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The Game Analysis for Agricultural Associations Influencing Government's Products Safety Regulation

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Abstract: The behavior of agricultural association has produced an important impact on the quality of agricultural products. This paper applies game theory to develop a model and analyzes the positive impacts caused by agricultural association on the behavior of government regulation. When the agricultural association participates in controlling agricultural products safety, the performance of government regulation can be improved effectively. The conclusion of model analysis is that the improvement of government regulation should be based on the mechanism of which government and agricultural association participates in controlling agricultural products safety risk together.

Keywords: Agricultural associations, agricultural products safety, government regulation

INTRODUCTION

From an economic point of view, the essence of agricultural products safety is manifestation of market failure. Western scholars recognize that food is not only experience goods but credence goods (Caswell and Padberg, 1992). The serious information asymmetries can be found in agricultural products market under the modern market economy. Market failure occurs when consumers lack sufficient information to assess the quality and quantity of the services or products (Hansmann, 1980). So, government intervention is necessary (Antle, 1995). But the government mechanism always focuses on the construction of laws and standards of vegetable safety, while neglects the implementation cost of specific regulations or standards and the benefit game between different protagonists in the market; and it leads to government failure (Henson and Caswell, 1999).

The failure possibility of controlling agricultural products safety exists at the same time in the government and market mechanisms. Most scholars abroad has been realized that there must be the third adjustment mechanism which different from the government and market mechanisms. That is, social intermediary organizations should take part in the governance of agricultural products safety actively. Social intermediary organizations, especially industry associations, play an important role the governance of agricultural products (food) safety in developed countries. For example, in Germany, 60% of the industry standards completed by industry associations (Cun-xiao, 2003). Currently domestic literature of which focused on agricultural products association are as following: One from the perspective of the governance and operation mechanism of the agricultural associations (Pan, 2005; Yu-long and Xiao-wei, 2009); Two from the perspective of the introduction of foreign agricultural associations (Zu-hui, 2002); Three from the point of view of the role of industry associations (Tai-qing, 2011; Zhou and Yong-dong, 2011); Four from the perspective of the practice of agricultural associations (Zhi-xiong, 2003; Pan, 2004; Yuan-hua, 2004).

Compared to the foreign study, the majority of domestic literatures focus on the important role of agricultural associations in promoting the development of the agricultural economy. But the research is still relatively weak which focus on the agricultural associations involved in the governance of product safety. The problem of agricultural products safety involved in the many aspects of the supply chain. As an intermediary organization which join the government and agricultural producers, agricultural association's behavior produce far-reaching impact on the overall safety of agricultural products. Based on the existing research, the main purpose of the paper is to develop a model and analyze the product safety control behavior of agricultural associations.

COLLUSION BETWEEN GOVERNMENT AND AGRICULTURAL PRODUCTS PROVIDER

Model: We assume that the government and agricultural products providers are rational economic man who pursuing their own interests to maximize.

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Agricultural products providers referred to providers in the rest of the article. U_1 refer to government utility function, U_2 the utility function of providers:

Let $U_1 = U_1(a, b, c)$

where,
a : The government's performance
b : The income of collusion rental
c : Collusion cost

Let $U_2 = U_2(f, g, h, t)$

where,
f : The contract income of provider
g : The rental income of collusion
h : The efforts costs of providers
t : Collusion cost

U_1 and U_2 satisfy the following conditions:

$$\frac{\partial U_1}{\partial a} > 0, \frac{\partial U_1}{\partial b} > 0, \frac{\partial U_1}{\partial c} < 0$$
$$\frac{\partial U_2}{\partial f} > 0, \frac{\partial U_2}{\partial g} > 0, \frac{\partial U_2}{\partial h} < 0, \frac{\partial U_2}{\partial t} < 0$$

As for U_1, we do not consider the cost of government regulation. The cost of government regulation strength is not borne by the government itself, but the initial principal (citizens). Government pay for collusion cost which provide rent-seeking space for provider. It depends on the value of *1-p* (given the institutional constraints δ), that is, the greater *1-p*, the higher the collusion cost of government.

