

Calculating Social Utility and d Values

Eqs. (2) and (3) were adopted based on the game theory model and assumptions to compute the social utility of public participation in Situations I, II, III, and IV as follows:

Situation I

In Situation I, the organization and local communities adopt responsible behaviors during public participation.

When governments value the social responsibility of PIMs (SR-PIMs), they encourage the organization to adopt responsible behaviors during public participation. When the public realizes the importance of SR-PIMs, they guide local communities to adopt responsible behaviors during public participation. Institutional arrangements (e.g., laws) also guarantee responsible behaviors of all participants and establish rules of negotiation during public participation. Consequently, all participants are willing to adopt responsible behaviors to participate in decision making.

The organization and local communities that obtain payoffs are α_1 and α_2, respectively, while those that acquire the social effect value are ξ_1 and ξ_2, respectively. Governments and the public that obtain social effect value are $\gamma_{11}\xi_1$ and $\gamma_{12}\xi_2$, respectively. According to Eq. (2), shown previously, the social utility of the players in Situation I is calculated as

$$V_1 = c + \gamma_{11}\xi_1, \qquad V_2 = \gamma_{12}\xi_2,$$
$$V_3 = \alpha_1 + \xi_1, \qquad V_4 = \alpha_2 + \xi_2$$

where V_i = social utility of the four players—namely, governments, the public, the organization, and local communities ($i = 1, 2, 3, 4$).

According to Eq. (3), also shown previously, the total social utility (U_I) of Situation I is

$$U_1 = V_1 + V_2 + V_3 + V_4$$
$$= c + \gamma_{11}\xi_1 + \gamma_{12}\xi_2 + \alpha_1 + \xi_1 + \alpha_2 + \xi_2$$

Situation II

In Situation II, local communities adopt responsible behaviors during public participation, whereas the organization adopts irresponsible behaviors.

The organization and governments inherently lack social justice and procedural fairness (Whitton et al. 2017). Social responsibility may be lacking in these players and the implementation of laws may be deficient. In contrast, the public and local communities concentrate on SR-PIMs. The institutional cost of adopting irresponsible behaviors is also high. Thus, they adopt responsible behaviors, and so the organization obtains payoff $\alpha_1 + \mu$. For irresponsible behaviors, the social effect value is low, $(a_1/a_1 + \mu)\xi_1$, while the value of a PIM devalues to $(\alpha_1/\alpha_1 + \mu)c$. The payoff of local communities is $\alpha_2 - \mu$. For responsible behaviors, the social effect value is ξ_2. The social utility of each player in Situation II, according to Eq. (2) is calculated as follows:

$$V_1 = \frac{\alpha_1}{\alpha_1 + \mu}c + \frac{\alpha_1}{\alpha_1 + \mu}\gamma_{12}\xi_1, \qquad V_2 = \gamma_{22}\xi_2,$$
$$V_3 = \alpha_1 + \mu + \frac{\alpha_1}{\alpha_1 + \mu}\xi_1, \qquad V_4 = \alpha_2 - \mu + \xi_2$$

According to Eq. (3), the total social utility (U_{II}) of Situation II is

$$U_{\mathrm{II}} = V_1 + V_2 + V_3 + V_4 = \frac{\alpha_1}{\alpha_1 + \mu}c + \frac{\alpha_1}{\alpha_1 + \mu}\gamma_{12}\xi_1 + \gamma_{22}\xi_2 + \alpha_1 + \frac{\alpha_1}{\alpha_1 + \mu}\xi_1 + \alpha_2 + \xi_2$$

Situation III

In Situation III, the organization adopts responsible behaviors during public participation, whereas local communities adopt irresponsible behaviors.

