Research on Incentive Algorithm of Engineering Cost Consulting Enterprises Based on Reputation Utility Model

Jian Xiang[(✉)], Guangpeng Xiao, and Jiazhen Huang

College of Business Administration, University of the Cordilleras, Gov. Pack Rd., 2600 Baguio, Benguet, Philippines
940520945@qq.com, kimi99@aliyun.com

Abstract. Taking the reputation incentive mechanism of the engineering cost consulting industry as the research background, and the reputation utility model is used to analyze the incentive effect of the reputation mechanism on the cost consulting enterprises. Through the model analysis, the reputation mechanism is an effective incentive way for the cost consulting enterprises, and has a positive significance for standardizing the behavior of the cost consulting enterprises and improving the governance level of the enterprises.

Keywords: Reputation utility model · Engineering cost consulting enterprise · Incentive algorithm · Management utility

1 Introduction

Engineering cost consulting is a very professional professional, which requires the employees to be based on engineering technology, with economic, legal, management and other knowledge of the compound talents [3]. At present, most of the cost practitioners are engaged in the passive preparation and audit of the pre-settlement of the project, and the awareness of the active control and management of the construction project cost is lacking, and its quality is difficult to match the needs of the engineering construction. Thus, the consulting quality is uneven, and the inferior quality of these consulting services directly or indirectly leads to the inferior quality of project management. At the same time, the engineering cost consulting industry lacks effective restraint and supervision mechanism for employees, lack of unified professional ethics, weak risk awareness of employees, and poor sense of responsibility in professional ethics. These problems are bound to restrict the healthy development of engineering cost consulting enterprises.

Reputation mechanism is an important mechanism to ensure the smooth implementation of the contract. It is an information set reflecting the historical records and characteristics of the actor. It can be used as a substitute for the explicit incentive contract to motivate and restrain the market behavior of agents [1]. The role of reputation is to provide an implicit incentive for long-term interest participants to guarantee their

short-term commitment actions, and reputation can therefore be an alternative to explicit contracts [2]. Enterprise reputation is the comprehensive evaluation of other enterprises' ability, efficiency, business philosophy, enterprise culture and other aspects obtained in the process of business activities. It is passed through the market and supported by law and morality, and needs long-term accumulation and has great stability. It can be said that reputation is a kind of intangible social capital of engineering cost consulting enterprises, and a good reputation is conducive to its high remuneration in the future enterprise operation. Cost consulting enterprise is a professional organization engaged in project management. It is of great significance to study the effective incentive mechanism of cost consulting enterprises to standardize enterprise behavior and improve enterprise governance. This paper will focus on analyzing the incentive of the reputation mechanism to the cost consulting enterprises, to provide beneficial exploration to improve the quality of project management.

2   The Incentive Performance of the Reputation Mechanism to the Engineering Cost Consulting Enterprises

The core of the reputation mechanism lies in the pursuit of long-term interests and giving up the short-term interests. Meanwhile, the incentive effect of the reputation mechanism on the actor is mainly reflected in the hidden aspects. Therefore, the conditions of the reputation mechanism can be summarized as follows [4]:

(1) The game is repeated enough enough. The more times the game repeats, the more active the cost consulting enterprises are to establish a reputation of honesty. If the uncertainty in the future is too great, the expected income of the cost consulting enterprises on the number of games will be reduced, thus affecting their enthusiasm to establish a reputation.
(2) Cost consulting enterprises attach great importance to long-term interests. That is, the cost consulting enterprises to long-term interest comparison results. The more attention the cost consulting enterprises attach to long-term interests, the more they ignore short-term interests, the greater the enthusiasm to establish reputation.
(3) The owner's discovery and punishment of the short-term behavior of the cost consulting enterprises. If the owner can find the short-sighted behavior of the cost-consulting enterprise in time and severely punish it, and the short-sighted behavior of the cost-consulting enterprise gets more punishment than the benefits obtained, then the enthusiasm to establish its reputation will be greater.

Due to the relative independence of the owner and the project cost consulting enterprises, this increases the difficulty of observing the behavior between each other to a considerable extent, and increases the possibility of speculation in the cost consulting enterprises. However, the short-term speculation of enterprises, from the long-term operation of enterprises, will increase the acquisition of business in the later stage, and increase the cost of stable and sustainable income. Therefore, the effective use of reputation information transmission function, once the enterprise speculation will be replaced by other similar competitive enterprises. In this way, the trust relationship based on the

enterprise reputation can be continuously and stably operated, and the explicit benefits brought by the reputation incentive will be fully reflected.

