Optimal contracts of production personnel's innovation based on slack resources

Heping Zhong*

School of Management, Xuchang University, Xuchang, 461000, Henan, China

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Abstract

Based on the analysis frames of the multi-task principal-agent model, this paper establishes a principal-agent model of production personnel's innovation based on slack resources and obtains the optimal incentive contracts for production personnel while they are engaged in "production task" and "slack innovation" through the analysis of the model. In order to improve the performance of production personnel's "slack innovation", on one hand, the firm can reward their "slack innovation" according to the optimal incentive contracts; on the other hand, the firm can optimize the incentive contracts for their "production task" according to the interdependence of the cost functions of "production task" and "slack innovation" to promote indirectly the performance of "slack innovation". The originality of this paper is not only examining the multi-task problems of the compensation incentives for production personnel's "slack innovation" but also considering the impacts of the firm's active actions to support the production personnel's "slack innovation" on incentive contracts.

Keywords: contract, incentive, optimization, multi-task agent model, innovation, slack resources, production personnel

1 Introduction

Production personnel are the production line staffs who are mainly engaged in relatively simple and procedural work such as product processing, the maintenance of equipment, repetitive daily management work and so on. They complete the operation of the specific technics process and produce specific products by use of professional skills, knowledge and experience in their specific jobs. They have a wealth of operational knowledge, experience and high On-site skills on product technics, quality, cost control and equipment capacity. Production personnel's position characteristics are practical and operational. They overcome difficulties to realize the drawings and programs what R&D personnel design.

Production personnel produce qualified products by virtue of their production skills, at the same time; they also participate in the research and development and process improvement by virtue of their skills. Because of their substantial experience, they have the potential of innovation and process innovation advantage, and play an irreplaceable role at least in the key links such as the product design, production and processing of technological innovation. Therefore, production personnel are the key strength in the success of the product innovation and process innovation.

Although production personnel play an important role in technological innovation activities, the existing literatures mainly focus on R&D personnel's innovation incentives (e.g. Wang, 2008; Pan & Wan, 2010; Zhong, 2012), which is lack of research on the production personnel's innovation incentives. Some scholars research the incentive problems for skilled workers combing with China's current situation lacking of skilled personnel (e.g. Pan, 2011), but these studies are mainly the macro-policy researches, lacking of the research on incentives for the production personnel's firm practice, especially lacking of the research on incentives for the production personnel's technological innovation.

Theory and practice show that production personnel's technology innovation activities are the fundamental means to improve the skills of production personnel. The innovation of a modern firm focuses on all-involvement innovation in a firm, and everyone is the source of innovation in a firm. The firm only improves the sense, capacity and efficiency of innovation of all staff in order to successfully innovate, improve innovation performance and achieve the best operation results (Xie et al., 2005). Therefore, researching incentives for production personnel's technological innovation and improving their innovation performance have great significance to achieve all-involvement innovation and improve the competitiveness of the technological innovation of a firm.

Based on the above, this paper constructs an incentive contract model of production personnel's innovation based on slack resources through applying multi-task principal-agent theory in the base of comprehensive drawing on previous researches. The novelty of this model is not only examining the multi-task problems of the compensation incentives for production personnel's

**Corresponding author* e-mail: Hepingz2004@163.com

technological innovation based on slack resources but also considering the impacts of the principal's active actions to support the agent's innovation based on slack resources on incentive contracts for the agent.

2 Analysis of production personnel's innovation behaviour

Production personnel bear the heavy production and processing tasks. In continuous repetitive production process, production personnel master the more knowledge of production equipment, materials, products, processes etc. and have a wealth of operational experience, so as to continuously improve the production and processing skills.

With the enhancement of production personnel's knowledge and skills, production personnel have the in-depth understanding of the performance and use of production equipment, and gradually grasp the knowledge and skills on saving materials, improving operation methods and processes, enhancing work efficiency and product quality. Thus, in the production process, they hold some slack resources such as the improvement of device performance and versatility, saving materials (raw materials, semi-finished products, and finished products), the secret of high-quality and high-efficiency operation methods, which provide a resource base for the next technological innovation activities. Driven by the innovative driving force imposed by the managers, production personnel will make use of slack resources at their disposal to engage in technological innovation activities if they have affluent time and effort after the completion of the formal production tasks. These innovative activities may be initiated by themselves or may also be pushed into the innovative team of other innovation personnel.