Because of government demands and legal requirements, the organization adopts responsible behaviors during public participation in PIMs. However, the public and local communities do not realize the significance of PIMs, and no law or regulation defines the behaviors of these players during public participation. Accordingly, local communities attempt to maximize their benefits by adopting irresponsible behaviors, and so the payoffs to the organization and local communities are $\alpha_1 - \mu$ and $\alpha_2 + \mu$, respectively. The social effect value of local communities' irresponsible behaviors is relatively low at $(\alpha_2/\alpha_2 + \mu)\xi_2$. Eq. (2) shows that the social utility of each player in Situation III is

$$V_1 = c + \gamma_{13}\xi_1, \qquad V_2 = \gamma_{23}\frac{\alpha_2}{\alpha_2 + \mu}\xi_2,$$
$$V_3 = \alpha_1 - \mu + \xi_1, \qquad V_4 = \alpha_2 + \mu + \frac{\alpha_2}{\alpha_2 + \mu}\xi_2$$

and Eq. (3) indicates that the total social utility (U_{III}) of Situation III is

$$U_{III} = V_1 + V_2 + V_3 + V_4 = c + \gamma_{13}\xi_1 + \frac{\alpha_2}{\alpha_2 + \mu}\gamma_{23}\xi_2 + \alpha_1 + \xi_1 + \alpha_2 + \frac{\alpha_2}{\alpha_2 + \mu}\xi_2$$

Situation IV

In Situation IV, the organization and local communities adopt irresponsible behaviors during public participation.

According to Li et al. (2012a), governments neglect the importance of social responsibility, the public lacks awareness of social responsibility and participatory knowledge (Shan and Yai 2011; Xie et al. 2014), and no law defines the rules of negotiation for stakeholders. Local communities ask the organization for additional compensation to offset their losses, but the organization refuses these requests and wants to shift losses onto the other side. Therefore, local communities and the organization may adopt irresponsible behaviors to game with each other and even cause conflicts and confrontation.

In this study, the payoffs of irresponsible players are inversely proportional to μ_1 and μ_2 in Situation IV. The social effect value is inversely proportional to irresponsible behaviors in the game theory model. Therefore, the numerator and denominator of the coefficients are inverse in Situation IV, which is different from Situations II and III. Other computational rules are same.

The social utility of each player in Situation IV can be calculated according to Eq. (2) as

$$V_1 = \frac{\alpha_1 - \mu_1}{\alpha_1}c + \frac{\alpha_1 - \mu_1}{\alpha_1}\gamma_{14}\xi_1, \qquad V_2 = \frac{\alpha_2 - \mu_2}{\alpha_2}\gamma_{24}\xi_2,$$
$$V_3 = \alpha_1 - \mu_1 + \frac{\alpha_1 - \mu_1}{\alpha_1}\xi_1, \qquad V_4 = \alpha_2 - \mu_2 + \frac{\alpha_2 - \mu_2}{\alpha_2}\xi_2$$

According to Eq. (3), the total social utility (U_{IV}) of Situation IV is

$$U_{\mathrm{IV}} = V_1 + V_2 + V_3 + V_4 = \frac{\alpha_1 - \mu_1}{\alpha_1}c + \frac{\alpha_1 - \mu_1}{\alpha_1}\gamma_{14}\xi_1 + \frac{\alpha_2 - \mu_2}{\alpha_2}\gamma_{24}\xi_2 + \alpha_1 - \mu_1 + \frac{\alpha_1 - \mu_1}{\alpha_1}\xi_1 + \alpha_2 - \mu_2 + \frac{\alpha_2 - \mu_2}{\alpha_2}\xi_2$$

