Research Article
Research on Protection of the Agricultural Products Quality Safety based on Evolution Game from the Perspective of the Supply Chain

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Abstract: This study firstly introduces the research status quo to protect the agricultural products quality safety. Secondly, the game model is established to ensure the agricultural products quality safety, respectively, analyzed from the horizontal relations and the vertical relationships in the supply chain of agricultural products. Finally, on the basis of the analysis model, measures to protect the agricultural products quality safety are proposed, the study shows that increasing government regulations of enterprises in the supply chain of agricultural products and giving full play to the supervision and guidance role of the media and consumers will help to ensure the agricultural products quality safety.

INTRODUCTION

With Chinese rapid economic development and improved level of consumption, the quality requirements of consumers for agricultural products have been increased gradually. However the Agricultural Products Quality Safety (APQS) is a systematic project involving all nodes in the agricultural supply chain from farmers to consumers, therefore, to protect APQS needs common governance to all nodes in the agricultural supply chain.

In recent years, some researchers began to study the supply chain of agricultural products (Mazé, 2001) analyzed the relationship of the agricultural products quality safety and the agricultural products governance structure and firstly proposed the rational use of game theory can improve the quality of agricultural products. Weaver (Robert and Kim, 2001) and Hudson (Darren Hudson, 2001) analyzed and discussed contract cooperative game in the food supply chain. (Celikbas, 1999) discussed the mechanism to coordinate in the supply chain by the punishment agreement. Their studies were generally based on the theory of transaction costs and incomplete contract theory, research priorities were focused on the theoretical analysis and empirical test of APQS from the vertical game. For Chinese researchers, (Zhang et al., 2004) analyzed the strategic choice in a game for the bodies of the food supply chain, repeated game and dynamic game of incomplete information (Li and Fu, 2009) using game theory to construct and analyze the credit game model and influencing factors. Tang (2010) discussed the trust in the supply chain of agricultural products using game theory and concluded when the

agricultural supply chain partner selected each other, there would be Pareto suboptimal outcome of the game and it was be realized Pareto would be improved in the long-term cooperation and in a game with punishment mechanism, the result tended to be optimal. They studied single analysis from the vertical game.

On the basis of the above scholars' researches, this study intends to discuss how to explore more total APQS from perspectives of both the vertical game and the horizontal game based on the supply chain of the agricultural products. The study, closely according to the results of the game model, puts forward factors that affect APQS and the corresponding strategies. Agricultural supply chain nodes involved in this study include: farmers, agricultural products processing enterprises, retail enterprises of agricultural products, agricultural products transport enterprises and consumers. The horizontal Game of the agricultural supply chain means Game among enterprises of a node in the supply chain. The vertical Game of the agricultural supply chain refers to the game relations among members of the upstream and downstream in the supply chain.

MATERIALS AND METHODS

The related research was finish at Wuhan University of Technology in Jan, 2012. The horizontal Game Model to protect APQS will be discussed taking the node of the agricultural products processing enterprises as an example in the agricultural supply chain, the analysis of the other nodes is similar to this.

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Assumptions:

- Supposed that there are two agricultural products processing enterprises and one agricultural marketing enterprise, separately are I enterprise, II Enterprise and III enterprise. Moreover, the agricultural products processing enterprises must sell their products to consumers through the agricultural marketing enterprise.
- For agricultural products processing enterprises I and II, the strategy collection is {cooperation, non-cooperation}, here, the cooperation refers to provide guaranteed quality safety of agricultural products for the agricultural marketing enterprise. The uncooperative means to provide agricultural products without guaranteed quality safety for sales enterprise. If and only if I and II both choose cooperation strategies in the course of the game, they can provide consumers with the qualified and safety agricultural products. And when both parties take uncooperative strategy or one party adopts a cooperative and the other takes uncooperative strategy, these will affect the quality and safety of agricultural products.
- The participation is completely rational. In the entire course of the game, assuming each game player always aims to achieve their own interests for the maximum, both in determining or in a non-deterministic environment, their decisions and judgments are correct and they can achieve their own interests maximized.