Production personnel's full-time work is to complete the production tasks. Different specialization makes the firm difficult to allocate appropriate resources for the production personnel's technological innovation activities. Even if production personnel's innovative projects have a larger value, the firm only configures rarely some key resources for their innovative projects, accordingly, production personnel can only use their own slack resources such as various real-time information, expertise knowledge, and a variety of personal relationships and relatively idle resources in the firm for technological innovation. Therefore, the production personnel's technology innovation activities are mainly technology innovation based on slack resources at the same time as production personnel complete production tasks.

Production personnel's technological innovation activities based on slack resources are mainly showed in the following areas:

(1) Improvement of the existing process methods. R&D personnel's knowledge about equipment and technics is limited, but production personnel have accumulated more equipment knowledge and skills in the repetitive operation of equipment, making it very easy to find product problems in the process and suggest improvement program. The "unique skill" and "unique technique" they grope in the production process greatly improved work efficiency and product quality.

(2) Design of new tools or improvements in equipment. Innovation comes from practice; the practice of the front-line production personnel is the source of innovation. In the long-term production process, production personnel will find the deficiencies or defects in the performance of existing equipment and some inefficient process methods. Accordingly, they will produce creative ideas of designing new tools or improving equipment performance, and use slack resources to test these ideas until new tools and improved equipment to improve the work efficiency are designed.

(3) Improvement of product. Any product needs to constantly be improved and perfected. In the production process, production personnel will naturally reflect product problems. With the increasing of product knowledge, they will find the problems of product design, especially the matching problems between products design and process technology, thereby, innovative proposals or programs to improve products may be made.

Obviously, production personnel's innovation activities based on slack resources are very useful for the development of a firm, which not only reduces the risk and cost of the innovation and improves the innovation performance, but also improves the efficiency of resources, especially what is important is that it trains a large number of high-skilled talents.

3 Incentive contracts

3.1 MODEL ASSUMPTION

Suppose the firm as a principal, production personnel as an agent. Then, on one hand, the agent is engaged in the formal production tasks arranged by the principal (for short "production task"); on the other hand, he is engaged in the technological innovation activities by use of slack resources (for short "slack innovation"). Thus, the model can be regarded as a multi-task agent model (Holmstrom & Milgrom, 1991; Zhang, 2004; Zhong, 2012). In order to make the analysis easier, we may make the following assumptions:

Assumption 1: Denote $a_i, i=1,2$ the level of the agent's effort, a_1 is the level of effort spent on the "production task" action, a_2 is the level of effort spent on the action of "slack innovation"; denote a_3 the level of the principal's effort spent on the active action of supporting the agent's "slack innovation" (for short "support slack"). With $C(a_3)$ denoting the cost of the principal's effort a_3, we assume $C(a_3)=\frac{b_3}{2}a_3^2$, b_3 is the

cost coefficient of the principal's effort a_3, $b_3 > 0$ (Zhang, 2004); with $B(a_1, a_2, a_3)$ denoting the expected gross benefits of the technological innovation activities, in order to conveniently analyse the question, we may assume $B(a_1, a_2, a_3) = f_1 a_1 + f_2 a_2 + f_3 a_2 a_3$ (Bernardo, 2001; Gibbons,2005; Zhong, 2012), where f_1 is the benefit coefficient of the output of the agent's effort a_1, $f_1 > 0$; f_2 is the benefit coefficient of the output of the agent's effort a_2, $f_2 > 0$; f_3 is the benefit coefficient of the output of the principal's effort a_3, $f_3 > 0$. This assumption is reasonable. Obviously, if the principal takes the active action to support the agent's "slack innovation", such as to enable the firm to maintain much slack resources, to actively promote the production personnel to coordinate with other departments and to actively encourage the production personnel translate slack resources into innovation output, then, the production personnel can easily possess some slack resources and access to the slack resources required for innovation, and is easier to use slack resources to produce the desired innovation output, that is, the principal's "support slack" action contribute greater to the agent's "slack innovation" action. Therefore, the principal's a_3 has an active influence on the agent's a_2, and thus generate positive impact on innovation output, that is $f_3 > 0$, and, the higher the principal's effort a_3 is, the greater the contribution to the innovation is.

