CHAPTER 12 GAME THEORY AND PPP*

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1. INTRODUCTION

Game theory can be defined as "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers" (Myerson, 1991). It can also be called "conflict analysis" or "interactive decision theory," which can more accurately express the essence of the theory. Still, game theory is the most popular and accepted name. In PPPs, conflicts and strategic interactions between promoters and governments are very common and play a crucial role in the performance of PPP projects. Many difficult issues such as opportunisms, negotiations, competitive biddings, and partnerships have been challenging the wisdom of the PPP participants. Therefore, game theory is very appealing as an analytical framework to study the interaction and dynamics between the PPP participants and to suggest proper strategies for both governments and promoters.

Game theory modelling method will be used throughout this chapter to analyze and build theories on some of the above challenging issues in PPPs. Through the game theory modelling, a specific problem of concern is abstracted to a level that can be analyzed without losing the critical components of the problem. Moreover, new insights or theories for the concerned problem are developed when the game models are solved. Whereas game theory modelling method has been broadly applied to study problems in economics and other disciplines, only until recently, this method has been

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applied to study problems in engineering management problems, including PPPs (see Ho, 2001; 2005; 2006; Ho and Tsui, 2009; Ho and Tsui, 2010). The author believes that, in PPP research, there will be great potentials in gaining important new insights and building new theories by applying this method. These new theories will help practitioners, including governments, developers, and bankers, etc., better cooperate together, with higher efficiency and effectiveness.

This chapter has two major objectives. First, we aim to introduce the concept of game theory and the application of game theory modelling in PPPs. Second, new insights and theories concerning PPPs from the game theory modelling will be presented and discussed; particularly, focusing on the opportunism problems and the contingency view of PPPs as a governance structure. The organization of this chapter is as follows. Section 2 introduces the basic concepts of game theory and game theory modelling. Section 3 discusses the problems of unbalanced profit structure in PPP projects, crucial to the game theory modelling in PPPs. In section 4, a model concerning another opportunism issue, renegotiation/hold-up problem, will be discussed. In terms of game theory modelling, this model demonstrates how to abstract a problem and develop theories. In terms of PPPs, this model provides important policy implications concerning the renegotiation/hold-up problem. Sections 5 and 6 deal with asymmetric information problems in PPPs. Section 5 focuses on the signalling games and examines some popular signals sent by developers. Section 6 emphasizes governments' screening strategies for differentiating the types of the promoters/bidders. In section 7, a contingency theory for PPPs as a governance structure that combines the models in sections 4 to 6 is discussed. Section 8 presents a case study of Taiwan High Speed Rail, one of the largest PPP project in the world, and illustrates the opportunism problems and their transaction costs, caused by wrongly adopting PPPs as a governance structure for this project. Section 9 concludes this chapter.

2. BASIC CONCEPTS OF GAME THEORY AND GAME THEORY MODELLING

The following introduction of the fundamentals of game theory basically follows Gibbons (1992) and Binmore (1992). Here games will be categorized by whether or

not players move sequentially and whether or not the information is complete. In terms of moving sequence of players, there are two basic types of games: static games and dynamic games. Complicated by the information owned by players, the games can be further categorized into: static games of complete information, dynamic games of complete information, static games with incomplete information, and dynamic games of incomplete information. Fudenberg and Tirole (1991), Mas-Collel et al. (1995) and Myerson (1991) have excellent in-depth discussions on game theory. Readers already had knowledge of game theory may skip this section; otherwise, they are suggested to read this section so as to better understand the game theory modelling applications presented in the chapter.

2.1 Static Game of Complete Information

Some essential concepts and definitions in game theory shall be illustrated by examples of a two-player game. General cases of *n*-players definitions are omitted for convenience. The first example is the prisoner's dilemma, as shown in Fig. 1. Two suspects are arrested and held in separate cells. If both of them confess, they will be sentenced to jail for 6 years. If neither of them confesses, they will be sentenced for only 1 year. However, if one confesses and the other does not, the honest one will be rewarded by being released (in jail for 0 years) and the other will be punished with 9 years in jail. In Fig. 1, the first number in each cell represents player 1's payoff and the second number is for player 2. We use the left side of the table to represent player 1 and use the top of the table to represent player 2.

		Player 2: Confess	Player 2: Not confess
Player 1	Confess	(**-6**, **-6**)	(0, -9)
	Not confess	(-9, 0)	(-1, -1)

Fig. 1. Static Game: Prisoner's Dilemma

Figure 1 is a "normal form representation" of a game that specifies the players in the game, the strategies available to the players, and the payoff of each player for his strategy. The normal form representation is usually used in representing a "static game" in which they act simultaneously, or more generally, each player does not know the other player's decision before he makes his own decision. If the payoff matrix as shown in Fig. 1 is known to all players, then the payoff matrix is a "common knowledge" to all players in a game. In addition, the players of a game are assumed to be rational; i.e., it is assumed that the players will always try to maximize their payoffs. This is one of the most important assumptions in any economic analysis. If the players' rationality and the game structure, including payoffs, are common knowledge, the game is called a game of "complete information." Conversely, if each player's possible payoff is privately known by himself only, it is a game with incomplete information or asymmetric information.

To answer how each prisoner will play/behave in this game, *Nash equilibrium*, one of the most important solution concepts in game theory, will be introduced. If game theory makes a unique prediction about each player's choice, then it has to be that each player is willing to play the strategy as predicted. Logically, this prediction

should be the player's *best response* to the other player's predicted strategy. No single player will want to deviate from the predicted strategy, that is, the strategy is *strategically stable* or *self-enforcing* (Gibbons, 1992). This prediction following the above solution concept is called a "*Nash equilibrium*" (NE). In the prisoner's dilemma, although the (Not confess, Not confess) may seem better for both players, it is unstable since every player wants to deviate from this solution to get extra benefit or avoid the other's betrayal. Any suspect who deviates from (Confess, Confess) will be hurt and any suspect who deviates from (Not confess, Not confess) will be rewarded. Therefore, the only predicted strategy that no player wants to deviate from is (Confess, Confess) and this is the Nash equilibrium in the prisoner's dilemma.

In some games there will be multiple Nash equilibriums; that is, the uniqueness of Nash equilibrium is not guaranteed. Fortunately the existence of multiple equilibriums will not be a problem. Much of the game theory is an effort to identify a compelling equilibrium in different classes of games to make the prediction appealing (Gibbons, 1992). For example, the concepts of mixed strategy Nash equilibrium or focal point can resolve the problem of multiple Nash equilibriums. Detailed treatment of this issue will not be introduced here. The Cournot model for duopoly market in economics is an example of static games of completion information.

2.2 Dynamic Games of Complete Information

Most of the analysis in this research will be using the dynamic game with complete or incomplete information. However, the previous introduction of static game is essential because those concepts will be used repeatedly in other classes of games and in this chapter. In contrast to static games, players in a dynamic game move *sequentially* instead of simultaneously. Since the moves are sequential, it will be easier and more intuitive to represent a dynamic game by a tree-like structure, called an "*extensive form*" representation. In a dynamic game, suppose that the player who moves in a later stage can fully observe previous player's moves and know his own location in the game tree. This assumption is called "perfect information" assumption. In dealing with games of incomplete information, the games will be transformed into games of "imperfect information," where the player who moves in a later stage cannot fully observe previous player's moves.

We will use the following simplified Market Entry example to demonstrate the

concepts of a game analysis. A new firm, New Inc., wants to enter a market to compete with a monopoly firm, Old Inc. The monopoly firm does not want the new firm to enter the market, because new entry will reduce the incumbent firm's profits. Therefore, Old Inc. threatens New Inc. with a price war if New Inc. enters the market. Figure 2 shows the extensive form of the market entry game. If the payoffs shown in Fig. 2 are known to all players, the payoffs are "common knowledge" to all players. If the game structure, including payoffs, are common knowledge, the game is called a game of "complete information." The game tree shows (1) New Inc. chooses to enter the market or not, and then Old Inc. chooses to start a price war or not, and (2) the payoff of each decision combination.

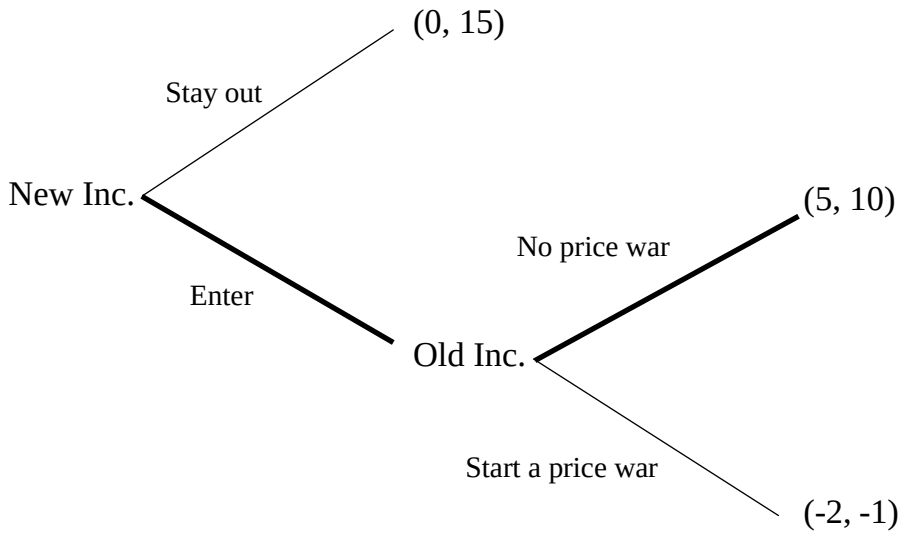

Fig. 2. Simplified Market Entry Game

A possible game prediction is that Old Inc. can use the strategy: to play "start a price war" if New Inc. plays "enter," so that Old Inc. can threaten New Inc. not to enter the market. As a result, it may seem that "stay out" and "start a price war if enter" is a solution satisfying the Nash equilibrium concept. Nevertheless, as shown in Fig. 2, the threat to start a price war is *not credible* because Old Inc. will not start a price war if New Inc. does enter; instead, Old Inc. will maximize the payoff by playing "no price war" after New Inc. enters the market unless the Old Inc. is behaving *irrationally*. New Inc. knows the threat's incredibility and therefore will maximize the payoff by playing "enter." Thus, the Nash equilibrium of the Price War game is (Enter,

No price war), an equilibrium that does not rely on the player to carry out an incredible threat. In a dynamic game, the equilibrium solution is a subgame perfect Nash equilibrium, which satisfies the sequential rationality by maximizing each player's payoffs in the subgames backward recursively (Gibbons, 1992).

