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Analysis of moral risk in the construction project based on information asymmetry

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ABSTRACT

During the process of project construction, owners and contractors have a principal-agent relationship. The asymmetric information between owners and contractors causes moral risk. This moral risk should be prevented or controlled. In this paper, the principal-agent theory in information economics is applied to construct the model for the moral risk of the contractors. The quantitative analysis revealed how the interests can be maximized and how the management level of the project is increased by establishing a constraint mechanism. Subsequently, specific suggestions to constrain the immoral behaviors of the contractors are proposed.

Key words: moral risk, construction projects, asymmetric information

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INTRODUCTION

In the process of modernization, China has accumulated a large amount of material wealth accumulation since the reform and opening up, which significantly improved the living standards of its people. However, the rapid development of the economy also brought negative effects such as the disregard for values and moral beliefs, prevalence of materialism, utilitarianism, and moral decline, doubts on the dominant ideology, and the general decline of social identity. All these effects severely affect the overall formation of the social interest relationship adjustment system. As a result, some people have unlimitedly expanded their economic requirements in the market economy, resulting in utility supremacy and unscrupulous competition.

The moral risk of project areas is especially prominent in China. Local construction projects frequently become the channel for money circulation for some government officials. Thus, moral risks in the management of construction projects exhibit a rapid increase, constituting potential risks to the lives of residents and threatening the security of properties at a certain extent. However, research on moral risk in construction projects in China is shallow at present. First, the role of moral risk in construction project management is not fully recognized and is often neglected in macroscopic planning, policy making, project implementation, and theoretical research. Second, moral risk is caused by many factors, which render the difficulty in preventing them at both theoretical and practical levels.

LITERATURE REVIEW AND THEORETICAL ANALYSIS

From the perspective of information economics, adverse selection and moral risk caused by asymmetric information and its corresponding opportunistic behavior are the root causes of behavioral risk among principal participants in projects. Before the contract is signed, asymmetric information leads to adverse selection. For example, during the bidding stage, the tender knows little about the technical strength, management level, and service quality of the bidder, while the bidder knows little about the construction intention, financial capacity, and business reputation of the tender. With the asymmetric information between the tender and the bidder, adverse selection easily occurs. After the contract is signed, asymmetric information leads to moral risk. For example, during the performance stage, by utilizing their own advantages, contractors give little attention to the quality of engineering construction or fail to perform as required, consequently damaging the interests of owners and the entire society. Such damages are mostly caused by the moral risk behavior[1]. Baiman and Williams analyzed the theoretical role of information and incentives in contracts[2], particularly in controlling the quality and cost of products and then provided a detailed theoretical formula[3].Abdulazizand Berendsstudied the significance and role of incentive mechanisms in contracts[4], particularly in controlling the cost and schedule of construction projects and realizing the project goals from the empirical perspective[5].

Different theories have explained moral risk from different perspectives. Information economics argues that under asymmetric information, the principal cannot accurately understand the wisdom, behavior quality, and efforts of the agent who may take advantage of this defect to enhance personal utility while disregarding the interests of the principal. Thus, moral risk and adverse selection are produced. From this perspective, moral risk is based on the assumption that a rational economics-inclined individual pursues the maximization of his/her self-interest. This assumption is one of the basic hypotheses in modern economics and is an important basis in social and management sciences research. This assumption holds that the behaviors of people in social activities are rational and motivated by self-interest and that people seek to maximize self-interest at the least cost. Project stakeholders, especially those with information advantages, choose to violate morality during the implementation stage to maximize self-interest. This action brings risks to the entire project and to other stakeholders. Without the constraints of external forces, the pursuit of particular interests drives participants to make selfish choices that violate morality and maximizes the moral risk for the entire project. In this paper, the principal-agent theory is used to create the moral risk model of the contractor in project construction. Suggestions on how to constrain the immoral behaviors of the contractor and how to improve the level of project contract management are proposed based on the quantitative analysis.

EXPERIMENTAL SECTION

The idea of solving moral risk is as follows. While the effort of the agent is not a variable that can be completely controlled, the principal can suggest the effort that must be at the level and preference of the agent. The moral risk model has three parts. The first part is objective function in which the contractor attempts to maximize his/her interests. The second part is incentive constraint in which at the approval of the contract and with the incomplete confirmation of the effort of the contractor, the effort level of the maximized objective function is chosen. The third part is involvement participation in which the earnings of the contractor are higher than or equal to those of the market upon signature of the contract. To facilitate the discussion, both the project quality and construction period are considered in estimating the project cost. In other words, the actual project cost in the present study includes not only the bidding price and the claims in general but also the losses caused by disqualified projects and delays.