Assumption 2: With $C(a_1, a_2)$ denoting the cost of the agent's effort, we assume that the function $C(a_1, a_2)$ is strictly convex. In order to conveniently analyse the question, we may assume $C(a_1, a_2) = \frac{b_1}{2} a_1^2 + b_{12} a_1 a_2 + \frac{b_2}{2} a_2^2$, $b_1 > 0, b_2 > 0$ (Zhong, 2012), where b_1 is the cost coefficient of the effort spent on the "production task" action, marginal cost change rate $\frac{\partial^2 C}{\partial a_1^2} = b_1 > 0$; b_2 is the cost coefficient of the effort spent on the "slack innovation" action, marginal cost change rate $\frac{\partial^2 C}{\partial a_2^2} = b_2 > 0$; b_{12} is the interdependent cost coefficient of "production task" and "slack innovation", $\frac{\partial^2 C}{\partial a_1 \partial a_2} = \frac{\partial^2 C}{\partial a_2 \partial a_1} = b_{12}$, when $b_{12} < 0$, the cost functions of the efforts of the two actions are complementary; when $b_{12} = 0$, the cost functions of the efforts of the two actions are independent; when $b_{12} > 0$, the cost functions of the efforts of the two actions are substitute (Holmstrom & Milgrom, 1991; Laffont & Martimort, 2002).

Assumption 3: The principal cannot observe the level of the agent's effort, but the result of the agent's effort $x_i, i = 1,2$ can be observed, suppose $X = x_1 + x_2$, $x_i = g_i a_i + \varepsilon_i$, where g_i is the output of per unit of effort in every action, $g_i > 0$, ε_i is exogenous random variable which is normally distributed with mean vector zero and variance σ_i^2 (on behalf of all the factors that the agent cannot control), ε_1 and ε_2 are independent (Gibbons, 2005).

Assumption 4: The principal takes the linear function for the **c**ompensation rule to pay the agent, namely, the compensation rule is $w(X) = w_0 + \beta_1 x_1 + \beta_2 x_2$, where w_0 is the fixed income of the agent, β_1, β_2 is the incentive factor of x_1, x_2 respectively, $\beta_1 \geq 0, \beta_2 \geq 0$.

Assumption 5: The principal is risk-neutral, the agent is risk aversion. And further assume that the agent has the utility function of unchanged absolute risk aversion, his preferences are represented by a negative exponential utility function $u(w) = -e^{-\rho w}$, where ρ measures the agent's absolute risk aversion, w is his compensation minus personal cost. Denote CE the agent's "certainty equivalent" money payoff, then CE meets $u(CE) = Eu(w)$, so one could utilize the exponential form to deduce that the agent's certainty equivalent is $CE = w_0 + \beta_1 g_1 a_1 + \beta_2 g_2 a_2 - \frac{1}{2}\rho(\beta_1^2 \sigma_1^2 + \beta_2^2 \sigma_2^2) - \frac{b_1}{2} a_1^2 - b_{12} a_1 a_2 - \frac{b_2}{2} a_2^2$, where $w_0 + \beta_1 g_1 a_1 + \beta_2 g_2 a_2$ is the expected payoff of the agent, $\frac{1}{2}\rho(\beta_1^2 \sigma_1^2 + \beta_2^2 \sigma_2^2)$ is the risk premium of the agent, $\frac{b_1}{2} a_1^2 + b_{12} a_1 a_2 + \frac{b_2}{2} a_2^2$ is the cost of the agent's effort (Zhang, 2004).

3.2 BASIC MODEL

The principal's expected profit is:

$$Y_P = f_1 a_1 + f_2 a_2 + f_3 a_2 a_3 - w_0 - \beta_1 g_1 a_1 - \beta_2 g_2 a_2 - \frac{b_3}{2} a_3^2$$

Because the principal is risk-neutral, therefore, the principal's expected profit is his certainty equivalent. Denote $\bar{w}$ the agent's reservation wage, so the constraint of the agent's participation is: $CE = w_0 + \beta_1 g_1 a_1 + \beta_2 g_2 a_2 - \frac{1}{2}\rho(\beta_1^2 \sigma_1^2 + \beta_2^2 \sigma_2^2) - \frac{b_1}{2} a_1^2 - b_{12} a_1 a_2 - \frac{b_2}{2} a_2^2 \geq \bar{w}$ the agent's incentive compatibility constraint is: $(a_1, a_2) \in \arg\max CE$. It is equivalent to $(a_1, a_2) \in \arg\max(\beta_1 g_1 a_1 + \beta_2 g_2 a_2 - \frac{b_1}{2} a_1^2 - b_{12} a_1 a_2 - \frac{b_2}{2} a_2^2)$.