2.3 Static Games of Incomplete Information

Games of incomplete information or asymmetric information are also called "Bayesian games," because it involves the use of Bayes' rules in solving for the equilibrium. Therefore, static games of incomplete information are also called static Bayesian games. The core issue of incomplete information is the existence of "*private information*" that is known only to specific players instead of to all players. This private information usually refers to the payoff functions of the players. The players with private information are called informed players. Similarly the players who are uncertain of the other players' payoff functions are uninformed players. The equilibrium of a Bayesian game is called "*Bayesian Nash equilibrium*." We won't be using this type of games in the models presented in the chapter.

2.4 Dynamic Games of Incomplete Information

After the introductions of static games of incomplete information, no extra explanation is required on what a dynamic game of incomplete information is. However, the possible equilibriums of this class of games are much more complicated than other classes of games, yet still closely related. In this class of games, asymmetric information on payoff functions will be converted to asymmetric information on players' "types," where different type of player has a different payoff function. The central concern of the equilibrium for this class of game is to resolve the asymmetric information problem by differentiating the "type" of a player. Since many games in the PPPs fall into this category, it is critical to fully understand their characteristics and the games' equilibrium concept: *perfect Bayesian equilibrium*.

In dynamic games of complete information, the subgame-perfect Nash equilibrium has to rule out incredible threats and time-inconsistent promises. However, in contrast to subgame-perfect Nash equilibriums, the perfect Bayesian equilibriums for dynamic games of incomplete information cannot be obtained

through backwards induction because it needs to be checked back and forth circularly. The primary steps to solve for perfect Bayesian equilibriums are to:

- find possible candidates of perfect Bayesian equilibriums, and
- check each candidate or each class of candidates for the satisfaction of perfect Bayesian equilibriums' sufficient conditions.

Two basic kinds of equilibriums are often checked for possible solutions. The first is the "pooling equilibrium," under which different types of informed players act indifferently and the uninformed player cannot differentiate the players' types according to their decisions. The second kind is the "separating equilibrium," under which different types of informed players act differently and, thus, the uninformed player can differentiate the types of informed players. For detailed explanations of why these conditions should be satisfied, one may refer to Gibbons (1992) and Fudenberg and Tirole (1991).

Spence (1973) was the first to show how "signalling" could be a solution to the asymmetric information problem. He modelled that, first, nature determines the types of worker's productivity ability: high (*H*) or low (*L*), with probability *p* of being type *H*. Here we name the high-ability workers as "worker *H*" and low-ability worker as "worker *L*." Second, the worker learns his ability and chooses his education level as a signal: high education or low education. For simplicity, it is assumed that it costs \$0 for both types of workers to obtain low education and costs C_H and C_L to obtain high education level for worker *H* and worker *L*, respectively. Third, the firm observes the worker's education level and offers the wage level, choosing from high wage or low wage.

The two basic possible equilibriums to be checked include:

1. Pooling equilibrium:

Intuitively, if the low-ability worker can obtain a high level of education as easily as the high-ability worker, the low-ability worker would want to obtain a high education level to convince the firm that he is high-ability worker. In this case, the firm cannot believe the signal sent by the workers, and therefore, will not offer a high wage level to the worker with a high education level.

2. Separating equilibrium:

The conditions for the signal to be effective or for the solution to be a separating equilibrium must be that it is not in the low-ability worker's interest to imitate the

high-ability worker. In this case, the firm will believe the signal regarding productivity ability and offer wages accordingly. These conditions can be expressed mathematically. The conceptual intuitions of these conditions are as follows. First, regarding the firm's wage offer decisions, the difference of the high-wage offer and low-wage offer must be large enough to compensate worker *H*'s extra education cost, but not large enough to compensate worker *L*'s high education cost. If the difference of wage offers are too large such that worker *L* is willing to incur extra education cost, the signal would become ineffective. Second, regarding the costs to different types of workers, worker *H*'s signalling cost, C_H, must be less than worker *L*'s signalling cost, C_L, which is usually true in the job market signalling game if we believe that worker *H* is smarter than worker *L*. Cho and Krep (1987) further showed that the separating equilibrium will be the only possible equilibrium. Detailed discussion regarding the job market signalling game can be found in Spence (1973,1974) and Cho and Krep (1987).

2.5 Theory Building through Game Theory Modelling in PPPs

To build theories through game theory modelling, first, a game theory model will be developed to properly abstract the problem of concern. In this step, appropriate assumptions have to be made to for simplifying the problem so as to focus on a few critical components. In addition to the knowledge of game theory, this model setup process needs sufficient domain knowledge for the problem. A thorough literature review or case studies generally will provide better and more precise understandings of the concerned problem and associated issues.

The second step is to solve for the conditions of all possible or specific equilibriums of the game model. The number of possible equilibriums and the complexity of the equilibrium solutions depend on the complexity of the game model and the number of variables associated with payoff functions.

The last step is to link the equilibrium conditions to the issues of the problem. If the equilibrium solutions are complicated, identifying possible contextual or contingency variables will narrow the possible solution space and provide more insights for the problem. Once the logic between different variable configurations and possible equilibriums are established, theories concerning the problem can be developed.

3. PROBLEMS OF UNBALANCED PROFIT STRUCTURES IN PPPs

3.1 Profit Structure and Profit Pool of a PPP Project

In PPPs, the sources of the promoters' investment returns will not only come from the returns of equity investments in the concessionaire, but also from the construction and operation contracts since the promoters would often act as the *major* contractors for construction and operation. Therefore, the promoters, being the controlling shareholders, will aim to maximize the overall value of the combined pool of profit components. In other words, the profit structure of promoters is inconsistent with that of the passive shareholders of concession firms.

The profit structure of a PPP investment can be better explained by the PPP business model illustrated in Fig. 3, which shows that the returns of PPP investment include equity returns, construction contract returns and operation contract returns. We will call the three profit components together the PPP "profit pool." From the promoter's perspective, the profits from a PPP investment are the overall returns from the profit pool. Moreover, how these components are pooled in terms of their relative proportion will have major influences in determining the returns from profit pool, the promoters' investment and potential opportunism, and the interactions between the government and promoters.

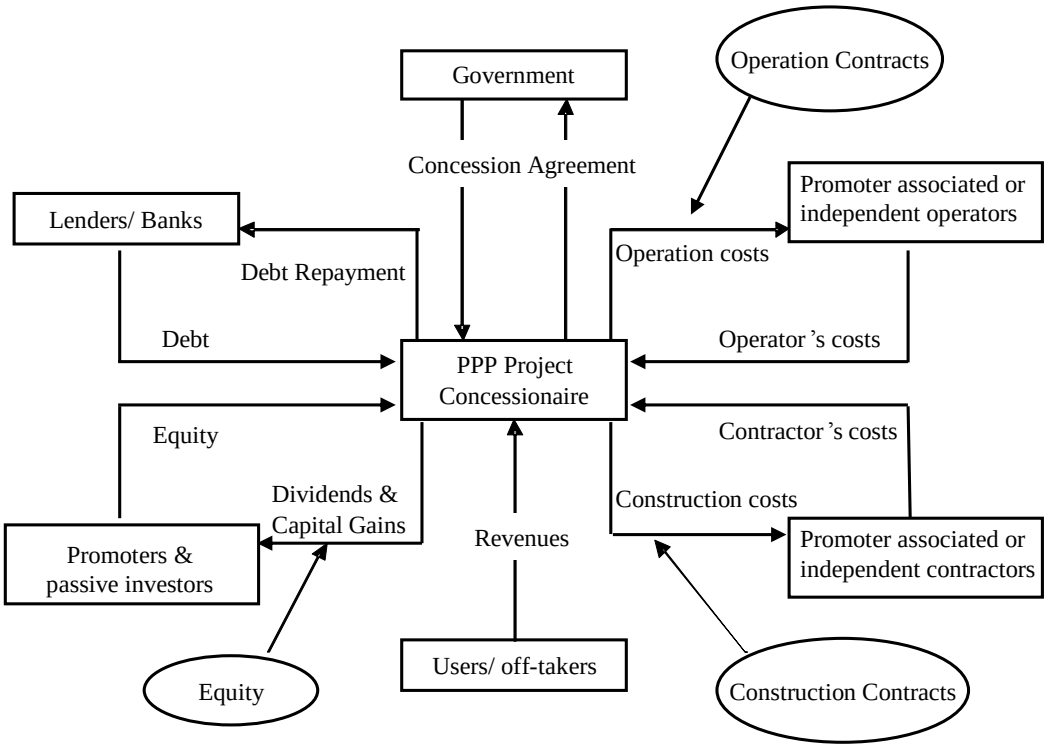

Fig. 3. Promoters' Profit Structure and Profit Pool in PPP Projects

- *First Component: Equity Returns.* The first component in the profit pool is the equity returns in a PPP firm, defined as equity value minus equity investment, denoted as E - I. In PPPs, following the project finance practice, the promoters will become one of the major shareholders of the PPP firm, whom shall be called "controlling shareholders" in this chapter. The equity invested by non-promoters will be considered as the "passive equity," owned by "passive shareholders." Unlike the passive shareholders, such as insurance companies, who mainly focuses on the returns from equity investment, the promoters, being the controlling shareholders, will aim to maximize the *overall* value of the combined pool of profit components. In other words, the equity returns are not the only profits sought by the promoters in a PPP project.
- *Second Component: Construction Contract Returns.* The construction contract returns refer to the profits from promoter's being the construction contractors of a PPP project. These construction related returns are denoted as P_C, where the subscript $_C$ represents construction contracts. As Walker & Smith (1995) observed, since most construction firms are thinly capitalized and rely heavily on short-term

debt financing for their capital needs, they are usually reluctant to invest their limited and expensive capital in PPP equity and largely focus on construction contracts. This is especially true when the concession period is long and the returns from equity are slow.

