Consulting Market Evolution and Adjustment of Hydropower Project in China

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Abstract: This paper establishes a model of evolutionary game theory in the condition of unconstrained market to illustrate the basic evolutionary law of consulting market according to the developing process of Chinese consulting market in hydropower project construction. Through analyzing the parameters, this paper proposes some strategies and methods to optimize the market behavior. Then some market constraint such as punishment laid on consulting company for violation behavior by chief department within certain industry is added into the model. Through improvement and further analysis of the model, it shows that the consulting of chief department is crucial in the process of creating good market environment and retreating from "lock" state. It also puts forward some beneficial suggestions on how to establish a regular consulting market with a healthy developing cycle. [The Journal of American Science. 2006;2(3):66-73].

Key words: evolutionary game theory; consulting market; incomplete information

Contents

1. Introduction

Since the implementing of project construction consulting (supervision) system in 1988, it has been playing a more and more important role in project construction. Meanwhile the consulting system has drawn much more social attention and gained universal recognition. On the whole, the result of its implementation is remarkable but there are still some problems. Some related investigation shows that the consulting system in our country is still in its primary stage. There are two main problems. Firstly, the construction consulting market is not regular and its competitive system is not complete. Secondly, the management level is not high enough and consulting engineers are not fully qualified (Guohui Jiang, 2005). So, what is the inner mechanism that causes such a phenomenon? How to solve the problem and form a good consulting market criterion? This paper just uses the evolutionary game theory to analyze the developing rules of consulting market in order to find out the ultimate reasons causing the existing problems. It also proposes some corresponding methods to achieve healthy and regular development of construction consulting market in our country.

Evolutionary game theory is one kind of game theory model, which is about mutual reaction of behavior strategy and iterative process. Its basic

principle is the theory of "survival of the fittest" in biological evolutionism. In the model, every behaving individual can choose different behavior strategies so as to gain corresponding "payment" and "adaptation degree". After a period of iteration, the adopting range of one kind of behavior can cause changes in its adaptation degree, which can make the behaviors of one individual begin to evolve according to the "survival of the fittest" principle.

The evolutionary game theory believes that the limited rational economic subject hardly knows whether it is in advantageous state or not exactly. Instead, it uses the most advantageous strategy to imitate gradually so as to reach a balanced state. Suppose there are many participants in one system. Then every game is going to carrying out stochastic sampling from all the participants. The selected participant will take part in the element game and can gain interest. Then the above process will be repeated. The evolutionary game theory is just the tool for analyzing such a process above. And it studies how the participants choose and adjust strategies during the whole evolutionary process, whether there is a stable balance point (Zhaohan Sheng , 2002) or not and how to explain the point.

In our present project construction consulting market, the consulting companies usually adopt the way of bidding to obtain commission contract. Whether a project legal entity decides to consign a task to a consulting company or not depends on the qualification and efforts of consulting engineers appointed by that company. If the consulting engineer is not quite qualified or even cooperates with the contractor to deceive the project legal entity, it will do much harm to the legal entity's interests. The large or middle size project legal entities often request the consulting companies to consign qualified consulting engineers according to certain promise. Although some entities adopt appointment guarantee, problems such as lower bail still exist. Some consulting companies often pretend to consign a high qualified consulting engineer when submitting a tender, but just send a common one in practice. They abuse the promise in order to gain consulting contract, which can make much incommodiousness to the management of legal entities and even can make them suffer some loss that is not deserved. In addition, in the incomplete information consulting market it is really very difficult for the project entities to choose a satisfied consulting engineer with high qualification. What they can only do is to surmise the general situation of the market through "study" and then revise their own behavior strategies to enhance the effectiveness of the consulting commission. Some consulting companies even use the way of using high-qualified consulting engineer to bid and appointing low-qualified personnel to gain extra income because of false information. As sometimes information is not complete, it often affects the choice of behavior strategies for both the project legal entity and consulting company. As a result, the market will be locked in an unhealthy state.

2. Establishment and Analysis of the Model

Suppose it happens in a natural market, which means a market without any constraint. The project legal entity and consulting company will begin to discuss the strategies. Suppose the legal entity will tend to choose a higher qualified consulting engineer for the sake of his own interest but during the negotiation process two kinds of performances will appear (Yuyin Yi, 2003 & Tiaojun Xiao, 2004): ① complying with appointment guarantee (B_1); ② violating appointment guarantee (B_2). Likewise, suppose the consulting company will select a high qualified consulting engineer and make up an appointment at first. But in fact two kinds performance will take place as well: ① complying with his promise (E_1); ② violating his promise (E_2).