Assumptions parameter: The cost to purchase the security raw materials and to get the safety certification of agricultural products is much higher for agricultural products processing enterprises to take cooperation strategy than the cost to take uncooperative strategy.

Supposed that: A represents the revenue agricultural products processing enterprises select the cooperation strategy in the process of game; B1 represents the investment including raw materials and safety testing fees when enterprises choose cooperation strategy, B2 represents the investment to choose uncooperative strategy; C when C represents the revenue gained when both sides select a non-cooperative strategy at the same time.

Supposed:

$$A - B_1 - C > 0, A - B_2 - C > 0, A - B_1 > 0, A - B_2 > 0, B_1 > B_2, C \neq 0$$

Supposed the probability to chooses cooperation, for I enterprise, is x (0<x<1) and the probability to chooses non-cooperation is 1-x. Similarly, supposed that the probability to choose cooperation, for II enterprise, is x (0<x<1) and the probability to choose non-cooperation is 1-y.

Table 1: The profit and loss statement of agricultural products processing enterprises

I enterprise	II enterprise	
	Cooperation	Un-cooperation
Cooperation	$A-B_1, A-B_1$	$A-B_1, A-B_2$
Un-cooperation	$A-B_2, A-B_1$	C, C

The game process among agricultural products processing enterprises: Based on the above assumptions and assuming parameters, the profit and loss of Game matrix for I and II can be drawn showing in Table 1.

Game Process and the Nash Equilibrium: In summary, the revenue can be gotten for I corporate to take cooperative strategy:

$$E = y (A-B_1) + (1-y) (A-B_1) \qquad (1)$$

The revenue can be gotten for I corporate to take un-cooperative strategy:

$$E_1 = y (A-B_1) + (1-y) C \qquad (2)$$

It can be known from formula (2) and (3) that the average revenue for 1 corporate is given in the following formula (3):

$$\overline{E_1} = xE_1 + (1-x)E_1 = x[y(A-B_1) + (1-y)(A-B_1)] + (1-x)[y(A-B_1) + (1-y)C] \qquad (3)$$

Similarly, the revenue to choose cooperation for II enterprise is given in the following formula (4):

$$\overline{E_2} = yE_2 + (1-y)E_2 = y[x(A-B_1) + (1-x)(A-B_1)] + (1-y)[x(A-B_1) + (1-x)C] \qquad (4)$$

Because I enterprise aims for the profit maximization, what the profit function derivates x is given in the formula (5):

$$\frac{d\overline{E_1}}{dx} = [y(A-B_1) + (1-y)(A-B_1)] - [y(A-B_1) + (1-y)C] \qquad (5)$$

Make $\frac{d\overline{E_1}}{dx} = 0$, then it can be gained:

$$y = \frac{A - B_1 - C}{A - B_2 - C}$$

Then the probability to choose un-cooperation for I enterprise is given in the following formula:

$$1 - y = \frac{B_1 - B_2}{A - B_2 - C}$$

That means 1 enterprise would gain the maximum profit when II enterprise's probability to choose cooperation is given in the formula (5).

Similarly, Because II enterprise aims for the profit maximization, what the profit function derivates y is given in the following formula:

$$\frac{d\overline{E_2}}{dx} = [x(A-B_1)+(1-x)(A-B_1)] - [x(A-B_1)+(1-y)C] \quad (6)$$

Make $\frac{d\overline{E_2}}{dx} = 0$, it can be gained:

$$x = \frac{A-B_1-C}{A-B_2-C}$$

Then the probability to choose un-cooperation for II enterprise is given in the following formula:

$$1-x = \frac{B_1-B_2}{A-B_2-C}$$

That means II enterprise would gain the maximum profit when the probability to choose cooperation for 1 enterprise is given in the formula (6).