The specific forms of U_1 and U_2 will be discussed next. We assume that the quality level of agricultural products in industry is $S = e+\theta$, where, *e* refers to the effort of provider to supply safe agricultural products, θ random variable and mean is zero. Variance is normal distribution of σ^2. So, $E(S) = E(e+\theta) = e$, E (S) refer to the expectations level of product safety in industry. We assume that contract revenue of providers is $X_0 + r(e + \theta)$ and its contract revenue expectations $E_1 = X_0 + re$, $0 \le r < 1$. *r* refer to the share of which from the industry earnings, X_0 refer to the basic earnings of providers. We assumed that the content of contract design only is to choose the value of *r*, the higher the value of *r*, the higher the utility level of providers.

The expected industry revenue is $X_0 + e(1-r)$ after deducting the provider's contract revenue. Industry revenue in reality is the basic assessment indicators of government performance and it can be observed easily by principals such as higher levels of government or public. Let government performance $I_G = \beta[X_0+e(1-r)]$, β refer to the provider's earnings reports coefficient. We assume that the conspired rent amounted of between provider and government are $L = (1-\beta)[X_0+e(1-r)]$ and rent can be allocation evenly between the government and the provider. Rental income of government and provider respective are:

$$L_1 = L_2 = (1-\beta)[X_0+e(1-r)]/2$$

Let the collusion cost of government regulation:

$$C = (1-p)^2/2(1-w)$$

c satisfy the following conditions:

$$\frac{\partial c}{\partial (1-p)} > 0, \frac{\partial^2 c}{\partial (1-p)^2} > 0, \frac{\partial c}{\partial w} > 0, \frac{\partial^2 c}{\partial w^2} > 0$$

That is, the marginal cost of government conspiracy increasing with the strengthen (1-p) of collusion space and system constraints (*w*).

According to the previous calculation, the government's utility function:

$$U_1 = y\beta[X_0+e(1-r)] + (1-\beta)[X_0+e(1-r)]/2-(-p)^2/2(1-w) \quad (1)$$

where,
y : The marginal substitution rate of between the government performance and its monetary income, $y \ge 0$
$z\beta[X_0+e(1-r)]$: The monetary income of which converted by government performance

The higher the value of *y*, the more strong government performance preferences.

Let utility function of providers is:

$$U_2 = X_0 + r(e+\theta) + (1-\beta)[X_0 + e(1-r)]/2 - de^2/2-(1-\beta)^2[X_0 + e(1-r)]/2(1-p) \quad (2)$$

where,
h : $de^2/2$ refer to the effort cost of providers
d : Cost coefficient of the effort
$t = (1-\beta)^2[X_0 + e(1-r)]/2(1-p)$: The collusion cost of providers

The value of *t* increased by the improvement of government regulation strength (*p*) and also the increasing of the value of (1-β) and $(1-\beta)[X_0+e(1-r)]$.

Game equilibrium: The pay function of government and providers are their utility function that is U_1 and U_2. Government's decision is how to choose the incentive

contract and regulation strength. *r* refer to the incentive contract and *p* regulation strength. Provider's decision is how to choose effort level and report coefficient. e refer to effort level and β report coefficient. Game order: at the first phase, the government start the game and its strategy choice is r; then provider's strategy is e at the second phase when government's strategy be observed by provider; government's strategy is *p* at the third phase and provider's strategy is β at the last phase when government's strategy be observed by provider.