Suppose the consulting company really violate his promise and send unqualified engineer after signing the contract. This hypothesis is quite reasonable. More interests can be attained if the consulting company

appoints unqualified consulting engineer. So they will tend to violate his promise if there is not any other constraint. Suppose three situations: E_1 and B_1 can not reach an agreement and both of them will suffer loss to some extend; B_1 and E_2 sign the guarantee contract and both attain deserved interests; E_2 and B_2 share the same strength so it is half to half to assume appointment guarantee or to pursue promise contract. Table1 shows the income matrix of project legal entities and consulting companies.

Table1. The income matrix of project legal entities and consulting companies'

Consulting company / Legal entity		Complying with promise	Violating promise
		E_1	E_2
Complying with appointment guarantee	B_1	$-C_2$, $-C_1$	G_B, G_E
Violating appointment guarantee	B_2	G_B-E, G_E+E	$G_B-E/2$, $G_E+E/2$

In Table1, $C_1>0$ equals to the legal entity's loss when no agreement is reached; $C_2>0$ equals to consulting company's loss when he fails to attain consulting contract; $G_E>0$ equals to consulting company's income when he gets the consulting contract; $G_B>0$ equals to legal entity's income (Since the legal entity consigns consulting company, which can reduce his own amount of managers, he gets this kind of income); $E>0$ equals to the consulting company's extra income if he do not assign high qualified consulting engineer.

Suppose among all the legal entities the proportion of those who adopt strategy B_1 is p and those who adopt strategy E_1 is q. According to the Malthusian dynamic equation, which means the increasing rate of strategies equals to its adaptation degree, if the adaptation degree of one strategy is higher than the average level the strategy will increase (Friedman D, 1998). The dynamics equation is as followings.

$$\dot{p} = p(1-p)(1,-1).A(q,1-q) \qquad (1)$$

$$\dot{q} = q(1-q)(1,-1).B(p,1-p) \qquad (2)$$

In the two equations,

$$A=\begin{bmatrix} -C_2 & G_B \\ G_B-E & G_B-E/2 \end{bmatrix}$$ and

$$B=\begin{bmatrix} -C_1 & G_E+E \\ G_E & G_E+E/2 \end{bmatrix}$$ refer to the income matrix of legal entities and consulting companies. So the copy dynamic equation of consulting market is as following.

$$\dot{p} = p(1-p)\left[E/2-(G_B-E/2+C_2)q\right] \qquad (3)$$

$$\dot{q} = q(1-q)\left[E/2-(G_E+E/2+C_1)p\right] \qquad (4)$$

Proposition1: if $G_B+C_2>E$, system (3)~(4) indicate that in plane M=$\{(p, q); 0\le p, q\le 1\}$ there are 5 balance points, which are unstable point (0, 0) and (1, 1), stable point (0, 1) and (1, 0), saddle point.

$$F=\left(\frac{E/2}{G_E+E/2+C_1},\frac{E/2}{G_B-E/2+C_2}\right)$$

Proof: only this situation $G_B+C_2>E$ is taken into consideration. If $G_B+C_2\le E$, the following equation can be achieved:

$$\dot{p} = p(1-p)\left[E/2-(G_B-E/2+C_2)q\right]$$

$$= p(1-p)\left[(1-q)E/2+(E-G_B-C_2)q\right]\ge 0$$

So, in plane M, p will increase from 0 to 1 monotonously. At this time all the legal entities will comply with the appointment guarantee contract, other wise they will be forced to exit the market. This kind of market state can not be maintained, so it is not taken into account in this paper.

If $G_B+C_2-E>0$, obviously system (3)~（4） contain 5 balance points: (0,0), (1,1), (0,1), (1,0), and *F*. Then the partial stable analysis (Xiaoxin Liao, 2000) will be carried out and such a conclusion will be reached: （0,0) and (1,1) are unstable source outward point; (0,1) and (1,0) are stable inward point; *F* is saddle point. The proof finishes now.

According to proposition1, phase of system (2) is showed as following Figure 1.

