Incentives for the Quality and Safety Traceability System of Agricultural Products

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Abstract The quality and safety traceability system of agricultural products is an important measure to protect the quality and safety of agricultural products. Farmers and food enterprises are main operators of the traceability system. If they are effectively encouraged to practice traceability system, food safety can be guaranteed from the source. This paper studies the incentive problem of agricultural product traceability system from two aspects - vertical contract coordination and government external incentive.

Key words Agricultural products, Traceability system, Incentive mechanism

With the characteristics of quality invisibility and utility lag, the agricultural products are typical experience goods. In addition, information asymmetry makes the responsibility not easy to be traceable after the incident of quality and safety of agricultural products. It is easy to form "lemon market" of agricultural products. Therefore, we need a management system to achieve information transmission, quality traceability, and accountability, so as to realize the goal of solving the problems of quality and safety of agricultural products and improving the level of quality of agricultural products. The quality and safety traceability system of agricultural products is an important measure to ensure the quality and safety of agricultural products in China. From the vertical contract between farmers and food companies (namely, the internal incentives and government's external incentives), we study how to motivate food enterprises and farmers to participate in the traceability system of agricultural products, thereby improving the quality and safety of agricultural products, and protecting the interests of consumers.

1 Vertical contract incentives

To ensure the food safety from the source of production, the food enterprises can take the cooperation mode of vertical integration, namely sign a production and sales contract with farmers to carry out food safety tracking, thereby achieving a regulatory role for the production behavior of farmers.

At the same time, it can reduce food safety risks and responsibilities of enterprises to some extent, and improve and optimize the management level of the supply chain of food enterprises.

This article will use the following model to explain how to achieve the restriction of vertical contract cooperation mechanism on the production behavior of farmers, and motivate them to provide more secure agricultural raw materials, so as to realize the purpose of controlling security risks from the production source.

Assuming the food enterprises and farmers aim to maximize profits, and the risk is neutral. Farmers can provide two kinds of raw agricultural materials with different quality for enterprises, namely ordinary agricultural products Q_L and traceable agricultural products Q_H; the corresponding unit payment of food enterprises is P_L and P_H, $P_H > P_L$; the basic framework of the contract between the parties is $\{(Q_L, P_L), (Q_H, P_H\}$.

What kind of agricultural products provided by farmers depend on whether they participate in the agricultural product traceability system, and the costs to be paid for participating in the agricultural product traceability system.

Here, we assume that what kind of agricultural products provided by farmers only depend on whether they participate in the agricultural product traceability system, that is, if the farmers do not participate in the agricultural product traceability system, then the product produced and provided is ordinary agricultural product Q_L; if the farmers participate in the agricultural product traceability system, then the product produced and provided is traceable agricultural product Q_H.

The farmers provide agricultural raw materials to food enterprises, and food enterprises process these raw materials and sell the final food to consumers. The final food is also divided into two categories, ordinary food and traceable food.

Assuming the consumers' willingness to pay for the two kinds of foods is P'_L and P'_H, $P'_H > P'_L$. It should be noted that the type of final food is subject to the combined effects of the type of agricultural products provided by farmers and whether the food enterprises participate in the agricultural product traceability system.

Only when both the farmers and food enterprises are involved in the traceability system can the final food be traceable food; but when there is only one party to participate and the other party's behavior can not be traced, the final corresponding food attribute is ordinary food, that is, each link in the supply chain will affect food traceability, and untraceability of any one link will cause the

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untraceability of final food.

Assuming the needed unit cost when the farmers participate in agricultural product traceability system is C, and the needed unit cost when the farmers do not participate in agricultural product traceability system is 0; the unit cost when the food enterprises implement food traceability system is C' and the unit cost when the food enterprises do not implement food traceability system is 0.

With profit maximization as the purpose, food enterprises' purchase of the traceable agricultural products and implementation of traceability system is the premise of producing the final traceable food. The food enterprises aim to make the profit obtained from producing traceable food greater than the profit obtained from producing ordinary food.

