Advances in Applied Economics and Finance (AAEF)
Vol. 1, No. 4, 2012, ISSN 2167-6348

Analysis of the Computational model of BOT Projects during Franchise Period

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Abstract –Computational modeling plays an increasingly important explanatory role in cases where we investigate systems or problems that exceed our native epistemic capacities. One clear case where technological enhancement is indispensable involves the study of complex systems.1 Even in contexts where the number of parameters and interactions that define a problem is small, simple systems sometimes exhibit non-linear features which computational models can illustrate and track. In recent decades, computational models have been proposed as a way to assist us in understanding emergent phenomena. OT is short for CBOT. The participants of BOT mode is simplified into 3 principal agents: project company-government-users. The risk graph of different agents in different stages is revised. By applying ABC classification and antinomy analysis, all kinds of risk of different agents in different stages and preventive measures were discussed in sequence of the occurrence period and the importance by taking the risk identification, analysis, evaluation and disposal as intrinsic logics. Project Finance has the characteristic of strong financing ability and has a very bright future in China. A Based on the analysis of franchise period influence factors, aiming at the expected VFM effect and profit of private entity, builds the computational model during franchise period, moreover, analyzes the evolution of the computational model when construction period has been shortened and development time point has been advanced. At last, demonstrates the model through calculation, and proves that is more scientific and effective.

Keywords –services sold to the public sector of BOT projects; franchise period; VFM; financial indemnity

1. Introduction

.With the rapid development of the infrastructure market, using the BOT model to develop our public projects has been taken more and more attention of our government. In areas such as roads, power plants and sewage treatment, many BOT projects are in construction or operations. For BOT project regarding the services sold to public sector is more common, its main feature is during the franchise period public services all sales to the government, and the cost of development and operation charges to government not to consumers. In the end of the franchise period, the project transferred to the government.

Risk management is an important part of BOT investment and financing mode, and the key to successful BOT is to identify, analyze, evaluate, and deal with the risk in a scientific and effective way. The BOT investment and financing mode is divided into 4 stages: concession-build-operate-transfer. B There is much difficulty and risk to run Project Finance, furthermore, the Chinese Law and Finance system is far from perfect, So Project Finance doesn't show the effect we hope to see, As for China, BOT is the best model to chose. If we want to increase the deficiency of applying Project Finance and boom economy, the followings should be done. First, Special organization should be set up to charge the Project Finance affair. Secondly, we need to promote the exterior environmental conditions such as Law and Finance system. Thirdly, professional persons should be cultivated. Then it is necessary for us to encourage private capital and state capita to take active part in Project Finance。

Yudong Zhang, and Lenan Wu (2009) proposed an improved bacterial chemotaxis optimization (IBCO), which is then integrated into the back propagation (BP) artificial neural network to develop an efficient forecasting model for prediction of various stock indices. Experiments show its better performance than other methods in learning ability and generalization. And then they thought traditional methods for 2D-3D feature based pose estimation problem require two inputs, and they can not work well due to lack of correspondences of input images. In order to solve the pose estimation problem more effectively and rapidly, they proposed a 6-point template which overcomes the shortcomings of traditional approaches, and use particle swarm optimization to find the optimal solutions. Experiments demonstrate that the proposed method is effective, anti-noising, and rapid. In order to improve this method in 2010 Yudong Zhang, Lenan Wu, Shuihua Wang and Wei Geng introduced a novel enhancement method based on pulse coupled neural network (PCNN) and human vision system (HVS) is proposed. And in the following years, Yudong Zhang and his colleagues adopted Multi-channel Diffusion Tensor Image Registration via Adaptive Chaotic PSO to overcome the weakness and use a new optimization method to improve their model.

