The Renegotiation on PPP Contracts and Subsidy Efficiency

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Abstract. Since 2014, PPP has been developing rapidly in China and widely used in infrastructure construction such as transport, energy, sewage. The characteristics of long time, large investment and high complexity of PPP projects lead to the high incidence of renegotiation. However, experience at home and abroad indicates that most renegotiations are caused by the speculation of firms, in order to obtain subsidies to avoid taking risks and thus bring social welfare losses. Therefore, how to set reasonable renegotiation subsidy to improve project efficiency is an urgent problem in practice. This paper examines the impact of renegotiation subsidies on moral hazard and project efficiency. The problem of moral hazard refers to the fact that firms choose to make low level of efforts in advance (before risks occur) aiming at private profits. The paper firstly analyzes the intrinsic influence mechanism of renegotiation subsidy on the efficiency of PPP project by building a game model based on the incomplete contract theory and game theory, and then discusses the key factors affecting project efficiency, and finally puts forward corresponding policy recommendations. The research results show that: Moral hazard makes risk events more likely to occur, but enterprises can avoid bearing all the losses with the support of renegotiation subsidies, thereby increasing the incidence of moral hazard. Therefore, over subsidy will reduce the ex-ante efficiency, even if the ex-post efficiency still can be achieved. Controlling the renegotiation subsidy to a certain extent can avoid the occurrence of moral hazard, and achieve ex-post efficacy and financial efficiency at the same time. Optimizing policy variables such as private profit B, opportunity cost of re-tendering τ and legitimate profit of firms R-I can lower the requirement of government's negotiating power, making it easier to control the subsidy to the above scope. The research results can provide government with reference about renegotiation in decision making and provide theoretical support for the practice of PPP renegotiation.

1. Introduction

PPP (Public-Private Partnership) means the government cooperates with and the private firm through a long-term contract to provide public products and service. The advantages of PPP are that it can reduce the government's fiscal pressure while sharing the the private firm's investment risk. Since 2014, China has vigorously promoted PPP, which has been widely used in infrastructure construction such as transportation, energy and sewage treatment.

PPP contracts are necessarily incomplete contracts because of the characteristics of long time, large investments and high complexity of PPP projects. When the initial contract cannot adapt to the new environment and changes, both parties need to supplement and adjust the initial contract through renegotiation. Xiong and Zhang study the costs and benefits of renegotiation and points out that in some PPP projects with high uncertainty, it is better to be flexible and allow renegotiation to take
place than to design a thorough contract[1]. In addition, according to the incomplete contract theory, Renegotiation can reduce the distortion of ex-ante non-contracting ex post verifiable investments by distributing ex-post earnings[2]. However, the result of renegotiation is often additional investment, which not only increases the financial pressure of the government, but also reduces the value for money evaluation of PPP projects.

A lot of PPP practice evidences show that the high frequency of renegotiation has become the main problem affecting the efficiency of PPP projects[3]. In order to reduce the occurrence of renegotiation, many scholars have conducted empirical research on the trigger factors of PPP renegotiation. Their research results show that the trigger factors for PPP renegotiation include changes in the macro environment such as political economy, social technology, etc., as well as micro factors at the project level such as incomplete regulation of contracts and insufficient opportunism[4,5,6]. Guasch Cruz et al. found that the time between the first renegotiation of PPP project and the signing time is very short [3], suggesting that PPP renegotiation occurs not only because of the anticipated difficulties, but also because of the defects in the initial contract design caused by the opportunistic behavior of both contracting parties. Both the government and the private sector are likely to show opportunistic behaviors. Private opportunistic behaviors mainly include two types: the opportunistic bidding aimed at winning the bid in the procurement stage, and the moral hazard after signing the contract. The opportunistic behavior of the government mainly refers to the intention of the government to correct the defects of the initial contract caused by insufficient preparation, such as excessive guarantee, through renegotiation.

This paper only considers the situation of private opportunism leading to the renegotiation of PPP contract, and focuses on the moral hazard problem. Moral hazard problem is the result of information asymmetry in the PPP projects. Firms tend to have more information such as project costs than the government, so the government can't completely supervision to the behavior of the firm, then the firm in advance (before risks) may be improper behavior (standing in the government's point of view). Such improper behavior may increase the private interests of the firm, but it requires taking greater risks, such as increasing the probability of risky events. When risk events outside the scope of the initial contract occur, PPP project may have financial problems and the firm may be faced with bankruptcy crisis, then the result of renegotiation is often subsidies. If the firm is not subsidized, the risk events will affect the operation of the project, or even lead to the cancellation of the contract and the suspension of the project, so that the public interest will be reduced to a certain extent. However, renegotiating subsidies means that firms do not have to bear all the risk losses, and the expectation of subsidies will give firms a stronger incentive to generate moral hazard.