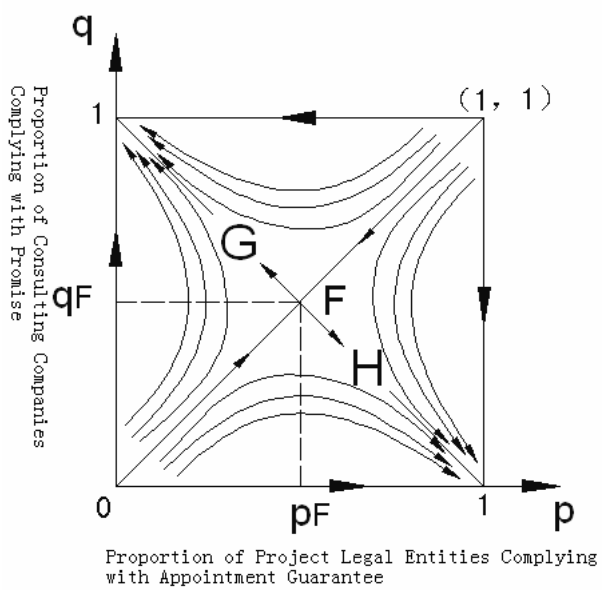

Figure 1. Evolution Rule of Consulting Market without Constraint

After analyzing Figure 1, we know if the initial state is within region G the system will converge at point (0,1), that is to say, all the legal entities fail to comply with the appointment guarantee contract, while all the consulting companies assume promise contract. So it will be evolved that the consulting companies will not dispatch high-qualified consulting engineers or even do not dispatch at all. If the initial state is within region H (the right down area of the line through point (0,0), (1,1) and F) the system will all converge at point(1,0) , namely all the legal entities comply with appointment guarantee contract, while all the consulting companies fail to comply with promise contract. So it will be evolved that consulting companies will surely dispatch high qualified consulting engineers.

Thus after a long-term "natural" evolution the result will be entirely different. Two kinds of market will appear. One is a normative market, in which legal entities assume appointment guarantee contract and consulting companies dispatch highly qualified consulting engineers based on the contract. The other one is a market whose behavior is not standard, in which legal entities carry out appointment guarantee contract but consulting companies do not dispatch highly qualified consulting engineers. Meanwhile, both the two markets are in stable state in the evolution. If any participant performs oppositely, he will not survive due to the selection of the market.

Although the normative consulting market is what we expect, it is not quite easy to make the consulting market develop in a fine circulatory direction. In the following part of this paper, we will analyze the parameter of the model to figure out its influence on market evolution and try to optimize the consulting market.

3．Parameter Analysis and Control

Suppose the initial condition of the system is stochastic and is distributed uniformly within plane M={(p，q)；$0\leq p$，$q\leq 1$}. The purpose of parameter analysis is to confirm whether the change of parameter can cause reduction of the G region and expansion of H region and meantime force point *F* move left upward. If these changes appear the system is supposed to be stable at point (1,0). In the following part of this paper, the influence of some parameter's changes on consulting market performance is discussed and some valid control methods are proposed.

1) Legal Entity's Income G_B for Consigning Consulting Company

At present, the consulting fee of domestic large and middle scale projects is mostly charged according to

its proportion in the whole project investment Generally, it is based on the No.497 Document issued by Chinese Price Bureau and Ministry of Construction jointly in 1992 and *Market-set Price Range of Hydropower Project construction supervision* published by the Hydropower Construction Supervision Branch which belongs to China's Construction Supervision Association in 2003. But different rate of consulting fee often can give different impact on market performance. When G_B increases (the consulting fee rate falls), coordinate p_F of saddle point F dose not change but q_F reduces, which means that saddle F moves down plane M so region H will reduce but region G expands. On the other way round, when G_B reduces (consulting fee rate increases), region H expands but region G reduces. It shows that if the consulting fee rate increases within a proper scope, the consulting companies will get more normal income. So the possibility for consulting companies not to dispatch qualified consulting engineers will decline and the market performance tends to be more rational. If the consulting fee rate falls, consulting company's normal income will be reduced so they will tend to dispatch consulting engineers without high qualification.