- *Third Component: Operation Contract Returns.* The third component in the profit pool is the returns from operation contracts undertaken by the promoter, denoted as $P_{O,}$ where $_O$ represents operation contracts. The operation contracts refer to the contracts for the daily operation and regular maintenance after the project is completed or the operation commences. For example, the insurance policies for the facility properties, firm employees or operation liability can be considered part of the operation contracts. Other operation contracts may include supply contracts for operational inputs, contracts for regular maintenance, and contracts for outsourcing services, etc. Those who are capable of undertaking operation contracts and consider these contracts profitable may invest in the project as one of the controlling shareholders. An important characteristic of the operation contract returns is that the returns are possible only when the project is completed and the PPP firm continues with the operation. This difference between construction contract returns and operation contract returns plays an important role in the governance design of PPPs as we shall discuss later.

3.2 Value of Profit Pool (VoPP)

The VoPP is defined by the sum of the returns from the above three components of a PPP profit structure, mathematically expressed as $E\text{-}I+P_C+P_O$. VoPP, thus, can be considered the net value to a promoter from a specific PPP investment; i.e., the overall profits to the promoter. Whereas traditional theories in corporate finance emphasize that a firm's objective is to maximize its value, or, equivalently, to maximize equity value, we argue that the objective of a PPP firm should be assumed to maximize the promoter's VoPP, because the VoPP is the returns of the major shareholder of the PPP firm, also the promoter. Note that, for passive or minority shareholders, equity returns are still their sole returns from the project and, therefore, the maximization of equity value is the objective of their investment. We argue that the deviation of the PPP promoter's objective from traditional objective in a non-PPP

firm creates serious problems, especially opportunisms, when the profit structure is unbalanced.

3.3 Problems of Unbalanced Profit Structure

An unbalanced profit structure in PPPs is defined by that the PPP profit structure is skewed to focus on the short-term profits, particularly, the construction contract returns, P_C. The unbalanced profit structure underlying PPPs gives the controlling shareholders the incentives of opportunism. The ownership structure of PPPs further gives the controlling shareholders the capability to exploit private information in seeking appropriable rents from passive investors. The controlling shareholder may benefit from manipulating the construction contract prices and clauses and, as a result, the minority shareholders, subject to severe information asymmetry, will suffer from losses in equity returns. As such, controlling shareholder-passive shareholder conflicts may seriously impair the financial situation and performance of the project and lead to significant transaction costs in PPPs.

In the cases where equity is allowed to be raised publicly before project completion, the passive shareholders will be in an even weaker position because of the serious information asymmetry in unfinished projects and the relief of the controlling shareholder's equity investment requirement. Moreover, since the use of project finance in PPPs allows a low equity ratio, the danger of early public equity raisings due to the unbalanced project structure problem is further aggravated.

4. PROBLEMS OF FINANCIAL RENEGOTIATIONS/HOLD-UP IN PPPs: DYNAMIC GAME OF COMPLETE INFORMATION

Financial renegotiation and the associated hold-up problems may happen when project cost, market demand or other market conditions become significantly unfavourable and cause the promoter to renegotiate with the government for subsidies or rescue. The dilemma faced by the government is that although financial renegotiation is not legitimate, the government is often tempted to accept the renegotiation because of the gigantic costs of project failure. Such inconsistency creates serious opportunism problems and associated transaction costs. A game theory

model developed by Ho (2006) analyzed the strategic interactions concerning renegotiation/hold-up and proposed related procurement and management policies from the perspective of renegotiation/hold-up. We shall present the model and discuss how the problem is modelled and what the major policy implications are.

4.1 Inefficiency due to Financial Renegotiation/Hold-up

4.1.1 Ex-ante inefficiency: aggressive investment and bidding

Expectation of government for renegotiation under project distress may cause opportunistic bidding, typically seen in construction practice. In opportunistic bidding, bidders, in their proposals, intentionally understate the possible risks involved or overstate the project profitability to outperform other bidders. In their pilot study on opportunistic bidding, Ho and Liu (2004) shows that, if a builder can make an effective construction claim, the builder will have an incentive to bid opportunistically. Similarly, if a request for renegotiation is always granted, promoters would have an incentive to bid optimistically or aggressively to win the project. An overly optimistic proposal can have a higher chance of winning given the fact that many crucial and promoter-specific project information in the bid proposal can be very difficult to be verified and the government tends to favour those proposals with beautiful financial forecasts. Therefore, if the bidders have an *ex ante* expectation of *ex post* renegotiation, they will have an incentive to bid opportunistically. Since this logic between governments' rescuing subsidies due to renegotiation and the project's early failure due to opportunism is not straightforward, the importance of financial renegotiation problem is underemphasized.

4.1.2 Ex-post inefficiency during the concession period

In his repossession game example, Rasmusen (2001) shows that if renegotiation is expected, the agent may choose inefficient actions that will reduce overall or social efficiency but increases the agent's payoff. In *PPPs*, after signing the concession, moral hazard problems may also occur if renegotiation is expected. As promoters are frequently the major contractors of *PPP* projects, they may not be concerned about cost overruns because they may benefit from such overspending. Moreover, promoters may not concern the operation efficiency either during the operation period.

4.2 Modelling of Financial Renegotiation/Hold-up and the Equilibriums

The behavioural dynamics of the renegotiation, or government rescue, plays a central role in *PPP* administration given that information asymmetry generally exists. Here, game theory is applied to analyze how the government will respond to the promoter's request for renegotiation and the impact of such renegotiation on PPPs.

4.2.1 Model Setup

The game theory framework for analyzing a *PPP* investment shown in Fig. 4 is a dynamic game expressed in an extensive form. Suppose a *PPP* contract does not specify any government rescue or subsidy in the face of financial crisis. Neither does the law prohibit the government from bailing out the *PPP* project by providing a debt guarantee or extending the concession period. Suppose also that government is not encouraged to rescue a project without compelling and justifiable reasons. Cost overrun or operation losses caused by inefficient management or normal business risk are not considered just reasons for government rescue, whereas adverse events caused by unexpected or unusual equipment/material price escalation may be justified more easily. It should be reasonable to assume that if the government grants a subsidy to a project on the basis of unjustifiable reasons, the government may suffer the loss of public trust or suspicion of corruption.

The dynamic game, shown in Fig. 4, starts from adverse situations where it is in the promoter's (denoted by D in the game tree) or lending bank's best interests to bankrupt the project if the government (denoted by G) does not rescue the project. Alternatively, the promoter can also request government rescue and subsidize for the amount of $\$U$, even though the contract clause does not specify any possible future rescue from the government. Here U is defined as the present value of the net financial viability change, and is considered as the maximum possible requested subsidy. Note that U is not the actual subsidy amount. The actual subsidy is determined in the renegotiation process discussed later.

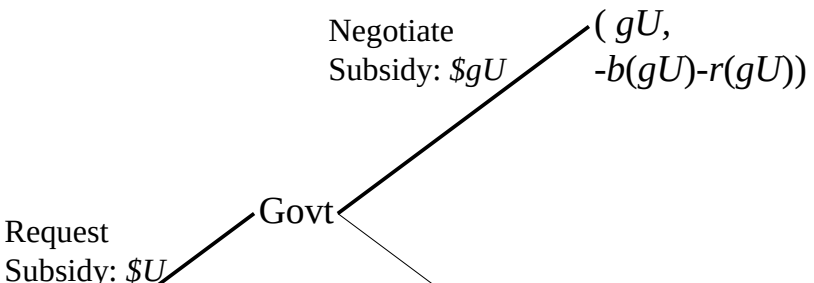

Fig. 4. Renegotiation Game's Equilibrium Path

On the other hand, if a *PPP* project is bankrupted, the payoff of government is $-b(G+\tau)$, the *political cost due to project retendering*, where G is the least required government funds for financially restructuring a project when a project is bankrupted and retendered, and τ is the opportunity cost for replacing promoters, which may include the retendering cost and the cost of interruption due to the bankruptcy and retendering process. Suppose that for a *PPP* project to proceed beyond procurement stage, the project must have been shown to provide facilities or services that can be justified economically. In this game, it is assumed that retendering is desired by government as often observed in practice if a project is going bankrupt.

Alternatively, as shown in Fig. 4, the promoter can negotiate a subsidy starting with the maximum amount $\$U$, where the subsidy can be in various forms such as debt guarantee or concession period extension. Typically the bank will not provide extra capital without a government debt guarantee or other subsidies. Because the debt guarantee is a liability to the government, but an asset to the promoter, a debt guarantee is equivalent to a subsidy from government. Other forms of subsidy may include the extension of the concession period, more tax exemption for a certain number of years, or an extra loan or equity investment directly from government.

After the promoter's request for subsidy, the game proceeds, as shown in Fig. 4, to its sub game: "negotiate subsidy" or "reject." If the government rejects the promoter's request, the project will be bankrupted and retendered and the payoff for both parties will be $(0,-b(G+\tau))$. If the government decides to negotiate a subsidy, expressed by the *rescuing subsidy ratio g*, a ratio between 0 and 1, the payoff to the promoter and the government will be $(gU,\ -b(gU)-r(gU))$, respectively, where $-b(gU)-r(gU)$ is the *political cost due to the rescuing subsidy to a private party*, including two functions *b* and *r*, as we shall explain later. To rescue a *PPP* project and provide rescuing subsidy to the original *PPP* firm could bring serious criticism toward government. If the government lacks compelling reasons for the subsidy, the criticism will cause significant *political* cost depending on the magnitude of the subsidy. The differences between the two functions will be discussed in detail later. Here '*g'* is not a constant and is used to model the process of 'offer' and 'counter-offer'. More details on negotiation modelling using *g* can be found in Ho and Liu (2004).

4.2.2 Modelling of Political Costs

- *Political Cost of Bailing out*

If government negotiates the subsidy with the existing promoter and rescues the project, the function of the political cost to government is modelled here as $b(gU)+r(gU)$, where $b(\bullet)$ is the function of political cost of budget overspending, and $r(\bullet)$ is the political cost of over subsidization. The mathematical modelling of the political cost of bailing out is based on the fundamental concept that resources are scarce. If the government has unlimited funds to spend there would be no political cost for bailing out a project. Since the government only has limited budget there will be a political cost should the additional funds be needed for the project. The more the government funds are needed, the higher the political cost is. Here $b(gU)$ measures the political cost caused by budget burden from subsidies and is considered the "basic" political cost. As shown in Fig. 5, the political cost of bailing out should be an *increasing* function of the amount of subsidy, *gU*.