Given that the social utility of Situation I has the largest value, U_{II}, U_{III}, and U_{IV} are subtracted from U_{I} to obtain d_1, d_2, and d_3 as follows:

$$d_1 = U_I - U_{II} = \frac{\mu}{\alpha_1 + \mu}c + \gamma_{11}\xi_1 + \left(\frac{1 - \gamma_{12}}{\alpha_1 + \mu}\right)\xi_1\mu > 0$$

$$d_2 = U_I - U_{III} = \gamma_{21}\xi_2 + \left(\frac{1 - \gamma_{23}}{\alpha_2 + \mu}\right)\xi_2\mu > 0$$

$$d_3 = U_I - U_{IV} = \frac{\mu_1}{\alpha_1}c + \left(\gamma_{11} - \gamma_{14}\frac{\alpha_1 - \mu_1}{\alpha_1}\right)\xi_1 + \left(\gamma_{21} - \gamma_{24}\frac{\alpha_2 - \mu_2}{\alpha_2}\right)\xi_2 + \mu_1 + \mu_2 + \frac{\mu_1}{\alpha_1}\xi_1 + \frac{\mu_2}{\alpha_1}\xi_2 > 0$$

For $\gamma_{11} \geq \gamma_{1(1+i)}$ and $\gamma_{21} \geq \gamma_{2(1+j)}$, where $i, j \in 1, 2, 3$.

Analysis and Findings

Result Analysis

Research has shown that, when each player adopts responsible behavior during public participation, PIMs produce maximum social utility; on the other hand, irresponsible behaviors have a serious impact on the effectiveness of public participation. The results demonstrate that Situation I produces maximal social utility and the most effective public participation. The absence of or flaws in institutional arrangements cause the emergence of the game space (μ). Furthermore, serious conflicts between the organization and local communities increase μ_1, μ_2, and d_3. The cancellation or aborting of PIMs is prompted when μ_1 and μ_2 are higher than α_1, α_2. If $\mu_1 = \mu_2 = 0$, then $d_3 = 0$, meaning that conflicts and game space impact the effectiveness of public participation.

Inference 1: Sound institutional arrangements reduce game space (μ) to guarantee positive behaviors of stakeholders in the public participation of PIMs.

The values of ξ_1 and ξ_2 are positively correlated with c, as well as d_1, d_2, and d_3. Therefore, ξ_1 and ξ_2 do not change the positivity

or negativity of d_1, d_2, or d_3 but do influence their size. Thus, PIMs are necessary in enhancing social effect through public participation to increase total social utility. The variables ξ_1 and ξ_2 comprise the immeasurable component (i.e., social effect value) of social utility, whereas c, α_1, α_2, and μ represent the measurable component (i.e., PIM value), thereby verifying that the social factors of PIMs should be valued as their economic and technical factors. The public therefore needs to encourage the positive behaviors of local communities by advocating SR-PIMs to improve the value of ξ_2. Otherwise, the irresponsible behaviors of local communities will impact the effectiveness of public participation. Similarly, governments and the organization must advocate SR-PIMs to enhance ξ_1. Otherwise, their irresponsible behaviors may render public participation in PIMs ineffective.

Inference 2: SR-PIMs solicit the positive behaviors of stakeholders to increase the social effect value (ξ) of public participation in PIMs.

Impacting Mechanism of Public Participation in PIMs

In Situation I, governments and the public positively participate, thereby prompting the organization and local communities to adopt responsible behaviors. Two tasks should be accomplished to achieve such a situation. The first task is improving the institutional arrangements of public participation in PIMs (Tang et al. 2008; Li et al. 2012b; Sun et al. 2016a); the second is cultivating awareness of SR-PIMs (Xie et al. 2014; Zeng et al. 2015). Inferences 1 and 2 indicate that sound institutional arrangements and high levels of SR-PIMs prompt effective and substantive public participation. The former provides rules to define the scope, contents, rights, and goals of public participation and to reduce the game space to minimize the value of μ. The latter guides participants in adopting responsible behaviors to increase the value of ξ. Substantive public participation generates the maximum social utility (Fig. 2).

