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Risk assessment model to build-operate-transfer financing via analytic hierarchy process method

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ABSTRACT

BOT financing is a way to fund from private capital and invest in infrastructure construction to release the fiscal burden of the government. While there exist certain risks due to the large amount of investment, complex participants and different interest. This paper took the XY WTE plant construction project in Beijing as an empirical case to study what the risks are when financing via BOT and how to manage them. We used the AHP method to establish a BOT financing risks assessment model and finally reached a risk ranking according to which we proposed some suggestions to manage risks.

KEYWORDS

BOT financing; AHP; Risk assessment model; Risk management.

INTRODUCTION

BOT (Build-Operate-Transfer) is a way to finance for project, which means that private sectors participate in infrastructure construction and provide public service to the society[1]. The basic thinking of BOT is that the local government the project started up provides concessions to those investors home and abroad to finance and construct the project. Part of the profit generated in the concessions duration will be paid to the local government as compensation and the ownership and managerial authority of the project will be returned to the local government when the project finishes[2]. WTE (Waste to Energy) is a well way to dispose urban wastes which can turn the heat generated by burning wastes into electricity. However, to build a WTE plant requires a large amount of cost, advanced technologies and will pollute a lot[3]. Consequences are that BOT is a feasible and effective way to finance for a WTE plant, which can not only reduce the fiscal burden but also can introduce some advanced technologies and management experience from the private sectors home and abroad[4]. In this paper, we applied the BOT financing in the construction of a WTE plant, and we utilized the AHP method to establish a risk assessment model. And then we conducted an empirical feasibility research based on the XY WTE plant in Beijing and finally we got the BOT financing risk ranking, according to which we proposed the corresponding suggestions to manage risks.

BOT FINANCING AND AHP

BOT financing

Description of BOT financing

In the field of international finance, BOT is not just a process of constructing, operating and returning a project but more a way to finance for project which has limited recourse[5]. BOT financing contains many participants which can be divided into nine groups that is the shareholders, the government, the clients, the insurance companies, the project companies, the banks, the building contractors, the operators and the supplies. The relationship among the nine participants is shown in the Figure 1.

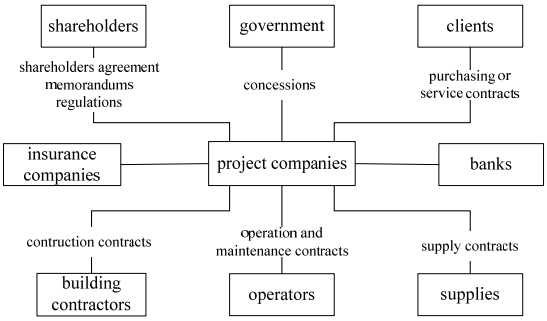

Figure 1 : Nine participants of BOT financing

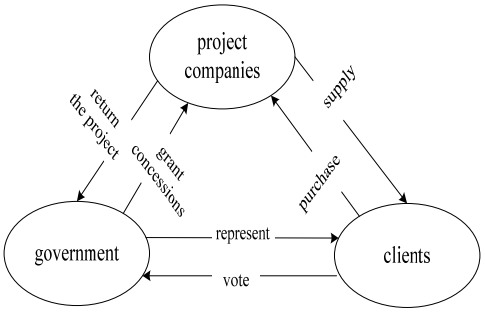

Figure 2 : Three participants of BOT financing

According to the interest each participants represent, we separate the nine participants into three groups that is the project companies, the government and the clients[6]. The other six participants share the same targets and represent the same interest, thus we group them as one aspect that is the project companies. In this way, the participants of BOT financing can be simplified as the Figure 2.

Steps of BOT financing and risk evaluation

Steps of BOT financing

BOT financing can be separated into two phases that is the preliminary conceptual phase and the post implementation phase. In the preliminary conceptual phase, there are mainly eight steps including designing and planning, starting up, preparing bidding, pre-qualifying and negotiating contracts. In the post implementation phase, there are mainly four steps that is designing, constructing, operating and returning the project[7].

Identification of risk factors in BOT financing

System risk refers to the adverse factors that can influence the whole project, which means that this sort of risk can't be controlled through a partial adjustment[8]. On the contrary, non-system risk can be avoided and prevented through certain measures because this sort of risk only influence some parts not the whole project. Some common risk factors of system and non-system risk are listed in TABLE 1.

