



INVESTOR AND VENTURE FUND MANAGERS REMUNERATION PAID MECHANISM BASED ON PRINCIPLE-AGENT MODEL

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Abstract

In order to solve problems in investor and venture fund managers remuneration paid mechanism, the paper presents the asymmetric information games existing in construction mechanism through information economics viewpoints. The paper building investor and venture fund managers remuneration paid mechanism based on principal-agent theory, remuneration excitement and risk constraints. The results of this paper are: (1) Under the venture fund managers' optimal efforts, investors willing to pay for agent fund profits' optimal proportion (2) venture fund manager willing to inject capital amount. The main contribution of this paper is to examine the problems of principal-agent relationship between the principal and agent. The paper validates the model (1) Optimal contract model between investor and venture fund managers (2) Equilibrium contract model between investor and venture fund managers. Finally, the paper gives some suggestions and conclusion on how to enhance the Investor and venture fund managers remuneration paid mechanism.

Keywords: Principle-agent model, game theory, asymmetric information, equilibrium contract

1. INTRODUCTION

Entrepreneurship is a critical activity in modern economies (Sharne and Venkataraman, 2000), economic growth and prosperity (Aulet and Murray, 2013). Venture capital is invested by firms or companies that use other people's money. Venture capital raises that money by offering investors a chance to take part in a fund that is then used to buy shares in a private company.

Principal-agent theory is broadly applicable in situations where multiple parties strive to maximize their utility and which have asymmetric information (Zhu *et al.*, 2011). The core of this theory is designing kind of inspector mechanism, risk sharing mechanism and encourage mechanism enable both of principal and agent to realize double win (Guo and Gu, 2006). The principal-agent theory occurs when one person or entity (the "agent") is able to make decisions that impact, or on behalf of, another person (the "principal"). Eisenhardt (1989) defines that definitions and foundational principles of agency theory from a business perspective. Holmstrom (1979) discuss how to improve a contractual relationship based on imperfect information. Strausz (1997) discuss the dynamics involved in a principal-supervisor-agent relationship and the ability of the principal to detect

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collusion between the supervisor and agent. Principal-Agent Models is a model for designing reward structure based on maximizing both the principal's expected utility and principal's information on the agent's actions (Zhang and Zenios, 2008). Principal-Agent Models is a graphical model for analyzing a principal-agent problem and finding equilibrium points in the relationship (Zhou, 2002; Qin, 2004). Kiser (1999) analysis of variations, strengths, and weaknesses of agency theory applied across. Braun (1993) examines of principal-intermediary-agent relationships in international politics.

Three types of principal agent theory model: State space formulation, which is proposed by Wilson (1969), Spence and Zeckhauser (1971). Ross (1973) firstly use Statespace formulation model. The advantage is that the relationship of each technique is naturally manifested. But, this method does not get economic informative solution. Mirrlees (1974, 1976) and Holmstrom (1979) developed Parameter fixed distribution formulation model. This approach has become a standardized model. Another model is call general distribution formulation. This is the most abstract method. Under the condition of information symmetry, principal agent theory framework is to choose the participation constraint, it call individual rationally constraint (IR), Incentive compatibility constraint (IC), and the principal expected utility function is maximization. Under the condition of information asymmetry, optimal sharing principles satisfy Mirrless-Holmstrom condition (Mirrlees, 1974, 1976; Holmstrom, 1979). Likelihood ratio is measurement of agent effort. Sharing principles is monotone likelihood ratio property. Mirrlees (1974, 1976) and Holmstrom (1979) introduce the first- order condition approach, which is used to justify acts of the agent as a continuous variable. Therefore, the effort level of agent is continuous variable, and assumed that it is one dimension continuous effort variable. Due to the first- order approach does not guarantee the optimal solution is the only issue. Grossman and Hart (1983), and Rogerson, (1985) export the first- order condition approach, and distribution function satisfy MLRP and CDFC (CDFC, convexity of distribution function condition). Guo and Gu (2006) propose that the main contradictions in the implementation of agential construction concentrated in information asymmetry between principal and agent. Li and Zhou (2011) in Moral Hazard problems set up an incentive contracts model for venture capitalist based on principal and agent. Li *et al.* (2012) uses a venture capital dynamic incentive model to study the substitution of reputation for the first stage compensation of earlier venture capitalist.

