Environmental Engineering and Management Journal

January 2018, Vol.17, No. 1, 237-244
http://www.eemj.icpm.tuiasi.ro/; http://www.eemj.eu

"Gheorghe Asachi" Technical University of Iasi, Romania

OPTIMIZATION OF INCENTIVE CONTRACTS LEADING ENTERPRISES TO PARTICIPATE IN LOW-CARBON AGRICULTURAL DEVELOPMENT

Xitai Sheng[1], Zhenji Zhang[1], Honghu Gao[1], Daqing Gong[1,2]*

[1]*School of Economics and Management, Beijing Jiaotong University, 100044, Beijing, China*
[2]*School of Economics & Management, Tsinghua University, 100044, Beijing, China*

Abstract

Based on principal-agent model, this paper tries to solve the asymmetric information problem between the investor and agriculture leading enterprises. A mathematical model of the incentive contract is designed, on the basis of which it is investigated the design of the incentive contract under different risk preference, the change of the income when implementing the incentive contract and the changing trends of the contractors' costs when an observable variable is included in the incentive contract. The results show that the agency costs borne by agricultural leading enterprises are positively correlated with risk appetite and external uncertainty factors, incentive cost, risk cost as well as the total agency cost of the agriculture leading enterprises are lower when contract invest more on low carbon technology. Finally, the conclusions are verified by numerical simulation.

Keywords: agriculture leading enterprise, asymmetric information, incentive contract, low carbon production

Received: October, 2017; Revised final: January, 2018; Accepted: January, 2018; Published in final edited form: January 2018

1. Introduction

With the rapid economic development, environmental degradation and resource depletion is becoming increasingly serious. Countries in the world began to pay great importance to the development of low-carbon economy (Flamos and Begg, 2010; Zhou et al., 2017). Low-carbon economy is achieved through low-carbon technologies, policy innovation to reduce greenhouse gas emissions, in order to achieve sustainable development (Chen et al., 2014, Flamos and Begg, 2010; Minihan and Wu, 2012). As an important economic sector, the development of low-carbon agriculture has gradually attracted people's attention.

Low-carbon agriculture refers to the science and technology that aims at reducing greenhouse gas content in the atmosphere, carbon emissions, increase carbon sinks and adapt to technologies changing. In the development of rural market and agricultural industrialization, the leading enterprises of agricultural industrialization are important carriers and main bodies of modern agricultural system. Besides their own business, agricultural leading enterprises shoulder the advance of the industrialization of agriculture, promoting the mission of the farmers' income and promoting regional economic development. Therefore, the investor needs to guide the agricultural leading enterprises, stimulate their social responsibility, design reasonable mechanism contracts to encourage agricultural leading enterprises to participate in the development of low-carbon agriculture. Agricultural leading enterprises can use advanced technology to

* Author to whom all correspondence should be addressed: e-mail: gongdq@bjtu.edu.cn

reduce carbon emissions, so as to achieve the way of low-carbon agriculture development. It was demonstrated that the investors support for agricultural enterprises can increase the agricultural production performance, having significant positive effect on leading enterprise performance (Chen and Jiang, 2010; Gong, 2007; Wen et al., 2014). However, some studies showed that the support of the investor is sometimes lacking in efficiency. For example, Lin and Zhang (2004) applying empirical research through 58 agricultural listed companies' data in the 2000-2002 showed that investor support for agriculture is inefficient, investor support does not bring the expectations of leading enterprises related output of the growth. Based on the micro data of the national agricultural leading enterprises in the 2007-2009, Cui and Liu (2014) observed that the investor's taxation applied to support the leading agricultural enterprises operating efficiently is inefficient or even ineffective. The support has a significant role to promote the efficiency and value-added tax, but it is not a policy tool that can achieve good policy expectations. Although studies have shown that the current investor support policies about agricultural leading enterprises are lack of efficiency, some researchers still think that it is necessary and important to carry out policy support for agriculture leading. For example, Ying and Nie (2009) found that it is important for the development of agricultural economy and the agricultural income with the investor's support, but some problems in the process of support are the key to lack of efficiency; Liu et al. (2011) found that investor's support is necessary, because the vulnerability of agriculture itself makes the growth of agricultural leading enterprises more difficult, while the development direction of the leading agricultural enterprises in investor's support is diversification. It is difficult to effectively monitor the leading agricultural enterprises by the investor, resulting in the loss of efficiency. Modern economics reveals that the cause of efficiency loss is the existence of information asymmetry and the investor will face the same problem when making a low-carbon production incentive contract (the government pays a certain amount of compensation for the environmental benefits produced by leading enterprises in low-carbon production) to encourage the leading agricultural enterprises.