Obviously, for each agro-processing enterprise, it is the optimal decision to select uncooperative strategy with the prerequisite for the other party to choose cooperation strategy. And the eventual strategy of Nash equilibrium is (C, C), namely two sides have chosen a non-cooperative strategy. It is because that, under the conditions of asymmetric information, the first one to take the cooperation strategy of agricultural products processing enterprises can obtain greater benefits in the short term, but due to the characteristics of the processing of agricultural products and its inherent properties, a processing enterprise cannot unilaterally enjoy the benefits from qualified agricultural products and other similar agricultural products processing enterprises will also follow suit in an attempt to participate in the redistribution of market interests, for this purpose, they even make shoddy foods and make consumer fraud, which will bring out bad consequences. On the one hand, this will result in vicious competition in the market of agricultural products and damage the enthusiasm of enterprises to provide quality protection for consumers and ultimately it will lead to poor quality foods are flooded into the market; On the other hand, due to the different market conditions and input costs, if encountering similar agricultural accidents, loss of agricultural enterprises to provide quality protection may be greater than the loss of poor quality agricultural enterprises, which will be more to dampen the enthusiasm to provide high-quality agricultural enterprises and ultimately lead to Nash equilibrium realized at the (C, C).

The game among agricultural products processing enterprises causes that they do not want to choose cooperation strategy, so the quality safety of agricultural products cannot be guaranteed. According to the result of the horizontal game, the reason can be drawn that impacts the strategy selected of agricultural products processing enterprises, which mainly due to the cost of businesses to choose cooperation and non-cooperation strategy. Thus, to ensure that the game results to develop along the correct direction that is beneficial for agricultural product quality and safety and make enterprises to take cooperation strategies in the horizontal game in the agricultural supply chain, measures should be taken to reduce the cost B_1 of cooperative enterprises and raise the cost B_2 of those enterprises to select uncooperative enterprise, until $B_1 \le B_2$, at this time, the Nash equilibrium of this game model eventually get the strategy of (cooperation, cooperation).

Then the study takes the processing enterprises as the core enterprise and considers its upstream and downstream enterprises as the non-core business to discuss the vertical game model to protect APQS.

Assumptions:

- The agricultural supply chain is consisted of two categories of businesses, the core businesses (agricultural products processing enterprises) and non-core businesses (farmers, agricultural retail businesses).
- If and only if the core businesses and the non-core enterprises both select the cooperation strategy, which will provide consumers with the qualified agricultural products and the overall interests of the supply chain is larger, smaller is the risk. On the other hand, when two types of enterprises both take uncooperative strategy or one party adopts the cooperative and the other takes the uncooperative strategy, the quality safety of agricultural products is affected.
- Both Game sides are limited rational. The traditional game theory assumes that the participant is completely rational, but on different nodes in the agricultural products supply chain, due to changeable supply chain environment and the limited nature of the judgment and experience, participants are very difficult to be completely rational, therefore, the study assumes that the both game sides are limited rational people, the strategies collection of both sides are (cooperation, non-cooperation), the parties of the transaction choose their own strategies considering their own groups' and other members' strategies, therefore, their game belongs to the evolutionary game between the two populations.

Assumptions parameter:

- The core businesses and the non-core businesses are choosing non-cooperation strategy, the respective maximum benefit is V_1 and V_2 and V_1 $V_2 > 0$.

