# CAN TRUST BETWEEN AN OWNER AND A CONTRACTOR BE ESTABLISHED: A PRINCIPAL-AGENT PERSPECTIVE

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**ABSTRACT**: The cooperation and trust among the project participants play a critical role in the success or failure of any delivery system in construction industry. But it is very difficult to establish trust between an owner and a contractor when rational people only pursue only their own material self-interest. Based on the principal-agent theory, this paper will introduce the altruistic behavior into the traditional principal-agent model, and model the reciprocal behavior between the owner and contractor. We will show that both the owner and the contractor benefit from their reciprocal behavior, and hence trust establishing between them is possible. More importantly, we will proof that the higher the project uncertainty is, the more important trust establishing is.

***Keywords***: *Owner, Contractor, Construction Industry, Trust, Principal-Agent Model, Reciprocal Behavior*

## 1 Introduction

The principal-agent theory can be applied in many fields. For example, in construction industry the owner usually calls for bid from interested firms and selects the lowest bidder. The selected contractor will perform the construction contract with the intention of achieving the owner's objectives. This is a classical principal-agent problem. The owner is principal and the contractor is agent. The owner's objectives, which is to ensure cost within budget and minimize the cost under delivering high quality finished projects on time in order to obtain the maximization profit, are affected by uncertainty and risk, and also by the action of contractor. But the owner can not observe the action of contractor entirely. Thus the owner can design a sharing contract to motivate the contractor to strive to reduce the construction cost besides monitoring the contractor's behavior. A fixed-price contract provides the strong incentives for the cost-reducing effort, but leaves all risk with the contractor. A cost-plus contract removes all risk from the contractor, but yields few incentives to decrease cost.

In the principal-agent theory, it is assumed that both the principal and the agent are rational and selfish, and behave according to maximizing their own benefits, namely they pursue only their own self-interests. However because the construction industry is a very competitive high-risk business, and many stakeholders, including project manager, owner, contractor, consultants, subcontractor, supplier, and manufacturers and so on, are involved, this rationality can easily result in little cooperation, lack of trust, and ineffective communication. For example, Bresnen's and Marshall's (2000) research shows that the lowest-bid-wins approach has been identified as an initiation of a mistrust cycle. Kadefors (2004) finds by several case studies that a bid-price-driven environment encourage suspicious and mistrustful attitudes that might eventually lead to project failure. Although many researches (Chan et al. 2005, Jin and Ling 2005) indicate that the cooperation, trust, and effective communication among the project participants play a critical role in the success or failure of any delivery system, this highlights the difficulty in establishing trust between the owner and the contractor when the rational people only pursue their own self-interests.

But psychological evidence (Simon 1990) indicates that there exists much altruistic behavior among mankind activities. Most altruistic behavior is very complex: people do not seek uniformly to help other people; rather, they do so according to how generous these other people are being. Rabin (1993) points out that people are willing to sacrifice their own material well-being to help those who being kind and to punish those who are being unkind. The research will introduce the altruistic behavior into the principal-agent model. The research will indicate that under some condition, both the owner and the contractor benefit from their reciprocal behavior, and hence trust establishing between them is possible. More importantly, we will proof that the higher the project's uncertainty is, the more important trust establishing is. The remaining of this paper is organized as following: Section 2 introduces the principal-agent model and applies it to the analysis of the relationships between the owner and contractor in construction industry. Section 3 introduces the altruistic behavior into the principal-agent model and discusses the model implication. Section 4 concludes.

## 2 The Rational Model

In this paper, a simple principal-agent framework, based on the Kawasaki and McMillan (1987) about optimal Principal-Agent contract, is adopted as the primary analytical tool. Although Kawasaki's and McMillan's research is about the design of contracts and empirical work in Japanese automobile industrial subcontracting, this paper does not try to test the predictions of the principal-agent model in construction industrial contracting because of the unavailability of detailed micro-level data and the different emphasis in this paper.