The principal-agent theory can provide a framework and method for solving the problem of asymmetric information, showing and how to use the principal-agent theory to design incentive contract to encourage the low-carbon production of leading agricultural enterprises and providing the basis decision-making for promoting agricultural low-carbon production. For this purpose, Antle and Stoorvogel (2006) examined the soil carbon budget of agricultural sustainable and impoverished potential impact of Kenya and other three countries by case studies. Finally, the corresponding measures are given. Willey (2011) considered that greenhouse gas emission trading can play an important role in the development of low carbon agriculture. Minihan and Wu (2012) found the main factors of carbon emission in agricultural production process, and considers that the resource situation, economic development level, technical level and consumption pattern will restrict the development of low-carbon agriculture. Luo and Xu (2010) argued that low-carbon agriculture is a low-energy, low-emission and low-polluting agricultural system in the context of global warming. Low-carbon agriculture is a kind of new agricultural methods with many functions such as regulating climate and ecological conservation. Zheng and Li (2011) proposed a sustainable agricultural development model based on agricultural greenhouse gas emission reduction and agricultural carbon sink increase. Zeng et al. (2013) analyzed the development of low-carbon agriculture in China and found that agricultural carbon emissions are increasing year by year in most part of China, while carbon emission has the Kuznetz inverted "U" type curve. Also, fertilizer and agricultural film are the main sources of agricultural carbon emissions. They also found that the performance of low-carbon agricultural development in the provinces of China meets the "Porter hypothesis" and the efficiency value of the panel data is convergent. Based on the experience of foreign countries and the reality of China, Peng (2015) showed that our country should make clear the goal of "*ensuring safety, promoting low-carbon*" fiscal policy that is, increasing the size of the agricultural subsidies improving the structure and efficiency of fiscal subsidies aspects such as perfecting fiscal subsidies. All these should further increase investment in rural environmental protection, strengthen the agricultural science and technology innovation.

In terms of incentive mechanism of low-carbon agriculture, there are few foreign literatures, and domestic literature mainly focusing on the incentive research of circular economy. To a certain extent, low-carbon agriculture is consistent with the circular economic goals. Zhou and Yin (2009) proposed a subsidy mechanism and incentive policy based on improving the clean production and minimizing agricultural surface sources of pollution. Wang (2014) constructed the principal-agent model between government and agricultural leading enterprises. The result showed that the government should improve the incentive strength of agricultural leading enterprises by reducing the degree of information asymmetry and consider the external environment of enterprises when making supportive policies. Yang and Chen (2016) studied the incentive mechanism of the new agricultural management to participate in the development of low-carbon agriculture and obtained the correlation between the degree of uncertainty and the observability of the results of the new agricultural management effort. The relationship between the optimal subsidy factor and the variance of cost coefficient, risk aversion and uncertain factors is studied.

Although there are some literature on the mechanism of low carbon development in agriculture, there are relatively few specific incentives for low-carbon production in agricultural enterprises and less rational research on contract optimization. How to design the contract and optimize it so that agricultural leading enterprises and the investor can get the maximum benefit, agricultural leading enterprises to actively participate in low-carbon production is the key goal of this study.

2. The principal-agent model

According to the basic hypothesis of "rational man" in economics, in this article we assume that the investor and agricultural leading enterprises are rational that is, both sides address minimum costs to obtain the biggest benefit. It is assumed that the efforts of the leading agricultural enterprises in low-carbon production can be quantified as one-dimensional variable, *e*. The output of low-carbon production of agricultural leading enterprises is expressed in a linear function, *π* (Gong et al., 2017). Their relationship is given by Eq. (1).

$$\pi = e + \theta \tag{1}$$

where *π* is the agricultural output of the leading enterprises with low-carbon production efforts; the extrinsic uncertainty is denoted by *θ* which follows a normal distribution $\theta_{\sim}N(0,\sigma^2)$ (σ^2 is low carbon production variance of output uncertainty). Therefore, when $E(\pi) = e + \theta = e, \mathrm{var}(\pi) = \sigma^2$, the output expectation is consistent with *e*, and the variance of output has nothing to do with the low-carbon effort of the enterprise and the output function is denoted by $\pi(e,\theta)$. In addition, to observe the performance of enterprises through efforts, the investor cannot obtain the exact information of the efforts of enterprises.