Several laws and policies are related to public participation in PIMs. The Constitution of the People's Republic of China grants the rights of citizens to participate in economic, public, and cultural affairs of state (Tang et al. 2008). Other public participation laws exist, such as the Urban and Rural Planning Law, the Environmental Impact Assessment Law, and the Environmental Protection Law (Sun et al. 2016b). The Communist Party of China implemented the "Decision of the Central Committee of the Communist Party of China on Several Major Issues of Comprehensive Deepening Reform." This decision is the basis of SIA public participation for and emphasizes the necessity and urgency of implementing the mechanism of social stability risk assessment in major sensitive decisions.

However, no special law exists for public participation in PIMs (Sun et al. 2016a), particularly those stipulating land requisition and compensation standards and the responsibility of participants. Loopholes in or the absence of institutional arrangements widen the game space (μ) among participants who immediately adopt irresponsible behaviors (Table 2). Fuzzy institutional arrangements are the critical factors influencing the success of PIMs (Taşan-Kok 2010) and the effectiveness of public participation. Therefore, improving laws or regulations for public participation in PIMs is urgent.

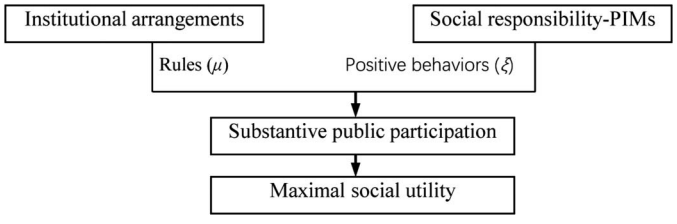

Fig. 2. Impacting mechanism of social utility in PIMs.

Table 2. Irresponsible behaviors of PIM public participation stakeholders

Stakeholders	Irresponsible behaviors
Governments	1. Regard the economic and technical impacts of PIMs rather than the social impact 2. Do not disclose timely information and make "closed decisions"
Organizations	1. Overemphasis on cost, quality, and time; perfunctory attitude toward public participation 2. Merely meet legal requirements without substantive public participation 3. Passively provide feedback information to public
Public	1. Neglect importance of SR-PIMs and indifferent to public participation 2. Rarely provide information on PIM public participation
Local communities	1. Make unreasonable demands and misunderstand their role in public participation 2. Act deceptively to inflate compensation

The social responsibility of stakeholders is one of the critical success factors for project management (Yang et al. 2010). Bice (2015) argued that SIA and corporate social responsibility (CSR) share fundamental values in handling various social issues. Furthermore, SIA should not be a statutory requirement because its completion may be "motivated by CSR" (Baines et al. 2013, p. 254). PIMs face special and complex challenges worldwide. CSR insufficiently addresses social issues. However, SR-PIMs can address social issues of PIMs in public participation.

Case Study

As a major project of Shanghai Municipality, SMCP was a planned extension to the Hongqiao Transportation Hub from Longyang Road Station (Fig. 3) for a total of 31.8 km with up to five stations and a maximum speed of 200 km/h. SMCP was designed to connect Shanghai Hongqiao International Airport and Shanghai Pudong International Airport by providing convenient and rapid public transport. This project represented great progress in technological innovation and application as well as in public transportation development. SMCP was selected as the case study here for the following reasons. First, SMCP was a PIM, in which approximately \$1.3 billion would be invested through state-owned capital. Second, public participation practice existed in environmental impact assessments. Third, Maglev Construction Ltd. (MCL) and local communities were the two stakeholders that would be gaming with each other. MCL was in charge of financing, management, construction, and operation, as well as public participation. Governments and the public had a strong influence on MCL and local communities, respectively.