We can use backward induction method to calculate the game equilibrium solution. When provider observed at the game final stages that government's strategy is *p*, its decisions are as following:

$$\max_{\beta} U_2 = \max_{\beta} \{X_0 + r(e+\theta) + \frac{(1-\beta)[X_0 + e(1-r)]}{2} - \frac{de^2}{2} - \frac{(1-\beta)^2[X_0 + e(1-r)]}{2(1-p)}\}$$

Optimization of the first-order conditions:

$$\frac{\partial U_2}{\partial \beta} = -\frac{1}{2}[X_0 + e(1-r)] + \frac{(1-\beta)[X_0 + e(1-r)]}{1-p} = 0$$

Solving above formula and gives the solution value:

$$\beta = \frac{1+p}{2} \quad (3)$$

that is, optimal reporting strategy of providers. When government predicted that providers choose the report coefficient based on $\beta = \frac{1+p}{2}$, the decision facing the government in the third stage are:

$$\max_{p} U_1 = \max_{p} \{y\beta [X_0 + e(1-r)] + \frac{(1-\beta)[X_0 + e(1-r)]}{2} - \frac{(1-p)^2}{2(1-w)}\}$$

$$s.t.r = \frac{1+p}{2}$$

Optimal strategy of government regulation can be solved:

$$\begin{cases} p = 1-(1-w)(\frac{1}{4}-\frac{y}{2})[X_0 + e(1-r)], & (0 < y < \frac{1}{2}) \\ p = 1, (y \geq \frac{1}{2}) \end{cases}$$

Table 1: Parameter definition

Parameter	Definition
P_1	The probability of the provider can be punished for its illegal behavior when co-strict supervision of the government and agricultural association
P_2	The probability of the provider can be found and punished for its illegal behavior when co-strict supervision of the government and agricultural association
P_3	The probability of the provider can be punished by agricultural association for its illegal behavior when co-strict supervision of the government and agricultural association. That is: $P_1 = P_2 + P_3$; $P_3 = P_1 - P_2$
P_4	The probability of the provider can be punished by agricultural association (strict control) for its illegal behavior under government's weak regulation
P_5	The probability of the provider can be punished by government for its illegal behavior under government's weak regulation
P_6	The probability of the agricultural association can be punished for its uncooperative behavior when government's strategy is strong regulation
r	The benefit of law-abiding provider, and *n* refers to the number of members of agricultural association
R	The benefit of illegal provider
K	The illegal providers may be punished by government or agricultural associations, and its fine is multiples of illegal benefit. Its fine is *KR*
F	The benefit of uncooperative agricultural associations
L	The uncooperative agricultural associations may be punished by government, and its fine are multiples of uncooperative benefit
$-R(1-P_1)/2$	Losses are shared equally by the parties when the government and the agricultural association cannot find illegal provider
C_1, C_2	The cost of government's strong regulation
C_0	C_0 refers to agricultural association's strict control cost, and it is zero under weak control
x_1, x_2, x_3, x_4	Occurrence probability of the four types of agricultural association, and $x_t = 1 - \sum_{j=1}^{4}(j \neq i)$
θ_1	$\theta_1 = x_1 + x_2$, that is, the probability of which agricultural association's strategy is strong regulation
θ_2	$\theta_2 = x_1 + x_3$, that is, the probability of which agricultural association's strategy is cooperation
β	β refers to the probability of strong regulation, 1-β the probability of weak regulation
γ	γ refers to the probability of illegal providers, 1-γ the probability of law-abiding providers
P_2KR	Providers can be fined when its illegal behavior be found by government
$\prod_{g1}$	The expected revenue of the government's strong regulation
$\prod_{g2}$	The expected revenue of the government's weak regulation
$\prod_{e1}$	The expected revenue of illegal providers
$\prod_{e2}$	The expected revenue of law-abiding providers

THE IMPACT OF AGRICULTURAL ASSOCIATIONS ON THE GOVERNMENT REGULATION BEHAVIOR

Model design: We assume that players are: government, agricultural associations and providers. Government's strategy: strong supervision, weak supervision; agricultural products association's strategy: to assist the government in the implementation of the food safety policies (cooperation), to assist the internal members to boycott the government regulators (uncooperative); strict control over the adverse selection behavior of its members (strict control) and not strictly control (weak control). Provider's strategy: providing unsafe food agricultural products (illegal), to provide safe food agricultural products (law-abiding).

We assume that the state of agricultural associations can be divided into four categories: (cooperation, strict control), (uncooperative, strict control), (cooperation, weak control) (uncooperative, weak control). When government's strategy is weak supervision, the punishment probability of the provider's illegal behavior is approximately zero. Parameter definition can be shown in Table 1.