- ΔV is the excess return that is created when cooperation strategy is chosen, the quality safety of agricultural products would be improved and the risk of the entire supply chain would be reduced.
- λ ($0 < \lambda < 1$) represents the partition coefficient of the excess return for the core businesses when they and non-core enterprises take cooperation strategy.
- C_1 and C_2 respectively denote the cost of investment for core businesses and non-core businesses to choose cooperation. Because it is necessary for two sides to pay the cost to work together to ensure the quality safety of agricultural products, such as testing fees, collection fees, supervision fees. And assume that $C_1 < \lambda \Delta V$, $C_2 < (1-\lambda) \Delta V$.
- When one party adopts a cooperative strategy and the other party takes the non-cooperation, in order to ensure the quality safety of agricultural products within the supply chain, it will take rewards the party taking the cooperative strategy and punish the party taking uncooperative strategy and rewards and punishments are on the basis of each maximum benefit when the both take uncooperative strategy, rewards and punishments coefficient is α ($0 < \alpha < 1$) and assume that $\alpha V_1 < C_1$, $\alpha V_2 < C_2$.
- Core businesses and non-core businesses both take uncooperative strategy, this will reduce the level of quality safety of agricultural products, the probability to be found by government or consumers is p, the losses of the agricultural supply chain is L, assuming the losses are shared with the core businesses and non-core business in proportion to the excess profits, namely λ also is said the loss-sharing coefficient and assume that pL<ΔV.
- The probability for core businesses to choose cooperation strategy is x ($0 \leq x \leq 1$) and the probability to choose uncooperative strategy is 1-x; the probability for non-core enterprises to take cooperation strategy is x ($0 \leq x \leq 1$) and the probability to select uncooperative strategy is 1- y.

The evolutionary game process of core enterprises and non-core enterprises: The game payoff matrix for the core businesses and non-core business is shown in Table 2.

In conclusion, the expected pay for core businesses to choose cooperation strategy is given in the following formula (7):

$$E_1 = y(V_1 + \lambda\Delta V - C_1) + (1-y)[(1+\alpha)V_1 - C_1] \quad (7)$$

The expected pay for the core businesses to choose un-cooperation strategy is given in the following formula (8):

Table 2: The vertical (core businesses and non-core businesses) game payoff matrix of agricultural supply chain

Core businesses	Non-core businesses	
	Cooperation	Un-cooperation
Cooperation	$V_1 + \lambda\Delta V - C_1$, $V_2 + (1-\lambda)\Delta V - C_2$	$(1+\alpha)V_1 - C_1$, $(1-\alpha)V_2$
Un-cooperation	$(1-\alpha)V_1$, $(1+\alpha)V_2 + C_2$	$V_1 - \lambda pL$, $V_2 - (1-\lambda)pL$

$$E_{1'} = y[(1-\alpha)V_1] + (1-y)(V_1 - \lambda pL) \quad (8)$$

According to formula (7) and (8), the average expected pay for the core businesses is given in the following formula (9):

$$\overline{E_1} = xE_1 + (1-x)E_{1'} \quad (9)$$

The replicator dynamics equation can be obtained in the formula (10) on the above formulas:

$$\frac{dx}{dt} = x(E_1 - E_{1'}) = x(1-x)[(\lambda\Delta V - \lambda pL)y + \alpha V_1 - C_1 + \lambda pL] \quad (10)$$

Similarly, the replicator dynamics equation to take cooperation strategy for un-core enterprises can be obtained in the formula (11):

$$\frac{dy}{dt} = y(E_2 - E_{2'}) = y(1-y)\{[(1-\lambda)\Delta V - \lambda pL]x + \alpha V_2 - C_2 + \lambda pL\} \quad (11)$$

Make dx/dt = 0, dy/dt = 0 then in the plane M = {(x, y): $0 \leq x$, $y \leq 1$}, five equilibrium point can be obtained: (1, 0), (0, 1), (0, 0) (1, 1) and the saddle point D (X_D, Y_D), in which:

$$X_D = \frac{C_2 - \alpha V_2 - (1-\lambda)pL}{(1-\lambda)\Delta V - (1-\lambda)pL}$$

$$Y_D = \frac{C_1 - \alpha V_1 - \lambda pL}{\lambda\Delta V - \lambda pL}$$

According to the method proposed by Friedman (1991), the stability of the equilibrium point can be obtained by local stability analysis of the Jacobian matrix. Among them, only (0, 0) and (1, 1) is the stable point, they are the Evolutionary Stable Strategy (ESS) and respectively represent the strategy of (cooperation, cooperation) and the strategy of (un-cooperation, un-cooperation) between the core businesses and non-core business.