Under normal circumstances, the reputation is crucial for the development of enterprises, and in order to maintain their long - term development, the enterprises will generally keep their reputation in the market, so we assume that to maintain this reputation, the enterprises can timely, actively and faithfully reflect the food traceability to consumers, then the conditions for food enterprises to produce traceable food are as follows:

$$P'_H - P'_L - C' \geqslant P_H - P_L$$

When the profits from the production of traceable food, having made up for the input costs for enterprises to implement food quality and safety traceability system, are still greater than the profits obtained from food enterprises' production and marketing of ordinary food, it is possible for the food enterprises to implement the food quality and safety traceability system, produce and operate the final traceable food.

There is the problem of information asymmetry between farmers and food enterprises, and asymmetric information will lead to opportunistic behavior. In terms of the information on the quality and safety of agricultural products, farmers have more advantages than food enterprises, so it is easy to produce opportunism in farmers.

In this article, the opportunistic behavior of farmers is to offer the ordinary agricultural products to simulate the traceable agricultural products.

As is previously mentioned, when producing the traceable agricultural products, the farmers will increase corresponding cost C, and the opportunistic behavior can make the farmers obtain the price of traceable agricultural products P_H higher than the price of ordinary agricultural products P_L without paying the cost C, thereby obtaining the greater profits.

For farmers' behavior of participating in traceability system, the food enterprises can not directly realize the supervision, and the food enterprises can only detect the quality of agricultural products provided by the farmers, to judge the attributes of agricultural products provided by the farmers, but any testing can not be perfect, which makes the opportunistic behavior of farmers still easy to produce.

Assuming the probability of the opportunistic behavior to be found is α, $0 \leqslant \alpha \leqslant 1$. The payment obtained by farmers is no longer P_H, but the relatively low price of ordinary agricultural products P_L.

And the farmers would produce a certain loss of F, and this loss can be the fines borne by farmers or the credibility loss, thereby leading to a long-term loss discounting.

Opportunistic behavior does not exist unilaterally, and there is also one in the food enterprises. The food enterprises will make use of their advantages in price to lower the price of acquired agricultural products.

In this article, food enterprises' opportunistic behavior can be reflected in the fact that the farmers provide traceable agricultural products to enterprises, but the price paid by the enterprises is the low price of ordinary agricultural products P_L.

Thus the farmers will generate the unit losses $P_H - P_L$. This probability of this opportunistic behavior in the food enterprises is assumed to be β, $0 \leqslant \beta \leqslant 1$.

The farmers' expected price after joining the vertical collaborative contract developed by the food enterprises must not be lower than the external reserve price.

In order to simplify the analysis, the farmers' reservation price is assumed to be 0, then the constraint for the farmers to participate in agricultural product traceability system is as follows:

$$(1-\beta)P_H + \beta P_L - C \geqslant 0 \tag{1}$$

The constraint for the farmers not to participate in agricultural product traceability system is as follows:

$$(1-\alpha)P_H + \alpha P_L - F \geqslant 0 \tag{2}$$

When there is opportunistic behavior in both, farmers are willing to participate in the agricultural product traceability system, and the incentive compatibility constraint for farmers to produce safe agricultural products is as follows:

$$(1-\beta)P_H + \beta P_L - C \geqslant (1-\alpha)P_H + \alpha P_L - F \tag{3}$$

Namely

$$C \leqslant (\alpha - \beta)(P_H - P_L) + F \tag{4}$$

Farmers will set a benchmark cost for their participation in the agricultural product traceability system. The right side of formula (1 -4) can be seen as the baseline cost. If the farmers' actual input is higher than this baseline cost, then the farmers will not participate in the agricultural product traceability system.

According to the formula (1 -4), this baseline cost is determined by four variables, α, β, F and $P_H - P_L$. α is the probability of farmers' opportunistic behavior to be found. The greater the probability, the greater the baseline cost. The probability of farmers' opportunistic behavior to be found depends on the effectiveness of food provided by the farmers tested by the food enterprises' detection systems. If the food enterprises' detection systems are more effective, it is more likely to constrain opportunistic behavior of farmers.

β is the probability of food enterprises' opportunistic behavior. The greater the probability, the smaller the baseline cost. It can be seen that the opportunistic behavior of food enterprises will affect farmers' enthusiasm for participating in agricultural product traceability system.