In this paper, we assume that the investor who cannot replace the enterprise for low-carbon production in the enterprise's low-carbon production process, can invest according to the observed performance of the enterprise, but as a risk - neutral decision – maker. The payment function is of a linear form $S(\pi(e,\theta))$ given by Eq. (2):

$$S(\pi(e,\theta)) = \alpha + \beta\pi \tag{2}$$

In the payment function, *α* denotes fixed income and *β* the incentive intensity that the investor gives enterprises for low-carbon production (*β* is low carbon production output spillover effects of an additional unit of the reward of enterprise income increase). The investor, as a client, guides enterprises to low-carbon production. This article assumes that the enterprise has the appetite for risk, while the investor expected utility function is in the form of Eq. (3).

$$E(\pi - S(\pi)) = E(\pi - \alpha - \beta\pi) = -\alpha + e(1-\beta \tag{3}$$

Low carbon production cost function for leading enterprise is in the form of Eq. (4).

$$C(e) = d + be^2/2 \tag{4}$$

Here *d* is the leading enterprise of low carbon production of fixed investment, such as staff training and the cost of machinery and equipment. Leading enterprises in low carbon production effort coefficient is *b*. If *b = e = 0*, the cost of leading enterprises in low-carbon production is zero, indicating that leading enterprises do not carry out low-carbon production. The Cost Function of leading enterprises in implementing low - carbon production is strictly increasing and the cost function is defined as: $C(e)>0, C'(e)>0, C''(e)>0$, where *b>0* (*b* is the effort cost coefficient). The bigger parameter *b* is, the greater negative effect it has. The expected revenue of agricultural leading enterprises is in the form of Eq. (5).

$$M = \alpha + \beta e - d - be^2/2 \tag{5}$$

The utility function of leading enterprises is maximized by the von Neumann-Morgenstern utility function. We define: $U = -e^{-rx}$, where *x* is the actual monetary income and *r* (different value of *r* leading enterprises have different risk attitude) is an absolute risk aversion measure. The leading enterprises are risk averse, so the cost of risk should be credited to the total cost. Eventually, the equivalence of income is *M*.

If the random variable *x* is the mean *m* and the variance of the normal distribution *n*, $x_{\sim}(m,n^2)$, the expected utility of leading enterprises is in the form of Eq. (6).

$$E(U) = \int_{-\infty}^{+\infty} -e^{rx}\frac{1}{\sqrt{2\pi n}}e^{-\frac{(x-m)^2}{2n^2}}dx = e^{-r(m-\frac{rn^2}{2})} \tag{6}$$

We can get $E(U) = U(m)$, so $-r(m - rn^2/2) = -r(M)$ which is equivalent to $M = m - rn^2/2$. As *θ* is the normal distribution, and $E[S(\pi(e,\theta) - C(e)] = \alpha + \beta e - C(e)$, $Var[S(\pi(e,\theta) - C(e)] = \beta^2\sigma^2$.

We consider $S(\pi(e,\theta) - C(e)$ as a random variable *x*. The deterministic income *M* is in the form of Eq. (7).

$$M = \alpha + \beta e - d - \frac{1}{2}be^2 - \frac{1}{2}r\beta^2\sigma^2 \tag{7}$$

The risk cost is denoted by $r\beta^2\sigma^2/2$, that is to say, the absolute risk attitude of the leading enterprises, the investor incentives for low-carbon production of leading enterprises and external factors of random uncertainties are positively related with the risk cost.

We assume the utility function of the client (the investor) is $Var(\pi(e,\theta)) - S(\pi(e,\theta))$ and the utility function of agricultural leading enterprises is $Var[S(\pi(e,\theta) - C(e)]$. We can get: $\partial V/\partial S<0, \partial U/\partial S>0; \partial\pi/\partial e<0, \partial c/\partial e>0$. According to the efforts e of the agricultural leading enterprises, the corresponding reward $S(\pi(e,\theta))$ is paid by the principal (the investor). The model can be established in the form of Eq. (8).

$$Max_{S(\pi(ae,\theta))}\int V(\pi(e,\theta) - S(\pi(e,\theta))f(\theta)d\theta$$
$$s.t\begin{cases} U\int S(\pi(e,\theta)f(\theta)d\theta - C(e) \geq \bar{s}(IR) \\ Max_\theta \int S(\pi(e,\theta)f(\theta)d\theta - C(e)(IC) \end{cases} \quad (8)$$

The incentive constraint is *(IC),* and the participation constraint *(IR).* The participation constraint *(IR)* is the minimum income if the agricultural leading enterprises implement low-carbon production. The principal (the investor) sets up the incentive mechanism, and the agent (the agricultural leading enterprise) chooses to maximize the effectiveness of the mechanism when participating in the mechanism (gain/loss) (Wen et al., 2014). The principal-agent model can be established in the form of Eq. (9).