In March 2006, the State Council approved the SMCP proposal (Fig. 4). The proposal indicated that SMCP would run through a residential area with a designed safety distance set to 22.5 m. In contrast, the standard safety distance in Germany was 500 m, while the experimental standard was 175 m. Residents claimed that noise and magnetic radiation could pose harm to their life and health (Southern Metropolis Daily 2008) and even depreciate the value of properties. However, the Chinese government and MCL disregarded the voices and made a "closed decision," thereby causing a huge public controversy, particularly in the local communities. the Shanghai Municipality did not disclose the details of

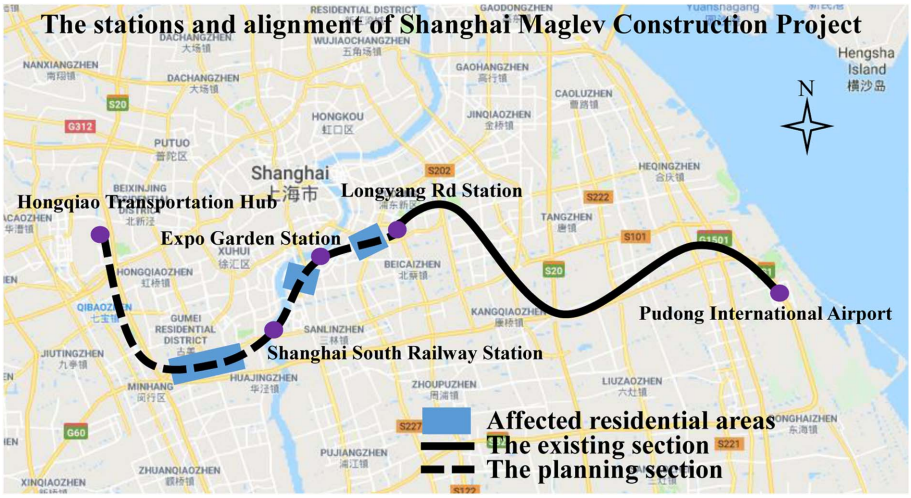

Fig. 3. Stations and alignment of SMCP. (Map data © 2018 Google.)

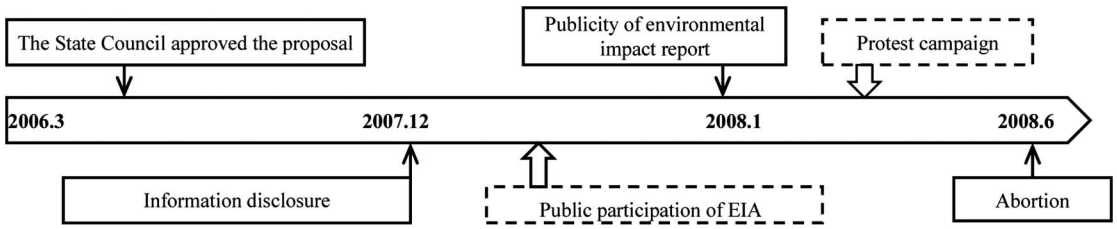

Fig. 4. Time axis of Shanghai Maglev construction project.

construction until December 29, 2007, and MCL hastily launched the environmental impact assessment public participation period. However, the government and MCL downplayed the opinions of the local communities. They intended to proceed with the project and burdened the local communities. Thus, MCL obtained a payoff of $\alpha + \mu$. The payoff for local communities was $\alpha - \mu$ when they accepted this plan, mirroring Situation II.

However, the local communities claimed that they would never accept a safety distance of 22.5 m. On January 2, 2008, the Shanghai Environmental Hotline website posted the SMCP environmental impact assessment publicity and SMCP's environmental impact report, which concluded that the project was feasible and would have insignificant environmental impact. The result of public participation was omitted. The local communities and the public did not accept this finding and questioned the process of public participation in EIA.