F is the large fines for farmers from opportunism or potential, high and long-term losses generated from the loss of credibility. If the value of F is greater, the farmers are more likely to reduce their opportunistic behavior, that is, from the adverse incentive aspect, the farmers are motivated to participate in agricultural product traceability system.

In addition, if the price that the food enterprises pay for the traceable foods ($P_H - P_L$) is higher, the farmers will be more willing to participate in the agricultural product traceability system.

Based on the above model, it is found that if the probability of farmers' opportunistic behavior to be found is greater, the probability of opportunistic behavior of food enterprises will be smaller; there will be severer punishment on the farmers' opportunistic behavior; the price that food enterprises pay for the traceable agricultural products will be higher; it is more likely to motivate the farmers to participate in agricultural product traceability system, thereby achieving the purpose of food safety and quality control from the source.

2 Government's external incentives

The government shoulders the principal responsibility in social public management, while the quality safety management of agricultural products is an important part of social public management, and it is increasingly important along with the frequent food safety incidents recently, therefore, the government has an unshirkable responsibility in ensuring the quality safety of food. Information asymmetry makes customers disadvantaged in learning the information about the quality safety of food, because they can hardly learn the production information of food merely relying on their own reach, and even if it is possible, the cost is high. Therefore, it is necessary for the government to get involved [2].

In the establishment of the traceability system for agricultural products, the government should take on the responsibility to stakeholders' behavior in the implementation of the system and the effective supervision, inspection and control of the traceable information records of agricultural products.

It is also necessary to establish and improve the relevant laws and regulations and the reward systems. Through the links of tracing the unqualified agricultural products and tracking the problems, there is a need to punish the persons who take responsibilities.

In addition, the government should also give appropriate reward to the enterprises which implement the quality and safety traceability system of agricultural products and practise honest operation, in order to encourage enterprises to actively implement traceability system.

That is to say, the government's external incentives include positive incentives and punitive adverse incentives.

Assuming T is the government's reward for the food enterprises due to the implementation of traceability system; L is the government's punishment on the food enterprises which nominally implement the food quality and safety traceability system, but in fact practise the opportunistic behavior.

Assuming the probability of the opportunistic behavior of food enterprises to be found is p $(0<p<1)$; V_1, V_2 and V_3 are the utility of three types of food enterprises, namely the food enterprises that do not implement the traceability system, the food enterprises that implement the traceability system, and the food enterprises that nominally implement the food quality and safety traceability system, but in fact practise the opportunistic behavior.

R, C and e are the food enterprises' profit, the food enterprises' costs and the food enterprises' effort to improve food quality and safety, respectively. R and C is the function of e, and $R'(e) > 0$, $C'(e) > 0$.

e_1 is the food enterprises' effort not to participate in the traceability system, and e_2 is the food enterprises' effort to participate in the traceability system, $e_2 > e_1$.

The utility function for the food enterprises that do not implement traceability system is as follows:

$$V_1 = R(e_1) - C(e_1).$$

The utility function for the food enterprises that implement traceability system and practise honest operation is as follows:

$$V_2 = R(e_2) - C(e_2) + T.$$

The utility function for the food enterprises that implement traceability system but practise opportunistic behavior is as follows:

$$V_3 = (1-p)[R(e_2) - C(e_2) + T] + p[R(e_1) - C(e_1) - L].$$

The incentive compatibility constraint for food enterprises that participate in the food traceability system is as follows:

$$V_2 \geqslant V_1;\ V_2 \geqslant V_3$$

In the process of implementing food traceability system, whether the food enterprises take opportunistic behavior, depends on the size of utility ΔV arising from the opportunistic behavior.

$$\Delta V = V_3 - V_2 = p[C(e_2) - C(e_1)] - p[R(e_2) - R(e_1) + L + T].$$

The derivation of ΔV to variables L, T and P is calculated, respectively:

$$\frac{\partial \Delta V}{\partial L} = -p < 0$$

$$\frac{\partial \Delta V}{\partial T} = -p < 0$$

$$\frac{\partial \Delta V}{\partial P} = -\{[R(e_2) - C(e_2)] - [R(e_1) - C(e_1) + L + T]\} < 0$$

From the above derivation, it can be found that in terms of ensuring the food quality and safety, if the government gives more rewards to the food enterprises that implement traceability system and practise honest operation, it is more likely to inspire food enterprises' enthusiasm for participating in traceability system.