Model analysis:

- The strategy of the agricultural associations is (cooperation, strong regulation) and x_1 refers to occurrence probability of *y*.
  When providers be punished for its illegal behavior, if the government's probability of strong regulation is β and then, government revenue is $R_{11} = P_2KR\text{-}R\ (1 - P_1)\ /2\text{-}C_1\text{-}C_2$, the agricultural associations revenue is $R_{12} = P_3KR\text{-}R\ (1\text{-}P_1)\ /2\text{-}C_0$. If agricultural suppliers comply with the law, government revenue is $R_{13} = -C_1 - C_{22}$, the agricultural associations revenue is $R_{14} = -C_0$.
  When providers be punished for its illegal behavior, if the government's probability of weak regulation is 1-β and then, government revenue is $R_{21} = R\ (1 - P_4)\ /2$, the agricultural associations revenue is $R_{22} = P_4KR\text{-}R\ (1\text{-}P_4)\ /2\text{-}C_0$. If providers comply with the law, government revenue is $R_{23} = 0$, the agricultural associations revenue is $R_{24} = -C_0$.R_0, R_{01}, R_{02} and R_{03} refer to the revenue of providers, respectively under different circumstances. As can be seen from game payoff matrix (Fig. 1), three expressions from left-to-right in quadrants of matrix representing the government revenue, the agricultural association's revenue, provider's revenue.
- The strategy of the agricultural associations is (not cooperation, strong regulation) and x_2 refers to y occurrence probability.

		Providers: Illegal behavior γ	Providers: Law-abiding behavior 1-γ
Government: Strong regulation β		R_{11}, R_{12}, R_0	R_{13}, R_{14}, R_{01}
Government: Weak regulation 1-β		R_{21}, R_{22}, R_{02}	$0, R_{24}, R_{03}$

Fig. 1: The payoff matrix of agricultural associations (cooperation, strong regulation)

		Providers: Illegal behavior γ	Providers: Law-abiding behavior 1-γ
Government: Strong regulation β		R_{31}, R_{32}, R_{0A}	R_{33}, R_{34}, R_{0B}
Government: Weak regulation 1-β		R_{41}, R_{42}, R_{0C}	R_{43}, R_{44}, R_{0D}

Fig. 2: The payoff matrix of agricultural associations (not cooperation, strong regulation)

		Suppliers: Illegal behavior γ	Suppliers: Law-abiding behavior 1-γ
Government: Strong regulation β		R_{51}, R_{52}, R_{0A}	R_{53}, R_{54}, R_{0B}
Government: Weak regulation 1-β		R_{61}, R_{62}, R_{0C}	R_{63}, R_{64}, R_{0D}

Fig. 3: The payoff matrix of agricultural associations (cooperation, weak regulation)

As can be seen from Fig. 2, when providers be punished for its illegal behavior, if the government's probability of strong regulation is β and then, government revenue is $R_{31} = P_2KR + P_6LF$, the agricultural associations revenue is $R_{32} = -R\ (1 - P_1)\ /2\text{-}(1\text{-}P_6)\ F\text{-}C_1\text{-}C_2$. If providers comply with the law, government revenue is $R_{33} = -P_6LF\text{-}(1 - P_6)\ F\text{-}C_1\text{-}C_2$, the agricultural association's revenue is $R_{34} = (1\text{-}P_6)\ F\text{-}P_6LF\text{-}C_0$. When providers be punished for its illegal behavior, if the government's probability of weak regulation is 1-β and then, government revenue is $R_{41} = -R\ (1 - P_4)\ /2$, the agricultural associations revenue is $R_{42} = P_4KR\text{-}R\ (1\text{-}P_4)\ /2\text{-}C_0$. If providers comply with the law, government revenue is $R_{43} = -F$, the agricultural associations revenue is $R_{44} = F\ -C_0$.R_{0A}, R_{0B}, R_{0C} and R_{0D} refer to the revenue of agricultural products suppliers, respectively under different circumstances.