At present, the research on government subsidy of PPP project mainly focuses on the form, calculation and effect of subsidy. Mason and Baldwin considered the government subsidy in PPP project from the perspective of option, and used the binary tree option pricing model to evaluate the non-monetary government compensation in PPP project [7]. Tong calculated the optimal ticket price and the corresponding subsidy for the urban rapid transit line project that can fully utilize the two goals of the project's capacity and the maximum ticket revenue [8]. Gao et al. studied the scope and optimal operating period length of government subsidies to enterprises when the demand for ppp-paid projects dropped and the mode of compensation was adopted during the operation period [9]. By establishing a dynamic game model, Ho discusses the conditions and scope of subsidies that the government should rescue projects when the private sector is faced with bankruptcy crisis [10]. However, the above studies are aimed at improving the ex post efficiency of the project, without considering the impact of government subsidies on the ex post efficiency of the project.

This paper studies the influence of renegotiation subsidy on the firm's moral hazard and even the project efficiency, and considers the influence of renegotiation subsidy on the ex ante and ex post
efficiency of the project. Firstly, a game model is established to study the mechanism of moral hazard under two types of contracts: rigid and flexible; Then, the realization degree of project efficiency under two types of contracts is analyzed and the key factors affecting project efficiency are identified; Finally, we discussed how to optimize the policy variables to improve the project efficiency and put forward reasonable Suggestions for the government's policy making according to the actual situation.

2. Benchmark: rigid contracts
The research object of this paper is government-paid PPP project, and renegotiation is not allowed in the benchmark model. The time series of PPP project is shown in figure 1.

![Figure 1. PPP project time series (benchmark).](image)

In period 0, the government G and the firm M sign a rigid PPP contract (for the convenience of recording, the following G represents the government, and M represents the enterprise), so renegotiation is not allowed. In period 1/2, M selected the effort level \( e_t \in \{e_H, e_L\} \) and invests in the project. Total project investment \( I \) includes construction investment \( V \) and operation investment \( B \), \( I = B + V \). If M chooses high effort level \( e_H \), operation cost \( B \) will be fully invested in the project operation; However, if M chooses low effort level \( e_L \) (moral hazard), operating cost \( B \) is transferred to private using. In period 1, risk events may occur, and the project will increase the cost \( C \) due to the occurrence of risk events. If the risk events occur, M need to make a decision in period 1+. When M is facing bankruptcy due to the generation of risk cost \( C \), M has the right to apply for early termination of the contract, and G shall make repurchase compensation to M. In general, PPP projects won't be permanently suspended, and the government will choose to run the project by another company or itself after the termination of the franchise agreement. The cost of re-bidding includes the project minimum recovery cost \( C \) and opportunity cost \( \tau \), such as liquidate expenses \( \tau_1 \), project stagnation loss \( \tau_2 \) and re-bid cost \( \tau_3 \) (In perfect competition, the bid price is 0). G itself to continue operating cost also includes \( C \), \( \tau_1 \) and \( \tau_2 \), but due to the lack of competition and innovation, would increase the cost of the system "\( v \)". When M runs the project to the end of period 2, G pays the franchise price \( R \) to M, and the public receives the benefit \( W \). The basic assumptions of the model are as follows:

1) Suppose that when M selects effort \( e_H \), the probability of the risk event not occurring is \( p_H \), when M selects effort \( e_L \), the probability of the risk event not occurring is \( p_L \) (\( p_H > p_L \)).
2) Suppose the franchise price \( R \) satisfies \( I \leq R < I + C \). If \( R \geq I + C \), no matter what level of effort is adopted, the firm will achieve non-negative profit, so as not to achieve the project efficiency.
3) Suppose M chooses high effort level as the social optimal choice, \( I + (1 - p_H)C \leq V + (1 - p_L)C \).
   The left and right sides of the inequality respectively represent the total expected cost when M selects the effort level \( e_H \) and \( e_L \). That is, \( \Delta pC - B \geq 0 \). Here, M has the complete information of \( B \), and G knows the size of \( B \) but doesn't know whether \( B \) is put into private using.
4) Suppose that the cost of operating by G itself is greater than the cost of re-bidding, \( C + \tau < C + \tau_1 + \tau_2 + \nu \).