In addition to the basic political cost, it is assumed that for the subsidy exceeding a justifiable amount, further political costs, $r(gU)$, would be incurred to reflect a serious resource misallocation. To define the function $r(\bullet)$, we shall first define *J*, the amount of the subsidy that can be justified without criticism of over subsidization,

In the model '*J'* is termed the "justifiable subsidy," which is considered by the public an eligible claim for subsidy. '*J'* can be measured by imagining the amount of 'claim' that could be granted to the promoter had the case gone to court. For example, the damages due to force majeur might be considered justifiable. If the subsidy is less than the justifiable claim, the government will not be blamed for over subsidization. Therefore, as illustrated in Fig. 5, $r(\bullet)$ can be defined by that $r(gU)$ is zero when $gU \le J$ and that $r(gU)$ becomes an increasing function when the subsidy is greater than *J*, meaning that the government will be criticized for over subsidization or suspected of corruption, and will suffer further political cost in addition to the basic political cost. The overall political cost of bailing out, $b(gU)+r(gU)$, as shown by the kinked curve in Fig. 6, is obtained by adding the two components in Fig. 5.

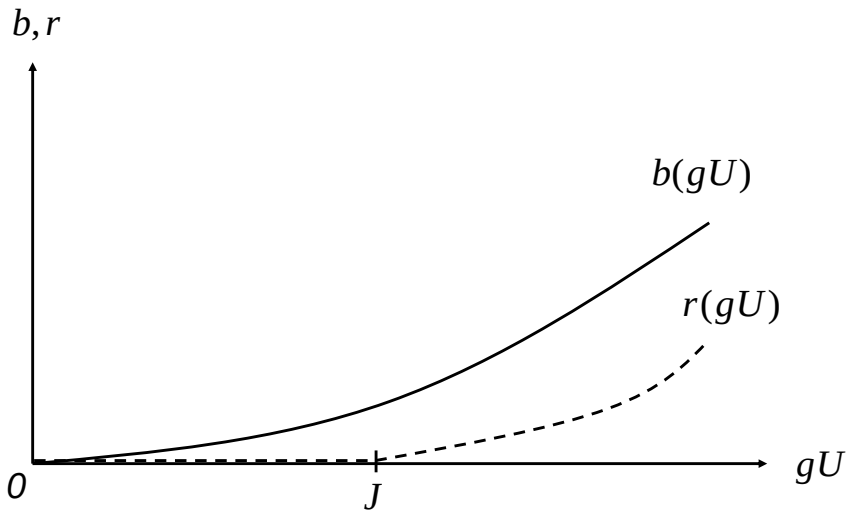

Fig. 5. Political costs of bailing out

- *Political Cost of Project Bankruptcy*

Assuming the lending bank can effectively monitor the project's financial status, it may be inferred at the time of bankruptcy that the overall value of the project is less than or close to the estimated total outstanding debt. As a result, under near bankruptcy conditions, it is unwise for the bank to continue providing additional

capital and, thus, the lending bank will deny further capital requests, even when such capital is still within project's original loan contract.

When a project is bankrupted, it will be considered "sold" to government and retendered to another private promoter given the assumption that the project is still worth completing. The government may want to regain control of the project for retendering because a *PPP* contract is usually related to public services and cannot be transferred directly to a new promoter without a new concession. From this point of view, to government, bankruptcy is equivalent to a costly replacement of the promoter. Because of the use of project finance in *PPP*s, the project to be retendered by the government will still be mainly financed by debt. As a result, when a project is bankrupted, the amount of budgeting burden can be modelled as $G+\tau$. Following the definition of function $b(\bullet)$, the political cost of project bankruptcy can be modelled by $b(G+\tau)$, as shown in Fig. 6.

4.2.3 "Rescue" or "No Rescue:" Nash Equilibriums of the Rescue Game

As mentioned previously, the financial renegotiation game tree derived above will be solved backward recursively and its Nash equilibrium solutions will be obtained. Since the values for the variables in the game's payoff matrix are undetermined, the payoff comparison and maximization cannot be solved for a unique solution. However, the conditions for possible Nash equilibriums of the game can be analysed. There are three candidates for the Nash equilibriums: (1) the promoter will "request a subsidy," and the government will "negotiate a subsidy," (2) the promoter will "request a subsidy" and the government will "reject," and (3) the promoter will choose "project bankruptcy." The first equilibrium shall be called "rescue equilibrium" and the second and third equilibriums will be called "no rescue equilibriums."

Ho (2006) solved for the conditions for "rescue equilibrium" and showed that it is impossible to rule out the "no rescue equilibriums." As shown in Fig. 6, when *G* is less than *S*, the intersection of the curves $b(gU)+r(gU)$ and $b(G+\tau)$, the rescue equilibrium will be obtained. Furthermore, this condition for rescue equilibrium will be expected by the promoters and will induce the opportunistic behaviours from the promoters. The most important policy implication from the analysis by Ho (2006) is that government polices on PPPs should try to reduce the magnitude of *S* so as to decrease the possibility of opportunism from the promoters. For example, as shown in

Fig. 7, when the slope of function $r(\bullet)$ becomes steeper due to certain polices, the magnitude of *S* will be reduced significantly. Similarly, *S* can also be effectively reduced when *J* or τ is reduced.

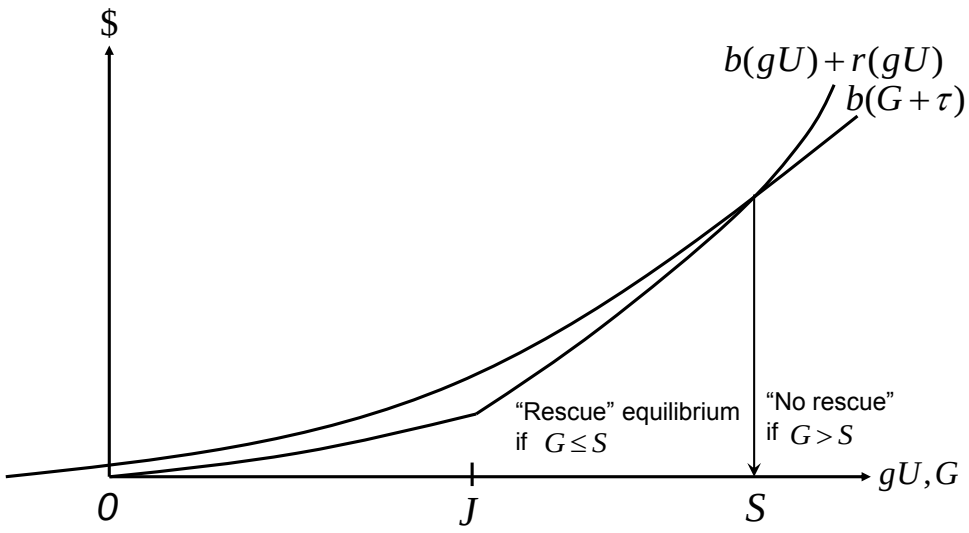

Fig. 6. Conditions for "rescue" equilibrium and "no rescue" equilibrium

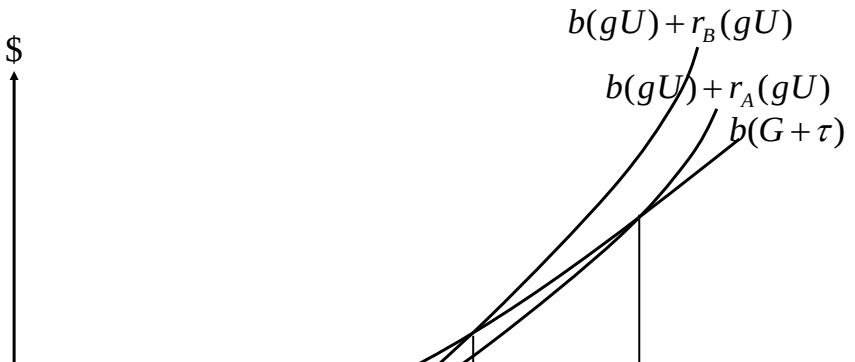

Fig. 7. Impacts of the change of $r(\bullet)$ on the equilibriums

4.3 Governing Principles and Policy Implications for Project Procurement and Management

Governing principles and administration policy implications can be obtained from the game theory analyses. Whilst the proposed model does not provide the approaches to quantifying the game parameters this pilot study focuses on the characteristics of the game parameters/functions and the relationship between these parameters. The focus will be on which strategies can reduce the renegotiation problem and enhance the administration in *PPPs*. Suggested governing principles and administration policies for *PPP* projects are given as follows.

Governing Principle 1: Be well prepared for renegotiation problems, as it is impossible to rule out the possibility of renegotiation and the "rescue" equilibrium.

Since it is impossible to rule out the "rescue" equilibrium, the government should be well prepared for the opportunism problems induced by the *ex ante* expectation of renegotiation as discussed previously. Policy implications from this principle include:

- In project procurement, the government should recognize the possibility of opportunism problems and cannot consider the promoter's financial plan as a binding, credible contract.
- The government could devise a mechanism to induce promoters to reveal more private information. For example, the government can establish a formal policy to disqualify a promoter if they are shown to have the history of behaving opportunistically.

Governing Principle 2: Although renegotiation is always possible, the probability of reaching "rescue" equilibrium should be minimized and could be reduced by strategies that increase the political cost of over subsidization, $r(\bullet)$, and reduce the promoter replacing cost, τ, and the justifiable subsidy, J.

One way to reduce the opportunism problems is to minimize the probability of "rescue" equilibrium and the promoter's expectation of the probability. Policy implications of this principle may include:

- Laws may regulate the renegotiation and negotiated subsidy, and such laws will increase $r(\bullet)$, when the subsidy is not justifiable.
- A good monitoring or 'early warning' system can give the government enough lead time to prepare for replacing a promoter with minimal impact, and hence, reduce τ.
- To reduce *J*, the government should pay attention to the quality of the contract in terms of content and implementation, e.g., the scope, risk allocation, documentation, and contract management process.

Governing Principle 3: The government should determine a fair justifiable subsidy, J, which corresponds to the promoter's responsibilities and allocated risks specified in the contract.

Holliday et al. (1991) argue that because of the scale and complexity of PPP projects they are *often promoter-led*, and it is extremely difficult to identify a clear client-contractor relationship. The "promoter-led" phenomenon implies information asymmetry and an opportunism problem in *PPP* projects where the promoter may hide information and have an incentive to behave opportunistically. Policy implications may include:

- The government can separate the promoter from the builder/contractor in a *PPP* project to have a clearer client-contractor relationship.
- The government can assign third party experts to serve on the Board of the project company to ensure proper monitoring and the collection of accurate information.
- Risk assignment between the concessionaire and government should be made explicitly in the agreement. This could help to determine a fair *J* in the future.
- The government should carefully consider and specify when they may intercede and what they should do. By temporarily taking over a project, the government

should focus on having more information regarding *J* and *G*, and on reducing τ through gaining longer lead time to prepare for the retendering.

