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The "BOOT+BTO" operation mode of the comprehensive utilization of water conservancy project

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ABSTRACT

The coexistence of public welfare and business nature of comprehensive utilization of water conservancy projects has affected application of its PPP project model. This paper studies the mixed investment characteristics and asset structure characteristics of the comprehensive utilization of water conservancy projects, and analyzes the problems of the BOT operation mode of the comprehensive utilization of water conservancy projects, such as high pressure of early operation and maintenance funds, vague risk definition and unequal risk responsibility. The operating facilities and non-operating facilities of comprehensive utilization water conservancy projects are "appropriately separated", and the operating facilities adopt BOOT mode and the non-operating facilities adopt BTO mode. The "BOOT+BTO" bundled operation model of PPP project of comprehensive utilization water conservancy project is constructed, and the feasibility and advantages of the "BOOT+BTO" operation mode of comprehensive.

Keywords: Comprehensive utilization of water conservancy project; PPP project; BOT operation mode; "BOOT+BTO" operation mode.

1. Introduction

The PPP model has gradually formed an innovative management mechanism of "partnership, benefit sharing and risk sharing" through mechanism conversion, system innovation and resource allocation of government departments and social capital to improve efficiency. Li et al. [1] comparatively compared and analyzed the operation mode characteristics of the five stages of the development of PPP projects in China: embryonic period, growth period, low tide period, prosperity period and standard period, and pointed out that under the new situation, PPP projects should be based on the principle of the steady progress of standardized development, with TOT as the mainstream model and BOT and other operating modes coexisting. He and Zhao [2] consider the risk preference of participants based on the basis of stochastic cooperative game model, and discussed the risk sharing game model of social capital PPP project under unequal status. Guasch et al. [3,4] statistically analyzed the renegotiation ratio of PPP projects in Latin America as high as 74.40%, and concluded that contract details, regulatory environment, and economic fluctuations triggered contract renegotiation, pointing out that high-frequency contract renegotiation has seriously affected the enthusiasm of social capital to participate in infrastructure construction; Nunzia et al. [5] used the Monte Carlo simulation method to determine the franchise period of the PPP project by constructing a win–win model of risk-sharing between the public and private parties. Yin et al. [6] established a hierarchical structure model of the trigger events of PPP project renegotiation and the core

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elements of the contract, analyzed the vertical and horizontal influence of the hierarchical structure model by using the improved analytic hierarchy process and system engineering model, and designed the design idea of PPP project contract terms renegotiation.

In the context of the implementation of PPP projects in the country, many water conservancy projects have adopted the PPP project development model. As of April 2021 [7], among the 10,020 projects in the PPP project management database of the national integrated information platform, there are 439 PPP projects in water conservancy construction, ranking 6th in terms of quantity and investment amount among 19 infrastructure and public service first-level industries. In terms of theoretical research on PPP projects in water conservancy engineering, Ameyaw and Chan [8] used fuzzy comprehensive evaluation methods to analyze the key risk factors of water resources PPP projects. Ke and Chan [9] took the water ecological civilization project in Henan Province as an example, using the PPP model to solve the problem of local government investment and financing of public welfare construction projects, and constructed a public welfare PPP project investment and financing mode based on investors, investment methods and return mechanism; Nie et al. [10] analyzed the risk sharing caused by the incomplete contract structure of the PPP project of the water conservancy project and the external environmental impact, and constructed the flexible adjustment mechanism of PPP project contract of water conservancy project; Li et al. [11] analyzed the existing problems in the implementation of PPP projects in water conservancy projects on the basis of investigating and summarizing the current situation of PPP models in water conservancy projects, and put forward countermeasures and suggestions, such as focusing on the preparation of project implementation plans and improving risk identification and prevention mechanisms; Yuan et al. [12] used an improved cloud model method to study the risk sharing of PPP projects in water conservancy projects; Li et al. [13] consider the value contribution, investment proportion, risk sharing and actual contribution of PPP project of quasi-public water conservancy project, and based on the Shapley value method, established a dynamic revenue distribution model for the decision-making stage and the operation stage; Zhang and Tariq [14] analyzed the reasons for the failure of the international water conservancy PPP project from the perspective of the government department, and proposed effective preventive measures.

As an important water conservancy infrastructure, comprehensive utilization of water conservancy projects have remarkable economic and social benefits such as flood control, power generation and water supply. However, engineering risks pose a great threat to society, economy and people's lives and property. Most of these projects are invested, constructed and operated by the government. However, due to its coexistence of public welfare and operation, and the risk of loss of revenue during franchise period caused by flood control and drought relief emergency dispatch, the popularization and application of PPP mode in comprehensive utilization of water conservancy projects are affected. On the basis of analyzing the structural characteristics of comprehensive utilization of water conservancy engineering assets and the defects of BOT operation mode, this paper constructs a BOOT operation mode for comprehensive utilization of water conservancy project operating facilities and the BTO operation mode for non-operational facilities, and studies the operation mode of "BOOT+BTO" of the PPP project of comprehensive utilization of water conservancy projects.

2. Comprehensive utilization of the BOT operation mode of water conservancy projects

2.1. Characteristic analysis of comprehensive utilization of water conservancy projects

The comprehensive utilization of water conservancy projects takes the reservoir hub as the control point, take the upper and lower reaches of the river basin as the line, the reservoir-controlled river basin and the influence area as the surface. According to the upstream of the reservoir, the rainfall situation, the surface water situation, the groundwater resource status, and the river catchment situation are controlled. Multi-objective comprehensive benefits such as flood control, power generation, water supply, irrigation, ecological environment, tourism and aquaculture can be realized through rational operation and dispatch.

