



# Journal of Applied Sciences

ISSN 1812-5654

**science**  
alert

**ANSI***net*  
an open access publisher  
<http://ansinet.com>

## Study on the Transmission of Information in the Supply Chain of Traceable Agricultural Products Based on Game Theory

<sup>1,2</sup>Yao Yuchen and <sup>1</sup>Shen Ju-Qin

<sup>1</sup>Business School, Hohai University, 210000, Nanjing, Jiangsu, China

<sup>2</sup>Business School, Jinling Institute of Technology, 211169, Nanjing, Jiangsu, China

---

**Abstract:** In the supply chain of traceable agricultural products, false information may come out and thereby the quality safety of agricultural products will be greatly influenced, because of the different interest choices among different parts in the chain. Based on the game theory, this study made a detailed analysis of the information transmission between farmers and retailers in three cases of asymmetric information and put forward the corresponding countermeasures.

**Key words:** Supply chain of traceable agricultural products, information, game theory

---

### INTRODUCTION

Recently, food safety incidents like melamine incident, Hogwash oil, Clenbuterol, exploding watermelons etc., emerge frequently. Food safety of agricultural products has a great effect on the nationals' health and the development of society. The implementation of traceability system can reduce the risk of food safety. But the "Horsemeat" scandal in Europe in January 2013 and the event of thousands of dead pigs floating in Huangpu River in March 2013 make people show more concern for the safety of traceable food. Information asymmetry is an important reason for safety problems in the supply chain of traceable agricultural products. As information asymmetry is a common state, in the course of establishing traceability system, the problems of false information will come out because of the interest selections among different parts. According to the survey, among all farmers with production records, 66.3% farmers make records by themselves which shows that information recording is still not fully traceable in production and there exist problems that information recording is incomplete, farmers transmit false information and retailers record incomplete information (Yan, 2011). The main parts of the supply chain of traceable agricultural products transmit false information which will influence the quality and safety of agricultural products directly and will cause all kinds of food safety problems. The study on the mechanism of information transmission in the supply chain of traceable agricultural products is an effective method to avoid quality and safety problems of traceable agricultural products.

In order to solve the problems of information transmission in the supply chain of agricultural products, many domestic and foreign scholars did some related research from different angles. Caswell and Mojduszka (1996) held that reasonable information institutions would ensure the efficiency of policy on the management of food safety in market mechanism. The records and transmission of quality and safety information of agricultural products played a very important role. If the records and transmission of information was abnormal, "inferior goods" would bring huge losses to consumers and the producers of "high-quality goods" would meet large losses. The agricultural product market would become "lemon market". Lee *et al.* (2011) held that Korean consumers were willing to pay 39% more for the beef with traceable information than the ordinary beef. By analyzing the static and dynamic game models between the government and the food production enterprises, Li (2010) held that problems of food safety were greatly related to "adverse selection" behaviors of food production enterprises and the government needed to announce relevant policies to alter "market failure" to provide sufficient market information for suppliers and demanders. Cui (2011) held that the transmission mechanism of quality signal had not formed a comprehensive system which brought about frequent quality and safety incidents of agricultural products. The scholars mainly studied the game between food producers, consumers and the government but few scholars considered the game of information transmission between farmers and retailers in the context of traceability. This study researches the main

parts of the supply chain of agricultural products and studies the game of information transmission between farmers and retailers in 3 aspects: Short-term game, long-term game and the game under multilateral supervision.

### MODEL ASSUMPTIONS AND VARIABLES DESCRIPTION

#### Model assumptions

**Assumption 1:** In the traceability mode, whether the agricultural products supplied by farmers are safe or not, farmers will not transmit the information that the agricultural products are unsafe to the downstream (retailers). If a farmer provides safe agricultural products, he will transmit true information to downstream; if a farmer does not provide safe agricultural products, he will transmit false information to downstream (retailers). Similarly, whether a retailer provides safe agricultural products or not, he will not transmit unsafe information of agricultural products to downstream. When a retailer provides safe agricultural products, he will transmit true information to downstream; when a retailer provides unsafe agricultural products, he will transmit false information to downstream (consumer).

**Assumption 2:** Since the establishment of a traceability system requires all companies in the whole supply chain (including farmers, food processing enterprises, logistics companies and retailers) to participate in the system and the system needs standardized identification, detection and recording software and hardware equipments, the establishment of traceability system requires high upfront costs. If a farmer complies with the retailer's contract strictly, he will transmit true information to downstream, the production costs will be higher and he will have to obtain lower profits. On the contrary, if a farm doesn't comply with the retailer's contract strictly, misuses agricultural chemicals such as pesticides, chemical fertilizers and additives in the process of producing agricultural products, transmits false information to downstream and obtains normal prices of traceable agricultural products with low production costs, he can obtain higher profits.

**Assumption 3:** If a retailer obtains unsafe agricultural products at lower prices and sells the agricultural products at normal prices to consumers as traceable products, that is, the retailer transmits false information to downstream, he will get more profits. Compared with transmission of false information, transmission of true information will obtain lower profits.