5. PROMOTERS' PPP STRATEGIES FOR SIGNALLING: DYNAMIC GAMES OF INCOMPLETE INFORMATION

5.1 Signalling Games in PPPs

Signalling games are the most widely applied class of dynamic games of incomplete information. The first move of such game is initiated by the player often called "Sender." The Sender has private information regarding his type; e.g., low productivity-ability or high productivity-ability. In the PPP signalling game, the promoter is the sender of signals and the government is the receiver. The main idea is that effective communication can occur if one type of player is willing to send a signal that would be too expensive for the other type of player to send (Gibbons,1992). Thus, it is important to know which signals under which conditions will reach the separating equilibrium in the PPP signalling game. The signalling game analysis is expected to provide both the promoters and government with deeper insights toward their strategies in PPPs.

In a PPP project, the promoter will send signals to the government in order to convince the government regarding the promoter's type. From the perspective of unbalanced profit structure problem, the promoter's types can be categorized into "long-term profit oriented" (LT type) or "short-term profit oriented" (ST type), which can be determined by the relative magnitudes of different components in the profit structure. Examples of signals may include the equity level of the project cost, the financial projections, and the self-exclusion of being a construction contractor, etc. One can also view *the proposal* itself *a collection of signals*. The actions of the government after receiving the "signals" or proposals would be the proposal evaluation scores that lead to the decision of project awarding.

5.2 Separating Equilibriums of the PPP Signalling Game and Equity Ratio as a Signal

The following analysis will be in the conceptual level, instead of technical details, so that the readers won't be distracted by the technical difficulties. In a PPP project, the promoter's payoffs are the VoPP, as discussed earlier. The VoPP and the relative magnitudes of its three components depend on the type of the promoter, which is unknown to the government. For the government, it is natural that a type *LT* promoter is favoured by the government over type *ST* promoter. In a signalling game, the *LT* promoter may try to send *costly signals* to signify the promoter's type. The costs of the signals are mostly reflected on the impacts, mostly negative, on the VoPP. For the signal to be effective so as to reach the separating equilibrium, the costs of the *LT* promoter's signal must be significantly lower than *ST* promoter's costs for sending the same signal. If the costs of a signal must render the VoPP to be negative, the promoter will not send such signal.

As argued previously, it is assumed that the government's major concern is the project's financial viability, reflected by the returns to the shareholders, specifically, $E - I$, the first component of the VoPP. However, the government's concern for the value $E - I$ is inconsistent with the promoter's concern for the VoPP, $E–I+P_C+P_O$. As argued previously, with a highly unbalanced PPP profit structure, it is possible that the promoter may have a loss on equity investment; i.e., negative $E - I$, but still enjoy a high overall VoPP due to the significantly higher P_C. Therefore, in a signalling game where the government is unsure about the promoter's type, the *LT* promoter's goal is to send the signals that convince the government that they have positive and reasonably good returns on equity investments. For example, some PPP promoters use "high equity ratio" as a signal for positive *E-I*, because, if the project is not financially viable, the high equity ratio will yield tremendous losses in equity. However, the costs of using high equity ratio do also raise the costs of the PPP investment since the required return rate/capital costs for equity is much higher than that of debts or bank loans. Here the high equity ratio may constitute a separating equilibrium because the *ST* promoter usually cannot send the same signals. The use of high equity ratio is too costly for the *ST* promoter because without the compensation from the construction

contract returns, the promoter may have a negative VoPP due to the losses from equity investment.

Note that a signal may be effective only under the game equilibrium; that is, the government can differentiate the quality or costs of the signal. If the government does not recognize the cost difference of the signal, then the *LT* promoter may not be willing to convey such costly signal. We shall come back to this off-equilibrium situation and its strategy implications in section 7.

5.3 Other Possible Signals and Their Effectiveness

Previously, it was concluded that the promoter's high equity ratio can be effective signals. Further analysis on the effectiveness of other potential signals sent by promoters can be evaluated. Here, we will discuss the effectiveness of some other popular signals sent by promoters. Note that the conclusions on the signal effectiveness can be different under different contexts.

5.3.1 Low Project Costs

It is reasonable that the government prefers those proposals that suggest lower project costs. However, since PPP projects are not procurement by traditional design-bid-build or design-build scheme, the proposed project costs are not paid by the government and not binding, there are virtually no subsequent costs/losses to the promoter for proposing understated, untruthful project costs. As a result, low project costs should not be an effective signal for separating equilibrium. In the off-equilibrium situation where the government does not realize the ineffectiveness of such signal, if the low project costs are one of the government's important evaluation criteria, the *ST* promoter may have incentives to imitate the low-cost promoters in order to enhance the proposal's winning probability. Consequently, if the government takes low project costs as a good signal, the cost information disclosed in the bid proposals will be distorted.

5.3.2 High future operating cash flows

The proposal's future operating cash flow or toll revenue projection is also one of the project's most critical financial figures because the project's financial viability mainly depends on such cash inflows. However, they may be also the most unreliable figures in the project proposal. Similar to the project cost signal, since the projection of

project cash inflows is not binding and the costs reporting the overly optimistic projection are minimal, this signal should be ineffective, let alone the difficulty of estimating the revenues for the long concession period. Unfortunately, inexperienced governments often take these cash inflow projections as one of the critical signals without evaluating their credibility or quality. When wrong signals are taken, the information will be distorted and the government will choose the wrong promoter.

5.3.3 Concession period proposed and profit/risk sharing scheme

The concession period and profit/risk sharing scheme shown in the proposal are almost *binding provisions* although the concession contract has not been signed. Therefore, the concession period and profit/risk sharing scheme will have material impact on the promoter's VoPP for different types of promoters. These two signals may be more effective in general.

5.3.4 Requesting no government subsidies

The subsidies from the government may be in the form of government debt guarantee, operating revenue guarantee, or direct subsidies for construction costs. These guarantees typically are provided only when the project's future revenue is not high enough or too uncertain such that the project cannot be financially viable without the government guarantee. In this case, some proposals may require certain government guarantees. However, the government usually prefers that the promoter does not require any subsidies or guarantees from the government. However, it is difficult to enforce such promise appeared in a proposal, especially when the government cannot tolerate project failures and does not have clear policies regarding post-awarding negotiation or financial renegotiation. In other words, if governments are subject to be easily held up, requesting no subsidies in the proposal should not be taken a good signal.

Alternatively, we argue that the government should thoroughly analyze the PPP project's financial feasibility from both the promoter's and shareholder's perspectives and decide whether subsidies are necessary before requesting for proposals. If it is decided that the subsidies may be necessary, the government should form and announce the subsidy policies upon the invitations for proposals. At the same time, the government should do her best to prohibit or discourage any post-awarding

requests for the subsidies if the promoter did not ask for the subsidies in the proposal. Under such context, requesting no subsidies may become an effective, credible signal.

5.3.5 Written commitments from the lending banks

The letter of commitments implies that the project will be able to be financed, with a reasonable interest rate. Because the sources and costs of debt play a crucial role in the success of PPP projects, a proposal without the lending bank's commitment may turn out to request the government for debt guarantee or interest subsidization after the project is awarded. Therefore, it may be easier for the LT promoter to obtain the letter of commitment from the banks. As a result, the written commitment from the lending banks is generally considered a good signal in practice if the lending banks are reputable banks with PPP experiences. However, since the banks are usually not bonded by the commitment and can refuse to provide loans in the concession/contract negotiation stage, some banks may not be so serious or conservative in their commitments so as to have the options for possible business. In this case, the effectiveness of this signal may not be as good as we have expected.

5.3.6 Self-restriction of not becoming a construction contractor

By definition, the *LT* promoter's major profits are mainly from equity returns, *E-I*, and/or operating related contract returns, P_O, instead of construction contract returns, P_C; thus, it may be less costly for the LT promoter to exclude himself from becoming the future construction contractor. This signal should be very effective. However, the signal may cause additional costs to the PPP firm/project, instead of the promoter, because of the sacrifice of the benefits of better design integration through contractor's actively participating in the early stage. The additional costs may render the proposal in an unfavourable situation in competitive bidding. Moreover, even for the LT promoter, many PPPs projects cannot be financially feasible without the extra returns from partially undertaking the construction contracts.

6. GOVERNMENT PPP STRATEGIES FOR SCREENING: DYNAMIC GAMES OF INCOMPLETE INFORMATION

6.1 Screening Games and PPPs

Alternatively, governments can play screening games by becoming the first mover and setting criteria for screening out unwanted promoters. "Screening" was used to refer to the market process studied in Rothchild and Stiglitz (1976), in which the information problem in the insurance model was similar to that in Spence's (1973) job market model as discussed previously in the introduction of game theory. In the screening game, the Receiver initiates the move and the Sender responds. An effective screening scheme design can induce the Sender to reveal private information or types. For example, in the job market analysis, the firm may make the first move by specifying a menu of contracts regarding the education levels and wage offers. The workers will then respond by selecting their preferred contracts. In the job market, an effective screening menu of contracts would induce the worker *H* to select the contract with a high education level and a high wage, and the worker *L* to select a low education level and a low wage contract. On the other hand, an ineffective screening scheme cannot induce the workers to reveal their types. For instance, if the difference of the wage level is too large, it may be optimal for worker *L* to imitate worker *H* invest more on education and obtain the high wage. If the difference of the wage level is too small, it may be optimal for worker *H* to select low education, thus eliminating the need to incur high education cost.

The use of screening criteria can be regarded as governments' strategies for the implementation of PPPs. The central issues and the game equilibrium concepts are very similar to those in signalling games. An effective screening criterion must be that only those who are of the desired type can satisfy the requirement with reasonable costs. We argue that since PPP projects are usually initiated by governments, who often have specific goals to achieve, playing screening games seem to be more sensible and effective for governments than waiting for the promoter or bidders to guess what the government wants and to send out ineffective signals.