Model Construction

We propose the following hypotheses. (1) The effort level of the contractor is a 1D continuous variable ($n \in [-\xi 1,\ \xi 2]$, where at $n = 0$, the contract completes the project by efforts conducted according to the bidding price of the contract). (2) The owner is risk neutral, whereas the contractor is risk adverse, but both are rational. (3) The effort cost c (n) of the contractor is equivalent to the monetary cost, and the cost coefficient $c(n) = mn^2/2$, where m > 0. Therefore, the enhanced management level of the contractor or the lazy work of the worker increases effort cost. Lastly, (4) the actual project cost is $a + \pi$, where a is the budget cost and π is the difference between the budget and actual costs. The linear form of the function that expresses the actual completion condition is adopted to simplify the calculation: $\pi = -n + \theta$, where θ is the mean value 0 and the variance is the normally distributed random variable of σ^2, which represents the exogenous uncertain factors.

Objective function (i.e., the expected cost of the owner): According to Hypothesis (4), $E\pi = E(-n + \theta) = -n, Var(\pi) = \sigma 2$. That is, the efforts of the contractor can reduce the project cost, and the effort level of the contractor determines the mean value of π but does not affect variance. Considering the linear contract $s(\pi) = a - \mu\pi$, where a is the budget cost and μ is the risk quota set by the contractor, every increase or decrease of π promotes the reward of the contractor to increase or decrease μ. If $\mu = 0$, the contractor does not undertake the risk, whereas if $\mu = 1$, the contractor undertakes all risks. The expected cost of the owner is computed as $E\nu = E(a + \pi - \mu\pi) = a + E(1 - \mu)\pi = a - (1 - \mu)a$.

Involvement Restriction: According to Hypothesis (2), the utility function of the contractor has the absolute risk aversion characteristics, that is, $u = -e^{-\rho\omega}$, where ρ is the absolute risk aversion measure and ω is the actual monetary income. The fixed cost of the contractor is set to F, which is the fixed cost of the project calculated according to the calculation rules of the bill of quantities issued by the country and enterprise quota. Thus, the actual income of the contractor is $\omega = s(\pi) - c(n) - F = a - \mu(-n + \theta) - \frac{mn^2}{2} - F$. The followingis thecertainty equivalent income of the contractor: $\mathrm{TCE} = \mathrm{E}\omega - \frac{1}{2}\rho\mu^2\sigma^2 = \mathrm{a} + \mu\mathrm{n} - \frac{1}{2}\rho\mu^2\sigma^2 - \frac{mn^2}{2} - \mathrm{F}$, where $\mathrm{E}\omega$ is the expected income of the contractor and $\frac{1}{2}\rho\mu^2\sigma^2$ is the risk cost. If $\mu = 0$, the risk cost is 0. The maximized expected utility function of the contractor $\mathrm{Eu} = -\mathrm{Ee}^{-\rho\omega}$ is equivalent to the maximized certainty equivalent income. Given $\overline{\omega}$ as the reserved income level of the contractor, if the certainty equivalent income is less than $\overline{\omega}$, the contractor will not accept the contract. Therefore, the involvement restriction of the contractor can be expressed as follows:

$$\mathrm{a} + \mu\mathrm{n} - \frac{1}{2}\rho\mu^2\sigma^2 - \frac{\mathrm{m}}{2}n^2 - \mathrm{F} \geq \overline{\omega}$$

Incentive Constraint: μ is given because the effort level n cannot be observed. The incentive constraint of the contractor means $\mathrm{n} = \mu/\mathrm{m}$.

Model Construction: The problem of the owner is to select μ to solve the following optimization problem:

$$\begin{gathered} \mathrm{M}_{\mu}\mathrm{ina} - (1-\mu)\,\mathrm{n} \\ \mathrm{s\,t}\,(IR)\mathrm{a} + \mu\mathrm{n} - \frac{1}{2}\rho\mu^2\sigma^2 - \frac{\mathrm{m}}{2}n^2 - \mathrm{F} \geq \overline{\omega} \\ (IC)\mathrm{n} = \mu/\mathrm{m} \end{gathered} \tag{1}$$