The principal-agent model is:

$$\max Y_P = f_1 a_1 + f_2 a_2 + f_3 a_2 a_3 - w_0 - \beta_1 g_1 a_1 - \beta_2 g_2 a_2 - \frac{b_3}{2} a_3^2, (1)$$

s.t.

$$w_0 + \beta_1 g_1 a_1 + \beta_2 g_2 a_2 - \frac{1}{2}\rho(\beta_1^2\sigma_1^2 + \beta_2^2\sigma_2^2) - \frac{b_1}{2}a_1^2, \quad (2)$$
$$- b_{12}a_1 a_2 - \frac{b_2}{2}a_2^2 \geq \bar{w}$$

$$(a_1, a_2) \in \arg\max(\beta_1 g_1 a_1 + \beta_2 g_2 a_2 - \frac{b_1}{2}a_1^2 - b_{12}a_1 a_2 - \frac{b_2}{2}a_2^2). \quad (3)$$

3.3 SOLVING MODEL

By (3), the incentive compatibility constraint becomes

$$a_1 = \frac{\beta_1 g_1 b_2 - \beta_2 g_2 b_{12}}{b_1 b_2 - b_{12}^2}, \quad (4)$$

$$a_2 = \frac{\beta_2 g_2 b_1 - \beta_1 g_1 b_{12}}{b_1 b_2 - b_{12}^2}. \quad (5)$$

By (4) and (5),

$$\frac{\partial a_1}{\partial \beta_1} = \frac{g_1 b_2}{b_1 b_2 - b_{12}^2} \qquad \frac{\partial a_1}{\partial \beta_2} = \frac{-g_2 b_{12}}{b_1 b_2 - b_{12}^2}$$
$$\frac{\partial a_2}{\partial \beta_1} = \frac{-g_1 b_{12}}{b_1 b_2 - b_{12}^2} \qquad \frac{\partial a_2}{\partial \beta_2} = \frac{g_2 b_1}{b_1 b_2 - b_{12}^2}$$

Obviously, from the practical significance, $\frac{\partial a_1}{\partial \beta_1} > 0$, thus $b_1 b_2 - b_{12}^2 > 0$. (6)

By (1), (2), (4), (5), the optimal incentive factors are:

$$\beta_1 = \frac{f_1 g_1 g_2^2 (b_3 Q - f_3^2 b_1) + (f_1 b_2 - f_2 b_{12}) g_1 \rho \sigma_2^2 b_3 Q}{M}, \quad (7)$$

$$\beta_2 = \frac{g_2 g_1^2 (f_2 b_3 Q - f_1 f_3^2 b_{12}) + (f_2 b_1 - f_1 b_{12}) g_2 \rho \sigma_1^2 b_3 Q}{M}, \quad (8)$$

where

$$M = g_1^2 g_2^2 (b_3 Q - f_3^2 b_1) + \rho\sigma_1^2 g_2^2 (b_1 b_3 Q - f_3^2 b_1^2)$$
$$+ \rho\sigma_2^2 g_1^2 (b_2 b_3 Q - f_3^2 b_{12}^2) + \rho^2 \sigma_1^2 \sigma_2^2 b_3 Q^2,$$
$$Q = b_1 b_2 - b_{12}^2$$

Obviously, from the practical significance, β_2 is an increasing function of f_2, namely, $\frac{\partial \beta_2}{\partial f_2} > 0$, thus $M > 0$.

The optimal condition of the level of effort of principal's "support slack" is:

$$a_3 = \frac{f_3(\beta_2 g_2 b_1 - \beta_1 g_1 b_{12})}{b_3(b_1 b_2 - b_{12}^2)}. \quad (9)$$

3.4 MODEL ANALYSIS AND DISCUSSION

Assumption 6: Production personnel are engaged in "production task" and "slack innovation" at the same time. Production personnel's "production task" action can be observed directly.

This assumption is reasonable in most cases for production personnel who are engaged in "production task" and "slack innovation" at the same time. Because production personnel's jobs are procedural and are easy to observe, his "production task" action can be observed directly.

Proposition 1: If the cost functions of "production task" and "slack innovation" of production personnel are independent $(b_{12} = 0)$, then, the optimal incentive contracts of the every action under the conditions of the incentive compatibility are independent each other, and the optimal incentive factors for "production task" are unaffected by the principal's "support slack" action. If the cost functions of "production task" and "slack innovation" of production personnel are interdependent and production personnel's "production task" action can be measurable directly, then, under the conditions of the incentive compatibility, on one hand, the firm can directly award his "slack innovation" according to the optimal incentive contracts to improve the performance of "slack innovation"; on the other hand, the firm can optimize the incentive for his "production task" to promote indirectly the performance of "slack innovation", and when the cost function of these two actions are complementary ($b_{12} < 0$), the firm should strengthen the incentive for the "production task", and the strengthening degree is increased as the complementary degree of the cost function of these two actions and the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" increases; when the cost function of these two actions are substitute, the firm should weaken the incentive for the "production task", and the weakening degree is increased as the substitute degree of the cost function of these two actions and the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" increases.

