

## Research on Influence Mechanism of Equity Motivation on R&D Input<sup>1</sup>

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### Abstract

*A game model between manager and shareholders is built to analyze the influence mechanism of equity motivation on R&D input based on the principal-agent theory. Research shows that there are inverted U-shaped relationships between equity motivation on R&D input, the modest equity should be gave for motivating manager.*

**Keywords:** equity motivation, R&D input, game, principal-agent relationship

### 1. Introduction

In today's society with an increasingly market competitive, enterprises must continuously research and development activities to enhance the capacity of technology innovation, so as to improve their core competitiveness. However, the biggest characteristic of modern enterprises is separation of ownership rights and management rights, which would lead to the principal-agent problem. The shareholders as principal expect managers to make the right R&D decisions in order to realize the goal of maximizing the wealth of shareholders, but they can't completely observed the behavior of the managers; And the managers as agent tend to be shortsighted to make decisions for their own interests, which is detrimental to the long-term development of enterprises. In 1976, Jensen and Meckling proposed that managerial ownership is an effective way to solve the principal-agent problem; it can reduce the operator's short-term behavior and reduce the agency costs, because the "golden handcuffs" will bind the long-term value of company with manager's interests together. Since then, scholars have done some research on the relationship between equity incentive and R&D investment.

Hellmann and Thiele (2011) found that the equity incentive was significantly positive correlated with enterprise R&D investment and technological innovation level. Chen (2011) also reached the same conclusion through empirical study on Chinese high-tech corporations. Li and Song (2010) found that, with the survey data of many countries' bank in China, the incentive can effectively promote the enterprises to increase innovation input and output, and the state-owned property inhibit the promoting effect. Jiang and Wang (2012) found that, with the survey data of the information technology industry, electronic industry and biological medicine manufacturing industry corporations from 2007 to 2009, the equity incentive can significantly improve the R&D expenditure in state-owned and non-state-owned company.

However, Bens (2002) found that the manager will pay less R&D investment when they given too much equity incentive, their behavior tend to be short-sighted. Xu (2012) found there are inverted U-type relationships between the equity incentive and R&D input or output by studying high-tech companies in China from 2007 to 2010. Tang (2011) found through the empirical research the inverted U type of relationship is obvious between equity incentive and R&D investment before the share reform in China, and it become positive correlation after the share reform. However, Tien and Chen (2012) thought the long-term incentive for executives have no significant effect on R&D investment by the empirical research for 107 American corporations.

We can find that these studies mostly use the method of empirical study, and the conclusions are not the same.

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Next, this paper will build a game model between shareholders and managers based on the principal-agent theory for analyzing the relationship of equity incentive mechanism and R&D investment, which will provide a theoretical reference for the development of enterprises.

## 2 Basic Assumptions and Descriptions of the Model

According to the law of diminishing marginal returns in western economics, at the beginning of the R&D investment, R&D investment in research and development production and same direction change. When R&D spending increases to maximize output, if continue to increase R&D investment, will be gradually reduce the situation of R&D output. Therefore, assuming that firms have plenty of cash flow for R&D investment, and managers have sufficient R&D investment options, enterprise managers for R&D investment activities of input and output function is

$$O = eh - \frac{1}{2}kI^2 + \theta \quad (1)$$

Among them,  $O$  is the output of R&D activities,  $I$  is the input of R&D activities;  $k$  ( $k > 0$ ) is the parameters of the degree of R&D activity diminishing marginal returns;  $e$  ( $e > 0$ ) is the parameters of the managers' effort degree in the process of R&D investment activities,  $C$  is the agent cost of the subjective effort,  $C = \frac{1}{2}te^2$ ,  $t$  ( $t > 0$ ) is the growth rate of marginal cost;  $\theta$  is immediately fluctuations, it obeys the normal distribution  $N(0, \sigma^2)$ ,  $\sigma^2$  is the risk degree of R&D investment project.

If there is no information asymmetry between managers and shareholders, namely regardless of principal-agent problem, even without any constraints and incentives, managers will make completely R&D investment decisions according to the interests of the shareholders of a company. At this point, the optimal R&D input that maximize R&D output is existing, the optimal R&D can be got by the first order conditions of the formula (1), namely  $I^* = \frac{1}{k}e$ , the managers' effort degree in the process of R&D determines the optimal value.