To express their concerns, several residents appealed to higher governmental authorities for assistance (*Shangfang*), while some protested against SMCP in the People's Square (*Sanbu*). Under this pressure, the Shanghai Municipality held a public hearing to gather opinions. However, MCL and the local communities could not reach a consensus. Thereafter, dissatisfaction and anxiety further spread over local communities, turning the case into Situation IV. At this time, the local communities' payoff, $\alpha_2 - \mu_2$, was considerably below zero. Over 3,000 people gathered in People's Square to protest against SMCP. The official newspaper reported that the protesters were harming social stability and challenging authority (*Jiefang Daily* 2008). The government eventually ordered MCL to resume negotiating with representatives of local communities. However, the local communities' requirements were substantially more than what MCL could afford. MCL's payoff, $\alpha_1 - \mu_1$, was considerably below zero. In June 2008, the Shanghai government ultimately announced the termination of SMCP because of the considerable divergence between the local communities and MCL. The unsatisfactory participation curve in Fig. 5 reflects the evolved mechanism of the public's emotion. Critical point 1 shows the local communities' payoff to be below zero, meaning that there would likely be protests against the project. In contrast, Critical point 2 indicates the organization's payoff to be below zero, meaning that the organization would probably suspend or cancel the project—typical of the "not in my backyard" (NIMBY) conflict syndrome.

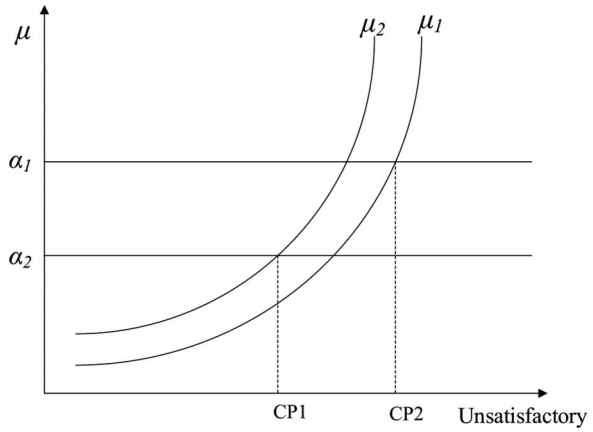

Fig. 5. Unsatisfactory curve in Situation IV.

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To evaluate this case, a numerical value. based on price levels in Shanghai in 2008 was estimated. The investment in SMCP was 1.3. Thus, $c = 1.3$. Accordingly, MCL could obtain 1.1 (α_1) as a construction value, while local communities could acquire 0.2 (α_2) in, for example, property requisition fees. It was assumed that 0.15 (μ) in additional benefit could be acquired by MCL or the local communities. After the conflict escalated, if MCL accepted the safety distance of 175 m, then it would shoulder the burden of additional cost, 1.4 (μ_1). Otherwise, the local communities would shoulder the burden of loss, 0.42 (μ_2). The social effect of MCL and the local communities was assumed to be 1 (ξ_1) and 0.18 (ξ_2), respectively, in billions of dollars. If MCL and the local communities were to adopt responsible behaviors, γ_{1i} and γ_{2j} would be equal to 1; otherwise, they would be equal to 0.5.

The social utility of SMCP public participation can be calculated as follows:

- In Situation I, if $\gamma_{11} = 1$ and $\gamma_{12} = 1$, then $V_1 = 2.3$, $V_2 = 0.18$, $V_3 = 2.1$, $V_4 = 0.38$, and $U_I = 4.96$.
- In Situation II, if $\gamma_{12} = 0.5$ and $\gamma_{22} = 1$, then $V_1 = 1.58$, $V_2 = 0.18$, $V_3 = 2.13$, $V_4 = 0.23$, and $U_{II} = 4.12$.
- In Situation III if $\gamma_{13} = 1$ and $\gamma_{23} = 0.5$, then $V_1 = 2.3$, $V_2 = 0.05$, $V_3 = 1.95$, $V_4 = 0.45$, and $U_{III} = 4.75$.
- In Situation IV, if $\gamma_{14} = 0.5$ and $\gamma_{24} = 0.5$, then $V_1 = -0.49$, $V_2 = -0.03$, $V_3 = -0.57$, $V_4 = -0.27$, and $U_{IV} = -1.36$.