To improve protein folding simulations, Yudong Zhang, and Lenan Wu (2010) compared CCGA with standard genetic algorithm (SGA) and immune genetic algorithm (IGA) for various chain lengths. It has shown that CCGA not only find global minima more reliably, but also be significantly faster in convergence. In order to perform document image denoising more efficiently and rapidly, Yudong Zhang, and Lenan Wu(2011) proposed a hybrid method which used the Otsu’s method to initial binary quantization, used two dimensional median filters to reduce the left pepper & salt noises, and performed open and close operators to eliminate the remained noises. Besides, a fast calculation strategy was proposed based on packed binary (PB) format and source word accumulation (SWA). The PB format uses a uint32 word to represent 32 binary pixels, and SWA is capable of directly performing erosion and dilation processes on this format. Yudong Zhang, and Lenan Wu(2012) presented a new approach based on Particle Swarm Optimization Sequence Quadratic Programming (PSOSQP). they created the optimization model using the variance ratio criterion (VRC) as fitness function. Then PSOSQP was introduced to find the maximal point of the VRC. The experimental dataset contained 400 data of 4 groups with three different levels of overlapping degrees: non-overlapping, partial overlapping, and severely overlapping. We compared the PSOSQP with genetic algorithm (GA) and combinatorial particle swarm optimization (CPSO). Each algorithm was run 20 times. For BOT projects regarding services sold to the public sector, the length of the concession period has a direct impact on both public and private benefits; therefore it’s vital for both public and private sectors. Li Qiming and Shen Liyin (2002) they build a computational model based on the following thinking: In the franchise period, the project profit proceeds to meet the expected return level of private entity, and it able to generate profits (Income greater than operation cost) for the government after project transferred(during the government operation period). Qin Xuan (2005) introduced the benchmark discount rate based on the CAPM, and developed the above computational model. Michael (2003) applied the real options theory in the computational model during franchise period. Yang Hongwei (2003) from the aspect of game theory analyzed the game between public and private sector to build of the decision-making model during franchise period. Zhao Lili and Tan Deqing(2009) force on the maximize of social benefits to determine the decision criteria of the BOT project during the franchise period. In summary, these studies reveal a certain extent of the decision-making principle of the BOT project during franchise period. However, in the choice of policy objectives and constraints theses documents are still unreasonable, embodied in two aspects as following:

$$t_1 = t_{21} + t_{22} \quad (1), \quad t_3 = t_1 + t_2 \quad (2)$$

$$I_g = \sum_{t=1}^{t_1} \frac{CO_{psc-g}}{(1+r)^t} \quad (3) \qquad I_p = \sum_{t=1}^{t_1} \frac{CO_{bot-p}}{(1+r)^t} \quad (4)$$

$$NPV_{psc} = \sum_{t=1}^{t_1} \frac{-CO_{psc-g}}{(1+r)^t} + \sum_{t=t_1}^{t_3} \frac{CI_{psc-g}-CO_{psc-g}}{(1+r)^t} \quad (5)$$

$$NPV_{bot-g} = \sum_{t=1}^{t_1} \frac{-f}{(1+r)^t} + \sum_{t=t_1}^{t_1+t_{21}} \frac{CI_{bot-g}-f}{(1+r)^t} + \sum_{t=t_1+t_{21}}^{t_3} \frac{CI_{bot-g}-CO_{bot-g}}{(1+r)^t} \quad (6)$$

$$NPV_{bot-p} = \sum_{t=1}^{t_{1+T_{21}}} \frac{f-CO_{bot-p}}{(1+r)^t} \quad (7)$$

(1)The measure of government revenue is overly absolute. The revenue of the government should not only consider the operating income after the transfer of the BOT project, but should be compared to the income of the traditional development method. Here we need to introduce the concept of VFM (Value for Money).In the BOT project, VFM used to evaluate the effect of use of funds, compared with traditional development methods to make sure whether the financial expenditure is reduced or the fiscal revenue is increased. In the developed countries that applied BOT and its relevant formula for the development of public projects, the government mainly used the VFM effect to measure the size of the revenue.