- The strategy of the agricultural associations is (cooperation, weak regulation) and x_5 refers to occurrence probability.
  As can be seen from Fig. 3, when providers be punished for its illegal behavior, if the

	Providers: Illegal behavior γ	Providers: Law-abiding behavior 1-γ
Government: Strong regulation β	R_{71}, R_{72}, R_{0A1}	R_{73}, R_{74}, R_{0B1}
Government: Weak regulation 1-β	R_{81}, R_{82}, R_{0C1}	R_{83}, R_{84}, R_{0D1}

Fig. 4: Payoff matrix of food industry association (non-cooperation, strong supervision)

government's probability of strong regulation is β and then, government revenue is $R_{51} = P_5 KR\text{-}R (1\text{-}P_5) /2\text{-}C_1\text{-}C_2$, the agricultural associations revenue is $R_{52} = -R (1\text{-}P_5) /2$. If providers comply with the law, government revenue is $R_{53} = -C_1\text{-}C$, the agricultural associations revenue is $R_{54} = 0$. When providers be punished for its illegal behavior, if the government's probability of weak regulation is $1\text{-}\beta$ and then, government revenue is $R_{61} = -R/2$, the agricultural associations revenue is $R_{62} = -R/2$. If providers comply with the law, government revenue is $R_{63} = 0$, the agricultural associations revenue is $R_{64} = 0$. R_{0A}, R_{0B}, R_{0C} and R_{0DC} refer to the revenue of providers, respectively under different circumstances.

- The strategy of the agricultural associations is (cooperation, weak regulation) and x_4 refers to occurrence probability.

  As can be seen from Fig. 4, when providers be punished for its illegal behavior, if the government's probability of strong regulation is β and then , government revenue is $R_{71} = P_5 KR\text{-}R (1\text{-}P_5) /2 + P_6 LF\text{-} (1\text{-}P_6) F\text{-}C_1\text{-}C_2$, the agricultural associations revenue is $R_{72} = -P_6LF + (1\text{-}P_6) F\text{-}R (1\text{-}P_5) /2$. If providers comply with the law, government revenue is $R_{73} = -C_1 - C_2$, the agricultural association's revenue is $R_{74} = (1\text{-}P_6) F\text{-}P_6LF$. When providers be punished for its illegal behavior, if the government's probability of weak regulation is $1\text{-}\beta$ and then, government revenue is $R_{81} = -R/2\text{-}F$, the agricultural associations revenue is $R_{82} = -R/2 + F$. If providers comply with the law, government revenue is $R_{83} = -F$, the agricultural associations revenue is $R_{84} = F$. R_{0A1}, R_{0B1}, R_{0C1} and R_{0D1} refer to the revenue of providers respectively under different circumstances.

Model solution: According to the payoff matrix, we can calculate the expected revenue of the strong government regulation:

$$\prod_{g1} = x_1 \{\gamma [P_2KR\text{-}R (1\text{-}P_1) /2\text{-}C_1\text{-}C_2] + (1\text{-}\gamma) (-C_1\text{-}C_2)\} + x_2 \{\gamma [P_2KR + P_6LF\text{-}R (1\text{-}P_1) /2\ 1\text{-}P_6) F\text{-}C_1\text{-}C_2] + (1\text{-}\gamma) [P_6LF\text{-} (1\text{-}P_6) F\text{-}C_1\text{-}C_2]\} + x_3 \{\gamma [P_5KR\text{-}R (1\text{-}P_5) /2\text{-}C_1\text{-}C_2] + (1\text{-}\gamma) (-C_1\text{-}C_2)\} + x_4 \{\gamma [P_5KR\text{-}R (1\text{-}P_5) /2 + P_6LF\text{-} (1\text{-}P_6) F\text{-}C_1\text{-}C_2] + (1\text{-}\gamma) [-C_1\text{-}C_2]\}$$

