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Research Article

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Modeling and analysis of knowledge sharing incentive mechanism in the internet of things collaborative innovation

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ABSTRACT

With the development of knowledge economic, the internet of things collaborative innovation is becoming an important way of science and technology innovation, knowledge sharing which as an effective operation support activity is not play a very good role. So the study of knowledge sharing incentive mechanism has the necessity. This paper which based on the principal-agent theory, constructing the basic incentive model and the incentive model considering monitoring signal of knowledge sharing in the internet of things collaborative innovation. Then we study the effect of incentive optimize model on increasing the degree of the science research institution's effort, improving the rationality of knowledge sharing incentive mechanism, reducing the moral hazard and analyze the valid parameter condition of incentive mechanism.

Key words: Collaborative innovation; knowledge sharing; principal-agent; incentive mechanism

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INTRODUCTION

In the era of knowledge economy, innovation is becoming more and more open, and between the creation of knowledge and application sector needs to build an open collaborative innovation[1].Collaborative innovationwhich takes knowledge value-added as its core is a kind of innovative organizational pattern to realize the intergation of each department and the innovation of science and technology [2]. The internet of things collaborative innovation refers to the main bodyof the interest chain of the internet of things, including corporations, scientific research institution and so on, which carry through the sharing and integration of resource and knowledge so as to solve the key issues in the development process of the internet of things [3]. The critical supporting activity of the internet of things collaborative innovation is knowledge sharing which is an important way for corporations to acquire external knowledge and realize value creation. However, many obstacles exist in the knowledge sharing process of the internet of things collaborative innovation. It's very difficult for scientific research institution on they own initiative to share knowledge without incentive. In addition,the knowledge elements and the effort level of knowledge sharing are very difficult to measure which can result in a large number of scientific research institutionat the expense of corporate interests to maximize their own benefits [4]. Therefore, the establishment of effective incentive mechanism for guiding knowledge sharing behavior can stimulate universities and scientific research institution to share knowledge to a certain degree and promote sustainability of knowledge sharing under the circumstance of the internet of things collaborative innovation [5].

At present the research about the incentive mechanism of knowledge sharing mainly from the following three aspects: the influence factors of knowledge sharing behavior, the symmetry and asymmetry of information in the process of knowledge sharing, the apprasial of knowledge sharing in the process of knowledge sharing. In the respect of the influence factors of knowledge sharing behavior, Yang JieJing and other professors built the three-phase incentive mechanism based on the analysis of the influence factors of knowledge sharing[6];Ma XiaoJuan and other researchers made an analysis about influence factors of knowledge sharing which based on

lifecycletheory, and then constructed the incentive mechanism of tacit knowledge sharing on project team[7]. For the symmetry and asymmetry in the knowledge sharing process, FanBing and other experts constructed a multi-stage model of knowledge sharing incentive mechanism in the condition of asymmetric information [8].Chang Tao researched the same question which based on the perspective of game theory [9].For knowledge sharing knowledge in performance appraisal process, Nie GuiHua and other experts studyed the incentive mechanism of knowledge sharing which based on the performance appraisal mechanism of knowledge [10].

The literature above reflects the importance of the incentive mechanism, but that is not study the incentive mechanism of the internet of things collaborative innovation.Therefore,in order to promote the main body of the interest chain of the internet of things to realize knowledge sharing and reduce the occurrence of moral hazard, this paper tends to introduce the monitoring signal to the incentive mechanism ofthe internet of things collaborative innovation, constructing the basic incentive mechanism and the optimization models with monitoring signalbased on the principal-agenttheory.In addition,this paper study the effect of the integration of supervision and incentive mechanism which on increasing the science research institution's effort level,improving the rationality of incentive contract of the knowledge sharingand the reducing the moral hazard.

DESCRIPTION AND ASSUMPTION OF THE QUESTION

Enterprise through incentive measures to induce science research institution which have private information to select the high level of effort to ensure knowledge sharing smoothly in the internet of things collaborative innovation. Enterprise pay the corresponding remuneration to science research institution based on the output of knowledge which is to realize incentives for knowledge sharing in the internet of things collaborative innovation. However, there is a certain moral hazard in the knowledge sharing process, because science research institution in information advantage and enterprise in the information disadvantage. Universities, scienceresearch institution have a strong motivation to take speculation to reduce the level of effort in the process of knowledge sharing, which will make knowledge sharing can not play the expected role.

For this reason, this paper intends to take some variables which can reflect science research institution's effort in a certain degree as the monitoring signal in the process of knowledge sharing. Such as the human resources, information resources, technical resources which universities, research institution side into the process of knowledge sharing, and the enterprise can observe these variables with no cost. The monitoring signal is introduced into the process of knowledge sharing incentives, when the level of science research institution's effort can not be easy observed, enterprise can increase incentive intensity to reduce moral hazard; on the contrary enterprise can increase the output share proportion which based on the monitoring signal to reduce moral hazard.