Model Analysis

Risks set by the contractor: The previously mentioned optimization problem can be re-expressed by bringing IR and IC into the objective function: $\mathrm{M}_{\beta}\mathrm{ax}\frac{\mu}{\mathrm{m}} - \frac{1}{2}\rho\mu^2\sigma^2 - \frac{\mathrm{m}}{2}\left[\frac{\mu}{\mathrm{m}}\right]^2 - \mathrm{F} - \overline{\omega}$. The first-order condition is $\mu = \frac{1}{1+\mu\rho\sigma^2} > 0$, which means that the contractor must bear certain risks. $\partial\mu/\partial\rho < 0$, $\partial\mu/\partial\sigma^2 < 0$ can be determined from $\mu = \frac{1}{1+\mathrm{m}\rho\sigma^2}$. That is, for a given μ, the larger the ρ or σ^2, the higher the risk cost. Therefore, the optimal risk allocation requires a smaller μ. The more the contract avoids the risks, the greater the variance of π. Besides, the lower the management efficiency, the lower is the risk set by the contractor. Extremely, if the contractor is risk neutral ($\rho = 0$), the optimal contract requires the contractor to assume all risks ($\mu = 1$).

Agency cost of the contractor: Under symmetric information, that is, under the condition that the efforts of the contractor can be observed, *IC* does not work and a can be realized at any level by satisfying *IR*. Therefore, the problem of the owner is to select μ to solve the following optimization problem:

$$\begin{gathered} \mathrm{M}_{\mu}\mathrm{ina} - (1-\mu)\,\mathrm{n} \\ \mathrm{s\,t}\,(IR)\mathrm{a} + \mu\mathrm{n} - \frac{1}{2}\rho\mu^2\sigma^2 - \frac{\mathrm{m}}{2}n^2 - \mathrm{F} \geq \overline{\omega} \end{gathered} \tag{2}$$

The first-order condition of optimization means that $\mathrm{n}^* = \frac{1}{\mathrm{m}}$ and $\mu^* = 0$. While the owner is risk neutral, the contractor is risk averse. The Pareto optimum risk sharing requires the contractor to not undertake any risk ($\mu^* = 0$), while the optimal effort level requires that the marginal expected profit of effort is equal to its marginal cost, that is, $1 = \mathrm{mn}$. Therefore, $\mathrm{n}^* = \frac{1}{\mathrm{m}}$.

Under asymmetric information, the owner cannot directly observe the effort level of the contractor. Therefore, agency costs are divided into two types. The first type is risk cost that appears because Pareto optimum risk sharing cannot be achieved under symmetric information. The second type is incentive cost that is obtained by subtracting the effort cost from the net loss of the expected output caused by the low effort level.

If the behavior of the contractor can be observed, the risk cost of the contractor is zero. Otherwise, the risk of the contractor is $\mu = \frac{1}{1+\mathrm{m}\rho\sigma^2}$. The risk cost is $\Delta\mathrm{RC} = \frac{1}{2}\mu^2\rho\sigma^2 = \frac{\rho\mu^2}{2\ (1+\mathrm{m}\rho\sigma^2)} > 0$. The incentive cost is $\Delta\mathrm{RK} = \Delta\mathrm{n} - \Delta\mathrm{c} = \frac{\rho\sigma^2}{1+\mathrm{m}\rho\sigma^2} - \frac{2\rho\sigma^2+\mathrm{m}\ (\rho\sigma^2)^2}{2\ (1+\mathrm{m}\rho\sigma^2)} = \frac{\mathrm{m}\ (\rho\sigma^2)^2}{2\ (1+\mathrm{m}\rho\sigma^2)^2} > 0$. Therefore, the general agency cost of the contractor is

$$\mathrm{AC} = \Delta\mathrm{RC} + \Delta\mathrm{RK} = \frac{\rho\sigma^2}{2(1+\mathrm{m}\rho\sigma^2)} > 0 \tag{3}$$

Expected cost of the owner: Under symmetric information, the expected cost of the owner under optimal incentive conditions is $\mathrm{E}\nu = \mathrm{a} - \mathrm{n}^* = \mathrm{a} - \frac{1}{\mathrm{m}}$, while under asymmetric information, the expected cost of the owner under optimal incentive conditions is $Ev' = a - \frac{\mu}{m}(1-\mu) = a - \frac{\rho\sigma^2}{(1+m\rho\sigma^2)}$. Arguably, $\frac{1}{m} > \frac{\rho\sigma^2}{(1+m\rho\sigma^2)}$. Therefore, Ev< Ev′.