$$Max_{S(\pi(ae,\theta))} - \alpha + e(1-\beta)$$
$$s.t\begin{cases} \alpha + \beta e - d - be^2/2 - r\beta^2\sigma^2/2 > 0 \\ Max_\theta \alpha + \beta e - d - be^2/2 - r\beta^2\sigma^2/2 \end{cases} \quad (9)$$

3. Model analysis

There are two kinds of information between the principal and the agent of the principal-agent model: symmetric and asymmetric. Firstly, under the symmetric information the principal (investor) can observe the low-carbon production effort of the agent (leading enterprise). Since the client (the investor) aims to maximize its own interests, in this case, the client do not want to pay to the agent (leading enterprises) more remuneration. The agent model is simplified in the form of Eq. (10):

$$Max_{S(\pi(ae,\theta))} - \alpha + e(1-\beta)$$
$$s.t \quad \alpha + \beta e - d - be^2/2 = \bar{s}(IR) \quad (10)$$

In this case, the participation constraint *(IR)* is satisfied and the incentive compatibility constraint *(IC)* does not work. Solving linear programming problems (Eq. 10), we can get e', β' (Eq. 11).

$$e' = 1/b, \beta' = 0 \quad (11)$$

Substituting (11) into the participation constraint, we can get s^* (Eq. 12).

$$s^* = \bar{s}(IR) + 1/2b \quad (12)$$

In the case of symmetric information, the principal (investor) can give the fixed income of the agent (leading enterprise) equal to the sum of the cost of the effort of the leading enterprise and the minimum retained income. At this point, the principal (investor) can observe the leading enterprises of low-carbon production efforts $e = 1/b$ and the incentive contract is Pareto-optimum.

Theorem 1: In the case of asymmetric information, if the share of leading enterprises is positive, in the process of low-carbon production the leading enterprises need to bear certain risks and the risk is positively correlated with external uncertain factors and risk appetite. Although the principal (investor) cannot observe the efforts of agents (leading enterprises), the investor can achieve their own expectations of the maximum benefit through the implementation of a reasonable incentive contract. When the agricultural leading enterprises maximize their efforts to determine their equivalent income, we can get the optimal low carbon production enterprise efforts by the incentive compatibility constraint conditions. If we solve the equation:

$$[\partial(\alpha + \beta e) - d - be^2/2 - r\beta^2\sigma^2/2]/\partial e = 0$$

the optimal effort level is $e = \beta/b$.

In the case of asymmetric information, if (α,β) is given, the efforts of the enterprise level equivalent to the incentive compatibility constraint. At this time of principal-agent problems can be established in the form of Eq. (13).

$$Max_{S(\pi(ae,\theta))} - \alpha + e(1-\beta)$$
$$s.t\begin{cases} \alpha + \beta e - d - be^2/2\text{-}r\beta^2\sigma^2 \geq \bar{s}(IR) \\ e = \beta/b(IC) \end{cases} \quad (13)$$

Because Holmstrom-Milgrom model requires the participation constraint as Eqs. (13-15), therefore, the solution of linear programming (Eq. 13) is available (Eq. 14):

$$e = \beta/b, \beta = 1/(1 + rb\sigma^2) \quad (14)$$

From Eq. (14), we know $\beta > 0$, in the process of low-carbon production of the leading agricultural enterprises need to bear a certain risk. That is to say, when $r = 0$, the agent (leading enterprises) is Complete risk appetite, we can get $\beta=1, e=e'$. When $r>0$, β decreases gradually with the increase of r, we know that the degree of incentive is getting smaller and smaller, the agent (enterprise) of low-carbon production efforts are gradually reduced.

Under the asymmetric information, the principal (investor) will have additional risk costs due to the incentive contract compared with information symmetry. In the case of symmetric information, the risk - neutral principal (investor) has full control of the agent 's efforts, and the risk cost is zero. In the case of asymmetric information, efforts information for the agent (business) is private. The risk cost is ΔAC (Eq. 15).

$$\Delta AC = r\beta^2\sigma^2 / 2 = r\sigma^2 / 2(1+rb\sigma^2)^2 \quad (15)$$

Under the asymmetric information, the difference between the expected return under the higher effort of the agent (firm) and the lower effort is the incentive cost. From Eqs. (11) and (14), we can get *e* (Eq. 16).