Knowledge sharing between science research institution and enterprise in the process of the internet of things collaborative innovation is a typical principal-agent relationship, the enterprise is the principal, universities, research institution is the agent. Before analyzing the questiongs, we need to introduce the following elements.

(1)The output of knowledge sharing in the internet of things collaborative innovation is closely related to the degree of science researchinstitution' effort, we will use a single decision variable$a$to represent the degree of science research institution's effort,$a \in A$, $A$is a set of the degree of effort. The output function of knowledge sharing is:

$$\pi = rpa + \theta (1)$$

Here: r is the knowledge sharing ability coefficient of science research institution, $r \geq 0$; and p is the the absorptive ability coefficient of enterprise, $p \geq 0$; $\theta$is theexternal random variable irrelevant to science researchinstitution and enterprise, whichis usually under Normal Distribution, and $\theta \sim (0, \sigma^2)$.

(2)Supposethe risk of enterpriseis medium; science research institution temps to avoid risk,and degree of risk aversion is ρ. The linearincentive contract designed by [11]:

$$S(\pi) = \alpha + \beta\pi (2)$$

Here:α is the fixed remuneration which enterprise pay for science research institution; $\beta$is the incentive intensity coefficient of enterprise, namely knowledge sharing output each additional unit, the enterprise will increase unit pay to science researchinstitution, $\beta \in [0,1]$, when$\beta = 0$,science research institution will bear no risks; when$\beta = 1$,science research institution will bear all risks.

(3)The effort cost of universities, research institution couldnot be neglected, and supposed effortcost function is [11]:

$C(a) = \frac{1}{2}ba^2$(3)

Here:$b$is the knowledge sharing cost coefficient of universities, research institution, $b \geq 0$.

(4)Let ωas actual earnings of universities, research institution; $E(\omega)$is expectation earning of science research institution; CEis confirmedequal earnings of science researchinstitution, indicating the earnings produced by science research institution's effort a; $\omega'$is remainingearnings, only when the confirmedequal earnings are more than the remainingearnings, science research institution will accept the contract which provided by the enterprise.

(5)Let v as actual earnings of enterprise, $E(v)$is expectation earning of enterprise.
(6)Enterprise can not fully observe the degree of science researchinstitution's effort, only through the monitoring signal to understand the effort of science research institution. Therefore the monitoring signalcan be expressed as$m = a + \delta$. δ is exogenous random variables,representing the monitoring accuracy. δ is usually under Normal Distribution, $\delta \sim (0, \sigma_1^2)$,$\theta$and δ are independent ofeach other.

ANALYSIS ON THE BASIC INCENTIVE MECHANISM MODEL
For the given $S(\pi)$, the enterprise's expectation earning function is:

$E(v) = E(\pi - S(\pi)) = -\alpha + (1-\beta)rpa$(4)

Science research institution's actual earnings is:

$\omega = S(\pi) - C(a) = \alpha + \beta(rpa + \theta) - \frac{1}{2}ba^2$(5)

Science research institution's confirmed equalearnings is equal to theexpectation earning minus riskcost caused by θ [11]:

$CE = E(\omega) - \frac{1}{2}\rho\beta^2\sigma^2 = \alpha + \beta rpa - \frac{1}{2}\rho\beta^2\sigma^2 - \frac{1}{2}ba^2$(6)

Due to enterprise in the information disadvantages, the key question for enterprise is to choose$(\alpha, \beta)$and maximize the expectation earning.So the following model was constructed:

$$\begin{cases} Max\ Ev = -\alpha + (1-\beta)rpa \\ IR\ \ \alpha + \beta rpa - \frac{1}{2}\rho\beta^2\sigma^2 - \frac{1}{2}ba^2 \geq \omega' \\ IC\ \ a \in \arg\max\left[\alpha + \beta rpa - \frac{1}{2}\rho\beta^2\sigma^2 - \frac{1}{2}ba^2\right]\ \forall a \in A \end{cases} \quad (7)$$

Involved restraint (IR) means science research institution' confirmed equal earnings is no less than the remaining earnings; incentive compatible restraint (IC) means when science research institution choose effort a, the confirmed equal earnings is maximal. And the solution is:

$a^* = \frac{\beta rp}{b}$(8)

The enterprise incentive model can be simplified as:

$Max\ Ev = \frac{r^2p^2\beta}{b} - \frac{1}{2}\rho\beta^2\sigma^2 - \omega' - \frac{r^2p^2\beta^2}{2b}$(9)