2) Extra income E

When E increases, p_F and q_F will go up as well. But q_F rises more than p_F, so saddle point F will move to the upper right corner of M region. Then region H expands while region G reduces. When E decreases, region H reduces while region G expands. Apparently if a consulting company does not dispatch high-qualified consulting engineer it will gain more extra income. So consulting companies will more likely tend to comply with the promise contract. But actually at this time, the possibility for project legal entities to comply with appointment guarantee contract increases as well. Then it is obvious that the self-adjustment function of the market has come into strong effect, which can contain the consulting companies' negotiating motivation.

3) Consulting companies' loss C_1 when agreement is not reached

When C_1 increases, p_F decreases but q_F keeps stable, namely point F will move to the left of plane M. So the area of H expands but the area of G reduces. Whereas when C_1 decreases, the area of H reduces but the area of G expands. It is obvious that the increasing of loss C_1, which results from failing to achieve the contract, will be effective on reducing the possibility of consulting companies to comply with contract and not dispatch high qualified consulting engineer. In fact, the consulting companies' loss, which results from failing to achieve contract, is tightly related with the scale of consulting market and construction market. If the ongoing projects in construction market are limited, the project legal entities will tend to monopolize the market. So it is not easy for the consulting companies to attain consulting work and the loss, which results from failing to achieve contract, will increase. Under this situation, consulting companies have to extend their business to other consultation fields so as to reduce their loss resulted from failing to achieve contact.

4) Legal Entities' Loss C_2 When Contract is not Achieved

When C_2 increases, p_F keeps stable but q_F decreases, which shows that point F will move down plane M. So region H will reduces but region G will expand. Whereas when C_2 decreases, region H will expand but region G will reduce. So when the project legal entities' loss, which results from failing to achieve contract, increases, it is more difficult for them to ask for appointment guarantee contract. Then the possibility for consulting companies to assume promise contract will increase. The project legal entities' loss which results from failing to achieve the contract is related with the scale of consulting market. If the market is small, the consulting companies are

limited. At the same time, it tends to be difficult for the project legal entities to find proper consulting companies, so their motivation of complying with appointment guarantee will decrease.

All in all, the consulting market holds its own operating disciplinarian and this model just reflects the basic operating disciplinarian. Based on such kind of disciplinarian, the consulting market can be controlled limitedly and will go ahead in a much better direction.

4．Improvement of the Model

In this model discussed above, the management and supervision of charge department within this industry is not involved, so the consulting companies will tend to not dispatch high qualified consulting engineers in order to gain extra income. If the charge department is involved and can give certain punishment for the consulting companies' violating behavior, when any violation happens project legal entities can appeal to charge department. If any violating behavior is testified, charge department can order the consulting companies to correct their behaviors and give certain punishment. Under this situation, suppose the consulting company's loss is R and the project legal entity's cost for supervising the consulting company's performance is K>0. So the income matrix of both them is showed as Table 2.

Table 2. Improved Income Matrix of Strategy Choice

Consulting company / Legal entity		Complying with promise	Violating promise
		E_1	E_2
Complying with appointment guarantee	B_1	$-C_2$，$-C_1$	G_B，G_E
Violating appointment guarantee	B_2	G_B-K，G_E-R	$G_B-K/2$，$G_E-R/2$

The dynamics equation of consulting market becomes as following:

$$\dot{p} = p(1-p)\left[K/2-(G_B-K/2+C_2)q\right] \quad (5)$$

$$\dot{q} = q(1-q)\left[-R/2-(G_E+R/2+C_1)p\right] \quad (6)$$

Proposition 2: If $K<G_B+C_2$, the system (5)~(6) indicate that there are 4 evolution game balance points in the plane M={(p，q)；$0\le p$，$q\le 1$}, which are saddle point(0,0) and (0,1), inward point(1,0) and source outward point(1,1).

Proof: as the same reasons in proposition1, here only $K<G_B+C_2$ is taken into consideration. When $K<G_B+C_2$, it is obvious that system (5)~(6) only contain 4 stable points in plane M={(p, q)；$0\le p$, $q\le 1$}, which are (0,0), (0,1), (1,0), (1,1). According to dynamics analysis, point (0, 0) and (0,1) are saddle points; point (1,0) is stable inward point; but point (1,1) is unstable source outward point.

From proposition2, the phase diagram of system (5)~(6) is showed in Figure 2.