### 2.1 The linear contract

Follow the Kawasaki's and McMillan's model, and suppose that the owner's payment function is as following:

$$p = b + \alpha(c - b), \qquad (1)$$

where *p* denotes the price paid, *c* is the accumulated construction cost, $\alpha$ is parameter chosen in advance by the owner and *b* is a target price which is agreed by both the owner and the contractor. If *c* exceeds *b* there is a cost overrun, and if *b* exceeds *c* there is a cost underrun. The sharing coefficient $\alpha$ determines how cost overrun and underrun are to be shared. In particular, if $\alpha = 0$, the contract is fixed price or lump sum one and so all the risk of cost fluctuations is borne by the contractor; if $\alpha = 1$, the contract is cost plus one and so the owner bears all the risks; if $0 < \alpha < 1$, the contract is an incentive one and so the risk is shared by the owner and the contractor. For convenience in mathematics, we sometimes suppose that $0 < \alpha < 1$ but do not specify it definitely.

The contractor's accumulated construction cost is

$$c = \square + \varepsilon - \xi. \qquad (2)$$

It has three components. The □ represents the contractor's ex ante expected cost. Suppose that both the owner and the contractor know the value □ . In fact, it is possible that $\square = b$ if the owner and the contractor have the same belief about the ex ante expected cost. The term $\varepsilon$ is a random variable which represents unpredictable cost fluctuations observed only by the contractor in the course of engineering construction. Although the owner can't observe the realization of $\varepsilon$, he does know its distribution, which is usually assumed to be normal with mean zero and variance $\sigma^2$, i.e. $\varepsilon \sim N(0, \sigma^2)$. The last term $\xi$ in the cost function denotes the reduction in construction cost because of the contractor's cost-controlling effort. The cost-reducing effort could include ensuring that the design successfully fulfills the needs of the owner and users and the design documents is constructible, complete, and coordinated, searching for lower-priced inputs, organizing the reasonable constructing, carefully managing raw material or final goods inventories and so on. This effort is costly to the contractor, and we suppose that it costs the contractor an amount $h(\xi)$ in terms of the assumed equivalent monetary cost. In particular, we suppose that the cost function of the contractor's effort is as following:

$$h(\xi) = \xi^2 / 2\eta. \qquad (3)$$

Here $\eta > 0$. It is evident that there are diminishing returns to the cost-controlling effort, i.e. $h'(\xi) > 0$, and $h''(\xi) > 0$, which is usually considered to be a reasonable hypothesis in line with reality. The parameter $\eta$ represents the contractor's management level and technological capacity to decrease the construction cost, which can not be observed by the owner. So the owner can not directly observe the level of the contractor's cost-controlling effort, and because the owner can't observe the realization of the random variable $\varepsilon$, he can't deduce the degree of the contractor's effort from his observation of the total cost *c*. Thus there is moral hazard. Since the owner can't know the contractor's degree of effort, he can't make his payment contingent upon it, and so he can't directly reward the contractor for his cost-reducing effort. He has to design a contract to motivate the contractor to reduce construction cost.

### 2.2 The contractor's optimization

In the principal-agent model, the owner acts as a Stackelberg leader and the contractor acts as a follower. But we must firstly consider the problem of contractor's optimization. With the above assumptions, we can get the contractor's profit function $\varpi = p - c - h(\xi)$ . Substituting the equation (3) for $h(\xi)$ gives

$$\varpi = (1-\alpha)(b - \square - \varepsilon + \xi) - \xi^2 / 2\eta \, . \quad (4)$$