$$e = \beta / b < 1 / b = e^*(\beta \le 1) \quad (16)$$

Cost savings of low-carbon production efforts is $\Delta C = (2r\sigma^2 + br^2\sigma^4)/2(1+rb\sigma^2)^2$. So the cost of incentives under asymmetric information can be obtained as follows ΔE (Eq. 17).

$$\Delta E = (e' - d - c(e')) - (e - d - c(e)) = br^2\sigma^4 / 2(1+rb\sigma^2)^2 \quad (17)$$

Total agency cost is AC (Eq. 18):

$$AC = \Delta RC + \Delta E = r\sigma^2 / 2(1+rb\sigma^2) \quad (18)$$

Theorem 2: Under the asymmetric information, the agricultural leading enterprises can get more share of the share and reduce the risk of agricultural leading enterprises agent when contract invest more on low carbon technical. If the compensation contract can be optimized, the leading agricultural enterprises will strive to achieve the share, so as to maximize their own expected utility.

Under the asymmetric information, we suppose that the investor can observe the degree of investment in low-carbon technology of agriculture is related to outside uncertainties, and has nothing to do with the low-carbon production efforts of leading enterprises, so the agricultural leading enterprises of the reward contract $S(\pi,\eta) = \alpha + \beta(\pi + \lambda\eta)$ (λ is the correlation coefficient of income and $\eta \sim N(0,\sigma_\eta^2)$ is the degree of investment in low-carbon technology of agriculture .

Given by the Investor of the reward contract, we can see he leading agricultural enterprises of certainty equivalent income is $S(\pi,\eta) = \alpha + \beta e - be^2/2 - r\beta^2(\sigma^2 + \lambda^2\sigma_\eta^2 + 2\lambda\operatorname{cov}(\pi,\eta))/2$, and participation constraints can be expressed as: $\alpha + \beta e - be^2/2 - r\beta^2(\sigma^2 + \lambda^2\sigma_\eta^2 + 2\lambda\operatorname{cov}(\pi,\eta))/2 \ge \bar{S}(IR)$. As the agricultural leading enterprises choose the best to determine their own maximization of income, from the first-order derivative of agricultural leading enterprise, we can get $e=\beta/b$.

Because η and e are not associated, we know that the investor's expected return is $E(\pi - \alpha - \beta\pi) = -\alpha + (1-\beta)\pi$.

Substituting participation Constraints and Incentive Constraint:

$$\max_{\beta,\lambda} \beta / b - r\beta^2(\sigma^2 + \lambda^2\sigma_\eta^2 + 2\lambda\operatorname{cov}(\pi,\eta))$$
$$/2 - \beta^2 / 2b - \bar{s}(IR)$$

is the objective function of the investor. From the first derivative about β, λ, we can get β, λ (Eqs. 19-20).

$$\beta = 1/[1 + rb(\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2)] \quad (19)$$

$$\lambda = -\operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2 \quad (20)$$

Because $\sigma^2, \sigma_\eta \ge \operatorname{cov}^2(\beta,\eta)$, we can see $0 < \beta < 1$. When $\operatorname{cov}(\pi,\eta) \ne 0$, if contract invest more on η, it can be seen from $\beta = 1/[1 + rb(\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2)] > 1/(1 + rb\sigma^2)$ that the leading share of agricultural leading enterprises has been improved and the incentive contract has also been improved. The risk of the agricultural leading enterprises is in the form of Eq. (21).

$$Var(S(\pi,\eta)) = \frac{\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2}{[1 + rb(\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2))^2]} < \frac{\sigma^2}{(1+rb\sigma^2)^2} \quad (21)$$

that is to say, the risk has been reduced.

Theorem 3: In the case of asymmetric information, when π,η is correlated, the investor can observe low-carbon production technology input of the leading agricultural enterprises. Incentive cost, risk cost as well as the total agency cost of the agriculture leading enterprises are lower when contract invest more on low carbon technical. When π,η has no relation with each other, the cost of leading agricultural enterprises does not change.