Supervision strength of the owner: As shown by $\mu = \frac{1}{1+m\rho\sigma^2}$,the greater σ^2, the smaller are the incentives obtained by the contractor and the higher is the general agency cost $\frac{\rho\sigma^2}{2(1+m\rho\sigma^2)}$. The certainty equivalent income of the contractor, $TCE = a + \frac{1-\rho m\sigma^2}{2m(1+m\rho\sigma^2)} - F$, is also smaller. To reduce σ^2, supervision must be strengthened. However, supervision requires cost. Thus, the owner must strike a balance between profit and cost. With $K(\sigma^2) = k/\sigma^2$ as the cost supervision function, where k is the supervision difficulty (i.e., the greater k, the more difficult is the supervision), the net welfare function is as follows: $W(\sigma^2) = a + \frac{1-\rho m\sigma^2}{2m(1+m\rho\sigma^2)^2} - F - \frac{k}{\sigma^2}$. The owner selects σ^2 to obtain the first-order condition of optimization $\frac{\rho^2 m\sigma^2 - 3\rho}{2m(1+m\rho\sigma^2)^3} = -\frac{k}{\sigma^4}$ and utilizes the derivative to obtain $\frac{\partial\sigma^2}{\partial k} > 0$ and $\frac{\partial\sigma^2}{\partial n} > 0$.

Visually, the higher the marginal productivity of the contractor, the higher is the marginal income brought by the supervision. Moreover, the higher the marginal cost of the efforts of the agent, the lower is the effort supply under any given incentive and the lower is the optimal incentive under a given σ^2. The lower the marginal income of supervision, the lower is the enthusiasm of the owner regarding supervision. Lastly, the more difficult the supervision, the higher is the marginal cost of supervision and the lower is the enthusiasm of the owner regarding supervision.

RESULTS AND DISCUSSION

We conclude the following based on the results of the model analysis:
(1) The optimal effort level under asymmetric information is strictly lower than that under symmetric information. Therefore, when the owner cannot observe n, the contractor will select $n < n^*$ to increase his/her own benefits. The contractor can impute the blame to an unfavorable external influence (e.g., force majeure) to avoid being blamed by the owner. Subsequently, the actual project cost increases, which is called as moral risk.

(2) Based on $\mu = \frac{1}{1+m\rho\sigma^2}$, where μ is the decreasing function of ρ, σ^2, and m, the more conservative the contractor, the lesser are the risks shared. However, the contractor is generally risk averse. Hence, optimal risk sharing holds that the contractor should not bear all risks.

(3) When the owner cannot observe the effort level of the contractor, the contractor will bear larger risks than those under symmetric information. At the same time, the low effort level results in increases expected cost, thus producing incentive cost. Therefore, asymmetric information causes the contractor to bear the agency cost, whereas symmetric information eliminates this cost.

(4) All information about the efforts of the contractor is valuable because it can reduce the cost of the contract. Therefore, the owner will prefer to pay money for the information, such as entrusting the engineer to supervise the behaviors of the contractor. Controlling the activities that have no influence on the result may also be useful despite their costs, as long as they can be used to indicate the effort of the contractor. The choice of the principal on supervision strength still depends on the balance between the relevant cost of supervision control and the marginal income of supervision.

CONCLUSION

As a result of the asymmetric information between the market entities, the behaviors of the contractors cannot be completely observed by the owner after the contract signing, thus leading to moral risk. The model described in this study shows that under asymmetric information, the efforts of the contractor are often less than those under symmetric information. Moral restraints can be realized by designing an internal mechanism and improving the external market.

Internal mechanism refers to the process of obtaining a reasonable contract with the agency to attain the behavior goal of the contractor to be close to the owner's goal, thus achieving a win-win situation and reducing the opportunistic behavior of the contractor. To improve the operational effectiveness of this mechanism, the owner must consider the corresponding measures and pay a certain price to drive the contractor to conform to the contract.

Therefore, the internal mechanism can reduce inefficiency in the agency relationship at a certain extent, but its effectiveness is restricted by information costs and the resulting incomplete information.

Externally, the fundamental solution to inhibiting moral risk is to reduce the degree of information asymmetry in the market [6]. The owner must obtain information related to the project to be built and must hire the contractor to implement the project. To form the complete system network information for the project, the vertical and horizontal information communication and delivery network and the database system should be constructed. In addition, the prices of building materials and labor costs in the market should be determined, as well as the construction period and the price of branch engineering. Finally, the data should be classified according to type, area, construction standard, and construction time.

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