The game tree of the benchmark model is shown in figure 2.
Firstly, consider the choice of G after M applies for early termination of the contract. We know from assumption 3, G's payment function of rebidding $W-I-C-\tau$ is bigger than operating by itself $W-I-C-\tau_1-\tau_2-\nu$. Therefore, G will choose to re-bid.

Then consider the choice of M when the risk occurs. M must choose to terminate early rather than continue to operate. Because at a high level of effort, M's payment function of choosing to continue operation $R-I-C$ is smaller than choosing to terminate the contract (0); At a low level of effort, M's payment function of choosing to continue operation $R-V-C$ is still smaller than choosing to terminate the contract ($B$).

Finally, consider how M chooses the effort level. The expected utility of choosing effort level $e_i (i=H,L)$ is: $\Pi^\text{form}_H = p_H(R-I)$; $\Pi^\text{form}_L = p_L(R-V) + (1-p_L)B$. Then the incentive conditions and participation conditions for M to choose $e_H$ are respectively:

$$\Pi^\text{form}_H - \Pi^\text{form}_L = p_H(R-I) - [p_L(R-V) + (1-p_L)B] \geq 0 \quad (1)$$

$$\Pi^\text{form}_H = p_H(R-I) \geq 0 \quad (2)$$

When the incentive condition (1) fails to stand, M will choose low effort level. The conditions for M to choose low effort level $e_L$ is:

$$\Delta p(R-I) - B < 0 \quad (3)$$

$$p_L(R-V) + (1-p_L)B \geq 0 \quad (4)$$

To sum up, the equilibrium solution of the benchmark model under a rigid contract that does not allow renegotiation is as follows:

a) $(e_H, \text{ apply for early termination, rebid })$ when $B \leq \Delta p(R-I)$

b) $(e_L, \text{ apply for early termination, rebid })$ when $\Delta p(R-I) < B \leq \Delta pC$
According to the above analysis, proposition 1 is presented below:

**Proposition 1** The rigid contract can not restrain the project termination problem and can not realize the ex-post efficiency of PPP project. But when $B \leq \Delta p(R-I)$, it can restrain the moral hazard problem and realize the ex ante efficiency of PPP project.

3. **PPP renegotiation model: flexible contracts**

The time series of the PPP renegotiation model is shown in figure 3. Compared with the basic model, the only difference is that it introduces a flexible mechanism for renegotiation, thus allowing renegotiation in period 1+.

- **Figure 3.** PPP project time series (renegotiation).

The game tree of the PPP renegotiation model is shown in FIG. 4, which is mainly different from the game tree of the basic model in two aspects. First, after considering renegotiation, the action space of M changes from {continue operation, early termination} to {apply for subsidy, continue operation, early termination}(the continued operation is omitted from the PPP renegotiation model). Second, after M chooses to apply for the subsidy, G needs to decide whether to agree or not.

- **Figure 4.** The game tree of benchmark model (flexible contract).

Now, the Nash equilibrium of the subgame is solved by backward induction. When the risk event occurs, G agrees to the subsidy on the condition that $W-R-S \geq W-I-C-\tau$. Similarly, the condition for G to reject the subsidy application and choose to buy back the project and re-bid is $S > I + C + \tau - R$. 
Then consider whether M will initiate renegotiation and submit subsidy application. It can be seen that M's profit of choosing not to initiate renegotiation and terminate the contract is the same as M's profit of choosing to initiate renegotiation but be refused by G. Therefore, M will choose to apply for subsidies under the condition \( S \geq I + C - R \); Otherwise, M won't.

Finally, how does M choose the effort level. The expected returns of M are related to the results of the game in the last two stages, and there are three kinds of results:

1) M applies for subsidies and G agrees with subsidies;
2) M applies for subsidy and G rejects the subsidy application and buys back the project;
3) M directly applies for early termination of contract and G buys back the project.