(1) Analysis from the perspective of project construction and operation management, the comprehensive utilization of water conservancy projects has a large investment, a long construction cycle, and complicated construction process. And it is greatly affected by diversion and interception projects, flood safety projects, resettlement of migrants, and ecological environment protection; The economic and social impact of the project is great, the safety of the project and flood control scheduling is related to the safety of the life and property of the public, and the water supply guarantee rate affects the production and living water safety of the residents in the water-affected area; At the same time, the project is a strategic infrastructure of the government's flood prevention and drought control public emergency dispatch, and the project operation and scheduling is subject to the comprehensive dispatch of flood control and drought control in the flow areas (region).
(2) From the perspective of project investment structure, the reservoir dam and water source protection facilities of comprehensive utilization water conservancy projects have the basic investment characteristics of long construction period, large investment and low income, and the functions of flood control, ice prevention and silt reduction have the public welfare investment characteristics, while the functions of power generation, water supply, irrigation, shipping, aquaculture and eco-tourism have the competitive investment characteristics with attractive investment. Therefore, the comprehensive utilization of water conservancy projects is a mixed investment project, and it is not suitable for a single type of investment management system.
(3) From the perspective of the project asset structure. The comprehensive utilization of water conservancy projects includes three categories: public welfare assets, operational assets, and public assets, as shown in Table 1. The comprehensive utilization of water conservancy projects

Table 1
The asset structure characteristics of comprehensive utilization of water conservancy project

	Investment entity	Ownership of the right of use	Benefits belong to	Water conservancy facility function
Public welfare Assets can be divided	Government/ Social Capital	The public	The public	Flood control, drainage, overrunning, reduction or diversion of water and sand
Operating assets	Government/ Social Capital	Government/ Social Capital	Government/Social Capital	Power generation, water supply, irrigation, shipping, or aquaculture
Common assets	Government/ Social Capital	Government/ Social Capital	Government/social capital, the public	Hub dams, diversion (discharge) buildings, and reservoir areas occupy an area

such as flood control, drainage, flood control, water diversion and sand transfer, and other functional facilities are public welfare and separable assets, which not only have the exclusivity of property rights but also have the non-competitive nature of benefit enjoyment, and are public welfare separable assets.Functional facilities such as power generation, water supply, irrigation, shipping, and aquaculture have exclusive property rights and exclusive benefits, and are operating assets; Functional facilities such as hub dams, diversion buildings, and areas occupied by reservoir areas are public assets, which should not only lay the foundation for the development of public welfare functions such as flood prevention and drainage, but also provide guarantees for the realization of operational functions such as power generation and water supply, which are public assets.

2.2. Normal mode of operation of the PPP project

The PPP project is a long-term cooperative relationship between public and private parties formed by government departments authorizing social capital to engage in the construction and operation of some infrastructure and public service projects that should have been the responsibility of the government through franchising, purchasing services, equity cooperation, etc. In order to enhance the capacity of infrastructure construction and improve the supply of public goods and services, and realize the public service function of government departments while bringing economic benefits to social capital. The State encourages infrastructure and utility franchising to take a BOT, BOOT, BTO, or other combination approaches.

(1) The BOT operation mode is that the project company obtains the project concession through competitive bidding (or consultation), responsible for project financing management of the project, and recovers the investment and financing funds to repay the loan through user payment and government preferential subsidies during the concession period, so as to obtain certain reasonable profits. In the BOT operation model, the government always has control over the project, restrictions can be placed on the charging price of public goods (or services) or the minimum rate of return on social capital, and ensures the reasonable expected returns of social capital.
(2) The BOOT operation mode is that the project company has both the right to operate and own during the franchise period after the completion of the project construction. The government allows the project company to mortgage the project assets within a certain scope (or term) to obtain more favorable loan terms, to a certain extent, to reduce the operation and maintenance capital pressure of the project company, so as to improve the quality of the project products (or services), or lower the price of the project product (or service). Compared with the BOT model, the BOOT model allows the project company to temporarily own the ownership of the project during the franchise period in terms of project property ownership. And the franchise period is generally longer than the BOT project.
(3) The BTO operation mode is that the project company obtains the right to develop and construct the project from the government. Responsible for project investment and financing and construction management, after the completion of the project, it will be handed over to the government, and the government will delegate the right of operation and maintenance of the project to the project company, so that it can obtain the operation and maintenance income through user payment or government payment. In contrast to the BOT model, ownership of the BTO project has been transferred to the government during the concession period. The transfer process can be a direct purchase of a product or service by the government, or it can be free of charge. Social capital obtains economic benefits through the economic operation of the project during the franchise period.
(4) The BOT+BT operation mode is part of the project to adopt the BOT operation mode, the government will authorize the financing, construction, operation, and maintenance of the project to the social capital, and social capital recovers investment and obtains reasonable profits by paying the users during the franchise period, and the project will be handed over to the government for free after the franchise period. The other part of the project adopts the BT operation mode, the government delegates the financing and construction of the project to the social capital, and the project will be handed over to the government after it is completed and accepted, and the government will pay the total investment and reasonable profit of the project to the social capital once or in several times. BOT+BT operation mode is mostly used in large-scale engineering construction, the government adopts the BOT model for profitable projects and the BT model for projects with the strong public welfare, which on the

one hand, it can improve the attractiveness of the project to social capital, reduce the government's construction financing pressure; On the other hand, the construction management experience of social capital can be used to improve the construction efficiency of the project.

2.3. BOT operation mode and its shortcomings of comprehensive utilization of water conservancy projects

Using PPP project development mode for comprehensive water conservancy projects, on the one hand, the government has alleviated the debt pressure of separate investment in water conservancy projects through the PPP model. It overcomes the shortcomings of investment overruns, delays in construction periods, inability to fully play design functions and even idle engineering facilities caused by the lack of competition and restraint mechanism in single government investment. On the other hand, the participation of social capital in water conservancy projects using the PPP model can enable the export of capital, management and technical advantages and obtain long-term stable economic returns, and realize life cycle management through optimization in design stage, strengthening in construction stage and modernization in operation stage. It has improved the efficiency of capital investment, the level of engineering construction and operation management, and the quality of social services.