TABLE 1 : Risk recognition

System risk	Political risk	It refers to the asset and revenue loss caused by wars, changed international relationship, changed policies or changed government.
	Law risk	It refers to the loss caused by faultiness and changes of the project's nation.
	Financial risk	It refers to the changes of external economic condition, including the risks in currency exchange, exchange rate, interest rate and inflation.
	Force majeure risks	It refers to the changes we can't foresee or avoid including natural disasters, wars and other accidents.
Non-system risk	Completion Risk	It refers to that the project can't be completed before the due time.
	Operational risk	It refers to that the level of operators' ability to manage the project may result in major operational difficulties.
	Credit risk	It refers to that limited recourse can't guarantee an effective credit security.
	Environmental risk	It refers to that the construction and operation of the project may offend the environment protection laws and regulations.

AHP

AHP (Analytic Hierarchy Process) is an effective method to convert qualitative questions to quantitative regulation by means of muti-level analysis[9].

Steps of AHP

There are mainly four steps to conduct an AHP analysis.

Establishing hierarchy

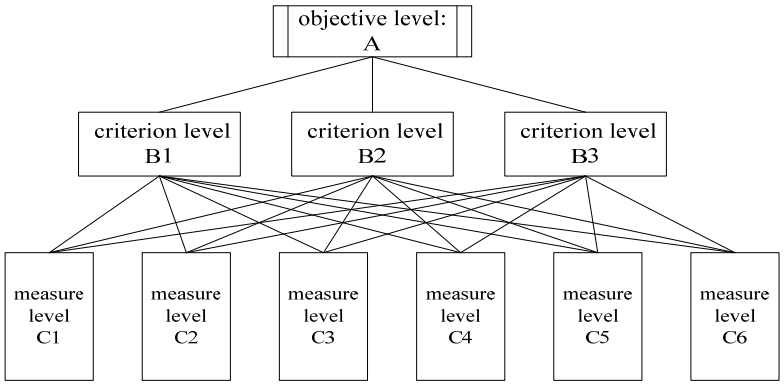

Figure 3 : Hierarchy of the project

Set up a judgment matrix

According to the relative importance of each level, we can set up a judgment matrix based on the scale TABLE as shown in TABLE 2.

TABLE 2 : Scale of judgment matrix

scale	meaning
1	The two factors share the same importance
3	The former factor is a bit more important than the later one
5	The former factor is very more important than the later one
7	The former factor is greatly more important than the later one
9	The former factor is extremely more important than the later one
2,4,6,8	These refer to the middle degree of the adjacent scale
reciprocal	The importance of factor *i* to factor *j* expresses as a_{ij} and on the contrary as $a_{ji} = \frac{1}{a_{ij}}$

Calculation of the judgment matrix

The largest eigenvalue of the judgment matrix expresses as $\lambda_{\max}$, and the eigenvector expresses as W. We should first calculate the single sort results according to relative importance, which stands for the factors of eigenvector of one level to another level. According to the single sort results we can calculate the eigenvector of the measure level to the objective level. Synthesize all the eigenvectors we can get the hierarchy. At last we conduct a consistency check of each eigenvector.

Consistency check

We first calculate the Consistency Ratio (CR) to examine the consistency of the judgment matrix. If $CR = CI / RI < 0.1$, it means that we have got the right consistency index (CI) or we should reset up the judgment matrix[10].

$CI = \frac{\lambda_{\max} - n}{n-1}$, n is the order number of the judgment matrix, $n>1$。

The RI (Random Consistency Index) of the nine-order judgment matrix is as follows[11].

TABLE 3 : *RI*

Order(n)	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.26	1.32	1.41	1.45

EMPIRICAL CASE OF XY WTE PLANT

Basic information of the XY WTE plant

The XY WTE plant locates in the Changping district in Beijing. It can dispose about 1200 ton wastes a day and about 0.4 billion ton a year. The heat generated by burning wastes is used for electricity generation. The heat generated by burning wastes is used for electricity generation. The construction of the plant includes three parts: primary production facilities, public and auxiliary production facilities and welfare and management facilities.