Proof: From assumption 6, because the production personnel's "production task" and "slack innovation" are not related, the cost functions of these two actions are independent, that is $b_{12} = 0$, by (7) and (8):

$$\beta_1 = \frac{f_1 g_1}{g_1^2 + b_1 \rho \sigma_1^2}, \quad (10)$$

$$\beta_2 = \frac{f_2 g_2 b_2 b_3}{g_2^2 b_2 b_3 - f_3^2 g_2^2 + b_2 b_3 \rho \sigma_2^2}. \quad (11)$$

Obviously, the optimal incentive factor β_1 and β_2 are independent. By formula (10), β_1 and f_3 are not related,

namely, the optimal incentive factors for "production task" are unaffected by the principal's "support slack" action.

If production personnel's "production task" action can be observed directly, then $\sigma_1 = 0$, by (7) and (8):

$$\beta_1 = \frac{\begin{array}{l} f_1 g_1 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ (f_1 b_2 - f_2 b_{12}) g_1 b_3 (b_1 b_2 - b_{12}^2) \rho \sigma_2^2 \end{array}}{\begin{array}{l} g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] \end{array}}, \quad (12)$$

$$\beta_2 = \frac{g_2 g_1^2 [f_2 b_3 (b_1 b_2 - b_{12}^2) - f_1 f_3^2 b_{12}]}{\begin{array}{l} g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] \end{array}}. \quad (13)$$

Obviously, from the practical significance, β_2 is an increasing function of f_2, namely, $\frac{\partial \beta_2}{\partial f_2} > 0$, Accordingly, $\frac{\partial \beta_2}{\partial f_2} = \frac{g_2 g_1^2 b_3 (b_1 b_2 - b_{12}^2)}{\begin{array}{l} g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] \end{array}} > 0$.

By (6):

$$\begin{array}{l} g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] > 0 \end{array}, \quad (14)$$

$$\begin{aligned} \delta_b &= \beta_1\big|_{b_{12} \neq 0} - \beta_1\big|_{b_{12}=0} \\ &= \frac{\begin{array}{l} f_1 g_1 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ (f_1 b_2 - f_2 b_{12}) g_1 b_3 (b_1 b_2 - b_{12}^2) \rho \sigma_2^2 \end{array}}{\begin{array}{l} g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] \end{array}} - \frac{f_1}{g_1} \cdot \\ &= \frac{\begin{array}{l} -b_{12} \rho \sigma_2^2 g_1^2 [f_2 b_3 (b_1 b_2 - b_{12}^2) - f_1 f_3^2 b_{12}] \\ g_1 \{ g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] \} \end{array}} \end{aligned}$$

By (13): $\frac{g_1^2 [f_2 b_3 (b_1 b_2 - b_{12}^2) - f_1 f_3^2 b_{12}]}{\begin{array}{l} g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] \end{array}} = \frac{\beta_2}{g_2}$.

Accordingly,

$$\delta_b = \beta_1\big|_{b_{12} \neq 0} - \beta_1\big|_{b_{12}=0} = \frac{-b_{12} \rho \sigma_2^2 \beta_2}{g_1 g_2}. \quad (15)$$

By (13):

$$\frac{\partial \beta_2}{\partial f_3} = \frac{\begin{array}{l} 2 f_3 g_2 g_1^4 b_3 (b_1 b_2 - b_{12}^2) [g_2^2 (f_2 b_1 - f_1 b_{12}) \\ -\rho \sigma_2^2 b_{12} (f_1 b_2 - f_2 b_{12})] \end{array}}{\begin{array}{l} \{ g_1^2 g_2^2 [b_3(b_1 b_2 - b_{12}^2) - f_3^2 b_1] + \\ \rho \sigma_2^2 g_1^2 [b_2 b_3 (b_1 b_2 - b_{12}^2) - f_3^2 b_{12}^2] \}^2 \end{array}}. \quad (16)$$

When $b_{12} < 0$,

By (15):

$\delta_b > 0$, δ_b increases as $|b_{12}|$ increases and increases as β_2 increases.

Thus $\beta_1\big|_{b_{12}<0} > \beta_1\big|_{b_{12}=0}$, the firm should strengthen the incentive for β_1, and β_1 increases as $|b_{12}|$ increases and increases as β_2 increases.