The contractor's profit $\varpi$ is random variable because of $\varepsilon$ 's randomness. It is normal distribution with the mean

$$E[\varpi] = (1-\alpha)(b - \square + \xi) - \xi^2 / 2\eta \, , \quad (5)$$

and the variance

$$Var[\varpi] = (1-\alpha)^2 \sigma^2 \, . \quad (6)$$

We suppose that the contractor's preferences over wealth can be described by negative exponential utility function, i.e. his utility functions have the following form:

$$u(\varpi) = -\mathrm{e}^{-\lambda_1 \varpi} \, . \quad (7)$$

which is the utility function of constant absolute risk aversion (CARA). The degree of absolute risk aversion is $R_a = -u''(\varpi)/u'(\varpi) = \lambda_1$ . If $\lambda_1 = 0$ , the contractor is risk neutral. If $\lambda_1 > 0$, he is risk averse. If $\lambda_1 < 0$, he is risk preferential. Here we assume that risk aversion is satisfied. Apply the concept about Certain Equivalent (CE) and let

$$E[u(\varpi)] = u(CE_1) \, . \quad (8)$$

Here $CE_1$ represents the contractor's Certain Equivalent profit. Substituting the equation (4) and (7) into (8) gives[1]

$$CE_1 = (1-\alpha)(b - \square + \xi) - \xi^2 / 2\eta - \lambda_1 (1-\alpha)^2 \sigma^2 / 2 \, . \quad (9)$$

It implies that there is indifference between the certain profit $CE_1$, and the risky profit, $E[\varpi] = (1-\alpha)(b - \square + \xi) - \xi^2 / 2\eta$ , which is the expected value in some gamble. So the value $\lambda_1 (1-\alpha)^2 \sigma^2 / 2$ is risky premium. The contractor may observe the random variable $\varepsilon$ either before or after choosing his level of cost-reducing effort $\xi$. He will choose to the level of his effort to maximize his expected utility or his certain equivalent income. So we have

$$\max_{\xi} E[u(\varpi)] = \max_{\xi} u(CE_1) = \max_{\xi} CE_1 \, .$$

From the maximizing first-order condition

$$dCE_1 / d\xi = (1-\alpha) - \xi/\eta = 0 \, ,$$

we can obtain the equation (7)

$$\xi = \eta(1-\alpha) \, . \quad (10)$$

Thus the contractor's cost-reducing effort increases as the sharing $\alpha$ decreases, i.e. the smaller is the sharing $\alpha$ , the more the contractor is responsible for his own costs and the stronger is his incentive to carry out the cost-reducing activity. So if $\alpha = 0$ , the owner gives the contractor the strongest incentive, the contractor bears all of the risk of cost fluctuations; if $\alpha = 1$, no incentive is given the contractor, the owner bears all the risk by his own. Hence $\eta$ in fact represents the degree of the contractor's moral hazard arising from asymmetric information.

**2.3 The owner's optimization**

Now turn to the owner's optimization problem. We firstly assume that utility function of the owner has the same form with the contractor. But his degree of absolute risk aversion is denoted by $\lambda_2$ and $\lambda_2 \le \lambda_1$ . Similarly with the contractor, the owner's certain equivalent payment is

$$CE_2 = b + \alpha(\square - \xi - b) - \lambda_2 \partial^2 \sigma^2 / 2 \, . \quad (11)$$

The owner designs a contract, that is, chooses the sharing parameter $\alpha$ to minimize his expected payment. But he must take into account the contractor's responses: first, the contractor will choose the level of the cost-reducing effort to maximize his expected utility, namely equation (10) must be satisfied; second, the contractor has the right of accepting or forgoing the contract offer, namely in order to ensure that the contractor accepts the contract offer, his expected utility must be more than the expected utility from his alternative activity, that is, his opportunity cost, which

[1] Easily $E[u(\varpi)] = -\exp(-\lambda_1 E[\varpi] + \lambda_1^2 Var[\varpi]/2)$

is assumed to be $\underline{CE}$[2] exogenously in terms of certain equivalent, i.e.

$$CE_1 = (1-\alpha)(b - \square + \xi) - \xi^2/2\eta$$
$$-\lambda_1(1-\alpha)^2\sigma^2/2 \geq \underline{CE}. \quad (12)$$

Therefore we have the following programming problem:

$$\min_{\alpha} CE_2 = b + \alpha(\square - \xi - b) - \lambda_2\partial^2\sigma^2/2,$$

subject to: equation (10) and (12)[3].