This study based on principal agent theory, analyses the dynamic gaming relation between principal and agent through a gambling model proposes principal contradictions in this system. It finishes the following works.

- (1) Describes the principal agent problem,
- (2) Creates the optimization problem
 - (a) Principal's optimization (Utility maximization)
 - (b) Participation constraint (IR)
 - (c) Incentive compatibility constraint (IC)
- (3) Calculates agent's optimal effort, principal's willing to pay for agent fund profits' optimal proportion, agent fund manage willing to inject capital amount.

This model considers the venture capitalists for venture capital funds into a certain proportion of personal capital and shares, and the introduction of venture capitalists observable variables. The results show that the model increases the incentive intensity venture capitalists; venture capitalists raised the expectations of income, but also contribute to the risk investors to choose high capacity of venture capitalists and encourage their efforts to work after signing the contract.

2. PRINCIPAL AGENT PROBLEM

Principal-agent theory offers theoretical insight into the motivations of various players in a contractual relationship.

The most basic elements of a principal – agent analysis are:

1. The principal designs a contract for the agent specifying the payment to be made to the agent following each possible outcome.
2. The agent either accepts or rejects the contract.
3. If the agent rejects the contract, he receives his reservation utility (chooses his best outside option).
4. If the agent accepts the contract, he chooses an action.
5. The outcome is realized, and the principal pays the agent according to the contract

3. INVESTOR AND VENTURE FUND MANAGERS REMUNERATION PAID MECHANISM

In this section, the concepts of investor and venture fund paid mechanism come from [Zhu \(2013\)](#) and [Zhang \(2014\)](#).

This paper uses the following notations:

π_i : Venture fund income in the i_{th} time.

s_i : Venture fund managers remuneration paid

α_i : Venture fund managers' fix profit

β_i : Venture fund managers' random profit

e_i : Venture fund managers' effort

T_i : The total investment amount in i_{th} time.

D_i : Venture fund managers injection of funds in i_{th} time.

Y_i : Venture fund managers injection of funds in i_{th} time. The number of shares acquired in the proportion of total shares Y_i and $Y_i \leq D_i / T_i$.

p_i : The probability of success of the venture fund managers operation in i_{th} time.

u_i : The noise impact of uncertainties on the income of the fund in i_{th} time. $u_i \sim N(0, \sigma_{u_i}^2)$

θ : Venture fund manager's capacity

$c_i(e_i, \theta)$: Venture fund managers' effect cost function, $\frac{\partial c_i(e_i, \theta)}{\partial e_i} > 0$, $\frac{\partial^2 c_i(e_i, \theta)}{\partial e_i^2} > 0$,

k : Constant

3.1. Assumptions

- (1) Venture fund managers invest N times.
- (2) Venture fund managers' fixed profit α_i in i^{th} time, β_i is fund profit commission ratio of venture capitalists in i^{th} time.
- (3) Venture fund managers' effect cost function $c_i(e_i, \theta)$ is a function of e_i and θ
- (4) Venture fund managers' effect can be expressed as cost function $c_i(e_i, \theta)$, when capability θ increases then $c_i(e_i, \theta)$ reduce, when effort e_i increases, then $c_i(e_i, \theta)$ is increases. Venture fund managers' effect cost function $c_i(e_i, \theta) = ke_i^2 / 2\theta$ ([Prendergast, 1999](#)) and $\frac{\partial}{\partial e_i} c_i(e_i, \theta) > 0$, $\frac{\partial^2}{\partial e_i^2} c_i(e_i, \theta) > 0$
- (5) Venture fund manager gains fixed income and variable income according to the contract, but also to obtain capital investment.
- (6) Venture fund managers injected capital. The number of shares acquired in the proportion of total shares Y_i and $Y_i \leq D_i / T_i$.
- (7) Principal can select the reward function, i.e. benefits system.

(8) The output of agent is linear function $\pi_i = e_i + \theta + u_i$, and u_i is the random variable of normal distribution whose average equals zero, and variance equals σ_u^2

3.2. Creating investors (principal) give venture fund manager (agent) remuneration paid

$s_i(\pi_i)$ is the investors (principal) give venture fund manager (agent) remuneration paid.

$$s_i(\pi_i) = \alpha_i + p_i\beta_i\pi_i + p_iY_i(1-\beta_i)\pi_i - (1-p_i)D_i \dots\dots\dots (1)$$

Where $[\beta_i + (1-\beta_i)Y_i]$ is called as Venture fund manager risk factor. When, $\beta_i = 0$ Venture fund manager's risk factor is Y_i . When, $\beta_i = 1$ Venture fund manager's risk factor is 1.