RESULT ANALYSIS OF EVOLUTIONARY GAME

In this study, the dynamic evolution of core businesses and non-core business game is described in the Fig. 1.
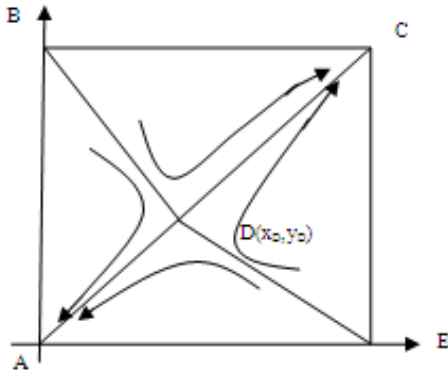
Fig. 1: Game system dynamic evolution graph of core businesses and non-core enterprises

The polyline BDE is the critical line that system converges to a different state, on the top of the polyline (BDEC part), the system converges to (cooperation, cooperation) ,and the core businesses and non-core businesses will choose cooperation strategies and thus form a fully cooperative relationship; in the bottom of the polyline (BDEA part) , the system converges to the (non-cooperation, non-cooperation), the core enterprise and non-core businesses will have to take a non-cooperative strategy to form a completely uncooperative relationship.

From the above analysis, it is impossible to be full cooperation and also to be completely uncooperative for the game equilibrium structure, which stable point that the evolution of the game between the two sides tends to depend on the size of S_{BDEC} and S_{BDEA}. When $S_{BDEC} > S_{BDEA}$, the probability of cooperation is greater than the probability of non-cooperation, the evolution will be toward comprehensive cooperation along DC path; When $S_{BDEC} < S_{BDEA}$, the probability of the cooperation is less than the probability of uncooperative, the system evolution will be toward the comprehensive uncooperative along the DA path; the probability of cooperation equals the probability of the un-cooperation when $S_{BDEC} = S_{BDEA}$, the evolution of the system direction is uncertain. According to Fig. 1, the area of the regional AOBD is given in the formula (12):

$$S_{BDEA} = \frac{1}{2}X_D + \frac{1}{2}Y_D = \frac{1}{2}[\frac{C_2 - \alpha V_2 - (1-\lambda)pL}{(1-\lambda)\Delta V - (1-\lambda)pL} + \frac{C_1 - \alpha V_1 - \lambda pL}{\lambda \Delta V - \lambda pL}] \quad (12)$$

The impact on evolution direction of game from the excess income distribution coefficient and loss sharing coefficient λ is analyzed as the following:

First, the SBDEA λ derivation is given in the formula (13):

$$\frac{ds_{BDEA}}{d\lambda} = \frac{(pL - \Delta V)(C_1 - \alpha V_1)}{[\lambda(\Delta V - pL)]^2} - \frac{(pL - \Delta V)(C_2 - \alpha V_2)}{[(1-\lambda)(\Delta V - pL)]^2} \quad (13)$$

According to formula (13), it can be drawn $(ds_{BDEA})/d\lambda^2 > 0$, therefore, the judgment can be drawn that SBDEA has the minimum value and SBDEC has the maxima value. From this, the probability of agricultural supply chain evolution towards comprehensive cooperation has the maximum.

Make $(ds_{BDEA})/d\lambda = 0$ and get the value in the formula (14):

$$\frac{(C_1 - \alpha V_1)}{\lambda^2} = \frac{(C_2 - \alpha V_2)}{(1-\lambda)^2} \quad (14)$$

When this formula is true, the probability of agricultural supply chain evolution towards comprehensive cooperation is up to the maximum and the evolution speed is up to the fastest.

DISCUSSION AND CONCLUSION

The study will propose measures to ensure APQS from the perspective of the supply chain.

Measures to ensure APQS are firstly based on the Horizontal Game. According to the analysis of the horizontal game, the following measures can be taken to reduce the cost B_1 of enterprises choosing cooperation strategies and to increase the cost B_2 of enterprises choosing uncooperative strategy, which will eventually make cooperation costs be less than the uncooperative cost and make the Nash Equilibrium of Game eventually transfer from the (non-cooperation, non-cooperation) to (cooperation, cooperation) and the game results are expected to develop to the direction that will help to protect the quality safety of agricultural products.