(2) Didn’t consider financial indemnity. For BOT projects (especially services sold to the public sector’), financial indemnity is an significant source of revenue of private entities. It is highly correlated with the franchise period. Usually the amount of financial indemnity increased can make the franchise period shorten. On the contrary, the amount of financial indemnity reduced can make the franchise period increased. Therefore, these two factors are inversely related. For this reason, this paper built a computational model modify the decision-making model created by Li Qiming and Shen Liyin, intends to give full consideration to both public and private expected income and financial indemnity, and will give an example to verify the validity of the model.

Yudong Zhang and Lenan Wu in their paper(2012), they proposed a novel image registration parameter solving technique. It used the NCC model to make the task as an optimization problem. Afterwards, it applied the FA method to solve the problem. And in the same year, in order to construct a spam detector with emphasis of reducing the error of mislabeling nonspams as spams, a hybrid spam detection system was proposed. Zhang, Yudong; Wang, Shuihua and Wu, Lenan used wrapper-based feature selection method to extract important features. F-measure is set as the objective function because it combines both recall and precision indicators. Particle swarm optimization (PSO) is used to accelerate the search procedures.

2. Construction of the computational model

As mentioned above, for BOT projects regarding services sold to the public sector', franchising period must satisfy two conditions, first the government can gain moderate VFM effect, second the private entities can get a modest investment return rate (r_0). In order to build a franchise model, we need to set the following parameters: t_1 =project construction period, t_2 =project operating period, t_{21} =project franchise period, t_{22}=project operated by the government, t_3=project life cycle, I_g、CI_{psc-g}、CO_{psc-g} and NPV_{psc} respectively represent the government investment、cash inflow、cash outflow and net present value in the traditional development model, CI_{bot-g}、CO_{bot-g} and NPV_{bot-g} respectively represent the government cash inflows、cash outflows and net present value in the BOT model, I_p、CI_{bot-p}、CO_{bot-p} and NPV_{bot-p} respectively represent the private entities investment、cash inflow、 cash outflow and net present value in the BOT model, r=benchmark discount rate, t=time period, f= financial indemnity by year. Assuming that the project construction period has no income and in each year government financial indemnity is equal, then the following equation:

Suppose further that in the traditional development model and BOT model, there are the following:

(1)Start point、the construction period and the operation period are the same, that if adopt the BOT model it will not develop the public projects in advance and will not change the construction period or operation period.

(2)The government operated period in the BOT model (t_{22}) are the same with it in the traditional model, the government cash inflow and outflow are equal in each year. That is $CI_{psc-g}=CI_{bot-g}$、$CO_{psc-g}=CO_{bot-g}$. Then ΔNPV_g and VFM effect and be expressed as :

$$\Delta NPV_g = \sum_{t=1}^{t_1+t_{21}} \frac{CO_{psc-g}-f}{(1+r)^t} \quad (8)$$

$$VFM = \frac{\Delta NPV_g}{I_g} \times 100\% = \frac{\sum_{t=1}^{t_1+t_{21}} \frac{CO_{psc-g}-f}{(1+r)^t}}{I_g} \times 100\% \quad (9)$$

Therefore, we can build BOT project regarding services sold to the public sector' computational model during franchise period are as follows:

$$VFM = \sum_{t=1}^{t_1+t_{21}} \frac{\frac{CO_{psc-g}-f}{(1+r)^t}}{I_g} \times 100\% \qquad (10)$$

$$r_0 = \sum_{t=1}^{t_1+t_{21}} \frac{(f - CO_{bot-p})}{(1+r)^t} / I_g \times 100\% \qquad (11)$$

$$t_{21} \le t_2 \qquad (12)$$

3. Model solution and its interpretation

Transform and sum of (10) and (11) to eliminate the financial indemnity variable (f), then the computational model during franchise period changes to:

$$I_g \times VFM + I_p \times r_0 = \sum_{t=1}^{t_1+t_{21}} \frac{CO_{psc-g}-CO_{bot-p}}{(1+r)^t} \quad (13)$$

With trial method we can find the franchise period (the trial method referred from [2], the following are the same). If franchise period is not longer than the expected project operating period (ie. satisfy formula (12)), then we can say it is the optimal value; Conversely, if franchise period is longer than expected project operating period. Then we can say that the entire operation period is operating only by private entities, and the expectation benefit for both public and private can't achieve. It means this project uses the BOT model can not meet the requirements of profit for both public and private sector.