Based on analyzing the asset structure characteristics and quasi-public welfare characteristics of the comprehensive utilization of water conservancy projects, the BOT operation mode of the comprehensive utilization of water conservancy projects is designed in combination with the actual situation and expected benefits, as shown in Fig. 1. The government selects social capital that meets the requirements of project investment and financing and construction, management operation and maintenance through public bidding (or competitive consultation), and the project company is responsible for financing management, construction management, and franchise period operation and maintenance management. Directly recovers funds through revenues from power generation, water supply, irrigation, shipping, etc., and obtain agreed reasonable profits. When the hydropower consumption agreed in the contract is lower than expected or the hydropower price adjustment is not in place, which leads to the income lower than expected, the government and social capital share the risks according to the contract. For public welfare operation and maintenance such as flood control, anti-bullying, dredging reduction, water diversion, sand transfer, and water source protection, use government payment to pay for operation and maintenance costs and corresponding reasonable profits.

Through the practical investigation and experience summary of the BOT operation mode of comprehensive utilization of water conservancy projects, it is found that there are the following deficiencies:

(1) In the initial operation stage after the completion of the BOT project of comprehensive water conservancy project, the power generation and water supply functions of the hub project cannot be fully realized, which will inevitably affect the efficiency of power generation and water supply, in addition to raising funds to maintain the operation of the project, the project company must also repay the investment and financing loans and interest during the construction period. In addition, the acquisition of power generation income and water supply income has a relative time lag, which leads to great pressure on the funds for the early operation and maintenance, which will also affect the effective play of public welfare emergency

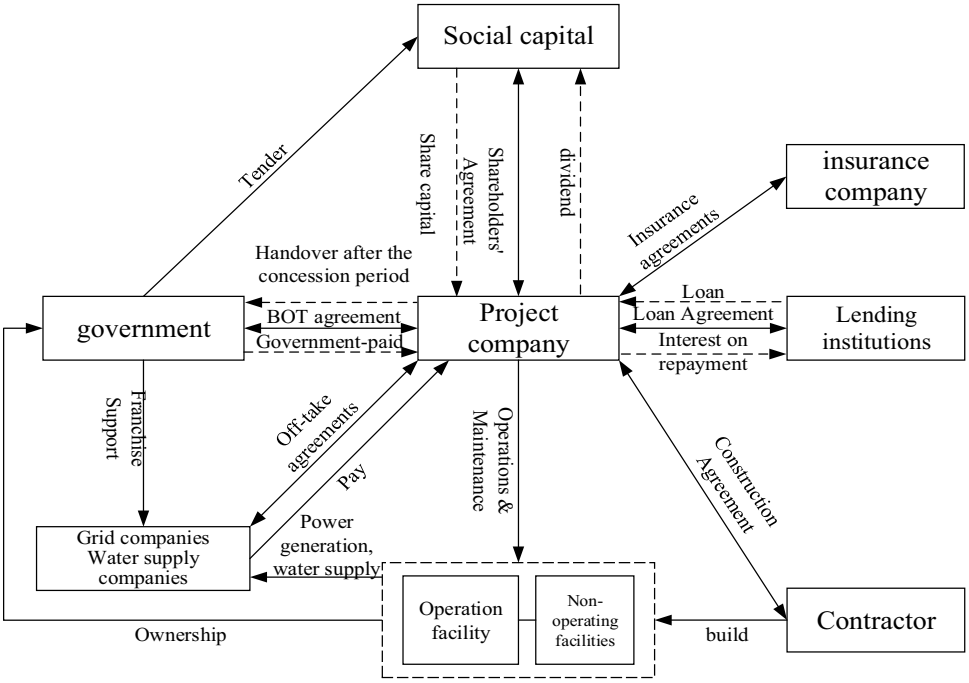

Fig. 1. The BOT operation mode of comprehensive utilization of water conservancy projects.

dispatch functions such as flood control, drainage, and drought resistance.

(2) When BOT operation mode is adopted in comprehensive water conservancy projects, the negotiation process of risk sharing between government and social capital is complicated, and it is difficult to achieve fair sharing between the public and private parties, which is easy to cause unilateral parties to bear too much risk responsibility. Opportunistic behavior that leads to a short-term search for a way out of the capital for social capital, or an increase in the government's fiscal burden, resulting in an unfair allocation of public resources.

(3) When the BOT operation mode is adopted for comprehensive utilization of water conservancy projects, the interface between the operation and maintenance of the operational special facilities, public welfare special facilities, and public facilities of the hub project is blurred. It's not conducive to the distribution of responsibilities and rights between the government and social capital. In particular, when the loss of revenue is caused by public emergency dispatch, the increase in operating costs and the overhaul of public facilities require the public and private parties to share the risk. It is easy to generate disputes over the allocation of risks and liabilities, affecting the subsequent operation of the hub project.

3. Comprehensive utilization of the "BOOT +BTO" operation mode of water conservancy projects

3.1. Design of "BOOT+BTO" operation mode of comprehensive utilization of water conservancy projects

From the perspective of project investment characteristics, functional facilities with competitive investment characteristics such as power generation, water supply, irrigation, and shipping that make comprehensive use of water conservancy projects, are called operational facilities. The functional facilities with basic investment characteristics such as hub dams and water source protection, as well as functional facilities with public welfare investment characteristics such as flood prevention, anti-bullying, dredging reduction, water, and sand diversion, etc., are called non-operational facilities. Aiming at the shortcomings of the BOT model of comprehensive utilization of water conservancy projects, such as greater pressure on pre-operation and maintenance funds, uneven sharing of risk responsibilities and vague definition of risks, etc., to achieve the multiple goals of reducing the cost of construction financing, improving the efficiency of construction operation and management, and effectively serving the public, considering the "appropriate separation" of operational and non-operational facilities for integrated utilization of water conservancy projects, the BOOT model is adopted for operational facilities, and the BTO model is adopted for non-operational facilities, and construct a "BOOT+BTO" bundled PPP operation mode.