If we know that the outcome of the last two stages of the game is the first one, M will choose high level of effort under the condition:

\[
(\frac{B}{\Delta p}) \leq C - S \quad \text{and} \quad I + C - R \leq S \leq I + C + \tau - R \quad \text{if} \quad R - I - \tau \geq 0
\]

\[
(\frac{B}{\Delta p}) \leq C - S \quad \text{and} \quad I + C - R \leq S \leq C \quad \text{if} \quad R - I - \tau < 0
\]

1) \( (e_H, \text{ apply for subsidies, agree with subsidies}) \)

2) \( (e_L, \text{ apply for subsidies, agree with subsidies}) \)

3) \( (e_H, \text{ apply for subsidies, rebid}) \)

4) \( (e_L, \text{ apply for subsidies, rebid}) \)

5) \( (e_H, \text{ early termination}) \)

6) \( (e_L, \text{ early termination}) \)

And by the same logic we get all six equilibrium solutions:

1) \( (e_H, \text{ apply for subsidies, agree with subsidies}) \) when \( \frac{B}{\Delta p} \leq C - S \) and \( I + C - R \leq S \leq I + C + \tau - R \); \( \text{if} \quad R - I - \tau \geq 0 \).

2) \( (e_L, \text{ apply for subsidies, agree with subsidies}) \) when \( C - S < \frac{B}{\Delta p} \leq C \) and \( I + C - R \leq S \leq I + C + \tau - R \).

3) \( (e_H, \text{ apply for subsidies, rebid}) \) when \( \frac{B}{\Delta p} \leq R - I \) and \( S > I + C + \tau - R \).

4) \( (e_L, \text{ apply for subsidies, rebid}) \) when \( R - I < \frac{B}{\Delta p} \leq C \) and \( S > I + C + \tau - R \).

5) \( (e_H, \text{ early termination}) \) when \( \frac{B}{\Delta p} \leq R - I \) and \( S < I + C - R \).

6) \( (e_L, \text{ early termination}) \) when \( R - I < \frac{B}{\Delta p} \leq C \) and \( S < I + C - R \).

From the equilibrium solution, it can be seen that when solution 1 is established, the project can achieve both the ex-ante and ex-post efficiency. When solution 2 is set up, the project can only realize the ex-post efficiency; When solution 3 and 5 are established, the project can only realize the ex-ante efficiency. When solution 4 and 6 are established, neither the ex-ante efficiency nor the ex-post efficiency can be realized. According to the above analysis, proposition 2 is obtained.

**Proposition 2** Under a flexible contract, the renegotiation subsidy should in the range of \( \{ x: I + C - R \leq x \leq I + C + \tau - R \} \). Only when \( S \leq C - \frac{B}{\Delta p} \), ex-ante and ex-post efficiency can be achieved at the same time, otherwise only ex-post efficiency can be achieved.

### 4. Impact analysis of PPP renegotiation on project efficiency

#### 4.1. Efficiency comparison between the benchmark model and PPP renegotiation model

The ratio of the benefits and costs of PPP project to the whole society is called social efficiency. All previous references to ex ante and ex post efficiency refer to social efficiency. Ex ante social
efficiency can be realized when the firm chooses high effort level and ex post social efficiency can be realized when the government chooses to subsidize the firm. In addition to social efficiency, the financial efficiency of PPP projects should also be considered in order to maximize VFM and meet the requirements of financial affordability. This paper measures the fiscal efficiency by the size of the government's fiscal expenditure, which is not only related to the response measures taken by the government after the event, but also related to the effort level of the firm before the risk event.

Figure 5 and 6 respectively describe the conditions for the selection of firm's effort level in benchmark model and renegotiation model when \( R - I - \tau \geq 0 \) or \( R - I - \tau < 0 \). Below, the efficiency of the two models will be compared in terms of social efficiency and economic efficiency.

![Figure 4](image1.png)  ![Figure 5](image2.png)

**Figure 4.** Efficiency comparison \(( R - I - \tau \geq 0 )\)  **Figure 5.** Efficiency comparison \(( R - I - \tau < 0 )\)

First of all, we examine the financial efficiency of projects under both contracts. It is easy to know that in all areas under rigid contract and areas of III, IV, V, VI under flexible contract, the government always chooses to buy back the project and re-bid after the risk event, and the expected payment of the government is \( p_i R + (1 - p_i) (I + C + \tau) \), \((i = H, L)\). Only in areas of I and II under flexible contracts will the government choose to subsidize enterprises, but the probability of risk in area II is high, so the financial efficiency is highest under flexible contract, in area I.