**Assumption 4:** In the supply chain, the main parts' transmission of false information may be found in three cases: (1) Found by consumers' complaints, (2) Exposed by the mass media when major food safety problems arise, (3) Inspected and found by the relevant departments of government. Suppose the three cases are incompatible and occur in certain probability, in any case, the government will punish the party that transmits false information.

#### Variables description:

- W = Obtained profits when retailers transmit true information
- V = Obtained profits when farmers transmit true information
- a = More profits if farmers transmit more false information than the truth
- b = More profits if retailers transmit more false information than the truth
- c = The effect on retailers' sales for the loss of customers caused by retailers' reputation damage
- d = The fine for retailers transmit false information
- e = The fine for farmers transmit false information
- $\alpha$  = The probability of transmission false information discovered through consumers' complaints,  $0 \leq \alpha \leq 1$
- $\beta$  = The probability of transmission false information discovered through the media exposure,  $0 \leq \beta \leq 1$
- $\theta$  = The probability of transmission false information discovered through government's inspection,  $0 \leq \theta \leq 1$

### GAME BETWEEN FARMERS AND RETAILERS

According to different degrees of information symmetry, three kinds of cases are discussed: The short-term game between farmers and retailers under asymmetric information; the long-term game between farmers and retailers under symmetric information; game between farmers and retailers under multilateral supervision and relative symmetric information. The result of the game changes with different degrees of information symmetry.

The short-term game between farmers and retailers under asymmetric information (Table 1).

In the short-term game, because of information asymmetry, if a retailer and a farmer choose to transmit true information at the same time, the returns that they obtain are W and V; if the retailer transmits true information and the farmer transmits false information, the retailer's gain is W, the farmer's gain is "V+a"; if the

Table 1: Short-term game between farmers and retailers

Retailer	Farmer	
	Transmit true information	Transmit false information
Transmit true information	W, V	W, V+a
Transmit false information	W+b, V	W+b, V+a

Table 2: Long-term game between farmers and retailers

Retailer	Farmer	
	Transmit true information	Transmit false information
Transmit true information	W, V	W-c, 0
Transmit false information	0, 0	0, 0

Table 3: Game between farmers and retailers under multilateral supervision

Retailer	Farmer	
	Transmit true information	Transmit false information
Transmit true information	W, V	W, V+a-( $\alpha+\beta+\theta$ )e
Transmit false information	W+b-( $\alpha+\beta+\theta$ )d, V	W+b-( $\alpha+\beta+\theta$ )d, V+a-( $\alpha+\beta+\theta$ )e

retailer chooses to transmit false information and the farmer chooses to transmit true information, then the retailer's gain is "W+b", the farmer's gain is V; if the retailer and the farmer choose to transmit false information at the same time, the returns that they obtain are "W+b" and "V+a". As can be seen, this model is a dominant strategy equilibrium, no matter what to choose, the retailer and the farmer will choose to transmit false information, obtain the return (W+b, V+a). In this case, the safety of agricultural products provided by the retailer could not be guaranteed.

The long-term game between farmers and retailers under asymmetric information (Table 2).

In the long-term game, information is symmetric, if a retailer and a farmer choose to transmit true information at the same time, the returns that they obtain are W and V; if the retailer transmits true information and the farmer transmits false information, the farmer will be expelled by the retailer eventually, the farmer's long term gain is 0, meanwhile the retailer's reputation is affected and his revenue fell C, to "W-c"; and as long as the retailer transmits false information, the consumer will not choose the retailer anymore, the gain of the retailer and the farmer is reduced to 0. This game is a dominant equilibrium too, no matter what to choose, the retailer and the farmer will choose to transmit true information, obtain the return (W, V). At this moment, the products provided by the retailer to the consumer are safe and reliable. In general, retailers have large business scales and certain brands and they can't recoup the investments in fixed assets and profits on a short-term basis. So, from the perspective of

retailers, they can only choose to transmit true information. For farmers, it is difficult to avoid short-term behavior completely, in order to ensure the quality of agricultural products, retailers usually sign with farmers. Retailers sign agreements with farmers, require the farmers to record on the production of agricultural products in accordance with the traceability system, the feed or fertilizer or epidemic prevention accords fully with the provisions of the enterprises. If the farmer transmits false information, retailers will cancel their cooperation and reduce his return to zero.

**Game between farmers and retailers under multilateral supervision (Table 3):**

In reality, transmission of information between farmers and retailers is often influenced by many factors. Transmission of false information may be found through consumer's complaints, disclosed by the media, or found by the inspection of the relevant functional department of the government. Supposing the three events are incompatible with one another, the probabilities of these events are  $\alpha$ ,  $\beta$  and  $\theta$ . No matter which event happens, the government will punish the farmers and the retailers. Provided the main parts of the supply chain of agricultural products transmit false information, the government will propose punitive governance. Assuming the fine made by the government for farmers' transmission of false information is e and retailers' transmission of false information is d, the short-term game between farmers and retailers could be transformed as shown in Table 3.