6.2 Government Roles, Strategies, and Promoter's Decisions

As argued previously, the promoter's maximization rationale should be applied to the investment's VoPP, instead of the equity value of the PPP firm. As a result, the promoter will make decisions according to the VoPP maximization rationale. However, if the government imposes certain PPP criteria or policy for screening, the

promoter's optimal decision will be affected by the policy. For example, if the government is constrained by the law or policy that forbids any forms of subsidy toward rescuing distressed projects, "no rescue" will be the equilibrium of the financial renegotiation game, expecting that it will more difficult to hold up the government, the promoter will then be less likely to bid aggressively.

6.2.1 Government Roles and Strategies

Smith (1999) maintained that "*by the beginning of the twentieth century, the relationship between the private sector and government in infrastructure procurement had begun to reach some kind of maturity*." He summarized that the relationship had made the government acting more possible roles today than before, including regulator, customer, facilitator, investor, planner, protector of the public interest, defender of the realm, guarantor, an agent of economic change, and supporter of export trade, etc. Depending on differences in countries and economic and political environments, the emphases on the government's roles are different. As a result, different roles expected upon the government by the public will result in different policies, and different policies will have critical impacts on the government's attitudes or strategies toward PPPs. For example, governments in emerging countries that mainly act as a planner and an agent of economic change may not have the policies against subsidizing a distressed PPP project, since the government's major role is to provide the infrastructure and boost the economy. In this case, the fairness concern may not be as important as that in developed countries. On the contrary, a government that mainly acts as a protector of public interest may have tighter regulations on the PPP project's tendering and contract management in order to prevent corruption, over-subsidization of the project, or project's unreasonably high returns.

6.2.2 Government's PPP Strategies and the Proposal Evaluation

The awarding of a PPP project under competitive scheme will usually be given to the proposal wining the highest overall evaluation scores. Thus, the evaluation criteria for assigning scores to a proposal will be crucial to the promoter's developing and bidding strategies. In PPPs, government screening strategies may be transformed into the evaluation criteria. From separating equilibrium perspective, effective evaluation criteria will have the promoters self-select into different levels of the criteria

according to their characteristics so that only the desired promoters will be selected or stand out.

6.3 Evaluation of Some Government PPP Screening Strategies

In this section, the effectiveness of some popular or possible government screening strategies or promoter evaluation criteria will be discussed. In fact, since the screening games are almost the same as the signalling games except for the moving sequence, the effectiveness of the signals discussed previously can be applied to the PPP screening when these signals are used as screening criteria.

6.3.1 Financial Package as an Evaluation Criterion

According to Tiong (1996), among those critical success factors in winning a PPP project, the "financial viability" was recognized as one of the most important factors. Tiong (1996) listed some typical government evaluation criteria toward a PPP project's financial package, including high equity level, low construction cost, acceptable tolls/tariff levels, and short concession period. In practice, governments typically will weigh the project's financial viability heavily in evaluating a proposal. The weighting of financial feasibility can range from 20% to 50%. As discussed in signalling games, the problem of focusing on financial package is that the promoter's "true" estimated figures are often unknown to the government and that the figures in the promoter's proposal may be manipulated toward winning the project. Therefore, overly emphasizing on financial plan will encourage the bidders to use optimistic estimations and will favour aggressive bidders.

6.3.2 High Equity Level Evaluation Criterion

According to Tiong (1995), equity level or equity ratio requirement is commonly specified in Request for Proposals (RFPs). In addition to minimum equity ratio required, some RFPs may further state that higher equity level is preferred. Tiong (1995) argued that the rationales behind this criterion are (1) high equity will reduce the project's debt burden; (2) it signifies the promoter's faith in the project's viability; and (3) it may motivate the promoter to complete the project on time and on budget. From the perspective of game theory, these rationales mean that high equity may either be a valid *signal* to signify the promoter's private information, such as project's

viability, or be able to *screen out* unqualified promoters. We may infer that high equity ratio is generally an effective strategy because, for promoters with a profit structure skewed to construction contract returns, it may be more difficult to counterbalance the loss due to equity investment when the equity ratio is high. Therefore, in screening rationale, the requirement of high equity level may screen out those promoters who do not have a financially viable project.

Nevertheless, high equity ratio as a criterion should be used with caution because the effectiveness is not guaranteed and the costs of this criterion to the promoters or society are very high. First, if the profit structure is highly unbalanced and skewed to the construction contract returns, it is possible that the loss due to certain level of higher equity ratio can still be compensated. Second, the equity ratio for screening purpose should exclude the equity from passive shareholders because the equity by passive shareholders is not related to the promoter's VoPP. In other words, the high equity ratio should be directly contributed by the promoter. Third, the use of high equity ratio will deviate from the spirit of project financing arrangement in PPPs and will significantly increase the cost of capital and will eventually be imposed back to the project users. In fact, it is very difficult practically for promoters to finance a large scale project with high equity ratio. As a result, high equity ratio criterion may discourage the participation of private parties.

6.3.3 Having explicit government subsidy policy

As discussed earlier in the renegotiation model, under the "no rescue" equilibrium, the government will not provide subsidies should critical adverse events occur. With explicit policy on limiting government's rescuing subsidy, subsidies for rescuing concession firms will be difficult to be justified. Because of the difficult to hold up the government for renegotiation, the VoPP of the *ST* promoter will be reduced significantly and the ST promoter will eventually be screened out by before or during the tendering process.

Note that the *non-confusion* of the PPP policy is no less important than the policy itself. If the government does not specify the policy regarding the post-awarding renegotiation, there will be two consequences. First, prudent and responsible promoters may assume that there will be no post-awarding subsidy and evaluate the investment accordingly. Second, aggressive promoters will be in better position in bid

competition by factoring in the fact that the PPP project will have a "rescue" equilibrium through renegotiation. Then, in the proposal selection, the government may favour the aggressive promoter's proposal since the proposal's figures based on the "rescue" equilibrium will outperform others' proposals. In this case, the government will fail in selecting a responsible promoter. On the contrary, if the government clearly specifies the conditions of post-awarding subsidies, all promoters will explicitly evaluate the value of the subsidy on the same ground. In this case, the government will have a better chance in awarding the project to a better promoter.

7 A CONTINGENCY VIEW OF PPPS AS A GOVERNANCE STRUCTURE: WHEN AND WHY?

While PPPs provide a new alternative for providing infrastructures, many failures in PPPs have shown us that PPPs, under certain situations, can be a wrong governance structure for providing infrastructures. However, few theories offer a systematic view on when PPPs are or are not a good governance structure and, maybe more importantly, why. Here we try to answer these questions by integrating the transaction cost economics and game theory view of PPPs.

7.1 Transaction Costs as a Criterion for Evaluating PPPs as a Governance Structure

While the higher efficiency due to better pooling of resources and high-powered incentives is largely emphasized in PPPs, the impacts of transaction costs embedded in PPPs are often understated. In fact, as we have observed in practice, the high transaction costs could render PPPs an inferior alternative for providing infrastructure. The definition of transaction costs here focuses on the costs due to opportunistic behaviours or the prevention of opportunistic behaviours. Different governance mechanisms present different trade-offs between benefits and transaction costs and, therefore, choosing from the alternative schemes of infrastructure deliveries entails careful evaluation of the comparative tradeoffs between transaction costs and benefits.

From the transaction cost economics (TCE) perspective, there might be distinctive and substantial transaction costs embedded in PPPs because of the potential opportunisms. These transaction costs include those that can be observably identified and measured and those that are hidden, not easily assessed. The hidden

transaction costs may significantly undermine the expected benefits and sometimes cause disastrous impacts on the society or project success. Specifically, we argue that there are two major sources of transaction costs in PPPs, namely, the unbalance profit structure problem and the hold-up induced renegotiation problem, which have been discussed in details in previous sections. The magnitude of the transaction costs thus depends on many factors associated with the two problems. Different type of projects in different environments or institutions will have very different transaction costs; therefore, a contingency theory of PPPs as a governance structure is desired.

7.2 Transaction Costs and the Dynamics between Governments and Promoters

Ho and Tsui (2009) proposed a process model, as depicted in Fig. 8, for the strategic interactions between governments and promoters in PPPs. This model integrates the signalling view and the screening view of PPPs. For government, it is essential to establish screening policies that may reduce the incentives for and capability of opportunism. Similarly, the promoters will make their investment decisions, such as concession negotiation, equity investment, and management efforts, etc., either in response to the government strategies or as signals of their types. All decisions made by the players are jointly determined by each player's objective and the interaction dynamics/game being played. Particularly, we assume that the government's objective is to maximize the overall social welfare (through which the government also maximizes the political benefits) and the promoter's objective is to maximize the overall returns from the PPP profit pool; i.e., VoPP. The degree of goal incongruence influences the interactions between the government and promoters.

In equilibrium, project characteristics and institutional environments that are related to information asymmetry, renegotiation and other opportunism problems will affect the parties' interaction dynamics and decisions. We shall identify these project and institutional factors later for determining whether PPPs are a good governance structure.