The BOOT operation mode of comprehensive utilization of water conservancy engineering operational facilities is shown in Fig. 2, and the BTO operation mode of non-operational facilities is shown in Fig. 3.

In the PPP project agreement of the comprehensive utilization water conservancy project, the terms of the BOOT agreement are set for the operational facilities, and the terms of the BTO agreement are set for the non-operating facilities. The terms of the BOOT agreement specify that the project company has ownership and operating rights for the duration of the concession of the operating facility during the franchise period, and can mortgage the assets of the operating facilities with the approval of the government. To obtain a bank loan with certain preferential conditions as part of

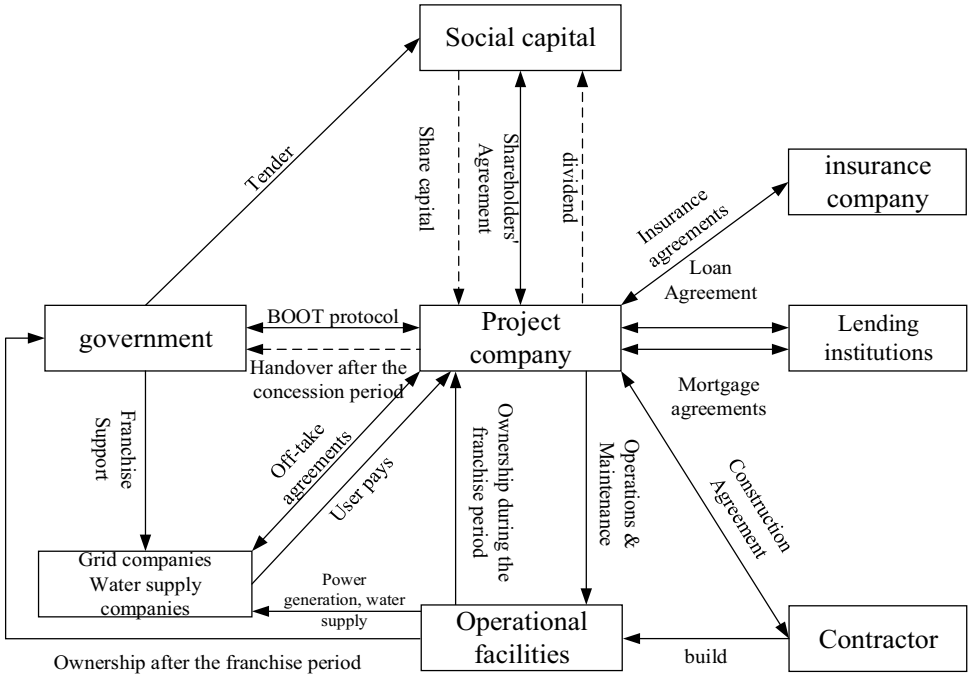

Fig. 2. The BOOT operation mode of the operational facilities of comprehensive utilization of water conservancy project.

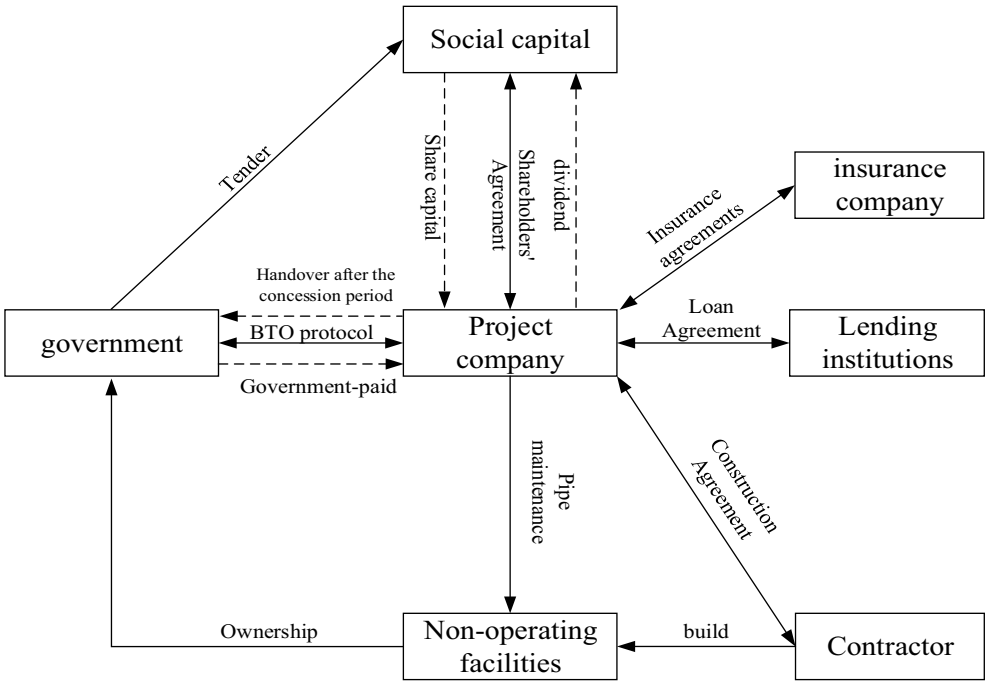

Fig. 3. The BTO operation mode for the non-operating facilities of comprehensive utilization of water conservancy project.

the fund for project operation and management maintenance, recover investments in projects such as income from power generation, water supply, irrigation, and shipping during the concession period, and repay bank loans, and get a reasonable investment profit. After the concession period is over, the operational facilities will be handed over to the government free of charge, the government (or its entrusted operation and maintenance company) is responsible for the subsequent operation and management maintenance and bears the corresponding operation and maintenance costs and obtains the corresponding operating income. The terms of the BTO agreement specify that non-operating facilities are handed over to the government after completion, and the government pays the financing costs, construction costs, and reasonable profits to the private capital at one time (or in stages). The project company is responsible for the operation and management maintenance of non-operational facilities during the concession period under the authorization of the government, and the government pays the project company the cost following the principle of "operation and maintenance cost + rationalized profit". There is no transfer of ownership of the project after the end of the franchise period, and the government (or its entrusted operation and maintenance company) is responsible for the subsequent operation and maintenance and bears the corresponding operation and maintenance costs.