To make farmers and retailers transmit real information, to achieve Nash equilibrium, only the conditions have to be met that  $b-(\alpha+\beta+\theta)d < 0$  and  $a-(\alpha+\beta+\theta)e < 0$ , namely  $\alpha+\beta+\theta > b/d$  and  $\alpha+\beta+\theta > a/e$ . If a and b are given, only when e and d are big enough or  $\alpha$ ,  $\beta$  and  $\theta$  are large enough, two inequalities can be set up. Namely if the benefits that farmers and retailers get for transmission of false information are given, only when the fine is large enough, or the consumer strengthens the capacity to identify and complain non-conforming products, or the media strengthens the disclosure for unqualified agricultural products, or the government strengthens the frequency and range of supervision, farmers and retailers will transmit real information, the environment of information transmission in the supply chain of agricultural products can be purified and the quality and safety of agricultural products can be promoted. If the fine is light, or information asymmetry exists because of invalid supervision, false information and unsafe agricultural products will flood agricultural markets. The agricultural markets will turn into "lemons market".

## CONCLUSION

Through the analysis of the game between stakeholders in the supply chain of agricultural products, we can see, it is inevitable that if farmers and retailers make short-time cooperation, they tend to transmit false information to improve their own incomes in the game. Only under information symmetry or in long-term game, all parties will tend to transmit true information. Specifically the following are suggestions.

**Strengthen the supervision and stimulation of farmers and retailers, so as to form an effective multilateral supervision mechanism:** Law enforcement should strengthen the supervision and stimulation of farmers and enterprises, increase penalties for farmers or retailers who transmit false information. In addition, it should strengthen the disclosure of food safety information and social supervision, increase rewards to the consumer or the media who disclose food safety problems, so as to form a good market environment of effective multilateral supervision.

**Enrich the recorded contents of traceability information:** The integrity of the information is helpful to improve the transparency of information. Now information recording is incomplete, for instance, the production records lack the records of picking period. Different pesticides are provided with various safety picking periods and some are 7 days, others are 15 days which are usually marked on the instructions of pesticides. If picking agricultural products in strict accordance with the time of plastochrone, according to the use standards of pesticides, pesticides generally will not residue in agricultural products. In order to boost production, some farmers use pesticides excessively and some begin to pick 1-7 days after medication, thus these will result in pesticide residues.

**Strengthen technical training of farmers:** As the main body of agricultural production, farmers' operations influence the safety of agricultural products directly. In reality, most farmers lack the common sense of using agrochemicals, like excessive use of pesticides, or irrational use of ripeners which will result in the unsafe production of agricultural products and cause the economic losses. The government should strengthen technical training of farmers, encourage them to learn the latest technology and obtain the abilities to produce qualified products.

**Improve the level of detection technology in food safety detection, enrich contents of detection:** Many big food safety problems may result in serious consequences and then be covered by the media, finally the government gets involved in the investigation and takes some measures. An important reason is that there are various kinds of agricultural chemicals, among which many unqualified agricultural products can't be detected by existing technology and equipments, such as the well-known drainage oil. Contents of detection are relatively simple, for example, melamine detection is added to contents of detection for milk powder after Sanlu milk powder incident occurred. The European Union requires all members to carry out DNA sampling for treated beef. The backward technology of food safety detection and the simple contents of detection result in transmission of false information and food safety problems.

**Establish a unified comprehensive database of agricultural products:** The establishment of a unified comprehensive database of agricultural products is an important condition for information transparency. Database storage of agricultural products can get complete information of food production, circulation and management shared between several parties. When safety problems of agricultural products arise, database of agricultural products will restore its entire production process, the transmission process and the management process, so as to find the source of food safety problems. A good food database should have certain screening mechanism. Different farmers and enterprises should be classified management. For example, farmers and enterprises with better food security situation should be divided into class A, the farmer or enterprise exposed to food safety problems should be divided into class B or class C according to the cause and extent of the mistakes. Make the records in the system available for public inquiry. The transparency of information can exercise the restraints upon farms and enterprises' behavior of transmitting false information, so that farmers and enterprises may play the game on a long-term basis and the game equilibrium brings the benefits of transmitting the true information for both parties.

## REFERENCES

- Caswell, J. and E.M. Mojduszka, 1996. Using informational labeling to influence the market for quality in food products. *Am. J. Agric. Econ.*, 78: 1248-1253.

- Cui, B., 2011. Discussion on the causes and containment way the quality and safety of agricultural products incidents occur frequently. *Modern Econ. Res.*, 11: 42-45.
- Lee, J.Y., D.B. Han, R.M. Nayga and S.S. Lim, 2011. Valuing traceability of imported beef in Korea: An experimental auction approach. *Austr. J. Agric. Resour. Econ.*, 55: 360-373.
- Li, R., 2010. Food safety analysis based on "adverse selection" and the game model-Thinking on the safety regulation of genetically modified food. *J. HuaZhong Agric. Univ. (Soc. Sci. Edn.)*, 2: 18-22.
- Yan, Q., 2011. Research on the trust and cooperation relationship between farmers and enterprises in process of traceability system construction. Master Thesis, Industrial Economics, Sichuan Agricultural University, China.