Before a NIMBY event, the largest social utility would be 4.96 in Situation I, followed by 4.75 and 4.12 in Situations III and II, respectively. Thus, the positive behaviors of stakeholders are shown to be beneficial to the social utility of PIMs. After a NIMBY event, local communities would bear the burden of loss μ_2 (0.42) if they were to accept the 22.5-m safety distance, thereby turning to Situation II. Similarly, if MCL were to accept a 500- or 175-m safety distance, it would bear the burden of loss μ_1 (at least 1.4), turning to Situation III. When the value of μ is larger than payoff α, public participation may not reach consensus, thereby turning SMCP into an ongoing NIMBY event, which is Situation IV. At this point, $\alpha_1 - \mu_1 = -0.3 < 0$, $\alpha_2 - \mu_2 = -0.22 < 0$, and $U_{IV} = -1.36 < 0$ (Fig. 5). A NIMBY event is the worst situation (Situation IV) for PIMs. What factors lead to this path?

The core questions about SMCP during the public participation period concerned the legality of the 22.5-m safety distance and the necessity of initiating the project. Local communities questioned the rationality of both issues and demanded a safety distance of 500 or 175 m, which was not supported by any regulation or scientific evidence. However, the distance should have been at least 30 m, pursuant to Article 42 of the Regulations of Shanghai Municipality on the Management Technique of Urban Planning (Land Use Construction Management). Despite a failure to meet the minimum distance, the State Council approved SMCP. Governments and MCL merely persuaded local communities to accept the initial plan without taking any further responsibility, with the result that local communities adopted irresponsible behaviors. The public also strongly questioned the necessity of SMCP because it did not appear to have economic benefits or to satisfy social needs. Furthermore, local communities complained that they would have no say over property or land to be requisitioned. The absence of institutional arrangements and SR-PIMs was the key factor that transformed the SMCP into a NIMBY event. The impacting mechanism indicates that the former brought game space among stakeholders to pursue μ, and that the latter caused the negative sentiments of stakeholders, lessening ξ.

The implementation of SMCP was decided by the governments and MCL, which paid attention only to the economic and technical aspects of the project. They disregarded the interests of local communities and the opinions of the public. Such a phenomenon indicates the absence of effective rules to include the opinions of the public in decision making. Current institutional arrangements do not guarantee high effectiveness of public participation, in which stakeholders negotiate with one another to reach consensus.

Responsibility is the invisible factor influencing the behaviors of all participants during public participation. SR-PIMs are economic and contractual relationships that enable internal stakeholders to reach consensus; social and noncontractual relationships endow external stakeholders with the identification of PIMs (Zeng et al. 2015). Nevertheless, only a few people or organizations recognize the necessity for SR-PIMs, as well as advocate it. The lack of SR-PIMs may generate negative emotions among stakeholders, possibly causing confrontation and distrust. In the case of SMCP, the absence of SR-PIMs resulted in local communities questioning the necessity of the project and in government and MCL treating the project as a means of fulfilling their own goals and interests.

Conceptual Governance Model for Public Participation in PIMs

Poor institutional arrangements and the lack of SR-PIMs are the culprits of irresponsible behaviors, which make public participation in PIMs ineffective because of conflicting interests. Furthermore, the specific reasons for this ineffectiveness are asymmetrical information among stakeholders, stakeholders' lack of participatory skills and knowledge, the absence of SR-PIMs, and ineffective laws/regulations.

For such reasons, a conceptual government model was proposed to enhance the enforcement of institutional arrangements and encourage the positive behaviors of participants (Fig. 6). Public participation should be conducted by a multiorganizational committee of PIMs, rather than a single agency/organization (Downs et al. 2003), consisting of governments, the organization, the public, and local communities.

Improving Institutional Arrangements

To reduce the game space, the committee and governments should establish information disclosure and feedback mechanisms for public participation (Sun et al. 2016b), and create principles and guidelines for public participation in PIMs. Meanwhile, informative materials regarding public participation should be produced. The committee should be the reservoir of experience and knowledge and should identify the loopholes in or obsolete aspects of policies to assist the legislative body in improving laws or regulations.