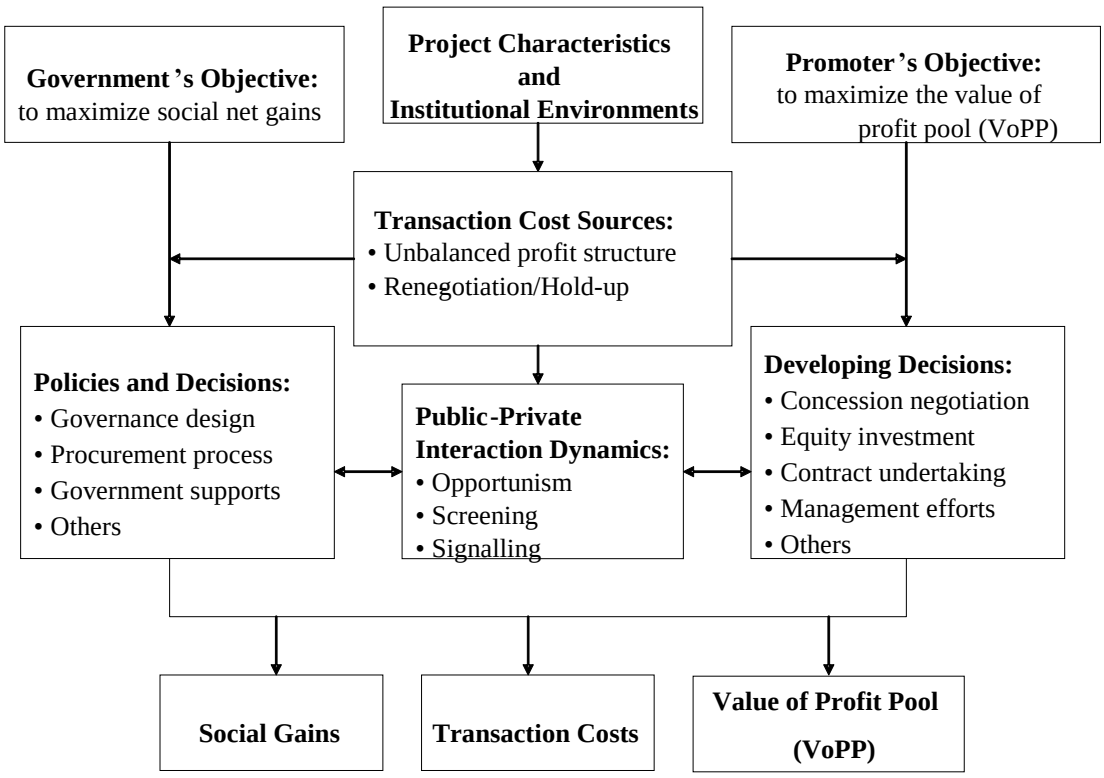

Fig. 8. The Process Framework of PPP Interaction Dynamics

7.3 The Difficulties of Screening and Signalling: Problems and Causes of Off-Equilibrium

7.3.1 Difficulties of Screening

In PPPs, the government can freely specify any combination of evaluation criteria and their weights. If the government clearly specifies the criteria and weights in the project's RFPs, the RFPs will become the menu of contracts in a screening game. An effective screening scheme may induce each promoter to *self-select* into the contract or evaluation scheme so that the best promoter will earn highest evaluation points.

Nevertheless, building an effective evaluation/screening scheme for PPP projects is a difficult task. One major reason is that there are many evaluation criteria and there

is no framework that can assess the impacts of each criterion on the promoter's profit structures. Therefore, the government must understand and be able to quantify or assess the impacts of each evaluation criterion on the promoter's profit structures. Although Ho (2001) proposed a real option framework for quantitatively assessing the VoPP, governments often lack the professional capability to apply such complicated model. Fortunately, with the concept of "unbalanced profit structure" discussed previously, governments can at least qualitatively assess the possibility of opportunism and the magnitude of induced transaction costs.

7.3.2 Difficulties of signalling

Following previous discussion, it may appear that some signals are very effective. For example, self-exclusion of undertaking construction contracts while the promoter's equity ratio is high can be a very effective signal. However, if the government has very limited knowledge on how to judge a signal, as we have often observed in practice, the use of effective signals may be too costly to the promoter and may even place the promoter in an unfavourable position in bid competition. If the promoter wants to adopt certain signal, the promoter should make sure that the government understands why the signals are effective that only a "good" promoter can send. Sometimes, the promoter who adopts and sends out effective signals should take the responsibility to educate the public and government why the signals are effective. Unfortunately, this is a very difficult task due to the conflict of interest and the government's lack of professional ability and slow learning.

7.3.3 Off-equilibrium and transaction costs

To complicate the problems, if the government is too naïve or too inexperienced in PPPs, the transaction costs caused by opportunism will be high, much higher than the costs for preventing the opportunism through signalling and screening. PPPs will become an inappropriate governance structure if the transaction costs are too high. For instance, given certain institutional environments and project characteristics, it is very likely that the screening strategies by the government will be either too stringent or too easy to be satisfied and that the signals sent by the promoters/bidders will not be recognized by the government as an indication of promoter's types. In this case, the results will be "off-equilibrium" and the probabilities of project failure will be

high. When the failure of the project is unendurable by and unacceptable to the government, the government would be easily held up by the concessionaire after the concession has been granted. There are few choices for the government but to bail out the project or provide ex-post subsidies in the event of distress. Having foreseen the government's actions, the promoter would submit opportunistic bids ex-ante in order to win the concession, and, then, appropriate excess profits ex-post from the government, at the costs of the public. Consequently, the economic efficiency cannot be achieved in equilibrium due to the wrongly adoption of PPPs as a governance structure for the particular project.

7.3.4 Governments' slow learning curve

One may argue that governments and promoters will gradually learn from experiences and eventually reach the desired equilibrium. However, governments often show a very slow learning curve in PPPs. Because of the slow learning curve, the transaction costs in PPPs will be much larger due to the off-equilibrium impacts. We aruge that there are three major reasons contributing to the slow learning curve. First, governments suffer from the rigidness of bureaucracy and have limited incentives and flexibilities in adjusting their practice or standard procedure. Sometimes, even when it may appear that a particular bidder is the best one for the project, governments cannot do too much in favouring this bidder but can only follow the standard procedure and use standard bid evaluation criteria and weights for procurement. Second, each PPP project is very unique considering the possible different situations, such as project types, locations, local governments involved, financing agencies, bidders, political environment, and the economy, etc. Therefore, it is very hard for governments or even scholars to accurately and objectively determine what the major causes are for project failures and to learn lessons. As a result, governments often learn little from past experiences in PPPs. Third, PPPs are often misused as a tool by governments for boosting economy for governments' re-election purposes. They may be too soft on promoters in ex-ante negotiation or ex-post renegotiation so that more infrastructures can be provided in a short period of time. To be worse, if a project succeeds, the government takes the credit and, if the project fails, it is likely that the consequences will be borne by the new government in next term. Therefore, as we have observed, PPPs have often been applied to those projects that can be easily procured by

traditional delivery methods or to those that are not in great needs. Thus, governments seldom admit these mistakes they have made and, thus, will not be able to learn. While governments have a slow learning curve, promoters have a quick learning curve due to market competition and their profit maximization objective. When the two distinctive learning speeds combine together, it will be optimal for promoters to engage in opportunisms, instead of sending signals that will not be correctly taken.

7.4 A Contingency Theory of PPPs as a Governance Structure

As shown in Fig. 8, the interaction dynamics between the public and private sectors affect each party's evaluation of the outcomes of a PPP project, namely, social gains, transaction costs, and the VoPP. More specifically, from the game theoretic perspective, whether PPPs are a good governance structure for a particular project depends on many factors, primarily centering on the potential transaction costs due to unbalanced profit structures and renegotiation/hold-up problems. These factors can be categorized into project factors and institutional factors, as summarized in Table 1. More detailed discussions are given as follows.

7.4.1 Factors causing high transaction costs due to unbalanced profit structures

Project factors that may cause high transaction costs due to unbalanced profit structure may include the followings:

- The profit structure tends to severely skew to large construction contract returns. For example, this may happen when the project scale is very large, the equity ratio is very low, and the major promoter is the future contractor.
- The profession of the major promoter is not related to future operation. This is usually a sign of potential unbalanced profit structure. On the other hand, when the profession of the major promoter is directly related to future operation, such as the most power plant PPPs, there will be much less concern for unbalanced profit structure.
- The uncertainty of future tolls/revenues is too high to have a reasonable forecast. For example, revenue forecast on rail/high-speed rail projects or on those unfamiliar, first-time projects is usually very imprecise. For this reason, promoters will heavily discount their long-term equity and operation returns and then inevitably focus on other short-term returns.

The institutional factors associated with unbalanced profit structure may include:

- The inexperienced government does not have professional capability in PPPs. In this case, the government may not realize the problem and associated costs of opportunism due to unbalanced profit structure.
- The legitimacy of government's subsidy for capital needs is high. In this case, the equity investment may be much lower than usual and, thus, will cause unbalanced profit structure.

7.4.2 Factors causing high transaction costs due to renegotiation/hold-up

Project factors that may cause high transaction costs due to renegotiation/hold-up may include the followings:

- The scale of the project is too large to fail. In this case, the government will be more likely to be held up for rescue if the project fails. In practice, few governments will allow mega-PPP projects to fail.
- The project is too important to fail. Particularly, when the project is politically important or has certain symbolic meaning to the government's performance, the project is usually not allowed to fail.
- The project is too complicated such that it is too costly to replace the incumbent promoter. Projects with very complicated know-how in construction or in operation are often very difficult to replace the incumbent promoter; thus, the government can be easily held-up for renegotiation.

The institutional factors associated with unbalanced profit structure may include:

- The inexperienced government without professional capability in PPPs can also cause the hold-up for renegotiation. For example, inexperienced governments may tend to use PPPs for large projects or important projects.
- When the financial market is immature, there will be few alternatives to handle a distressed project except the subsidy from government. In developed countries with matured financial markets, problems of project distress are often resolved through market mechanism; e.g., the two rounds of financial restructuring in the Channel Tunnel.
- When the government has low tolerance for project failure, the promoter may sense the government's attitude and the opportunity of hold-up.

- Similar to an immature financial market, an immature legal system can provide few alternatives other than government subsidies in resolving project distress.
- Lastly, legitimacy of government subsidies will form the promoter's ex-ante expectation on the opportunity for renegotiation/hold-up.

Table 1. Negative factors for PPPs as a governance structure

Project Factors	Institutional Factors
• Project scale: too large to fail [R] • Project importance: too important to fail [R] • Project complexity: too difficult to replace the incumbent firm [R] • Profit structure: skewed to large construction contract returns [U] • Profession of the promoter: not related to future operation [U] • Uncertainty of future tolls/revenues: too high to have a reasonable forecast [U]	• Government's professional capability in PPPs: inexperienced [U, R] • Financial market: immature [R] • Government's tolerance for project failure: low [R] • Legal system: immature [R] • Legitimacy of government subsidies: high [U, R]

[U]: factors contributing to unbalanced profit structure; [R]: factors contributing to renegotiation/hold-up

8. CASE STUDY OF TAIWAN HIGH SPEED RAIL

Ho and Tsui (2010) conducted a case study of Taiwan High Speed Rail (THSR) project in studying the opportunism problems in PPPs. Here we shall discuss this case from the perspective of PPPs as a governance structure.

8.1 General Background

The THSR project is the largest transportation infrastructure in Taiwan and also one of the largest PPP projects in the world. The concession period is 35 years. The high speed rail connects Taiwan's major cities from north end to south end by running trains up to 300 km/hour through the 345 kilometers route. The capital structure of the THSRC was originally targeted at 30% equity and 70% debt ratio, and was later revised to 25%: 75% equity and debt ratios. Using almost seven years, Taiwan High Speed Rail was completed in January 2007, with a 14 month delay. The actual total costs of the project upon completion were about $17.3 billion, including $3.2 billion costs committed by government and $14.1 billion invested by private parties, taking accounts of $1.7 billion cost overruns.