3.2. Feasibility analysis of the operation mode of "BOOT+BTO" of comprehensive utilization of water conservancy projects

From the technical point of view, the Boot operation mode and the BTO operation mode have been successfully applied in many PPP projects. Accumulated a certain amount of experience in project financing, design management, construction management, and operation management, thus providing a solid technical support for adopting the "BOOT+BTO" operation mode in PPP projects of comprehensive utilization of water conservancy projects. From the perspective of cost control, when the "BOOT+BTO" operation mode is adopted for the PPP project of comprehensive utilization of water conservancy projects, the project company with dual functions of operating manager and non-operating manager will take into account the effects of both operating and non-operating facilities in the design stage and construction stage, actively adopt new technologies, new processes and new methods to reduce unnecessary cost waste, and strive to reduce the transportation and management costs in the operation stage by optimizing the design in the construction stage. From the perspective of economic benefits, the adoption of the "BOOT+BTO" operation mode can not only attract social capital to participate in the PPP project of comprehensive utilization of water conservancy projects, but also reduce the financial pressure of social capital in the early stage of project operation through government repurchase and mortgage financing., which can produce positive economic benefits for both the government and social capital. Therefore, it is feasible to adopt the "BOOT+BTO" operation mode for the PPP project of comprehensive utilization of water conservancy projects.

3.3. Comprehensive utilization of the advantages of the operation mode of "BOOT+BTO" of water conservancy projects

Compared to the BOT model, the advantages of the operation mode of "BOOT+BTO" for the comprehensive utilization of water conservancy projects are mainly reflected in three aspects: financial pressure, risk responsibility definition, and public welfare function.

(1) The financial pressure of social capital in the early stage of project operation under the "BOOT+BTO" model is relatively small.

During the concession period of the BOT operation mode of the comprehensive utilization of water conservancy projects, the operational facilities benefit from good operational maintenance, while the non-operating facilities need to rely on the revenue support of operating facilities or government subsidies to ensure operation and maintenance. In the "BOOT+BTO" mode of operation, the project company has ownership of the concession period of the operating facility. With the consent of the government, the operating facilities can be mortgaged to financial institutions for financing loans to obtain certain operation and maintenance fund support. At the same time, the government needs to acquire ownership of non-operating facilitiesand entrust them to the project company for operation and maintenance according to the agreement. The capital flow of the BOT operation mode and the "BOOT+BTO" operation mode of the comprehensive utilization of water conservancy projects is shown in Figs. 4 and 5, respectively.

In the early stage of operation of the operation mode of "BOOT+BTO" of the comprehensive utilization water conservancy project, the capital inflow of the project company includes mortgage financing loans of operating facilities and government repurchase of non-operating facilities. In addition to the income from concessions, government subsidies when there is insufficient demand for water and electricity, and related payments for government purchases of services, It also includes mortgage financing loans for operating facilities and government buybacks for non-operating facilities. The capital outflow of the project company includes the project operation and maintenance cost, financing loans and interest during the construction period, and mortgage loans and interest during the operation period. Compared to the BOT model, the mortgage financing loans and government repurchases of the "BOOT+BTO" operation model can reduce the pressure on the project company's operation and maintenance funds to a certain extent, and alleviate the influence of the relative lag of franchise income, government subsidy and government payment on the project operation and maintenance, which is conducive to ensuring the comprehensive utilization of water conservancy projects to bring benefits into play.

(2) The risk liability of the project under the "BOOT+BTO" mode is relatively clearly defined.

The asset structure characteristics and responsibility and rights structures of the operational facilities and non-operational facilities of the comprehensive utilization of water conservancy projects are different. This makes the ownership, use, and benefits of ownership also different. Under the BOT model, the project company is responsible for the operation and maintenance of the project franchise period. When the adjustment of operation scheduling rules leads to the loss of project revenue, how to define the responsibility for the loss of revenue between the government and social capital is rather vague, especially for the public assets. In "BOOT+BTO" mode, during the concession period, the government and the private capital can adopt appropriate operating modes according to the asset structure characteristics of the hub project, the operational facilities adopt the BOOT model, its ownership is temporarily owned by social capital, and the non-operating facilities adopt the BTO mode, the ownership of which is owned by the government. The responsibilities for different assets of hub projects is relatively clear, and the distribution of liability for loss of income caused by risk events is also relatively clear.