By (16) and (6): $\frac{\partial \beta_2}{\partial f_3} > 0$, β_2 increases as f_3 increases.

Because β_1 increases as β_2 increases and β_2 increases as f_3 increases, β_1 increases as f_3 increases.

Accordingly, when $b_{12} < 0$, the firm should strengthen the incentive for β_1, and β_1 increases as $|b_{12}|$ increases and increases as f_3 increases.

By (5) and (6): $a_2 = \frac{\beta_2 g_2 b_1 + \beta_1 g_1 |b_{12}|}{b_1 b_2 - b_{12}^2}$, a_2 increases as β_1 increases.

By assumption 3, x_2 increases as a_2 increases. Thus, x_2 increases as β_1 increases, namely, to strengthen the incentive for the "production task" can improve the performance of "slack innovation".

Therefore, when the cost functions of the two actions are complementary, the principal should strengthen the incentive for the "production task", and the strengthening degree is increased as the complementary degree of the cost function of these two actions and the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" increases.

When the cost functions of the two actions are complementary, the harder one action works, the lower the marginal cost of the other action (Holmstrom & Milgrom, 1991). The principal strengthens the incentive for the agent's "production task" will prevail the agent on "production task" to work harder, but it has lowered the marginal cost of "slack innovation" action, thereby reduces the risk of "slack innovation" and thus can improve the performance of "slack innovation". In the same way, if the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" is greater, and the principal's effort of "support slack" is higher, the production personnel can easily maintain some slack resources and access to the slack resources required for innovation activities, the more slack resources the agent controls, the greater enthusiasm for innovation the agent has, and the more efforts the agent takes (Wang & Pu, 2005). On one hand,

it promotes the performance of "slack innovation", on the other hand, it reduces the marginal cost of "production task" and thus improve the performance of "production task".

When $b_{12} > 0$,

By (15): $\delta_b < 0$, δ_b decreases as $|b_{12}|$ increases and decreases as β_2 increases.

Thus $\beta_1\big|_{b_{12}>0} < \beta_1\big|_{b_{12}=0}$, the firm should weaken the incentive for β_1, and β_1 decreases as $|b_{12}|$ increases and decreases as β_2 increases.

By (16) and (6):

If $g_2^2(f_2b_1 - f_1b_{12}) > b_{12}(f_1b_2 - f_2b_{12})\rho\sigma_2^2$, then $\frac{\partial\beta_2}{\partial f_3} > 0$, β_2 increases as f_3 increases.

Because β_1 decreases as β_2 increases and β_2 increases as f_3 increases, β_1 decreases as f_3 increases.

Accordingly, when $b_{12} > 0$, if $g_2^2(f_2b_1 - f_1b_{12}) > b_{12}(f_1b_2 - f_2b_{12})\rho\sigma_2^2$, the firm should weaken the incentive for β_1, and β_1 decreases as $|b_{12}|$ increases and decreases as f_3 increases, namely, the weakening degree for β_1 increases as $|b_{12}|$ and f_3 increases.

If $g_2^2(f_2b_1 - f_1b_{12}) < b_{12}(f_1b_2 - f_2b_{12})\rho\sigma_2^2$, then $\frac{\partial\beta_2}{\partial f_3} < 0$, β_2 decreases as f_3 increases.

Because β_1 decreases as β_2 increases and β_2 decreases as f_3 increases, β_1 increases as f_3 increases.

Accordingly, when $b_{12} > 0$, if $g_2^2(f_2b_1 - f_1b_{12}) < b_{12}(f_1b_2 - f_2b_{12})\rho\sigma_2^2$, the firm should weaken the incentive for β_1, and β_1 decreases as $|b_{12}|$ increases and increases as f_3 increases, namely, the weakening degree for β_1 increases as $|b_{12}|$ increases and decreases as f_3 increases.

Generally speaking, the marginal value of the production personnel's innovation results is much higher than the "production task". Production personnel's "slack innovation" is mainly "five small" activities of "innovation and improvement of performance" combined with "production task", so these two actions are complementary.

If the production personnel is busy in his production tasks, the cost function of these two actions are substitute because of time and effort limitations. However, production personnel is not very busy in practice, the substitution of these actions is very little. In an addition, the agent's risk aversion and profit-driven decide that the risk of production personnel's "slack innovation" is smaller and the marginal cost change rate of production personnel's "slack innovation" is not more than that of his "production task". Thereby, in most cases, $g_2^2(f_2b_1 - f_1b_{12}) > b_{12}(f_1b_2 - f_2b_{12})\rho\sigma_2^2$, that is, generally, the weakening degree for β_1 increases as $|b_{12}|$ and f_3 increases.