3 Reputation Model Application Analysis

3.1 KMRW Reputation Model

The reputation model of Kreps, Milgrom, and Roberts and Wilsom (1982) (hereinafter referred to as the KMRW reputation model) introduces the incomplete information into the repeated game and solves the cooperation of the participants who cannot be realized in the complete information game. They demonstrated that participants' incomplete information about other participant payment functions or strategic space has an important impact on the equilibrium results, and that cooperative behavior occurs in finite times of games, as long as the game is repeated long enough (not necessary to be infinite)Barro and Vickers (1986) applied the KMRW reputation model to the analysis of the owner's monetary policy [5] On the basis of this model, this paper analyzes how to motivate cost consulting enterprises.

3.2 Model Establishment and Application Analysis

3.2.1 Establishment and Analysis of the Utility Function of Cost Consulting Enterprises

α Represents the owner's identification of the type of cost consulting enterprise. Let $\alpha = 0$ represent the type of cost consulting enterprises as cooperative; Let $\alpha = 1$ represent the type of cost consulting enterprises as non-cooperative. V represents the damage rate of the cost consulting enterprise to the owner, $0 \leq V \leq 1$; V^e is the expected damage rate of the cost consulting enterprise by the owner, $0 \leq V^e \leq 1$. The single-stage utility function of the cost consulting enterprise is established as follows:

$$U = -\frac{1}{2}V^2 + \alpha(V - V^e) \tag{1}$$

If $\alpha = 0$, that is, the cost consulting enterprise is a cooperative enterprise; if $\alpha = 1$, that is, the cost consulting enterprise is a non-cooperative enterprise. The pair of cooperative and non-cooperative utility functions is shown in Table 1:

(a) If the cost consulting enterprise is cooperative, the utility function is $U = -\frac{1}{2}V^2$, and only when $V = 0$, its utility can be maximized. $V = 0$ means that cost consulting enterprises choose cooperation, which is in line with the assumed type of cost consulting enterprises.

Table 1. Enterprise type utility function comparison

Type of enterprise	Cooperation	Noncooperation
Utility function	$U = -\frac{1}{2}V^2$	$U = -\frac{1}{2}V^2 + V - V^e$

(b) If the cost consulting enterprise is not cooperative. Because of $0 \leq V \leq 1$, therefore: $U = -\frac{1}{2}V^2 + V - V^e$, where $-\frac{1}{2}V^2 + V > 0$. As V^e is the expected damage rate of the cost consulting company by the owner, as a rational cost consulting company, it focuses more on obtaining long-term benefits, so it may strictly implement the contract to protect the interests of the owner in the early stage of cooperation, in order to reduce the owner's expectation of adverse evaluation. So V^e is sufficiently small to be fully realized. It can ensure that non-cooperative cost consulting enterprises obtain the corresponding income.

The above analysis can see that the established utility function is logically consistent with the actual behavior of cost consulting enterprises.

3.2.2 Application Analysis of the Utility Function of Single-Stage and Multi-Stage Game Cost Consulting Enterprises

Due to the setting of α, Eq. (1) strictly distinguishes cooperative and non-cooperative operators. The following analysis will focus on non-cooperative cost consulting enterprises ($\alpha = 1$ type of cost consulting enterprises).

In the single-stage game, the non-cooperative cost consulting enterprises seek the first-order conditions for formula (1):

$$\because U = V - \frac{1}{2}V^2 - V^e \therefore \frac{\partial U}{\partial V} = 1 - V$$

The utility of the cost consulting enterprise is the largest $\frac{\partial U}{\partial V} = 0$, and the damage rate of the cost consulting enterprise to the owner is $V = 1$, Since the premise is that $\alpha = 1$ can be obtained by analyzing $V^e = 1$ mainly for non-cooperative cost consulting enterprises, the utility of the cost consulting enterprise is $U = -\frac{1}{2}$, that is, the expected damage rate of the cost consulting enterprise is equal to the actual damage rate caused by the cost consulting enterprise, that is, $V = V^e$. It can be seen that in a one-time game, it is not necessary for non-cooperative cost consulting enterprises to choose cooperation.

Assuming that the game repeats the T-1 stage, Let X_{t-1} be the probability that the stage cost consulting enterprise chooses cooperation, Y_{t-1} is the probability that the owner thinks the cost consulting enterprise chooses cooperation, $X_{t-1} = Y_{t-1}$ in equilibrium.If the owner does not observe the damage behavior of the cost consulting enterprise to himself in the t stage, then according to Bayes' rule, the posterior probability that the owner considers the cost consulting enterprise to be cooperative in the t stage is:

$$P_t(\alpha = 0/V_{t-1} = 0) = \frac{P_{t-1} \times 1}{P_{t-1} \times 1 + (1 - P_{t-1}) \cdot X_{t-1}} \geq P_{t-1} \tag{2}$$

where, P_{t-1} is the probability that the cost consulting enterprise in stage $t-1$ is cooperative, and 1 is the probability value that the cooperative cost consulting enterprise chooses cooperation.