Solve the principal-agent model(10), and the result is：

$$\begin{cases} \beta^* = \frac{r^2p^2}{r^2p^2 + b\rho\sigma^2} \\ a^* = \frac{r^3p^3}{br^2p^2 + b^2\rho\sigma^2} \end{cases} \quad (10)$$

ANALYSIS ON THE INCENTIVE MECHANISM OPTIMIZATION MODEL

The basic model of incentive mechanism above doesn't take the external random factors which may have an impact on the output knowledge sharing into account, if the enterprise pay remuneration to science research institution solely on the basis of the ouput of science research institution knowledge sharing, it will lead to science research institution's positive decline. In the following, we will introduce monitoring signal to observe the degree of science research institution' effort in the process of knowledge sharing, combining the mechanism of supervision and encouragement mechanism together, which can not only reduce the science research institution' speculation, but also can help the enterprise to set up more reasonable remuneration. By above, the science research institution's remuneration not only depends on the output of knowledge sharing, but also depends on the monitoring signals which can reflect the science research institution's effort, so enterprise's incentive contract can be improved.The linearincentive contract designed by [11]:

$S(\pi) = \alpha + \beta\pi + \gamma m$(11)

Here:γ is the output share proportion coefficient,and$\gamma \geq 0$.

For the given $S(\pi)$, the enterprise's expectation earning function is:

$E(v) = E(\pi\text{-}S(\pi))=\text{-}\alpha+(1\text{-}\beta)rpa - \gamma a$(12)

The science research institution's confirmed equal earnings function is:

$CE = \alpha+\beta rpa + \gamma a - \frac{1}{2}\rho\beta^2\sigma^2 - \frac{1}{2}ba^2 - \frac{1}{2}\rho\gamma^2{\sigma_1}^2$(13)

After introducing monitoring signal, the incentive mechanism model can be improved as:

$$Max\ Ev = \text{-}\alpha+(1\text{-}\beta)rpa - \gamma a$$
$$\begin{cases} \text{IR}\ \ \alpha+\beta rpa + \gamma a - \frac{1}{2}\rho\beta^2\sigma^2 - \frac{1}{2}ba^2 - \frac{1}{2}\rho\gamma^2{\sigma_1}^2 \geq \omega' \\ IC\ \ a \in \arg\max\left[\alpha+\beta rpa + \gamma a - \frac{1}{2}\rho\beta^2\sigma^2 - \frac{1}{2}ba^2 - \frac{1}{2}\rho\gamma^2{\sigma_1}^2\right]\ \forall a \in A \end{cases} \quad (14)$$

When the science research institution takes effort a , the confirmed equal earnings is maximal, so the solution is:

$a^{**}=\frac{\beta rp+\gamma}{b}$(15)

Similarly, enterprise's incentive model can be simplified as:

$$Max\ Ev = \frac{r^2p^2\beta+\gamma r}{b} - \frac{1}{2}\rho\beta^2\sigma^2 - \omega' - \frac{(\beta rp+\gamma)^2}{2b} - \frac{1}{2}\rho\gamma^2{\sigma_1}^2 \quad (16)$$

Solve the principal-agent model(18), and the result is：

$$\begin{cases} \beta^{**}=\frac{r^2p^2{\sigma_1}^2}{r^2p^2{\sigma_1}^2+b\rho\sigma^2{\sigma_1}^2+\sigma^2} \\ \gamma^{**}=\frac{rp\sigma^2}{r^2p^2{\sigma_1}^2+b\rho\sigma^2{\sigma_1}^2+\sigma^2} \\ a^{**}=\frac{rp(\sigma^2+r^2p^2{\sigma_1}^2)}{b(r^2p^2{\sigma_1}^2+b\rho\sigma^2{\sigma_1}^2+\sigma^2)} \end{cases} \quad (17)$$

RESULTS AND DISCUSSION

The following main analysis how accurately monitoring signal will affect the optimal effort levelof science research institution, the science researchinstitution' confirmed equalearnings, the optimal incentive intensity, the optimal output share proportion and the enterprise's expectation earning. Referencing the data of Hu xinping [12], and combining with the related properties and conclusion, we set the related parameters as shown below:

α=0.1, r=0.8,b=0.5,p=0.6,ρ=5, $\sigma^2 = 4$.

According the corresponding formula, we can get the result:

a^*=0.0216, β^*=0.0225, CE^*=0.0950, Ev^*= − 0.089.