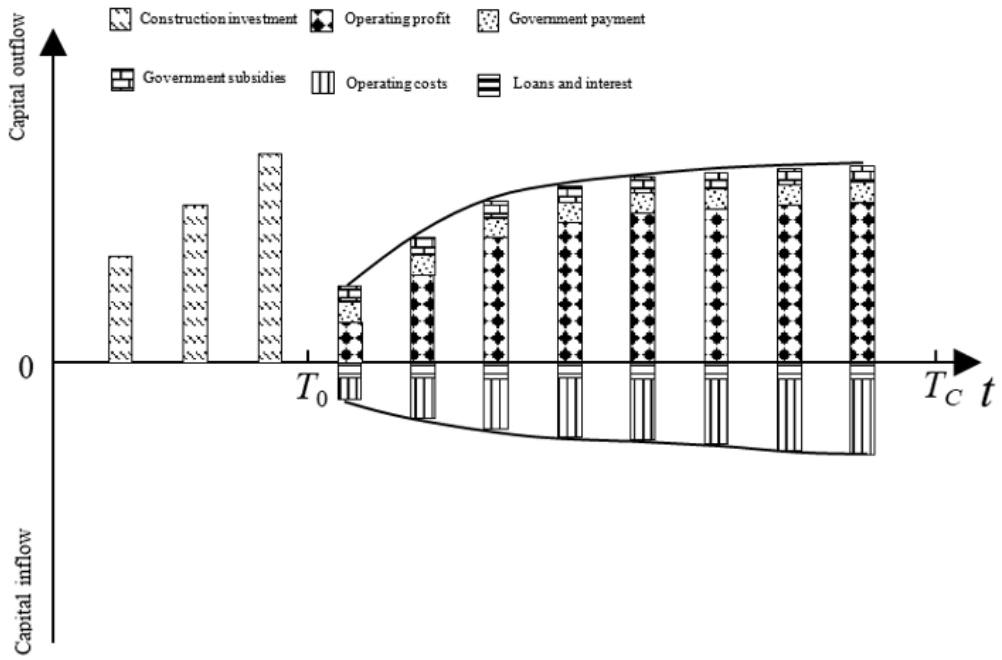

Fig. 4. The fund flow of BOT operation mode of comprehensive utilization of water conservancy project.

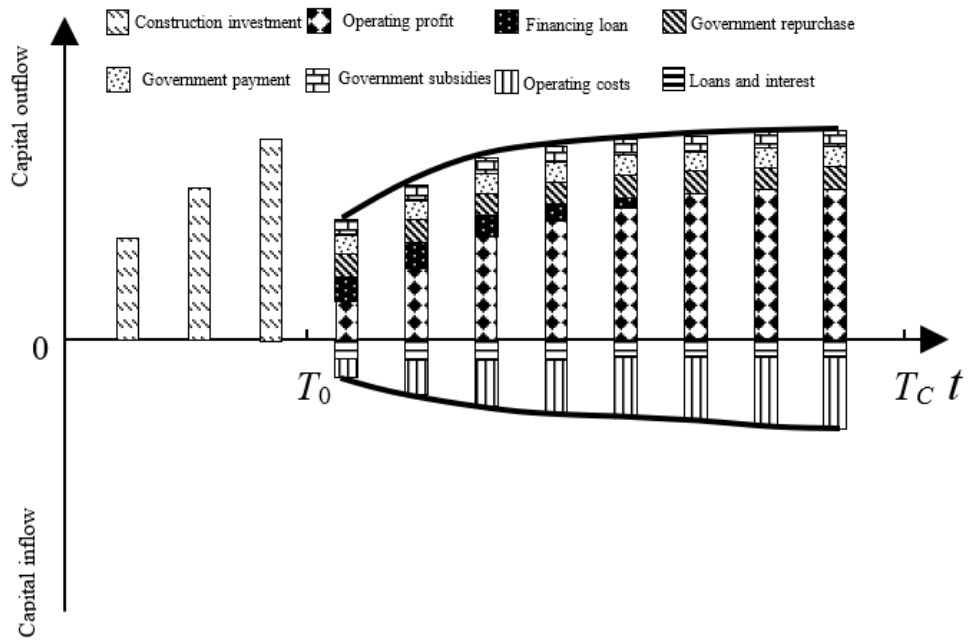

Fig. 5. The fund flow of "BOOT+BTO" operation mode of comprehensive utilization of water conservancy project.

(3) The public welfare function of the hub project under the "BOOT+BTO" mode is more secure. The economic and social benefits of comprehensive utilization of water conservancy projects need to be paid equal attention, in particular, the realization of benefits such as power generation, water supply, and shipping must be premised on ensuring public functions such as flood prevention, drought control, flood control, water and sediment regulation. When the "BOOT+BTO" operation mode is adopted for comprehensive utilization of water conservancy projects, after the completion of the project, the government has ownership of non-operating facilities under the BTO model; and the government pays to ensure the normal play of its public welfare function; The financial pressure for the government to pay this part of the construction cost and reasonable profit at one time or in stages is relatively small. The project company has the ownership of the operating facility concession period of the BOOT model and can make a mortgage loan as the subject matter. It will not affect the actual control of the government over this part of the facility and can incentivize the project company to do a good job of operation and management maintenance to improve the level of profitability, which is conducive to ensuring that the surplus value of the facilities at the time of project handover and the functions after handover can continue to play, and strive for a lower power supply (water) price for the public, while the government can put more experience into the supervision and management of the construction and operation of hub projects.

4. Case studies

A comprehensive utilization water conservancy project is mainly based on water supply and irrigation, combined with power generation, taking into account flood control, its irrigation and rural drinking water income are low, which is a public welfare investment; The urban and industrial water supply and power generation parts are operating investments, considering the subsidizing irrigation projects and rural drinking water with some urban water supply and power generation income, and implement water-based and electricity-based water-based maintenance to ensure the healthy operation of irrigation projects. The project intends to adopt the BOT operation mode to introduce social capital to participate in the construction management and operation management of the hub project and the backbone project of the irrigation district. However, due to the strong social welfare, poor economic benefits and long investment return period of the projects, the four legal person bidding for BOT projects successively ended in failure. By consulting the contract documents of the first four BOT project bidding for the comprehensive utilization water conservancy project, the following problems were analyzed:

(1) The project adopts BOT mode, the project company only has the right to operate the hub project, and has no right to mortgage the hub project to a third-party financial institution for loans, and the operating profit margin of the backbone project of the irrigation district is small, compared to the "BOOT+BTO" mode, it will increase the financial pressure of the PPP project company to bear the operating period expenditure and repay the construction period loan in a certain period after the completion of the project, which will affect the operational efficiency of the project.
(2) The BOT project contract lacks the agreement of price adjustment mechanism. Water supply revenues and power generation revenues are important sources of income for the hub project, within 30 y of the concession

period, the increase in the cost of water supply and power generation will inevitably lead to a reduction in revenue space. Under such circumstances, how the government and social capital reasonably adjust the price of water and electricity, and define the price adjustment mechanisms such as price adjustment conditions, price adjustment methods and adjustment measures to ensure that the reasonable returns of social capital will not be affected, it is a problem that must be considered in the design of BOT project contract mechanism.