8.2 The Tendering and Construction of the Project and the Crises Encountered

There were only two alliance teams competing for the project, Taiwan High Speed Rail Alliance (THSRA) and China High Speed Rail Alliance (CHSRA). Since the technical concerns were limited due to the technology maturity, the competition was focused on the financial issues. In their financial proposal, CHSRA requested government to invest $4.6 billion to make the project financially viable. On the other hand, THSRA requested zero additional government investment, and further promised that the government may receive at least $3.2 billion royalty-like payback from the project operation revenue. Finally, the project was awarded to THSRA in September 1997. The financial projection of THSRA immediately received criticism for being overly optimistic.

The first crisis faced by the Taiwan High Speed Rail Corporation (THSRC), the concession firm, was the inability to obtain the debt financing of $10 billion after winning the concession. In this project, the private promoters did not utilize the international debt markets for financing partly because Taiwan government to subsidize the loan interest by a rate far below the market. However, since the THSR was the first PPP mega project in Taiwan, the banks had no faith in financing the project at a below market fair rate without government's "full" debt guarantees. At last, a trilateral agreement was entered into among the government, THSRC, and the syndicate bank, which provided that the government shall assume the outstanding debt in the event that the concession agreement is terminated for any causes. Among the $10 billion of debt financing, $8.6 billion came from government owned/controlled banking systems and only $1.4 billion belonged to private

commercial banks. Note that in this event the Prime Minister Mr. Hsiao explicitly expressed his attitude toward the project that "the project is not allowed to fail" and "government will do everything to support the project."

The second crisis concerned the raising of equity. According to the concession contract, the total amount of equity to be raised was $4 billion and the timetable for equity raising was specified in the debt financing contract. The fulfilment of the timetable was a prerequisite for withdrawing funds from the loan credit facility. For the following seven years before project completion, the THSR constantly had difficulties fulfilling the equity requirement. The inability to raise sufficient equity had caused the crisis of the THSRC's breach of the concession contract. The major reason of the crisis was because the market had substantial doubt on the project profitability and regarded that the THSRC's financial proposal was too optimistic. Note that the doubt on the project profitability could also be seen from the initial shareholders' reluctance and refusal of investing more equity later on although they had the capacity to do so. As a result, a couple rounds of renegotiation took place and finally the banks had to accept the THSRC's proposal to reduce the total equity amount to $3.3 billion.

Taiwan government played a crucial role in bailing out the THSRC from the equity raising crisis. The government was criticized of having the government owned/controlled enterprises (GOEs) make substantial equity investment in the THSRC. However, the last equity investment of $0.23 billion by the government controlled non-profit organizations in September 2005 caused one of the most serious criticisms for government's unjustifiable aids and failure in monitoring the project. During this equity raising crisis, the government announced again that "government is determined to ensure the completion of the high speed rail." As discussed previously, for projects that are too important or too big to fail, government will often suffer from the soft budget constraints. In fact, the government's "September 2005 equity investment" was later determined by the court that it was illegal for this non-profit organization to make the equity investment. Up to date, the total passive equity investment by GOEs, government controlled non-profit organizations, and government owned banks was about 37.4% of total equity, while initial equity invested by the promoters was only about 28.5% of total shares.

The third crisis was the cost overrun. Around one year before the project completion, only three months after the government's "September 2005 equity investment," the THSRC announced that the total cost overrun was estimated to be $1.7 billion or so due to the estimated one year schedule delay and construction cost overrun. Due to the serious political impact of previous government illegal equity investment, the government had ruled out the possibility of providing any equity investment or liability guarantees. For the first time, the government formally announced that the government would make plans to takeover the project if the THSRC could not raise either equity or debt to finance the additional capital needs. After the government took the "hard" position on the budget constraint, the THSRC could no longer hold up to renegotiate and, thus, decided to supplement the capital gap through debt financing, even though it was a daunting task for the THSRC to obtain another $2 billion debt at this stage to supplement the capital needs for cost overruns.

8.3 Financial Distress

THSRC has been facing financial difficulties since the commencement of operation in 2007 due to the overly optimistic forecast of market demands. The actual operational revenues met only less than half of the forecast. As a result, the revenue could not cover the operating costs and expenses. In 2008, THSRC generated $0.7 billion in revenue, while the total costs and expenses amounted to about $1.47 billion, including depreciation and amortized expenses $0.58 billion and interest expenses $0.53 billion. Until the end of 2008, THSRC had suffered from an accumulative loss of equity in the amount of $2.05 billion, more than 60% of the total equity amount. According to the concession contract, THSRC shall maintain its equity/debt ratio above 25% at the end of each fiscal year. In fact, THSRC could not have complied with such requirement since the year 2003. By the end of the year 2008, the equity/debt ratio had dropped to 6.96% and THSRC had no capability to fill the financial gap, which had obviously constituted the material breach of the concession contract. Notwithstanding, the government continued to tolerate the breach of contract. As of January 2010, the government was still determined to bail out the project and kept lending its hands to the concessionaire. Government's current plan is to help THSRC obtain a new loan to repay the old one.

8.4 Remarks

8.4.1 Problems due to Unbalanced Profit Structures

From the perspective of PPP profit structure, the original promoters/shareholders controlled the whole procurement of the construction in the amount of $14.1 billion while only $0.89 billion were injected by the original investors in the equity of THSRC. Therefore, given such unbalanced profit structure, the controlling investors /promoters naturally had the incentives to overly estimate the traffic demands to win the concession, recoup their investment, and let the passive stakeholders suffer the losses during the operation period. In fact, the promoters were seriously criticized that they had recovered most of their investments from the undertaking of the construction contracts of the project.

The THSR project demonstrated how transaction costs were incurred due to unbalanced profit structures. When the promoters identified rent seeking opportunities due to project's unbalanced profit structure, they would bid very aggressively using overly optimistic financial projection so as to win the project. The actual traffic demands of THSR during operation were only half of the original estimates in their bids and the projects were both delayed by a year or so. Since the project was awarded to the firms with the most unrealistic forecasts, they soon faced financial difficulties either during the construction phase or in the early stage of operation. The promoter of the THSR has made excess profits during the courses of government rescues and/or undertaking the project's major contracts. The failure of the project and the inefficient project execution created substantial transaction costs to the government.

Moreover, we found that this project exhibited project and institutional characteristics discussed earlier in section 7 that had led to unbalanced profit structure in PPPs. The THSR project was unique and the first of its kind in the country. Consequently, the information asymmetry between government/public and constructors was considerable and created excess construction profits and the incentives for the constructors to become the controlling promoters. In addition, since the project scale was so big that investments from passive shareholders were needed, the constructor-promoters could limit their equity investments to relatively smaller proportions. As a result, the THSR project was prone to a highly unbalanced profit

structure, which then led to subsequent project failures and transaction costs. From the governance structure perspective, this case study showed that there were many substantial disadvantages in adopting PPPs as the governance structure for projects exhibited the characteristics in Table 1.

8.4.2 Problems due to Renegotiation/Hold-up

From the perspective of renegotiation/hold-up, taking over the project by government involved substantial costs because of the original debt guarantee provided by the government for the first syndicate loan. If the concession contract was early terminated, the government must assumed the outstanding amount of the first syndicate loan, around $8.45 billion according to THSRC's annual report of 2008. As a result, the government was subject to hold-up and intended to grant subsidies to THSRC in expectation of turning the situation around and delaying the project's insolvency.

We also found that this project also exhibited some characteristics that might cause governments to be held-up. For example, since this project was one of the largest PPP projects in the world, the political and economical impacts of project failures was extremely high and the government was help up for renegotiation. Contrarily, in the more matured institutional environments such as the UK and France, the inefficiency caused by held-up was well recognized and the public had very limited tolerance toward renegotiation. For example, in Channel Tunnel project, the two governments made it explicit that no subsidies could be granted in any cases. Again, this case showed that there were many substantial disadvantages in adopting PPPs as the governance structure for projects exhibited characteristics shown in Table 1.

9. CONCLUSIONS

In PPPs, conflicts and strategic interactions between PPP promoters and governments are very common and play a crucial role in PPPs. Many complicated issues such as opportunisms, negotiations, competitive bidding, and partnerships challenge the wisdom of both governments and promoters. Thus, game theory, focusing on the strategic interactions and economic behaviours, is very appealing as an analytical

framework to study the interaction and dynamics between the PPP participants and to form proper strategies for both governments and promoters. In this chapter, game theory modelling method is used for analysis. Particularly, we focus on the opportunism problems and the determinants of PPPs as a governance structure. Through the game theory modelling, these problems are abstracted to a level that can be analyzed. Moreover, new insights or theories for the concerned problems are developed along the solving of game models. These new theories can help practitioners, including governments, developers, and bankers, etc., better coordinate together with higher efficiency and effectiveness.

In this chapter, first, we identify two major opportunism problems commonly seen in PPPs, namely, the unbalanced profit structure problem and renegotiation/hold-up problem. There two problems contribute to the major transaction costs in PPPs, related to transactional hazards and inefficiency. The magnitude of these transaction costs has critical impacts on whether PPPs are a suitable governance structure for a specific project. Second, we present two approaches that aim to restore the efficiency due to the opportunisms in PPPs. In the first approach, the promoters try to send signals to the government to signify that they are the long-term profit oriented type promoters. In the second approach, the government try to use screening strategies to discourage the opportunistic, short-term profit oriented promoters from participating in PPP projects. The effectiveness of some popular or potential signalling and screening strategies is also discussed. Third, the contingency view of PPPs as a governance structure is presented. We argue that the slow learning curve of governments and the fast learning curve of promoters tend to render the interactions off the equilibrium and, thus, limit the effectiveness of signalling and screening strategies. Thus, the focus of whether PPPs can be a good governance structure for a particular project turns to those factors that affect the propensity of opportunisms in unbalanced profit structure and renegotiation/hold-up. Lastly, the case study of Taiwan High Speed Rail project shows that how those unfavourable factors for PPPs as a governance structure proposed by the contingency theory actually contribute to the high transaction costs in the project.

We believe that governments can benefit from the proposed contingency framework by avoiding the use of PPPs when project and/or institutional factors predict possible significant transaction costs caused by opportunisms. By doing so,

higher efficiency will be achieved and project success rate. At the same time, when PPPs are used in the right projects, the long-term profit oriented promoters will benefit from the reducing pressure from the opportunistic promoters and, thus, have higher willingness to participate and have better performance.

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