It can be seen from formula (2): if the cost consulting enterprise chooses the cooperation at this stage, then the probability of the owner thinking that the cost consulting

enterprise is the type of cooperation in the next stage will increase. If $X_{t-1} < 1$, the strict inequality of Eq. (2) holds; If $X_{t-1} = 1$, then the Eq. (2) is true.

If the cost consulting enterprise chooses not to cooperate, the posterior probability of the owner believing that the cost consulting enterprise is cooperative is:

$$P_t(\alpha = 0/V_{t-1} = 1) = \frac{P_{t-1} \times 0}{P_{t-1} \times 0 + (1 - P_{t-1}) \cdot X_{t-1}} = 0$$

That is to say, if the cost consultation enterprises $T - 1$ phase not cooperative strategy, the owner will deduce cost consultation enterprises is not cooperative, such cost consultation companies will continue to cooperate with the landlord due to loss of reputation and lose the opportunity, it also reflects the uncooperative cost consultation companies focus on long-term interests, also have enthusiasm to cooperate.

Now let's put the analysis in the last two stages of the game. In stage T, it is no longer necessary for cost consulting enterprises to establish a good reputation for cooperation. Therefore, the owner's optimal choice is $V_T = 1$, ,(obviously $\alpha = 1$), and the owner's expected damage rate to the cost consulting enterprise is:

$$V_T^e = V_T \times (1 - P_t) = 1 \times (1 - P_T) = 1 - P_T$$

The utility level of the cost consulting enterprise at this time is as follows:

$$U_T = -1/2V_T^2 + (V_T - V_T^e) = -1/2 + (1 - (1 - P_T))\, U_T = P_T - 1/2 \quad (3)$$

Formula (3) Shows that the utility of the non-cooperative cost consulting enterprise in the final stage is the increasing function of reputation, that is, the more the owner considers the cost consulting enterprise to be cooperative in the past, that is to say, the larger P_T is, the greater the utility of the cost consulting enterprise in the final stage will be.

Now we analyze the behavior choice of the cost consulting enterprise in stage $T - 1$. It is assumed that the non-cooperative cost consulting firms have always chosen the cooperative strategy before the $T - 1$ stage. Therefore, according to Formula (2), $P_{T-1} > 0$, the expected damage rate of the cost consulting enterprise by the owner:

$$V_{T-1}^e = V_{T-1}^* \times (1 - P_{T-1})(1 - X_{T-1}) = 1 \times (1 - P_{T-1})(1 - X_{T-1}) \quad (4)$$

Where, $V_{T-1}^* = 1$ is the maximum damage value of cost consulting enterprises to owners' interests in $T - 1$ stage, $1 - P_{T-1}$ is the probability of non-cooperation of cost consulting enterprises in $T - 1$ stage, and $1 - X_t$ is the probability of non-cooperation strategy of non-cooperative cost consulting enterprises that owners think.

Let δ be the discount factor of cost consulting enterprises, which is used to indicate the patience degree of non-cooperative cost consulting enterprises pretending to be cooperative. This article considers only pure strategy, i.e. $Y_{T-1} = 0, 1$.

We can compare the utility of the two strategic choices of the cost consulting enterprise in the $T - 1$ stage:

(i) If a non-cooperative cost consulting enterprise chooses non-cooperation strategy in stage $T - 1$, namely, $Y_{T-1} = 0$, $V_{T-1}^* = V_{T-1} = 1$, then $P_T = 0$, namely, in stage

$T - 1$, after the owner discovers the non-cooperative behavior of the cost consulting enterprise, it must believe that the cost consulting enterprise is non-cooperative in stage T ($P_T = 0$). In this case, because of $V_T^e = 1 - P_T$, $V_T = 1$; The $V_T^e = V_T = 1$. Suppose that the expected damage rate of the owner to the cost consulting enterprise in the $T - 1$ stage is V_{T-1}^e, then the total utility of the non-cooperative cost consulting enterprise is:

$$U_{(T-1)}(\alpha = 1) + \delta U_T(\alpha = 1)$$
$$= -\tfrac{1}{2}V_{(T-1)}^2 + (V_{(T-1)} - V_{(T-1)}^e) + \delta\left[-\tfrac{1}{2}V_T^2 + (V_T - V_T^e)\right]$$