Venture fund manager's actual income is $w_i(e_i, \theta)$:

$$w_i(e_i, \theta) = s(\pi_i) - c_i(e_i, \theta) = \alpha_i + p_i\beta_i\pi_i + p_iY_i(1-\beta_i)\pi_i - (1-p_i)D_i - ke_i^2/2\theta \dots\dots\dots (2)$$

If agents (Venture fund manage) accept this contract, it choose to maximize it's expect profit as:

$$\begin{aligned} \text{Max } EU_{VC} &= E \sum_{i=1}^N (s_i(\pi_i) - C_i(e_i, \theta)) = E \sum_{i=1}^N w_i(e_i, \theta) \\ &= E \sum_{i=1}^N [\alpha_i + p_i\beta_i\pi_i + p_iY_i(1-\beta_i)\pi_i - (1-p_i)D_i - ke_i^2/2\theta] \dots\dots\dots (3) \end{aligned}$$

Let $U_i = [\alpha_i + p_i\beta_i\pi_i + p_iY_i(1-\beta_i)\pi_i - (1-p_i)D_i - ke_i^2/2\theta]$, the maximum of (3) is equal to the maximum of U_i .

By $\partial U_i / \partial e_i = p_i\beta_i + p_iY_i(1-\beta_i) - ke_i/\theta = 0$, it obtain:

$$e_i = \frac{\theta \times p_i}{k} [\beta_i + Y_i(1-\beta_i)] \dots\dots\dots (4)$$

$$\partial^2 U_i / \partial e_i^2 = -k/\theta \leq 0 \dots\dots\dots (5)$$

It takes the derivate of e_i with respect to p_i, β_i, Y_i , the derivates are:

$$\begin{aligned} \frac{\partial e_i}{\partial p_i} &= \frac{\theta}{k} [\beta_i + Y_i(1-\beta_i)] \geq 0 \\ \frac{\partial e_i}{\partial \beta_i} &= \frac{\theta \times p_i}{k} (1 - Y_i) \geq 0 \dots\dots\dots (6) \\ \frac{\partial e_i}{\partial Y_i} &= \frac{\theta \times p_i}{k} (1 - \beta_i) \geq 0 \end{aligned}$$

According the above conditions we get the following results:

- (a) The probability of success of the venture fund managers operation in i_{th} time p_i increases, Venture fund managers willing pay more efforts.
- (b) Venture fund managers' random profit β_i increases, venture fund managers pay more efforts.
- (c) The number of shares acquired in the proportion of total shares Y_i increases; Venture fund managers pay more efforts.

3.3. Creating equilibrium contract model between investors (principal) and venture fund manager (agent)

The relationship of investor between venture fund managers is a principal-agent problem. Optimal incentive contract design is based investors and venture fund manager on the basis of their utility maximization. Investor and venture fund manager reach an agreement by game theory, is an equilibrium contract. The equilibrium contract satisfies the following conditions:

- (a) Venture fund manager accepting the contract, the resulting expected utility cannot be less than does not accept the contract in the maximum effectiveness of the resulting. This is Participation constraint.
- (b) Investors' utility maximization achieved at the venture fund manager as a precondition to achieve utility maximization. This is Incentive compatibility constraint.
- (c) After Venture fund manager remuneration paid, investors profit cannot increased by using other contract. This is objective function of principal optimization.

The equilibrium contract model of investor and venture fund manager, venture fund manager satisfy participation constraint and incentive compatibility constraint.

$$\text{Max } EU_{inv} = E \sum_{i=1}^N (\pi_i - s_i(\pi_i)) \dots\dots\dots (7)$$

$$\text{S. t. IR } EU_{VC} = E \sum_{i=1}^N (s_i(\pi_i) - c_i(e_i, \theta)) \geq s_0 \dots\dots\dots (8)$$

$$\text{IC max } EU_{VC} = E \sum_{i=1}^N (s_i(\pi_i) - c_i(e_i, \theta)) \dots\dots\dots (9)$$

From Equation (8) and Equation (7) can be writing as:

$$\begin{aligned} \text{Max } EU_{inv} &= E \sum_{i=1}^N (\pi_i - s_i(\pi_i)) = E \sum_{i=1}^N [(\pi_i - c_i(e_i, \theta)) - (s_i(\pi_i) - c_i(e_i, \theta))] \\ &= E [\sum_{i=1}^N \pi_i - \sum_{i=1}^N (c_i(e_i, \theta) - s_0)] \dots\dots\dots (10) \end{aligned}$$

When venture fund manager certainty equivalent income obtained not less than the opportunity to get paid (assuming the maximum expected value s_0). Venture fund manager will accept the risk of the contracting project.