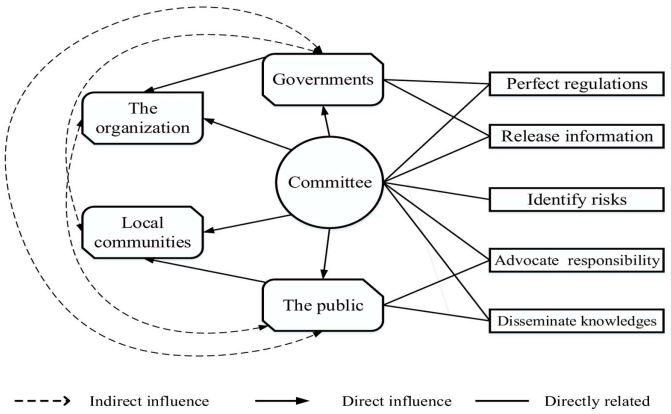

Fig. 6. Conceptual model of governance framework for public participation in PIMs.

Cultivating SR-PIMs

To produce responsible behaviors, awareness regarding SR-PIMs, such as social equity and legal, environmental, and regional development responsibilities, should be advocated and cultivated among all stakeholders during public participation (Zeng et al. 2015). Irresponsible behaviors of participants must be supervised, while positive behaviors must be promoted. The committee should cooperate with the public and local communities to identify the social risks in public participation and work with government and the organization to prevent a NIMBY event.

Strengthening Organization Building

The participatory capacity of stakeholders should be strengthened by organization building. Organizations and governments should establish special departments to manage public participation. Local communities should select representatives to a committee that will publicize necessary knowledge, negotiate with other stakeholders, and enhance cohesion and concerted action among local communities. NGOs and mass media play additional roles in advocating responsibility awareness, spreading knowledge, coordinating stakeholders, and assisting vulnerable groups in protecting their legal rights.

Conclusion

The high effectiveness of public participation is known to be important to the success of PIMs. To improve effectiveness, social utility equations were established to measure the effectiveness of public participation in PIMs, combined with a game theory model to compute social utility. SMCP was adopted as a case study to validate the model and the impacting mechanism. The results show that Situation I is the best public participation scenario. Moreover, the effectiveness of public participation is subject to the behaviors of stakeholders, which are influenced by two factors. First, poor institutional arrangements generate the game space (μ), which causes uneven division of interest among key stakeholders. Second, the lack of awareness regarding SR-PIMs results in irresponsible behaviors of participants and a reduction in social effect (ξ).

This study helps to close the gap in knowledge on how to measure the effectiveness of public participation in PIMs and the methods to improve it. It also provides a quantitative method to identify the direction of substantive public participation and guarantee the success of PIMs. The policy implication of PIMs for the global community is that high effectiveness of public participation entails responsible behaviors among stakeholders by perfecting institutional arrangements and cultivating SR-PIMs to reduce game space and expand social effects.

Data Availability Statement

All data generated or analyzed during the study are included in the published paper. Information about the *Journal*'s data-sharing policy can be found here: http://ascelibrary.org/doi/10.1061/(ASCE)CO.1943-7862.0001263.

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Notation

The following symbols are used in this paper:

c = value of PIM;
α = payoff of player;
α_1 = payoff of organization;
α_2 = payoff of local communities;
γ_{1i} = coefficient between organization and government in Situations I, II, III, and IV; $i = 1, 2, 3, 4$;
γ_{2j} = coefficient between local communities and public in Situations I, II, III, and IV; $j = 1, 2, 3, 4$;
μ = transferable payoffs between organization and local communities in Situations I, II, and III;
μ_1 = loss on organization in Situation IV;
μ_2 = loss on local communities in Situation IV;
ξ = social effect of each player;
ξ_1 = social effect payoff of organization; and
ξ_2 = social effect payoff of local communities.

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