Next, we will examine the social efficiency of the projects under the two contracts. Table 1 summarizes the scope of social efficiency realization under the two contracts. It can be seen that the flexible contract realizes the ex-post efficiency that the rigid contract can't realize, but it produces the problem that ex-ante efficiency can't be realized in \( I_{\text{shadow}} \).

| Contract Types   | Social Efficiency | I | \( I_{\text{shadow}} \) | \( I_{\text{blank}} \) | III | IV | V | VI |
|------------------|-------------------|---|------------------------|------------------------|-----|----|----|----|
| Rigid Contract   | Ex-ante           | √ | √                      | ×                      | √   | ×  | √  | ×  |
|                  | Ex-post           | × | ×                      | ×                      | ×   | ×  | ×  | ×  |
| Flexible Contract| Ex-ante           | √ | ×                      | ×                      | √   | ×  | √  | ×  |
|                  | Ex-post           | √ | √                      | ×                      | ×   | ×  | ×  | ×  |

\( \sqrt{ } \) means the implementation, \( \times \) means it cannot be implemented
According to the above analysis, the following three propositions are obtained.

**Proposition 3** Rigid contracts cannot achieve ex-post and financial efficiency.

**Proposition 4** Under the conditions that \( C - \frac{B}{\Delta p} < S < I + C + \tau - R \) and \( S \leq R - I \), although renegotiation can avoid the problem of project termination under rigid contract and achieve the ex-post efficiency, it causes the problem of moral hazard and cannot achieve the ex-ante efficiency.

**Proposition 5** Under the conditions that \( I + C - R \leq S \leq I + C + \tau - R \) and \( S \leq \frac{C - B}{\Delta p} \), renegotiation avoids project termination and government's finance problem, achieving the ex-ante efficiency, ex-post efficiency and financial efficiency at the same time.

4.2. Analysis of key factors affecting project efficiency
The impact of each variable on project efficiency is examined below.

(1) **Subsidy S**
The project achieves optimal efficiency when the conditions of proposition 5 are satisfied, which have two restrictions on subsidy \( S \): first, the subsidy range is \( S \in \{ x : I + C - R \leq x \leq I + C + \tau - R \} \); second, subsidy \( S \) should be less than or equal to \( C - \frac{B}{\Delta p} \). In fact, the subsidy \( S \) is determined by the negotiating power between firm \( M \) and government \( G \). In order to achieve the optimal efficiency, the negotiating power of government needs to satisfy \( g \geq \frac{1}{\tau} \left( \frac{B}{\Delta p} + \tau + I - R \right) \).

(2) **Private interests \( B \)**
The greater the self-interest \( B \), the greater the government's negotiating power over subsidies must be in order to achieve optimal project efficiency when the other parameters are fixed.

(3) **The opportunity cost of re-bidding \( \tau \)**
The greater the opportunity cost of re-bidding, the greater the government's negotiating power over subsidies must be in order to achieve optimal project efficiency when the other parameters are fixed.

(4) **Legitimate profits \( R - I \)**
When the firm adopts opportunistic bidding behavior, that is, it wins the bid at a low price and expects to gain additional benefits through bilateral renegotiation. In order to achieve optimal project efficiency, the government must increase its negotiating power when legitimate profits \( R - I \) is low.

(5) **Risk costs \( C \)**
That is, the minimum recovery cost of the project when the risk event occurs. The change in \( C \) will not affect the government's demand for negotiating power, but will increase the cost of subsidies.

5. **Conclusions**
Considering the characteristics of PPP projects and the incomplete contract theory, PPP project renegotiation is inevitable. Renegotiation caused by opportunistic behavior will damage social welfare. This paper focuses on the moral hazard of firms' opportunistic behavior after the signing of PPP contract, constructs a game model, and studies the internal influence mechanism of renegotiation and government subsidy on the efficiency of PPP project. The following three conclusions are drawn: First, over subsidy will reduce the ex-ante efficiency, even if the ex-post efficiency still can be achieved. Second, controlling the renegotiation subsidy to a certain extent can avoid the occurrence of moral hazard, and achieve social efficacy and financial efficiency at the same time; Third, optimizing policy variables such as private profit \( B \), opportunity cost of re-tendering \( \tau \) and legitimate profit of firms \( R - I \) can lower the requirement of government's negotiating power, making it easier to control the subsidy to the above scope.
Although a series of research results have been obtained in this paper, the following deficiencies still exist and need to be further improved: First, the government's payment function dose not consider the political cost. In fact, the larger the amount of government subsidies, the greater the political impact they have as spending beyond the government budget. Second, the discussion of opportunistic bidding is too rough, so the consideration of bidding can be added to analyze the influence of opportunistic behavior on the bid price.

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