It takes the derivate of equation (10) with respect to β_i , set the derivate equation to zero. The derivatives are:

$$\frac{\partial \pi_i}{\partial e_i} \times \frac{\partial e_i}{\partial \beta_i} - \frac{\partial c_i}{\partial e_i} \times \frac{\partial e_i}{\partial \beta_i} = 0 \dots\dots\dots (11)$$

Substituting $\pi_i = e_i + \theta + u_i$, $c_i(e_i, \theta) = ke_i^2 / 2\theta$, $e_i = \frac{\theta \times p_i}{k} [\beta_i + Y_i(1 - \beta_i)]$ into Equation (11) yields

$$p_i \times [\beta_i + Y_i(1 - \beta_i)] - 1 = 0 \dots\dots\dots (12)$$

Under the Venture fund manager's optimal effects, Venture fund managers injected optimal, investors willing pay Venture fund managers' random optimal profit β_i :

$$\beta_i^* = \frac{1 - Y_i p_i}{p_i(1 - Y_i)} \dots\dots\dots (13)$$

Where $0 \leq \beta_i^* \leq 1$

And the Venture fund manager optimal effects in :

$$e_i^* = \frac{\theta \times p_i}{k} [\beta_i^* + Y_i(1 - \beta_i^*)] = \frac{\theta}{k}$$

It takes the derivate of equation (10) with respect to Y_i , set the derivate equation to zero. The derivate are:

$$\frac{\partial \pi_i}{\partial e_i} \times \frac{\partial e_i}{\partial Y_i} - \frac{\partial c_i}{\partial e_i} \times \frac{\partial e_i}{\partial Y_i} = 0 \dots\dots\dots (14)$$

Substituting $\pi_i = e_i + \theta + u_i$, $c_i(e_i, \theta) = ke_i^2 / 2\theta$, $e_i = \frac{\theta \times p_i}{k} [\beta_i + Y_i(1 - \beta_i)]$ into Equation (14) yields

$$p_i \times [Y_i + \beta_i(1 - Y_i)] - 1 = 0 \dots\dots\dots (15)$$

Under the venture fund manager's optimal effects, Venture fund managers injected optimal capital, the number of shares acquired in the proportion of total shares Y_i :

$$Y_i^* = \frac{1 - \beta_i p_i}{p_i(1 - \beta_i)} \dots\dots\dots (16)$$

And the Venture fund manager optimal effects in i_{th} time :

$$e_i^* = \frac{\theta \times p_i}{k} [\beta_i^* + Y_i(1 - \beta_i^*)] = \frac{\theta}{k} \dots\dots\dots (17)$$

$s_i(\pi_i)$ is concave function and $c_i(e_i, \theta)$ is convex function. $\frac{\partial c_i(e_i, \theta)}{\partial e_i} > 0$, $\frac{\partial^2 c_i(e_i, \theta)}{\partial^2 e_i} \geq 0$.

Since $s_i(\pi_i)$ is concave function and $c_i(e_i, \theta) + s_0$ is convex function, therefore e_i^* is the tangent of $s_i(\pi_i)$ and the tangent of $c_i(e_i, \theta) + s_0$ parallel effect level. e_i^* is investor hope venture fund managers' effort level in i^{th} time (Participation constraint) (see Figure 1).