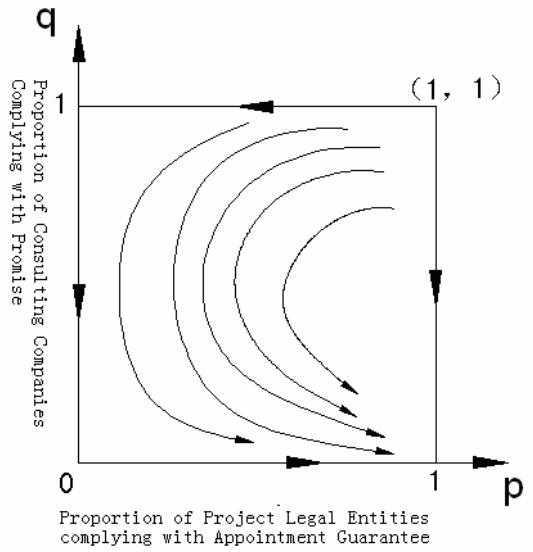

Figure 2. Evolution Law of Consulting Market under Supervision of Charge Department

In Figure 2, setting out from any original state in

plane M, the system will converge at point (1,0). Under this situation all the project legal entities will comply with appointment guarantee contract or promise contract, and meantime they will adopt some ways of supervision to protect their interests. And all the consulting companies will dispatch high qualified consulting engineers according to the contract. So the consulting companies will tend to perform more legally and rationally under the threatening of punishment. And the consulting market will evolve into a normative market eventually. But this punishment is closely related with the rate of project legal entities' appeal and the strength of law enforcement. But if some project legal entities are over-tolerant or the charge department cannot execute the law strictly, the violation behaviors will also increase.

5. Conclusion of the Model and its Enlightenment

In Fig1, if the initial state is within region G the consulting market will evolve into a nonstandard market. If it is within region H the market will evolve into a more rational and complete one. Obviously, the evolving path of consulting market sensitively depends on its initial state in some extend. And the evolution of consulting market has the nature of path dependence. So if the initial state comes into region G for some accidental reasons, the market will tend to be inefficient and even go into an unhealthy "lock" state at last. So the project legal entities should strengthen self-protected consciousness and be stricter when selecting consulting companies. It will be much more helpful to request consulting companies to provide the name list of consulting engineers and a complete appointment guarantee contract. If any violation behavior happens, quick notification to charge department is also necessary. If so the market will come into a healthy circle and ends in a rational and complete one.

If the system comes into a sub-excellent or inefficient state, its recovery path depends on the nature of all the factors that form its self-enforcement system. In the consulting market the self-enforcement system for income increasing results from its own effect, such as cooperation effect. As long as the communication between charge department, project legal entity and consulting company is strengthened so as to reach some agreement, the recovery path is realized. As showed in Fig2, under supervision of charge department the consulting market will develop itself along a healthy circular path and evolve into a more normative market. Even though the market begins to go along an inefficient path, it can also get out from the "lock" state and achieves recovery path as long as the charge department executes the law rigidly and be unanimous with project legal entity.

Since the reform of project construction management system still stays in its beginning tage in our country now, many violating behaviors have come out. In order to make the market more normative and evolve along a healthy path, the selection of a definite project management system is necessary. Through study effect, cooperation effect and supervision, the system for income increasing is established. Then after a complete selection by the market, a more clear and inspiring project management system with constraint function comes into being and replaces the former one so as to avoid "closedown" state. In such a circular process, income will increase gradually and the consulting market will finally go along a healthy path and evolve into a normative market.

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References

4. Guohui Jiang. Water Recourse Project Supervision. China: Beijing. Water Power Press. 2005.
5. Zhaohan Sheng, Depeng Jiang. Evolutive Economics, China: Shanghai. Sanlian Bookshop. 2002.
6. Yuyin Yi, Tiaojun Xiao. Evolution and Control of Credit Market of China. Journal of Southeast University 2003; Vol. 33 (4): 483~486.
7. Tiaojun Xiao. Game Theory and its application. Shanghai Sanlian Bookshop 2004.
8. Friedman D. On Economic Applications of Evolutionary Game Theory. Journal of Evolutionary Economics 1998(8): 15～43.
9. Xiaoxin Liao. Theory and Application of Stability for Dynamical Systems. Beijing: National Defence Industry Press 2000.