By (5) and (6): $a_2 = \frac{\beta_2 g_2 b_1 + \beta_1 g_1 |b_{12}|}{b_1 b_2 - b_{12}^2}$, a_2 increases as β_1 decreases.

By assumption 3, x_2 increases as a_2 increases. Thus, x_2 increases as β_1 decreases, namely, to weaken the incentive for the "production task" can improve the performance of "slack innovation".

Therefore, when the cost functions of the two actions are substitute, the principal should weaken the incentive for the "production task", and the weakening degree is increased as the substitute degree of the cost function of these two actions and the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" increases.

When the cost functions of the two actions are substituting, the harder one action works, the higher the marginal cost of the other action is (Holmstrom & Milgrom, 1991). The principal weakens the incentive for the agent's "production task" will prevail the agent on "slack innovation" with more energy, thus can improve the performance of "slack innovation". In the same way, if the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" is greater, and the principal's effort of "support slack" is higher, the production personnel can easily maintain some slack resources and access to the slack resources required for innovation activities, the more slack resources the agent controls, the greater enthusiasm for innovation the agent has, and the more efforts the agent takes (Wang, Pu, 2005). On one hand, it promotes the performance of "slack innovation", on the other hand, it increases the marginal cost of "production task". Because the agent is risk-aversion, the effect of strengthening the incentive for the "production task" is not so much at this time that the firm should weaken the incentive for the "production task" to save costs.

Assumption 7: When production tasks of the production personnel are full, the cost functions of "production task" and "slack innovation" of production personnel are substitute, that is $b_{12} > 0$; when production tasks of the production personnel are not full, the cost functions of these two actions are complementary, that is $b_{12} < 0$.

This assumption is reasonable. If the agent's cost with the two tasks at the same time is more than the total of the cost the agent is engaged in one task respectively, the cost functions of these two tasks are substitute. In other words, after a task is executed, another task will be harder to implement. If the agent's cost with the two tasks at the same time is less than the total of the cost the agent is engaged in one task respectively, the cost functions of the

two tasks are complementary. In other words, when a task is executed, another task will be easier to implement (Laffont & Martimort, 2002). In the case that a person's energy is certain, the more efforts he spends on one work, the higher the marginal cost of another work is (Holmstrom & Milgrom, 1991). Production personnel's full "production task" take up his major energy, then production personnel's slack innovation activities would be reduced, that is, when a task is executed, another task will be harder to implement, so the cost functions of the two actions are substitute, that is $b_{12} > 0$ (Holmstrom & Milgrom, 1991); but when "production tasks" of the production personnel are not full, production personnel have wealthy effort for "slack innovation" activities, generally speaking, production personnel's "slack innovation" activities and the expertise knowledge and the technology of the "production task" are related, in this way, the more in-depth production personnel's understanding about "production task" is, the more easily the innovations about "production task" generate, in the same way, production personnel's "slack innovation" activities around the "production task" are beneficial to improve the performance of "production task", in other words, when a task is executed, another task will be easier to implement, the cost functions of these two actions are complementary, that is $b_{12} < 0$ (Holmstrom & Milgrom,1991).

Proposition 2: When production personnel's production tasks are full, the firm should weaken the incentive for his "production task" to induce him to do some "slack innovation" activities; when production personnel's production tasks are not full, the firm should strengthen the incentive for his "production task" to encourage him to do some "slack innovation" activities.

Proof: by assumption 7, if production personnel's production tasks are full, the cost functions of "production task" and "slack innovation" of production personnel are substitute, that is $b_{12} > 0$; if production personnel's production tasks are not full, the cost functions of these two actions are complementary, that is $b_{12} < 0$. Therefore, by Proposition 1, when production personnel's production tasks are full, the firm should weaken the incentive for his "production task" to induce him to do some "slack innovation" activities; when production personnel's production tasks are not full, the firm should strengthen the incentive for his "production tasks" to encourage him to do some "slack innovation" activities.

This also meets with the fact. When production personnel's production tasks are full, the firm often give relatively low piecework wage or hourly wage; in this way, some skilled workers who have high skills and strong innovation abilities will take advantage of the slack resources mastered by themselves for innovation activities, and find ways to improve the work efficiency of the "production task" through improved technic to increase the personal income. When production personnel's production tasks are not full, the firm should strengthen the incentive for their "production task" to encourage them find ways to improve the performance of "production task". Obviously, only through innovation activities around the "production task", the firm can improve work efficiency and quality of the "production task", thus contributing to the production personnel's "slack innovation" activities.