(3) The BOT project contract lacks a compensation method for the loss of revenue in the event of emergency dispatch. As a watershed control project, this project will inevitably need to adjust its operation and dispatching rules in case of over-standard water supply, abnormal drought events or abnormal flood events. How to effectively compensate the loss of project income caused by this is related to the sustainable operation of comprehensive utilization water conservancy projects. Defining the compensation method of loss of income in the contract mechanism can ensure the reasonable income of social capital while realizing the flood control and drought relief dispatching function of key projects.

In view of the shortcomings of the contract mechanism adopting the BOT operation mode for the comprehensive utilization of water conservancy projects, try to operate in a bundled PPP project with "BOOT+BTO", in which the water supply system project and power generation system project with strong business operation adopt the BOOT operation mode, the hub dam project and the backbone project of the irrigation district with strong public welfare adopt the BTO operation mode, The provincial water investment company, local government, and social capital adopt the cooperation method of "BOOT+BTO" to jointly establish a PPP project company, as shown in Fig. 6.

The contracting mechanism for designing the operation mode of "BOOT+BTO" of the comprehensive utilization water conservancy project is as follows:

(1) Return mechanism: adopt the form of feasibility gap subsidy, the benefits of the project company are shown in Fig. 7, including water supply revenue, power generation revenue, government payment, local government subsidies, and revenue loss compensation. (1) The local government undertakes that all the power generation of the hub project will be absorbed by the local government in coordination with the local power grid, and assisted the project company and the power company to sign grid connection agreements, grid price agreements, and electricity sales agreements, etc. (2) Before reaching the design year level, the government subsidies for irrigation water fee income and rural drinking water fee income, ensure that the income from irrigation water and rural drinking water is not less than 12 million yuan/y. (3) Local governments take 30 y as the commitment period, the first 20 y are cycled into 5 y, the last 10 y are a cycle of commitments to water consumption, water prices, electricity prices, local governments undertakes the government procurement services agreed in the agreements such as inadequate water price, water quantity, electricity price and electricity quantity. (4) The project begins in the 5th year after the operation, if the water consumption does not reach the promised amount, the

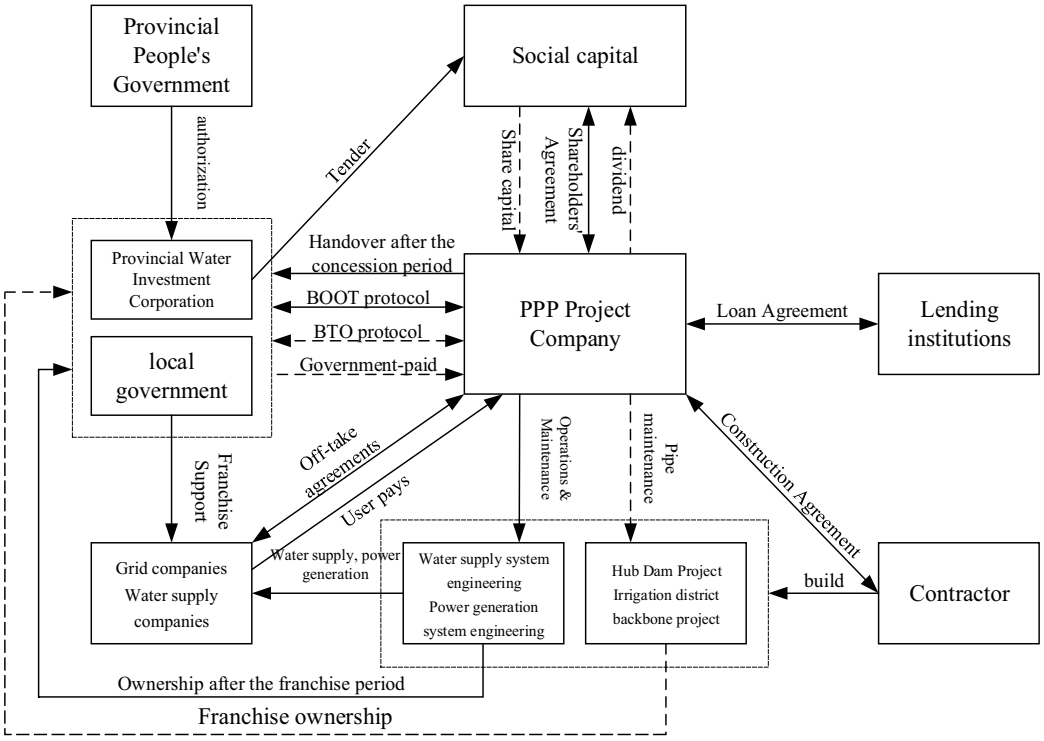

Fig. 6. The "BOOT+BTO" operation mode of comprehensive utilization of the water conservancy project.