Prove: Under the condition of asymmetric information, the risk cost is ΔRC_η , when the investor will observe the efforts of the agricultural leading enterprises in low carbon production level (Eq. 22).

$$\Delta RC_\eta = \frac{r(\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2)}{2[1 + rb(\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2)]^2} \quad (22)$$

The cost savings of low carbon production is is ΔC_η and the incentive cost is ΔE_η (Eq.23).

$$\Delta E_\eta = \frac{br^2(\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2)^2}{2[1 + rb(\sigma^2 - \operatorname{cov}^2(\beta,\eta)/\sigma_\eta^2)]^2} \quad (23)$$

The total agency cost is AC_η (Eq. 24).

$$AC_\eta = \Delta RC_\eta + \Delta E_\eta = \frac{r(\sigma^2 - \mathrm{cov}^2(\beta,\eta)/\sigma_\eta^2)}{2[1 + rb(\sigma^2 - \mathrm{cov}^2(\beta,\eta)/\sigma_\eta^2)]} \quad (24)$$

By Eqs. (18) and (19), we can get the following conclusions:

- when π,η is not related, η does not affect the contract remuneration;
- when π and η is negative correlation, λ is negative: When η is positive and the value of θ is large, the agricultural leading enterprises can reduce the payment to avoid external impact without paying a higher effort as they have a better external environment. When η is negative, the value of θ is small, and the result is opposite.
- when π and η is positive correlation, λ is negative: When η is positive and the value of θ is small, the agricultural leading enterprises have poor external environment and make great efforts for agricultural low-carbon production. At this time, it is necessary to increase transfer payment to avoid external environment. When η is negative, the value of θ is large, and the result is opposite.

We can get the following conclusions from Eqs. (20-22):

- If $\mathrm{cov}(\pi,\eta)=0$, it does not affect the agricultural leading enterprises to bear the cost whether η is considered.
- If $\mathrm{cov}(\pi,\eta)\neq 0$, risk costs, incentive costs and agency costs are reduced. In the extreme case, that is when $\sigma^2 = \mathrm{cov}^2(\beta,\eta)/\sigma_\eta^2 = 1, \beta = 1$, the agricultural leading enterprises strive to achieve optimal, and does not assume any risk. Thus, for any observed variable which contains more information (e,θ)than the original variable (π,η), and the cost to the variable is less than the resulting cost of agency cost reduction, the agricultural leading enterprises can get more rewards with lower risk when the observed variable is included.

4. Numerical analysis

The information between the agricultural leading enterprises and the investor is not fully symmetrical in the process of low-carbon production. In this paper, the author designs the mechanism that the investor encourages the agricultural leading enterprises to implement low-carbon production and analyzes the influence of the low-carbon production technology input to the agricultural leading enterprises in the case of asymmetric information. The above conclusions are verified by numerical simulation. We assume that $\sigma^2 = 0.8$ is the variance of external disturbance, the covariance of low carbon production technology input factors and the degree of agricultural low carbonization is $\mathrm{cov}(\pi,\eta)=0.4$, the variance of input of low-carbon production is $\sigma_\eta^2 = 0.6$ and $b = 2$ is low carbon production cost coefficient. The parameter settings in this article are shown that the external environment of leading agricultural enterprises is better. The result is similar when the external environment of leading agricultural enterprises is bad, so we omit it. In this chapter, Matlab (R2016b) software is used for example analysis, and the results are shown as below. Firstly, we analyze the link between the general agent cost and the parameter changes.

4.1. Risk preference and the influence of uncertain factors on the general agent cost

According to the set of parameters, we can get the agency cost of agricultural leading enterprises in low carbon production *AC, as*: $AC = r\sigma^2 / 2(1+2r\sigma^2)$. The results of the numerical simulation are shown in Fig. 1.

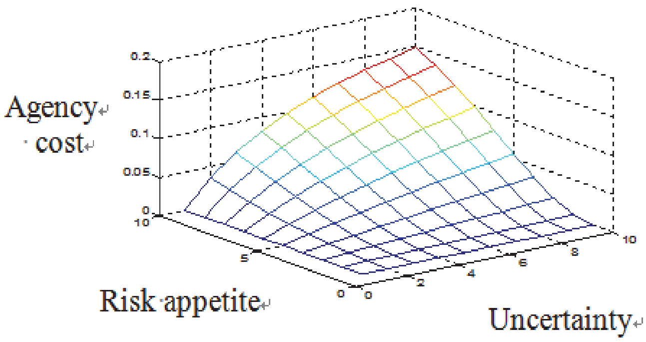

Fig. 1. The connection between AC and σ^2, r

We can see that low carbon production agency cost is positive related to the risk preference of agricultural leading enterprises and the uncertainties from Fig. 1. By the first derivative of σ^2, r, that is:

$$\partial\beta / \partial a = 2rb\sigma^2 / (a^2 + rb\sigma^2)^2 > 0$$
$$\partial\beta / \partial r = ba^2\sigma^2 / (a^2 + rb\sigma^2)^2 > 0.$$

We know that the numerical simulation results are consistent with the change trend of σ^2, r. Under the influence of external factors and risk preferences, agency costs are increasing, based on their own earnings, the investor and leading agricultural enterprises should make the appropriate interpretation of the preferences.