In real life, however, the above situation does not exist, the information is asymmetric between the shareholders and managers. Shareholders shall pay the agency cost in order to make managers more consideration to the long-term interests of the enterprise, and they need to design appropriate constraints and incentive mechanism for tending to meet consistent on the interests of managers and them. The appropriate equity incentive can make the enterprise managers pay more attention to shareholders and the long-term development of the enterprise. This paper assumes the enterprise managers' real income is equal to the sum of the fixed income, the reward and equity income of making R&D activities minus the own efforts cost, namely

$$p = w_0 + bI + h[O - (w_0 + bI)] - \frac{1}{2}te^2 \quad (2)$$

Among them,  $p$  is managers' real income;  $w_0$  is managers' fixed income;  $b$  ( $0 < b < 1$ ) is the bonus coefficient of making R&D activities coefficient, it is proportional to the managers' working ability;  $h$  ( $0 < h < 1$ ) is the proportion of equity incentive.

There is risk in making R&D investment decisions, this paper assume the cost of risk is  $\frac{1}{2}\beta\sigma^2h^2$  according to the theory of Von Neumann-Morgan Stanley. we can assume managers is the people of risk aversion because of managers as a agent need to pay human capital to the enterprise, namely  $\beta > 0$ .

## 3. The Establishment and Solution of the Model

Managers' certainty equivalent income by making R&D investment decision is equal to the expectations of actual income deduct the risk cost, we can obtain the result of the following by combined with the formula (1) and (2):

$$CE = E(p) - \frac{1}{2}\beta\sigma^2h^2$$

$$= (1-h)(w_0 + bI) + h(eI - \frac{1}{2}kI^2) - \frac{1}{2}te^2 - \frac{1}{2}\beta\sigma^2h^2 \quad (3)$$

The shareholder's goal is to maximize all the interests of the shareholders include managers; The manager will choose the R&D inputs to maximize their income. As a result, the game model of shareholders and managers can be built are as follows:

$$\max_h [E(O - p) + CE] \quad (4)$$

$$s.t. \quad w_0 + bI \geq U_0 \quad (\text{IR}) \quad (5)$$

$$\max_I CE \quad (\text{IC}) \quad (6)$$

Formula (5) is the enterprises' participation constraint (IR), he would choose to make R&D activities only when the managers' short-term income reached his minimum utility level. To meet this condition, shareholders must allow managers maximize their own interests on the optimal investment level in order to make managers go the most optimal R&D investment, which meet the incentive compatibility constraint (IC) of the formula (6).

We can obtain the following result by combined with the formula (1), (3) and (4):

$$\max_h \left( eI - \frac{1}{2}kI^2 - \frac{1}{2}\beta\sigma^2h^2 \right) \quad (7)$$

we can also obtain the following result by combined with the formula (3) and (6):

$$I^{**} = \frac{e}{k} + \frac{b(1-h)}{kh} \quad (8)$$

$I^{**}$  is the optimal R&D input when managers to maximize returns, we can obtain the following result by the calculation of the first derivative combined with the formula (7) and (8):

$$\frac{b(1-h)}{k} - \beta\sigma^2h^4 = 0 \quad (9)$$

we can find the second derivative is existing. So  $h$  meet the formulas (9) is the optimal equity incentive levels to maximize shareholder interests. We can get the following results by calculating the left and right limit because of  $0 < h < 1$ :

$$\lim_{h \rightarrow 0} \frac{b(1-h)}{k} - \beta\sigma^2h^4 = \frac{b}{k} > 0$$

$$\lim_{h \rightarrow 1} \frac{b(1-h)}{k} - \beta\sigma^2h^4 = -\beta\sigma^2 < 0$$

So the optimal equity incentive level which meet these conditions is existing theoretically.

Managers' enthusiasm with R&D investment activities will be higher when given a percentage of equity incentive due to  $I^{**} > I^*$ . Managers tend to more cautious in making research and development activities when  $h$  reach the optimal equity incentive level and continuously raise by  $\frac{\partial I}{\partial h} < 0$ .

#### 4. Conclusion

In order to deeply understanding the internal influence mechanism of equity incentive for enterprise R&D input, this paper establishes the game model between shareholders and managers of firms based on the principal-agent theory, and we get the relation formula between the exogenous variables and the optimal proportion of equity incentive and the optimal R&D input by solving the model. The article's conclusion is the input of R&D investment activities will increase when managers are given a percentage of equity incentive. The optimal proportion of equity incentive that can maximize shareholder value is existing theoretically, manages will reduce R&D investment activities for increase self-interest when this proportion more than the optimal value.

So, there are inverted U-shaped relationships between equity incentive and R&D investments. Enterprises should establish and perfect the equity incentive mechanism for the managers in order to promote their technology innovation level. However, they need grasp a degree of the equity incentive, or there may be serious insider control problem.

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