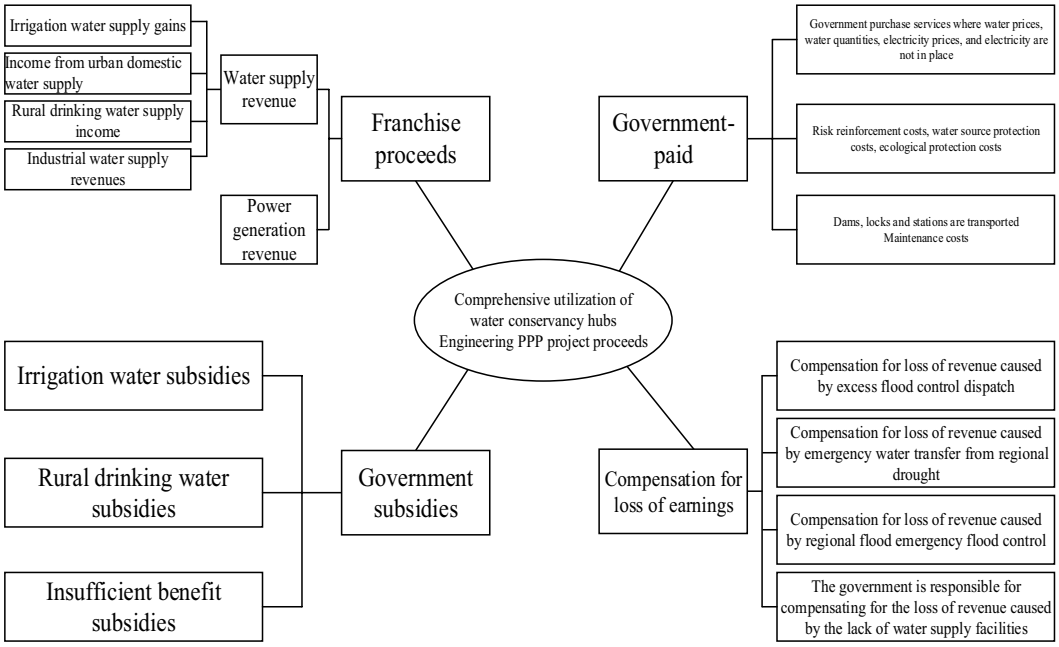

Fig. 7. The revenue composition for the PPP project of comprehensive utilization of water conservancy project.

government will give the project company a subsidy of no more than 10 million yuan/y.

(2) Risk sharing: (1) The government bears non-commercial risks, such as political and public policy adjustment risks, social, legal, and financial risks, public safety and environmental risks, land acquisition, and resettlement risks. (2) Social capital bears the financing, construction, and operation risks of the project, etc. For example, when the financing amount is lower than the financing amount agreed in the contract, the remaining part will be financed by each shareholder of the project company as the financing subject according to the share ratio; The increase of investment caused by price fluctuation or change of initial scope shall be borne by social capital; The increase in investment caused by the delay in the construction period is borne by the social capital, and the delayed loss is paid to the government according to the contract. (3) When the revenue loss of PPP project is caused by the implementation of public welfare emergency dispatch for flood control and drought relief, the reduction of irrigation water demand in wet years or the adjustment of operation dispatch rules caused by major public activities, the project company and the government shall adopt the interval progressive method to determine the revenue loss compensation amount according to the trigger compensation threshold agreed in the contract, and negotiate to determine a reasonable revenue loss compensation method.

(3) Policy support: (1) The local government promised that within 15 y after the completion and operation of the hub project, when the financial internal rate of return audited by a third-party institution is lower than the expected financial internal rate of return, the government input port does not participate in the sharing, priority is given to social capital to enjoy a share to ensure a reasonable return on social capital. (2) Support the project company to implement the hub project reservoir area during the concession period, tourism development, and agricultural development in the dam area, the relevant proceeds go to the project company. (3) When the financial internal rate of return at the end of the franchise period is lower than the expected financial internal rate of return, the project company may apply to the government to extend the franchise period. (4) After the completion of the project, the project company can apply to the government for adjusting the ratio of water consumption for power generation and water supply, on the premise of ensuring water supply for urban and rural areas, irrigation and other public welfare. (5) On the premise of not changing or affecting the use function of the hub project and ensuring the public welfare water supply such as urban and rural water supply and irrigation water, the project company may apply to the government to expand the total installed capacity of the power station after the technical and economic demonstration is feasible. (6) After the end of the franchise period, if the government continues to entrust the operation and management of the hub project, the project company has the priority right to undertake the operation and management.

(4) Exit mechanism: (1) More than 10 y of operation during the franchise period, social capital can withdraw in consultation with the government. (2) When the project company violates laws and regulations or contractual agreements, operating without authorization and endangering the public interest and safety, affecting the safety of water conservancy hubs, products, and services that do not meet expectations and harm the public interest, The government can take back the right to operate in advance. (3) It is really necessary to terminate the management right ahead of time due to force majeure or unexpected

reasons, or if the PPP agreement needs to be changed due to the revision, abolishment or major adjustment of laws and policies, and no agreement is reached, the government and social capital will negotiate and decide to withdraw from the agreement. (4) When PPP project cooperation is suspended, both the government and private capital are entitled to compensation for losses, expenses, and expenses suffered by the defaulting party as a result of its failure to comply with all or part of the relevant agreement to terminate the cooperation, and such compensation shall be paid by the defaulting party; In case of social capital default, the government has the right to recover the right to recover the right of project construction and operation for free.

5. Conclusion

The comprehensive utilization of water conservancy projects uses the PPP model to attract social capital to participate in construction, operation, and management, in order to achieve the multiple goals of optimizing investment and financing methods, reducing government capital pressure, improving the level of project construction and operation management, meeting the requirements of flood prevention and drought control in river basins, and ensuring the investment income of social capital. Aiming at some of the shortcomings of BOT operation mode of comprehensive utilization of water conservancy projects in contract mechanism and operation implementation, the BOOT operation mode of comprehensive utilization of water conservancy projects and BTO operation mode of non-operating facilities are designed, which is conducive to reducing the financial pressure of project companies in the early operation stage. The feasibility of "BOOT+BTO" operation mode of comprehensive utilization of water conservancy projects is analyzed from the perspectives of technology, cost control and economic benefits. The advantages of "BOOT+BTO" operation mode are analyzed, and the "BOOT+BTO" operation mode of comprehensive utilization water conservancy project is verified by an example, which plays a positive role in promoting the efficient application of PPP mode in comprehensive utilization water conservancy project.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest

It is declared by the authors that this article is free of conflict of interest.

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