If the government imposes severer punishment on the enterprises with unlawful practice, it is more likely to effectively restrain the food enterprises' production behavior, and reduce the

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ble emulsified dispersed liquid with vinegar, soy sauce, vegetable oil, fruit juice, gravy, and vegetable juice, which is good for emulsification property of vegetable oil, protein, and aqueous solution and can make them form stable uniform emulsified liquid.

2.5 Satisfying other demands Apart from improving sensory properties of foods, preventing deterioration and extending the shelf life, increasing varieties and convenience of foods, favorable for food processing, food additives have other merits. Diabetes patient can not eat sugar, but it can use non-nutritional sweetener to replace sugar. For example, TGS or Aspartuyl Phenylalanine Methyl Ester can be produced to sugar-free foods. In all, merits of food additives bring more color and convenience for our life. Some experts say "without food additives, there will be no modern food industry". Thus, food additives are of great importance to the food industry. And we should know and understand merits of food additives.

3 Demerits of food additives

Food accidents, such as "lean meat", "poisonous milk powder", "Sudan red", and "ripener", occur frequently in recent years. Even primary children know some key words about food security. Merits of food additives are obvious. However, some profit-oriented enterprises and retailers cast eyes at food additives. They add excessive or illegal additives in foods, which harms health of consumers or even life of consumers.

3.1 Excessive addition Some of food additives that have functions of improving food quality and extending the shelf life have certain toxicity, so it is required to take strict control over their application. For example, excessive intake of D-sodium erythorbate (antioxidant) will lead to a series of intestines and skin diseases, while excessive intake of sodium nitrite (coloring agent) may benumb vasomotor center, respiratory center, and peripheral blood vessel. Unfortunately, there are many cases of excessive use of food additives. Deep-fried twisted dough sticks and deep-fried dough cakes use excessive alum (leavening agent). Nevertheless, the alum contains aluminum, while excessive residue of aluminum will lead to disorder of nervous system of children and will contribute to occurrence of degenerative brain disorder.

3.2 Illegal use of food additives In *National Food Safety Standard - Standards for Uses of Food Additives* (GB2760 - 2011), there are provisions of scope, maximum level and usage principle of more than 2000 existing food additives. The *Food Safety Law* implemented on June 1st, 2009 makes more than 80% food additives have product standard. Illegal use of food additives is criminal act and should be struck at strictly in compliance with laws. Thus, we should use food additives in strict compliance with laws and the usage of food additives beyond the scope is not allowed.

Illegal addition of inedible substances in foods is varied: Sudan red may be added to chilli powder and foods containing hot pepper; protein concentrate and melamine may be added to dairy products; pigment green may be added to tea; Auramine may be added to soyfood; poppy shell may be added to hotpot seasoning; potassium bromate may be added to wheat powder.

4 Conclusions

From the above analysis, it can be known that food additive is a double edged sword. On the one hand, it not only brings convenience for us, but also promotes development of modern food industry. On the other hand, it may be used by lawless people and consequently harms our health and life. It is hoped that food additives could bring into full play their merits, but not bring demerits.

Besides, the state should constantly improve related laws and strengthen supervision of food production and circulation. In addition, people engaged in food production, circulation and selling should raise their legal and responsibility awareness, but do not pay attention only to benefit. Furthermore, as consumers, we should learn more knowledge about food security and select proper foods. In sum, it is hoped that we should bring into play merits of food additives and get rid of demerits of food additives to the maximal extent.

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opportunistic behavior; if the government's regulation efficiency is higher, the probability of the opportunistic behavior of food enterprises to be found will be higher, and it is more likely to encourage the enterprises practise honest operation and reduce the opportunistic behavior.

In summary, if the government can implement effective supervision, it will play a better role in ensuring the quality and safety of agricultural products, curbing the opportunistic behavior, and providing effective incentives for the food enterprises to implement food traceability system and practise honest operation.

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