4.2. The impact on the reward share and risk of leading agricultural enterprises after joining η

From theorem 2, we can get the reward share and risk of leading agricultural enterprises (details in Table 1). From Table 1 we can get: (1) the reward share and risk of leading agricultural enterprises is negatively related with its risk appetite.

Table 1. The impact on the reward share and risk of leading agricultural enterprises after joining η

Reward share		***Risk***	
Not joining η	*Joining η*	*Not joining η*	*Joining η*
0.8621	0.9042	0.5945	0.4333
0.7576	0.8251	0.4591	0.3492
0.6757	0.7587	0.3652	0.3051
0.6098	0.7022	0.2974	0.2614
0.5556	0.6536	0.2469	0.2264
0.5102	0.6112	0.2082	0.1980
0.4717	0.5741	0.1780	0.1747
0.4386	0.5411	0.1539	0.1552
0.4098	0.5118	0.1344	0.1388
0.3846	0.4854	0.1183	0.1249

Table 2. The impact on the incentive cost, the risk cost and the agency cost after joining η

Incentive cost		***Risk cost***		***Agency cost***	
Not joining η	*Joining η*	*Not joining η*	*Joining η*	*Not joining η*	*Joining η*
0.0048	0.0023	0.0297	0.2166	0.0345	0.024
0.0147	0.0076	0.0459	0.0361	0.0606	0.0437
0.0263	0.0146	0.0548	0.04576	0.0811	0.0603
0.0381	0.0222	0.0595	0.0523	0.0976	0.0744
0.0493	0.0300	0.0617	0.0566	0.1111	0.0866
0.0600	0.0378	0.0625	0.0594	0.1224	0.0972
0.0698	0.0514	0.0623	0.0611	0.1321	0.1064
0.0788	0.0526	0.0616	0.0621	0.1403	0.1147
0.0871	0.067	0.0605	0.0624	0.1475	0.1221

The reward share is improved and the low carbon production of the agriculture leading enterprise is encouraged when an observable variable is included in the incentive contract. (2) The risk of agricultural leading enterprises have a certain degree of reduced and the floating of risk change smaller when an observable variable is included in the incentive contract.

4.3. Impact on the incentive cost, the risk cost and the agency cost after joining η.

We can get the incentive cost, the risk cost and the agency cost before and after joining η. More details are given in Table 2.

From Table 1 we can get: (1) the risk appreciate is positive related to the incentive cost, the risk cost and the agency cost. (2) Incentive costs are significantly reduced and the risk cost change which is gradually stabilized first reduced and then rise when an observable variable is included in the incentive contract. (3) The agency cost has been reduced.

5. Conclusions

The investor is not sure about the leading agricultural enterprises low-carbon production efficiency, while the benefits of both parties are different due to the different incentive contracts. In addition, the risk attitude of agricultural leading enterprises will also affect the contract optimization problem. This paper studies the optimization of incentive contracts under asymmetric information through principal-agent theory.

This paper studies the contract problem considering the risk preference and the degree of effort of the agricultural leading enterprises. Also, the agricultural low-carbon production technology is joined in the incentive contract, which is better to eliminate the performance changes caused by non-self-factors of agricultural leading enterprises, and a more effective link between performance and the efforts of agricultural leading enterprises and low carbon production capacity is established, so that the design of the contract is more scientific. At last, the research is validated by numerical simulation. The results show that the variable of agricultural low-carbon production technology, which contains more information than the agricultural output function of leading enterprises, the degree of effort and the external uncertainties are joined in the compensation contract. The total agent cost is reduced, so as to realize the contract between the investor and the agriculture leading enterprise. The investor and the agriculture leading enterprise benefit sharing and risk-sharing can effectively promote the low carbon agricultural production.

This study just considers the low-carbon input of agricultural leading enterprises in the contract, which can reduce the incentive cost, the risk cost and the agency cost, but we does not prove the scope of the reduction. In addition, the distribution of uncertain factors is assumed to be normal distribution, but the actual production environment is more complex, which will be further considered in the following research.

Acknowledgments
The study is supported with the fundings from Beijing Natural Science Foundation (041501108), the China Postdoctoral Science Foundation (2016M591194), Beijing Municipal Commission of Economy and Information Technology (B16M00140,B17I00110) and the National Natural Science Foundation (71132008,71390334). We appreciate their support very much.