The above formulas known from (3), (4) and above are:

$$-\frac{1}{2} + 1 - V_{T-1}^e - \frac{1}{2}\delta = \frac{1}{2} - V_{T-1}^e - \frac{1}{2}\delta \qquad (5)$$

Where V_{T-1}^e is shown by Eq. (4)

(ii) If non-cooperative cost consulting enterprises choose cooperation in stage $T - 1$, that is, $Y_{T-1} = 1$, and $V_{T-1} = 0$, then the total utility function of non-cooperative cost consulting enterprises is:

$$U_{(T-1)}(\alpha = 1, V_{(T-1)} = 0) + \delta U_T(\alpha = 1, V_T = 0)$$
$$= -1/2V_{(T-1)}^2 + (V_{(T-1)} - V_{(T-1)}^e) + \delta\left[-1/2V_T^2 + (V_T - V_T^e)\right]$$
$$= -V_{(T-1)}^e + \delta(P_T - 1/2) \qquad (6)$$

The utility function of stage-to-stage cooperation strategy of non-cooperative cost consulting enterprises is shown in Table 2.

Therefore, if Eq. (6) is greater than Eq. (5), it means that the cooperative behavior strategy adopted by cost consulting enterprises in stage $T - 1$ is better than the behavior of non-cooperative strategy. This is equivalent to

$$\frac{1}{2} - V_{T-1}^e - \frac{1}{2}\delta \le V_{T-1}^e + \delta(P_T - \frac{1}{2}) \Rightarrow P_T \ge \frac{1}{2\delta} \qquad (7)$$

Because, in the equilibrium case, the owner's expectation X_{T-1} is equal to the choice of the cost consulting enterprise, then $X_{T-1} = Y_{T-1} = 1$, then known from Eq. (2): $P_{T-1} = P_T$ then Eq. (7) becomes:

$$P_{T-1} \ge \frac{1}{2\delta} \qquad (8)$$

Table 2. Comparison table of cooperative strategy utility functions

Strategy	Cooperation	Noncooperation
Utility function	$\frac{1}{2} - V_{T-1}^e - \frac{1}{2}\delta$	$-V_{T-1}^e + \delta(P_T - \frac{1}{2})$

Formula (8) indicates that, if the probability that the owner thinks that the cost consulting enterprise is cooperative is not less than $\frac{1}{2\delta}$ at the stage $T-1$, the non-cooperative cost consulting enterprise chooses cooperation rather than non-cooperation. The existence of the solution, but the game equilibrium strategy must be $P_{T-1} \geq \frac{1}{2\delta}$, said by the previous set δ of cooperative cost consultation enterprises as collaborative degree of patience, although to a cooperative cost consultation enterprises in terms of its essence is not cooperative, but as a rational cost consultation enterprises out of consideration for to obtain long-term utility maximization, He has to be patient enough to choose cooperative behavior from stage 1 all the way to stage $T-1$, which means that in general X is sufficiently large to be possible, and therefore $P_{T-1} \geq \frac{1}{2\delta}$ is true; Otherwise, non-cooperative cost consulting enterprises will only obtain short-term utility.

4   Conclusions

By applying the above KMRW reputation model, the coping strategies adopted by the cost consulting enterprises in different periods in the incomplete information repeated game are demonstrated from the perspective of game theory. It can be seen from the strategies chosen by the engineering cost consulting enterprises in different periods that the cost consulting enterprises always want to maximize their own interests under certain conditions. But if the game repeated enough, at the same time cost consulting enterprise if not short-term behavior enterprise, in the repeated game, if he at some stage of the game process of the loss of the owner, the owner is likely to terminate and continue to cooperate, and then cost consulting enterprise will lose future earnings will be more than its current short-term income. Therefore, the cost consulting enterprises through strictly performing the contract, and actively safeguard the interests of the owners, to establish a good reputation for cooperation, it should become the best choice for rational cost consulting enterprises. Thus it can be seen that the reputation mechanism is an effective incentive way for the cost consulting enterprises in the process of strictly performing the contract with the owner. Through the above analysis can also see for reputation mechanism for cost consulting enterprise effective incentive to have specific conditions, first game must be repeated, the parties should have enough patience, and the bad behavior of the parties can be found, but the author thinks that with the improvement of market competition mechanism, the social integrity level, through the establishment of cost consulting enterprise effective reputation record, and establish a long-term cooperation mechanism between the owner and cost consulting enterprise, reputation mechanism incentive effect can be effectively realized.

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