When the variance value of the accuracy of the monitoring signal$\sigma_1{}^2 \in [1,20]$, and the higher the variance value, the lower the accuracy of the monitoring signal, we can use matlab simulation software to analysis the change of the optimal effort levelof science research institution, the science research institution's confirmed equalearnings,the optimal incentive intensity of the enterprise, the optimal output share proportion which based on monitoring signal and the enterprise's expectation earning. As shown in fig.1.

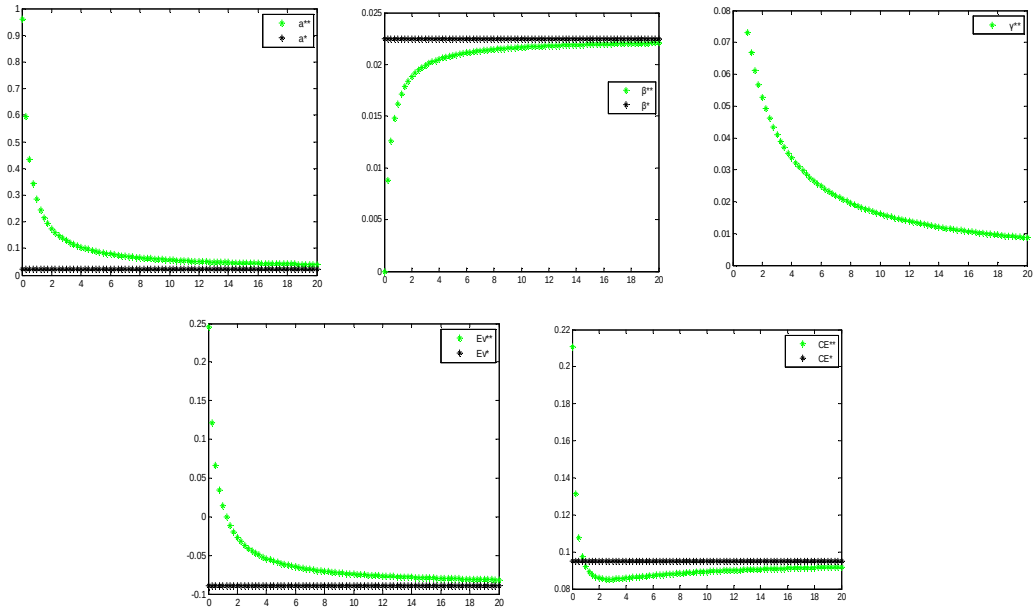

Fig.1 the change trend of each variable with monitoring accuracy reduce

Fig.1 shows that the introduction of the monitoring signal can obviously improve the effort level of science research institution and reduce moral hazard. And the effort level of science research institution decrease as the accuracy of monitoring signal decreases;enterprise's incentive intensity for science research institution increases as the accuracy of monitoring signal decreases; the optimal output share proportion based on monitoring signal decreases as the accuracy of monitoring signal decrease; the enterprise's expectation earning decreases as the accuracy of monitoring signal decreases; at a certain age, the science research institution's confirmed equalearningsdecreases as the the accuracy of monitoring signal decreases, and when the variance of the accuracy of monitoring signal is higher than the threshold value that equals 3.25, the science research institution's confirmed equalearnings will no longer decrease, showing slow growth trend.

CONCLUSION

This paper which based on the principal-agent theory, constructing the basic incentive model and the incentive model considering monitoring signal of knowledge sharing in the internet of things collaborative innovation, studying the effect of incentive optimize model on increasing the degree of effort and improving the rationality of knowledge sharing incentive mechanism and reducing the moral hazard and the valid parameter condition of incentive mechanism. The results showed that: (1) The introduction of the monitoring signal can obviously improve the effort level of science research institution and reduce moral hazard; (2) The effort level of science research institution decrease as the accuracy of monitoring signal decreases, and the optimal effort level in incentive optimize model is higher than the optimal effort level in basic incentive model, namely$a^{**} \geq a^*$; (3) Enterprise's incentive intensity for science research institution increases as the accuracy of monitoring signal decreases, and the incentive intensity for science research institution in incentive optimize model is lower than the the incentive intensity for science research institution in basic incentive model, namely$\beta^{**} \geq \beta^*$;(4) The optimal output share proportion based on monitoring signal decreases as the accuracy of monitoring signal decrease; (5) The enterprise's expectation earning decreases as the accuracy of monitoring signal decreases, and it in incentive optimize model is higher than it in basic incentive model; (6) At a certain age, the science research institution's confirmed equalearningsdecreases as the the accuracy of monitoring signal decreases, and when the variance of the accuracy of monitoring signal is

higher than the threshold value that equals3.25, the science research institution's confirmed equalearnings will no longer decrease, showing slow growth trend. Further research we could consider the impact of the cost of the introduction of the monitoring signal for knowledge sharing incentive.

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