References

Antle J.M., Stoorvogel J.J., (2006), Predicting the supply of ecosystem services from agriculture, *American Journal of Agricultural Economics*, **88**, 1174-1180.

Cui B.Y., Liu X., (2014), Does investor tax support improve the efficiency of agricultural enterprises? - Empirical Evidence from 482 Leading Agricultural Enterprises in China, *Economic Issues*, **9**, 20-25.

Chen Q.J., Jiang R.C., (2010), A study on the influence mechanism of "Market - policy" Dual - orientation on agricultural enterprises' performance - an example of the agriculture leading enterprises in Pan - Yangtze River Delta, *Nankai Management Review*, **13**, 123-130.

Chen H., Wei J., Zhu D.D., Fen Q., Niu W.J., (2014), How to achieve a low-carbon economy in China: from individual attitudes to actual consumption behaviors, *Environmental Engineering and Management Journal*, **13,** 1165-1172.

Flamos A., Begg K., (2010), Technology transfer insights for new climate regime, *Environment, Development and Sustainability*, **12**, 19-33.

Gong D., Tang M., Liu S., (2017), Reconsidering production coordination: a principal-agent theory based analysis, *Advances in Production Engineering and Management*, **12**, 51-61.

Gong W.H., (2007), Monitoring and analysis report of the industrialization of agriculture national key leading enterprises, *Rural Economy and Science Technology*, **18**, 10-12.

Luo J.W., Xu L., (2010), The origin, connotation and development countermeasure of low - carbon agriculture, *Agricultural Modernization Research*, **31**, 701-703.

Liu K.C., Zhang M.L., Bao L., (2011), An empirical analysis of the effects of diversified non - agricultural business strategies on the output performance of leading agricultural enterprises based on the empirical data of agricultural leading enterprises in Jiangxi Province, *China Rural Economy*, **12**, 25-34.

Lin W.L., Zhang L.Q., (2004), The efficiency of leading enterprises in agricultural industrialization by investor 's tax and subsidy - a case study based on agricultural listed companies, *China's Rural Economy*, **10**, 33-40.

Minihan E.S., Wu Z., (2012), Economic structure and strategies for greenhouse gas mitigation, *Energy Economics,* **34**, 350-357.

Peng X.Q., (2015), Research on fiscal policy to promote the development of low-carbon agriculture, *Finance Research*, **7**, 34-39.

Wen F., Gong X., Cai S., (2016), Forecasting the volatility of crude oil futures using HAR-type models with structural breaks, *Energy Economics*, **59**, 400-413.

Wen F., He Z., Dai Z., Yang X., (2014), Characteristics of investors' risk preference for stock markets, *Economic Computation & Economic Cybernetics Studies & Research*, **48**, 235-254

Wen F., Xiao J., Huang C., Xia X., (2018), Interaction between oil and US dollar exchange rate: nonlinear causality, time-varying influence and structural breaks in volatility, *Applied Economics*, **50**, 319-334

Wang X., (2014), Government's incentive strategy for agricultural leading enterprises based on principal-agent theory, *Jiangxi Social Sciences*, **3**, 46-51.

Willey Z., (2011), Harnessing farms and forests in the low-carbon economy, *Environments*, **36**, 89-90.

Xu W., Zhang Z., Gong D., (2014), Cooperative supply chain management under asymmetric information, *Journal of Applied Research and Technology,* **12**, 182-191.

Yin C.B., (2009), Research on subsidy mechanism and incentive policy of agricultural cleaner production in China, *Ecological economy*, **11**, 149-152.

Yang G., Chen Y., (2016), Design of the incentive mechanism that new agricultural operators participate in low-carbon agricultural development, *Chinese Journal of Population, Resources and Environment*, **26**, 94-99.

Zeng D.L., Ji F.R., Li S.F., (2013), Empirical analysis on the development of low-carbon agriculture in China, *Chinese Journal of Population, Resources and Environment*, **23**, 30-35.

Zheng H., Li Y., (2011), Analysis of low carbon agriculture development model, *Agricultural Economy*, **32**, 26-29.

Zhou Z., Xiao Y., Ziqi D., Liu L., Chen X., Zeng H., (2017), Determinants of corporate carbon efficiency: evidence from CDP 2011-2014 questionnaire for Standard & Poor's 500 index companies, *Environmental Engineering and Management Journal*, **16**, 1595-1608.

Ying L.Y., Nie F.Y., (2009), A tentative study on the institutional innovation of financially supporting the leading enterprises in agricultural industrialization, *Economic Review*, **3**, 104-106.