Further analysis formula (13), we can found the left-hand side is the income of both public and private and the right-hand side is the difference of the operating costs of public and private, which shows the BOT project for both public and private benefits derived from its operating costs reduce. Compared with the traditional development methods, the operation and development of BOT project which developed by private entities can effectively reduce investment and operating costs. This is mainly due to: Private entities are the actual beneficiaries from the costs reduce of the project operation. Therefore it prompted an actively attitude looking for ways to reduce costs. Such as introduce the advanced technology、equipment and business management methods, optimization of capital structure, strengthen the control on the various aspects during the construction and operation periods. At the same time, private entities are more scientific and more effective in risk assessment than the government. They can actively take risk prevention measures or measures to control the occurrence of risk events, thereby reducing the risk of loss.

We can find that private entities funding、level of technical and management and their resulting brings the size of effect of the cost reduce directly affect the level of both public and private revenue. Therefore, if the conditions set out in formula (12) not satisfied, ie, when $t_{21} > t_2$, it mainly due to the cost reduction effect made by private entities via financial、technical or management advantages is less than the benefits requirement of both public and private. Therefore, it's not suitable for using the BOT model to develop.

For formula (13), we can do the following variant:

$$\begin{aligned} I_g \times VFM + I_p \times r_0 &= \sum_{t=1}^{t_1} \frac{CO_{psc-g} - CO_{bot-p}}{(1+r)^t} \\ &+ \sum_{t=t_1}^{t_1+t_{21}} \frac{CO_{psc-g} - CO_{bot-p}}{(1+r)^t} \\ &= \Delta I + \sum_{t=t_1}^{t_1+t_{21}} \frac{CO_g - CO_p}{(1+r)^t} \quad (14) \end{aligned}$$

Assume that the difference between annual cash outflow under the traditional development model and the annual cash outflow under the BOT model is equal (ΔCO), then the formula during the franchise period (15) can be drawn, and put the obtained franchise period into formula (11), the formula of financial indemnity can be derived as following formula (16):

$$t_{21} = \frac{\ln \Delta CO - \ln[\Delta CO - (I_g \times VFM + I_p \times r_0 - \Delta I) \times (1+r)^{t_1} \times r]}{\ln(1+r)} \quad (15)$$

$$f = \frac{(1+r_0) \times I_p \times r + CO_{bot-p} \times [1-(1+r)^{-t_{21}}] \times (1+r)^{-t_1}}{1-(1+r)^{-(t_1+t_{21})}} \quad (16)$$

4. The impact on the computational model when service supply in advance

Compared with the traditional development, using the BOT model can often make the supply of public services ahead, mainly in the following two cases:

(1)Construction period (including construction preparation time) shorten brought the supply in advance.

In the traditional development model, the government usually negotiate with the design companies、banks or other financial institutions and construction unit, it links alternating in times; However in the BOT project, the relations have been identified in the project pre-bid between the private entities and other coordinate corporations. More tacit understanding has been established in the project development process, they not have to re-commission agent, this shortened the time of project development in the convergence between the various aspects. Thus shortening the construction period of the entire project ,the project completed and put into use ahead of the schedule, bringing the public services supply in advance.

(2)The project development point put forward to bring the service in advance.

In the traditional development model, the government needs to have sufficient sources of funding in order to develop the project. Therefore, the project will start at a certain point in the future; But in the BOT project model, the project can be started after the two parties of made a consensus that will encourage the supply of public services ahead of the schedule.