BOT financing risk hierarch of the XY WTE plant

Based on the circumstances of XY WTE plant's BOT financing, we set up the hierarch as shown in Figure 4.

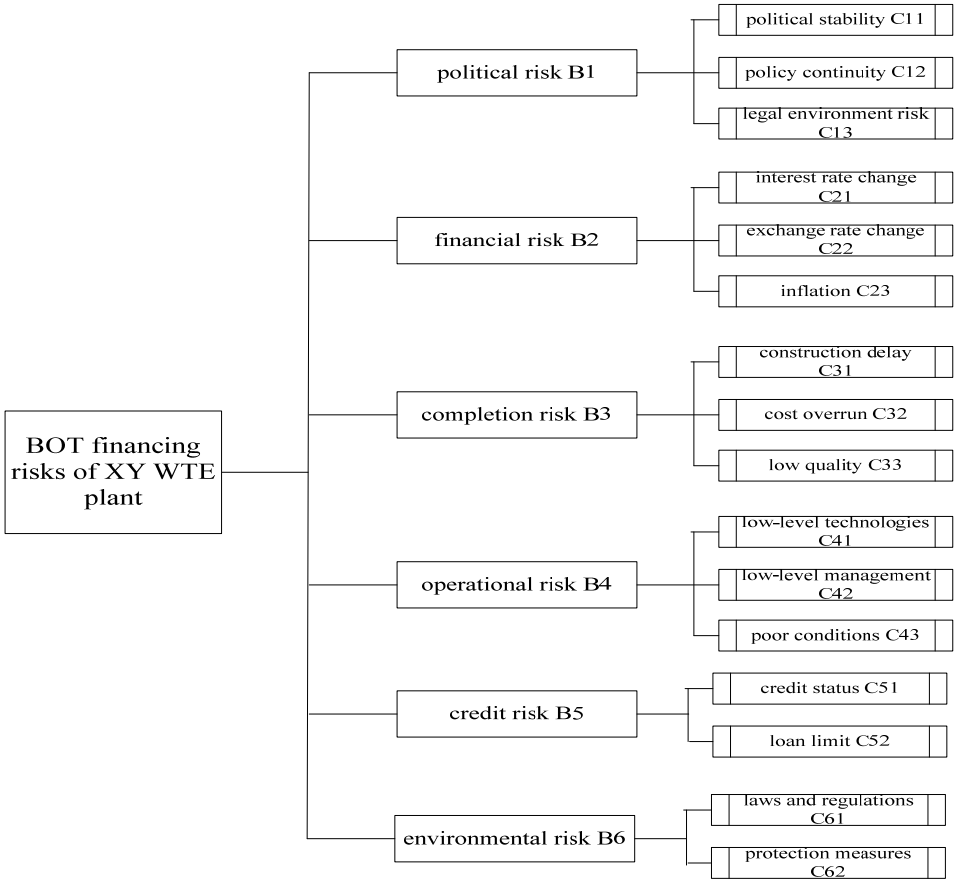

Figure 4 : Risk hierarch of BOT financing

Judgment matrix and consistency check

We first utilized the Delphi method to consult some experts by sending the feasibility report of constructing the XY WTE plant to them and aggregating their feedbacks. We totally sent out 200 questionnaires and withdrew 158 ones. According to the results, we set up the judgment matrix according to Tab. 2 as shown in TABLE 4.

TABLE 4 : Judgment matrix of A and B levels

A	B1	B2	B3	B4	B5	B6	Normalized weights Wi
B1	1	1/2	1/5	1/5	1/4	1/5	0.0411
B2	2	1	1/5	1/5	1/3	1/5	0.0541
B3	5	5	1	1/2	4	3	0.2708
B4	5	5	2	1	3	4	0.3509
B5	4	3	1/4	1/3	1	1/3	0.1095
B6	5	5	1/3	1/4	3	1	0.1736

λ_{max} =6.4809, CI=0.09818, RI=1.26, CR=0.076<0.1, passing the consistency check.