Government should strengthen the supervision of agricultural products. The efforts of the Government to strengthen the detection of agricultural products and improve the reward system will have a positive effect on the protection of the quality safety of agricultural products. On one hand, the government increases the number of times to detect and monitor agricultural products and combines regular testing and occasional detection of the quality of agricultural products and severely punishes enterprises providing unsafe agricultural products, which can improve the cost B_2 of enterprises to choose a non-cooperative strategy; On the other hand, the government are always providing material and spiritual rewards to enterprises who provide safety agricultural products, such as the tax relief, publicity of the credibility of enterprises by the media, which can reduce the cost B_2 of companies to choose cooperation strategy; and in the process, the government should be possible to increase B_2 and to reduce B_1, eventually $B_1 \leq B_2$, the Nash equilibrium of the horizontal Game finally arrives at (cooperation, cooperation), so that the quality safety of agricultural products are guaranteed.

Table 3: Influence factors of cooperation relationship evolution between core enterprises and non-core business of the agricultural products supply chain

Parameter	Relationships with x_D, y_D	Relationships with SBDEA	Evolution direction
λ	λ is inversely with x_D and proportional to y_D	Undefined	Undefined
α	α is inversely with x_D and y_D	Inverse	Cooperation
p	p is inversely with x_D and y_D	Inverse	Cooperation
ΔV	ΔV is inversely with x_D and y_D	Inverse	Cooperation
L	L is inversely with x_D and y_D	Inverse	Cooperation
$V_1 V_2$	V_1 is inversely with x_D and V_2 is inversely with y_D	Inverse	Cooperation
$C_1 C_2$	C_1 is inversely with x_D and C_2 is inversely with y_D	Inverse	Cooperation

Media and consumers should play the supervisory role. The media, as the carrier of the dissemination of information, timeliness and fast are its characteristic and also is the wide audience, therefore, the government might demand the media to play a role of supervision on the quality safety of agricultural products so that agricultural product quality issues of enterprises can be timely disseminated publicly. Under the conditions, the cost B_2 of providing unsafe agricultural will be increased. While the affirmative publicity of the safety of agricultural products is help to improve sales of agricultural products, thereby reduce the cost of B_1 of enterprises providing safe agricultural, eventually $B_1 \leq B_2$.

Consumers perform the supervision of agricultural products supply chain which will result in the node constraint. At the same time, consumers, through their own purchase process, appeal to enterprises in the supply chain of agricultural products to provide the qualified and safety agricultural products. For example, consumers give preference to those with quality certification in the purchase process and refuse to buy those without the quality safety guarantee, thus, consumer supervision behavior can make enterprises' cost B_2 increased to provide unsafe agricultural products, ultimately $B_1 \leq B_2$.

Measures to ensure APQS are based on Vertical Game. According to the analysis of the vertical game, the incentive mechanisms, monitoring mechanisms, revenue mechanisms, loss mechanisms, cooperation costs are factors affecting game. To adjust the influential factors to make companies in the supply chain to choose cooperation strategy so that Game gets beneficial results.

Establish a fair and equitable systems and mechanisms of benefits distribution and loss-sharing. As shown in Table 3, the excess return distribution coefficient and loss-sharing coefficient λ has a undefined relationship with x_D, y_D and S_{BDEA}, the change of λ does not determine the direction of the evolution of the game, but in order to protect the quality safety of agricultural products in the supply chain, it is necessary to establish a fair and equitable systems and mechanisms of distribution of benefits and loss-sharing between nodes in supply chain. If the excess return distribution is unequal, the enterprises obtaining less excess returns easily break the balance to protect the quality of agricultural products and at the same time, if the loss-sharing is unreasonable, the enterprises with more loss-sharing are more willing to protect the safety of agricultural products, but those enterprises with less loss-sharing are relatively easy to provide unsafe agricultural products because of the small losses and easy to take uncooperative strategies.