Compared with the traditional development method, we assume that only construction period is shortened, project development point is not changed, t_1' = construction period in BOT project, Δt_1 means the value of construction shorten period, ei. $\Delta t_1 = t_1 - t_1'$, then the relative indexes change to :

$$NPV_{PSC} = \sum_{t=1}^{t_3} \frac{CI_{psc-g} - CO_{psc-g}}{(1+r)^t} \quad (17)$$

$$NPV_{bot-g}^{(1)} = \sum_{t=1}^{t_1'+t_{21}} \frac{CI_{bot-g} - f}{(1+r)^t} + \sum_{t=t_1'+t_{21}}^{t_1'+t_2} \frac{CI_{bot-g} - CO_{bot-g}}{(1+r)^t} \quad (18)$$

$$NPV_{bot-g}^{(1)} = \sum_{t=1}^{t_1'+t_{21}} \frac{f - CO_{bot-p}}{(1+r)^t} \quad (19)$$

$$I_P^{(1)} = \sum_{t=1}^{t_1'} \frac{-CO_{bot-p}}{(1+r)^t} \quad (20)$$

$$\Delta I^{(1)} = I_g - I_P^{(1)} \quad (21)$$

Thus, according to formula (13) we can obtain the computational model during franchise period when construction period is shortened:

$$I_g \times VFM + I_P^{(1)} \times r_0 = \left(NPV_{bot-g}^{(1)} - NPV_{PSC}\right) + NPV_{bot-p}^{(1)} = \sum_{t=1}^{t_1'+t_{21}} \frac{CI_{bot-g} - CO_{bot-p}}{(1+r)^t} + \sum_{t=t_1'+t_{21}}^{t_1'+t_2} \frac{CI_{bot-g} - CO_{bot-g}}{(1+r)^t} - \sum_{t=1}^{t_3} \frac{CI_{psc-g} - CO_{psc-g}}{(1+r)^t} \quad (22)$$

Similarly, the trial method can be used to obtain the value of franchise period, according to the value we obtained whether they meet the formula (12) to determine the value is valid or not.

Assume that the difference between the annual outflow of cash under the traditional development model and the BOT project model is equal ($\Delta CO^{(1)}$), franchise of the formula (23) can be obtained, and then introduced the value of franchise period into formula (11) and financial indemnity computational model can be drawn as formula (24), i.e.:

$$t_{21}^{(1)} = \Delta t_1 + \frac{1}{\ln(1+r)}\{\ln \Delta CO^{(1)} - \ln[\Delta CO^{(1)} - (I_g \times VFM + I_P \times r_0 - \Delta I^{(1)}) \times (1+r)^{t_1} \times r + (1-(1+r)^{-\Delta t_1}) \times (CI - CO_{bot-p} - CI \times (1+r)^{-t_2} + CO_{psc-g} \times (1+r)^{-t_2}) \times (1+r)^{\Delta t_1'}]\} \quad (23)$$

$$f^{(1)} = \frac{(1+r_0) \times I_p \times r + CO_{bot-p} \times [1-(1+r)^{-t_{21}^{(1)}}] \times (1+r)^{-t_1'}}{1-(1+r)^{-(t_1'+t_{21})}} \quad (24)$$

When construction shorten and development point advanced effect both exist, we introduce Δt_2 as the time period of projects development advanced and

The above shift react impact of development point ahead to the related indicators. After this transformation, the BOT project can be transformed when only exists the effect of construction period shorten. Introducing the variables to formula (22), we can obtain formula (25):

$$I_g^{(2)} \times VFM + I_P^{(1)} \times r_0 = \left(\sum_{t=t_1'+t_{21}}^{t_1'+t_2} \frac{CI_{bot-g} - CO_{bot-g}}{(1+r)^t} - \sum_{t=1}^{t_3} \frac{CI_{psc-g}^{(2)} - CO_{psc-g}^{(2)}}{(1+r)^t}\right) + \sum_{t=1}^{t_1'+t_{21}} \frac{CI_{bot-g} - CO_{bot-p}}{(1+r)^t} \quad (25)$$

Similarly, the trial method can be used to obtain the value of franchise period, according to the value we obtained whether they meet the formula (12) to determine the value is valid or not.