4 Conclusions

The paper uses multi-task principal-agent model to research the coordination incentive problems for production personnel to be engaged in daily "production task" and "slack innovation" at the same time under the conditions of the information asymmetric. The results show that the optimal incentive contracts of "slack innovation" have nothing to do with the interdependence of the cost functions of the two actions, and when the cost functions of the two actions are complementary, the firm should strengthen the incentive for "production task"; when the cost functions of the two actions are substitute, the firm should weaken the incentive for "production task".

Therefore, in order to improve the performance of production personnel's "slack innovation", on one hand, the firm can reward their "slack innovation" according to the optimal incentive contracts; on the other hand, the firm can optimize the incentive contracts for their "production task" according to the interdependence of the cost functions of "production task" and "slack innovation" to promote indirectly the performance of "slack innovation".

In general, if production personnel's production tasks are full, the cost functions of "production task" and "slack innovation" of production personnel are substitute, then, the firm should weaken the incentive for their "production task" to prevail them to do some "slack innovation" activities, and the weakening degree is increased as the substitute degree of the cost function of these two actions and the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" increases. if the production personnel's production tasks are not full, the cost functions of these two actions are complementary, then, the firm should strengthen the incentive for their "production task" to encourage them to do some "slack innovation" activities, and the strengthening degree is increased as the complementary degree of the cost function of these two actions and the marginal value of the principal's "support slack" contribution to the agent's "slack innovation" increases.

This paper has not considered the impact of the slack level and newly-added resources of a firm on the incentive contracts for production personnel's innovation based on slack resources, which provides opportunity for future research efforts.

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References

[1] Wang Yanmei, Zhao Xinan 2008 Incentive and Monitoring for R&D Staff in Software Enterprises *Journal of Northeastern University (Natural Science)* **29**(5) 750-2 *(In Chinese)*
[2] Pan Yingwen, Wan Difang 2010 Study on Influence of Uncertainty on R&D Researchers' Incentive Contract Design, *Chinese Journal of Management* **7**(4) 525-8 *(In Chinese)*
[3] Heping Zhong 2012 Incentive contracts for R&D personnel's technological innovation based on organizational slack *International Review on Computers and Software* **7**(4) 1803-11
[4] Pan Ming 2011 Incentive mechanism for highly skilled talent of SME in Zhejiang Province *China Adult Education* **2011**(19) 144-6 *(In Chinese)*
[5] XIE Zhang-shu, YANG Zhi-rong, XU Qing-rui 2005 A Study on the ALL-involvement Innovation of Enterprise and Organizational Mechanisms *R&D MANAGEMENT* **17**(5) 7-13 *(In Chinese)*
[6] Holmstrom B, Milgrom P 1991 Multi-task principal-agent analyses: Incentive contracts, asset ownership and job design *Journal of Law, Economics and Organization* **7** 24-52
[7] Zhang Weiying 2004 *Game and Information Economics* Shanghai: Shanghai People's Publishing House *(in Chinese)*
[8] Bernardo A E, Cai H, Luo J 2001 Capital Budgeting and Compensation with Asymmetric Information and Moral Hazard *Journal of Financial Economics* **61**(3) 311-44
[9] Gibbons R 2005 Incentives Between Firms (and Within) *Management Science* **51**(1) 2–17
[10] Laffont J J, Martimort D 2002 *The theory of incentives I: the principal-agent model* Beijing, China: China Peoples University Press *(In Chinese)*
[11] WANG Chang-lin, PU Yong-jian 2005 The Research of the Control Rights Incentive Mechanism in Technological Innovation *Journal of Industrial Engineering & Engineering Management* **19**(3) 52-5 *(In Chinese)*

Authors

Heping Zhong, born on August 28, 1966, Chongqing, China

Current position, grades: Associate Professor
University studies: Xuchang University, China
Scientific interest: Technology Innovation, Game Theory
Publications: 48
Experience: Heping Zhong received the Bachelor degree in Engineering from Huazhong University of Science and Technology in 1991, MBA degree from Wuhan University in 2003, Ph.D. degree in Business Administration from Chongqing University in 2009. He is currently an associate professor at Xuchang university, China. His research interests include firm strategy and innovation, high-tech industry development and technological innovation, information technology application. Dr. Zhong is a member of the International Association of Computer Science and Information Technology, and has got several scientific or technical awards of Henan provincial level.