TABLE 5 : Judgment matrix of B1-C and B2-C levels

B1	B11	B12	B13	Wi	B2	B21	B22	B23	Wi
C11	1	1/5	1/2	0.1149	C21	1	2	1/4	0.2014
C12	5	1	5	0.7028	C22	1/2	1	1/5	0.1179
C13	2	1/5	1	0.1822	C23	4	5	1	0.6806

λ_{max} =3.0536, CI=0.0268, RI=0.58, CR=0.046<0.1, passing the consistency check; λ_{max} =3.0246, CI=0.0123, RI=0.58, CR=0.021<0.1, passing the consistency check.

TABLE 6 : Judgment matrix of B3-C and B4-C levels

B3	B31	B32	B33	Wi	B4	B41	B42	B43	Wi
C31	1	2	1/3	0.2519	C41	1	2	3	0.5247
C32	1/2	1	1/3	0.1593	C42	1/2	1	3	0.3338
C33	3	3	1	0.5889	C43	1/3	1/3	1	0.1416

λ_{max} =3.0536, CI=0.0268, RI=0.58, CR=0.046<0.1, passing the consistency check; λ_{max} =3.0536, CI=0.0268, RI=0.58, CR=0.046<0.1, passing the consistency check.

TABLE 7 : Judgment matrix of B5-C and B6-C levels

B5	B51	B52	Wi	B6	B61	B62	Wi
C51	1	1/3	0.25	C61	1	1/5	0.17
C52	3	1	0.75	C62	5	1	0.83

λ_{max} =2, CI=0, RI=0.58, CR=0<0.1, passing the consistency check; λ_{max} =2, CI=0, RI=0.58, CR=0<0.1, passing the consistency check.

Results of matrix calculation and the risk ranking

According to the above calculations, the risk ranking of B level is as follows:

TABLE 8 : Risk ranking of B level

A	Wi	Ranking
B1	0.0411	6
B2	0.0541	5
B3	0.2708	2
B4	0.3509	1
B5	0.1095	4
B6	0.1736	3

Integrating the results of B level and C level, we can calculate the risk ranking of C level as follows:

Suggestions of managing BOT financing

TABLE 9 : Risk ranking of C level

B	Risk factors	Calculation of weight Wi of Bi × Wi of Cij	Wi	Ranking
C11	political stability	B1 0.0411× C11 0.1149	0.0047	16
C12	policy continuity	B1 0.0411× C12 0.7028	0.0289	11
C13	legal environment risk	B1 0.0411× C13 0.1822	0.0075	14
C21	interest rate change	B2 0.0541× C21 0.2014	0.0109	13
C22	exchange rate change	B2 0.0541× C22 0.1179	0.0064	15
C23	inflation	B2 0.0541× C23 0.6806	0.0368	9
C31	construction delay	B3 0.2708× C31 0.2519	0.0682	6
C32	cost overrun	B3 0.2708× C32 0.1593	0.0431	8
C33	low quality	B3 0.2708× C33 0.5889	0.1595	2
C41	low-level technologies	B4 0.3509× C41 0.5247	0.1841	1
C42	low-level management	B4 0.3509× C42 0.3338	0.1171	4
C43	poor conditions	B4 0.3509× C43 0.1416	0.0497	7
C51	credit status	B5 0.1095× C51 0.25	0.0274	12
C52	loan limit	B5 0.1095× C52 0.75	0.0821	5
C61	laws and regulations	B6 0.1736× C61 0.17	0.0289	10
C62	protection measures	B6 0.1736× C62 0.83	0.1447	3

According to the risk ranking result above, we propose some suggestions to manage the BOT financing risk as follows:

Bring in the advanced technology abroad to improve the technology of burning wastes and improve the existing production conditions

Enhance the quality controlling of WTE plant to ensure the safety production and improve workers' safety awareness to take protection measures

Take steps to prevent and dispose the pollution generated in production. Abide by the national environmental protection laws and regulations and try to save energy and increase greening.

Introduce advanced management mode to improve the efficiency and effectiveness. Supervise the management from both from managers to workers and from workers to managers.

CONCLUSIONS

In this paper, we applied the BOT financing into investing the construction project of WTE plant. We used the AHP method to evaluate the financing risk and get a risk ranking based on the XY WTE plant in Beijing, according to which we proposed some suggestions to manage risk. The result we studied in this paper can also provide some experience in investing other infrastructure construction projects applying the BOT financing, which is beneficial to the residents and society.

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