By backward induction, we can attain the solution:

$$\alpha = \lambda_1\sigma^2/(\eta + \lambda_1\sigma^2 - \lambda_2\sigma^2). \quad (13)$$

It is the optimal sharing rate between the owner and the contractor. The $0 \leq \alpha \leq 1$ will be satisfied if $\eta \geq \lambda_2\sigma^2$.[4] We can consider how the project's risk affect the sharing rate by which taking with respect to $\sigma^2$, namely $d\alpha/d\sigma^2 = \lambda_1\eta(\eta + \lambda_1\sigma^2 - \lambda_2\sigma^2)^{-2}$, which is greater than zero. The sharing rate increases as the variance of cost fluctuation $\sigma^2$, which implies that the high uncertainty in engineering project requires that the owner bears more risk and the contractor less risk. This brings about a weak incentive to the contractor. From the owner's perspective, there is a tradeoff between incentive and risky premium $\lambda_1(1-\alpha)^2\sigma^2/2$. Additionally the sharing rate decreases as the contractor's cost-reducing ability $\eta$. When the contractor has the outstanding management level and technical competence, especially excellent design ability, the owner will give him more incentives and let him bear more risk. The contractor's and the owner's risk-aversion degree also have effect on the sharing rate.

Substituting equation (13) for $\alpha$ in equation (10), we have

$$\xi = \frac{\eta(\eta - \lambda_2\sigma^2)}{\eta + \lambda_1\sigma^2 - \lambda_2\sigma^2}. \quad (14)$$

It is easily seen that the project's risk has a negative effect on the contractor's cost-reducing effort, while his own management ability and technical level have a positive effect on his cost-reducing effort.

Thus we get the optimal contract between the owner and the contractor as the sharing parameter $\alpha$ and the cost-reducing effort $\xi$ show respectively by (13) and (14).

We easily get the owner's certain equivalent payment in equilibrium:

$$CE_2 = \underline{CE} + \square - \frac{\eta^2 - (\eta - \lambda_1\sigma^2)\lambda_2\sigma^2}{2(\eta + \lambda_1\sigma^2 - \lambda_2\sigma^2)}. \quad (15)$$

## 3 The Irrational Model

Although the above model can provide the insight about how to motivate the contractor to act on behalf of the owner, it can not explain the existing trustful behavior between them. In this section, we will introduce the altruistic behavior into the rational model, namely we suppose that the owner firstly formulates some kind to the contractor, and then the contractor is willing to reciprocate the owner's kind. Remarkably note that because the following model is based on the rational model, the value of $\alpha$, $\xi$, $CE_1$ and $CE_2$, is the one in equilibrium in the rational model.

In this section, we will proof that the owner and the contractor will both benefit from their trust each other. And the higher project's uncertainty is, the more important trust each other is.

## 4 Concluding remarks

In this paper we apply the principal-agent model to analyze the relationships between the owner and the contractor in construction industry. This brings about the optimal sharing rate and the contractor's optimal cost-reducing effort, which are respectively the function of the owner's and contractor's risk preferences, the contractor's management ability and technical level, and the project's own risk. It is a result that the owner minimizes his payment and the contractor maximizes his profit. Maybe this is exactly the cause that it is difficult for trust establishing between them.

In consideration of this fact, the paper will introduce the altruistic behavior into the traditional principal-agent model, and model the reciprocal behavior between the owner and contractor. We will show that both the owner and the contractor benefit from their reciprocal behavior, and hence trust establishing between them is possible. More importantly, we will proof that the higher project's uncertainty is, the more important trust establishing is.

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[2] That $\underline{CE} = 0$ is possible if the perfectly competent market holds.

[3] In the equation (9), $CE_1 = \underline{CE}$ must hold when the owner minimizes his expected payoff.

[4] $\eta \geq \lambda_2\sigma^2$ is always satisfied as long as $\lambda_2$ is small enough as footnote 1.

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