Assume that the difference between the annual outflow of cash under the traditional development model and the BOT project model is equal ($\Delta CO^{(2)}$), franchise of the formula (26) can be obtained, and then introduced the value of franchise period into formula (11) and financial indemnity computational model can be drawn as formula (27), i.e.:

$$t_{21}^{(2)} = \Delta t_1 + \frac{1}{\ln(1+r)}\{\ln \Delta CO^{(2)} - \ln\left[\Delta CO^{(2)} - \left(I_g^{(2)} \times VFM + I_p \times r_0 - \Delta I^{(2)}\right) \times (1+r)^{t_1} \times r + \left(1-(1+r)^{-\Delta t_1}\right) \times \left(CI - CO_{bot-p} - CI^{(2)} \times (1+r)^{-t_2} + CO_{psc-g}^{(2)} \times (1+r)^{-t_2}\right) \times (1+r)^{\Delta t_1'}\right] \quad (26)$$

$$f^{(2)} = \frac{(1+r_0) \times I_p \times r + CO_{bot-p} \times \left[1-(1+r)^{-t_{21}^{(2)}}\right] \times (1+r)^{-t_1'}}{1-(1+r)^{-(t_1'+t_{21})}} \quad (27)$$

5. Applications of computational model during franchise period

A public project will adopt the BOT model to develop, assuming that the project construction period is 5 years; total operation period of the project is expected to be 20 years. in the traditional development model investment of 2 million Yuan each year is needs during the construction period, the annual cash inflow during operating period is 0.75 million Yuan、cash outflow is 0.6 million Yuan. In the BOT project model the private entities investment of 1.75 million Yuan each year is needed, annual operating costs is 0.45 million Yuan during the franchise period; after the franchise period, the way of government's operating cash flow and its in the traditional development model is the same. Assumed that the government expected VFM effect is 20%, private entities expected investment income rate is 8%, benchmark discount rate is 5%.

(1)In the condition that the service supply time unchanged. Applying formula (15) and (16), we can obtain t_{21}=15.66 years, f=0.9409 million Yuan

(2)In the condition that construction period is shortened. In the BOT project model and base on the formula (10) we further assume that shorten the construction period of 3 years, during the construction period private entities' annual investment is 2.8 million, ceteris paribus, applying formula (23) and (24), we can obtain t'_{21}=12.13 years, $f^{(1)}$=1.1214 million Yuan.

(3)Consider the second time factor, based on the condition (2), suppose further that the construction period of BOT project ahead of 3 years, that is if the project develop by the government, the construction period would 3 years later at least. Assuming that after 3 years the government need an investment of 2.45 million each year to develop this public project. Applying formula (26) and (27), we can obtain t'_{21}=14.95 years, $f^{(2)}$=1.0507 million Yuan.

Thus, the proposed computational model of franchise period and financial indemnity has good application in reality.

6. Conclusion

In this paper, for BOT projects regarding services sold to the public sector, regarding VFM effect as government revenue measure, considering the factors of private entities expected revenue and financial indemnity, we built the computational models of franchise period and financial indemnity. And then we analyzed the evolution of the franchise period computational model in two situations. The computational model in this paper has changed the computing idea and influencing factors of Li Qiming and Shen Liyin'. It is more objectively reflect the objectives and requirements of both public and private parties in the BOT project.

Finally we use an example to prove that the computational model has good application in reality. At the same time VFM effect has a direct impact on the size of the financial indemnity and franchise period. So the VFM effect needs to determine appropriately. But in this paper we didn't give fully analysis to it.

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