The weak government regulation:

$$\prod_{g2} = x_1 [-R (1\text{-}P_4) /2] + x_2 \{\gamma [-R (1\text{-}P_4) /2] + (1\text{-}\gamma) (-F)\} + x_3\gamma [-R/2] + x_4 [\gamma (-R/2) -F + (1\text{-}\gamma) [-F]$$

Let, $\prod_{g1} = \prod_{g2}$

where,
$x_4 = 1 - x_1 - x_2 - x_3$, and substitute:
$\theta_1 = x_1 + x_2$
$\theta_2 = x_1 + x_3$ into the above equation to obtain the balanced probability of illegal provider:

$$\gamma_0 = C_1 + C_2 - P_6 (L + 1) (1 - \theta_2) /R \{[(P_2 - P_5) K + (P_1 - P_4) /2 -1/2] \theta_1 + P_5K +1/2\} \quad (4)$$

When the values of θ_1 are large enough (closing to 1), we can transform approximately the denominator in equation:

$$R \{[P_2K + (P_1\text{-}P_4) /2] \theta_1\}$$

The above equation can be changed as following:

$$\gamma_0 = C_1 + C_2 \text{-} P_6 (L + 1) (1 - \theta_2) /R \{[P_2K (P_1 - P_4) /2] \theta_1\} \quad (5)$$

The balanced probability of the strong government regulation:

$$\prod_{e1} = x_1 \{\beta[-P_1KR + R (1 - P_1 + r] + (1 - \beta) [R (1 - P_4)\text{-}P_4KR + r]\} + x_2 \{\beta[-P_1KR + R(1 - P_1) + r + (1 - P_6) F/n] + (1 - \beta) [R (1 - P_4) - P_4KR + r]\} + x_3 \{\beta [(1 - P_5) R + P_5KR + r] + (1 - \beta) [R + r]\} + x_4 \{\beta [-P_5KR + R (1 - P_5 + 1 - P_6) F/n + r] + (1 - \beta) [R + F/n + r]\}$$

$$\prod_{e2} = x_1 [\beta r + (1 - \beta) r] + x_2 \{\beta [r + (1 - P_6) F/n] + (1 - \beta) (R + F/n)\} + x_3 [\beta r + (1\text{-}\beta) r] + x_4 \{\beta [r + (1 - P_6) F/n] + (1 - \beta) (R + F/n)\}$$

Let, $\prod_{e1} = \prod_{e2}$, equilibrium solution of β is:

$$\beta_0 = P_4 (K+1) \theta_1 / (K + 1) [P_5 - (P_4 - P_5 - P_1) \theta_1] \quad (6)$$

We assume that the value of θ_1 equal to 1 approximately and then:

$$\beta_0 = P_4 (K + 1) / (K + 1) (P_1 - P_4) \quad (7)$$

CONCLUSION

From above model analysis, we can draw conclusions as following: Firstly, when (the marginal substitution rate of the government income is greater than or equal to), regulators' strategy is not collusion, but supervision. When, w<1, then p<1, the government has the tendency of collusion. If with the increase of the value of Y, the government regulation initiative also improved and its collusion degree decreased. Secondly, Agricultural association plays important roles in the improvement of government regulation.

From Eq. (5), γ and $\theta 1$ inversely, it shows that to enhance government capacity of agricultural products safety governance, we need to build a mechanism that the agricultural association to participate in agricultural products safety governance. From equation Eq. (7), if θ, agricultural association the probability of strictly control, is large enough, the law enforcement capacity of government (reflected by Pz and Px) can be regarded as exogenous variables. Punishment variable K changing in the numerator and denominator on the same direction, thus can be ignored K. the equilibrium probability of government regulation can be a constant. It shows that agricultural association to promote effectively the function transformation of government regulation.

In recent years, China's agricultural products safety become more and more seriously. It reflects that the lack of cooperative behavior among the government and agricultural association. Therefore, government should recognize that its capability is limited. Through mobilizing the agricultural association to participate in agricultural products safety governance, government can improve its learning mechanism and supervision capacity. Government should try to development the agricultural association; construct the institutional environment of which the agricultural association involved in agricultural products safety governance.

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