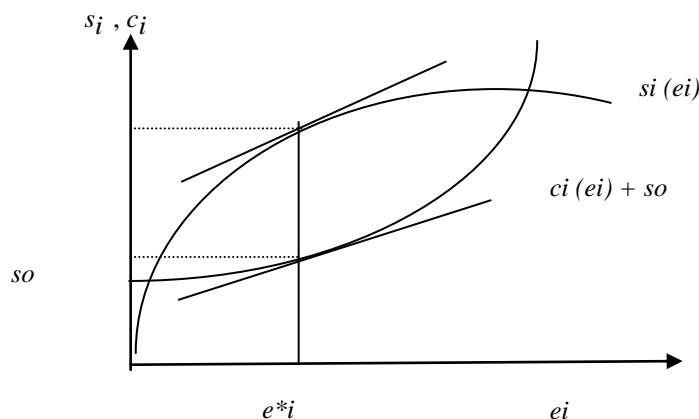


Figure 1: Investor hope venture fund managers' effort level (Participation constraint)

According the above conditions we get the following conclusion:

- (1) The stronger the ability of venture fund manager prefer to bear their own greater risk's contracts
- (2) Under fund returns is uncertainty, the venture fund manager is more risk-averse and increases the effort cost coefficient, then venture fund manager is willing to risk is smaller.
- (3) In order to performance of ability, the venture fund manager often choose a greater risk contract.

4. ILLUSTRATION

4.1. Problem

Zhu (2013) Assume that venture capital investment project in three phases. In each phase has the amount of investment of 6000,000. In each phases has the amount of 20,000 injected into the venture fund. The fixed-income of venture fund manager is 10,000. The probability of success of the venture fund managers operation in each phase is 0.7. The first phase, its profit is 1,000,000, Venture fund managers' random profit s 0.3. The second phase, its profit is 2,000,000, Venture fund managers' random profit s 0.4. The third phase, its profit is 2,000,000, Venture fund managers' random profit s 0.5. Assume that Venture fund manager's capacity is 1 and the relationship coefficient is 0.8.

We know that: (1) Venture fund managers' profit in each time (2) Venture fund managers' effort and the number of shares acquired in the proportion of total shares according the above problem, we have $k = 0.8, \theta = 1$. Calculate s_i, e_i and Y_i^* by using Excel software, Venture the result is denoted as table 1. Where,

$$s_i(\pi_i) = \alpha_i + p_i\beta_i\pi_i + p_iY_i(1-\beta_i)\pi_i - (1-p_i)D_i$$

$$e_i = \frac{\theta \times p_i}{k} [\beta_i + Y_i(1-\beta_i)]$$

$$Y_i^* = \frac{1-\beta_i p_i}{p_i(1-\beta_i)}$$

Table 1: Venture investment results

	A	B	C	D	E	F	G	H	I
	T_i	D_i	α_i	P_i	π_i	β_i	s_i	e_i	Y_i^*
1	600	20	10	0.7	100	0.3	26.633	0.283	1.612
2	600	20	10	0.7	200	0.4	62.810	0.368	1.714
3	600	20	10	0.7	600	0.5	221.011	0.452	1.857

4.2. Result analysis

- (1) When the π_i increase in each time, Venture fund managers' profit s_i will increase.
- (2) The probability of success of the venture fund managers operation in each time is 0.7 and Venture fund managers' random profit is 0.3, then venture fund managers' effort is 0.283.
- (3) When venture fund managers' random profit β_i increases, then venture fund managers pay more efforts and venture fund managers injected more capital in this project.

5. CONCLUSION AND DISCUSSION

The research shows that principal-agent problem, optimal contract model between investor and venture fund manager, and equilibrium contract model between investor and venture fund manager. We find that (1) Moral risk and reversion choice problem by asymmetrical information in the agent relationship could be controlled by designing reasonable contract form and surveillance system, (2) The contracts model in principal-agent problem can raise the incentive intensity and increase the venture investor's expected income, (3) The incentive contracts model help for investors to choose the venture fund manager of high capability and inspire the venture fund manager to work hard after the contracts and effective to solve the moral risk and reversion choice problem. The following methods encourage venture fund manager to redouble its efforts to venture capital.

- (1) Incentive remuneration paid model was changed to continuous paid incentive model.
- (2) The implicit incentive mechanism was changed to explicit incentives. Venture fund manager obtained the profit unrelated of the income obtained in the previous phase.
- (3) Investors may require venture capital fund managers to invest some amount. It gives the formation of the venture fund manager forced action.

Venture fund manager and venture entrepreneur remuneration paid mechanism is Principal-agent problem. Building venture fund managers and venture entrepreneur remuneration paid mechanism based on principal- agent theory, remuneration paid and risk constraints is next studies issue.

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