The reward system will be established and improved. As shown in Table 3, α and x_D and y_D is inversely proportional and S_{BDEA} also is inversely proportional. This indicates that with α increasing, the agricultural supply chain evolution is towards full cooperation, that means, under the conditions of the other coefficients unchanged, the greater the incentive coefficient, the greater the rewards of cooperation and the punishment of non-cooperation and the more beneficial to the evolution direction of the cooperation.

In order to ensure that both sides take cooperative strategy, the rewards and punishments of the stakeholders in the supply chain should be increased, the penalties for unsafe agricultural products should be strengthened and the cost of risk to provide unsafe agricultural products should be increased. And at the same time, more rewards should be greatly given to enterprises providing qualified products to encourage enterprises to take cooperation strategy to ensure the quality safety of agricultural products.

The supervision system should be established and improved. As shown in Table 3, p and x_D, y_D and S_{BDEA} is inversely proportional, which suggests that, as p increases, S_{BDEA} gradually become larger, the system, along the DC path, evolutes in the direction of all-round cooperation as shown in Fig. 1. That means the greater the probability of discovery by the government and consumers when enterprises provide unsafe agricultural products under the conditions of other coefficients unchanged, the more willing to choose a cooperative strategy to reduce losses.

Both sides of the game in the supply chain tend to choose cooperation strategies, this needs governments and consumers, as well as media to increase supervision, especially the government should play vigorously supervision.

A reasonable income distribution mechanism should be established. When all other variables are constant, ΔV and x_D, y_D and S_{BDEA} is inversely proportional that can be obtained from Table 3. This shows that, when both sides of the game trend to adopt a cooperative strategy, the greater the excess return, the

greater the attractiveness of the core businesses and non-core businesses, the higher the probability they choose to cooperate, the more conducive to make the evolution in the direction of cooperation.

The government can offer material reward and reputation reward to enterprises to improve their excess returns when they take cooperation strategy. If the government can issue the results of the detection and supervision, so that enterprises providing the safety agricultural products can build a nice image in consumers' mind, which will be favorable to their development. At the same time, the government can provide enterprises with material reward, which also can improve their excess returns.

On the other hand, when the other variables are constant, V_1 is inversely proportional to x_D and also is V_2 to y_D, while they are inversely proportional to S_{BDEA}. This shows that, as the V_1 and V_2 increase, the agricultural supply chain will be towards to the comprehensive cooperation evolution. That means, when other variables are unchanged, the less benefits that both sides of the game obtain by uncooperative strategy, the more likely to select the cooperation strategy for them and the more conducive to make evolution in the direction of cooperation.

The maximum income should be reduced when enterprises take uncooperative strategy by severely punishment. Once enterprises are found to provide unsafe agricultural products, should severely punishment in economic be taken and at the same time, the media should make a publicity of enterprises' behavior to consumers and to reduce enterprises' income, it is expected to guide the vertical game to the direction of cooperation evolution.

A sound mechanism of loss should be established. When all other variables are constant, it can be seen L and x_D, y_D and S_{BDEA} are inversely proportional. This indicates, as L increases, the agricultural supply chain is towards to comprehensive cooperation, namely once unsafe agricultural products are found, the greater the losses caused by them, the more tend to choose cooperation strategies for core businesses and non-core business and the more conducive to the direction of cooperation evolution.

The government, consumers and the media should play its supervision functions, at the same time; the government should develop strict punishment mechanisms and measures to increase the punishment of enterprises providing the unsafe agricultural products, which will guide both sides of the game in the supply chain to select the cooperation strategy to provide consumers with the safety agricultural products.

The cost of enterprises to choose cooperation may be reduced. When all other variables are constant, the C_1 is inversely proportional to x_D and C_2 is also inversely proportional to y_D and they are inversely proportional to S_{BDEA}. This indicates that the smaller cost of the cooperative strategy, the greater probability of core businesses and non-core businesses to choose

cooperation, the more conducive to the cooperation evolution. In order to guide the nodes in the supply chain of agricultural products to provide consumers with the quality safety of products, it is important to reduce the cost of cooperation among the nodes.

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