



Analysis of the Quality Safety of Farm Products Based on the Game Theory

Xiaoming Yang

Wuhan University of Technology

Wuhan 430070, China

Zhejiang Institute of Mechanical & Electrical Engineering

Hangzhou 310053, China

Tel: 86-571-8883-7150 E-mail: yxming0460@sina.com

Abstract

Based on the fact that the academe rarely researches the quality safety of farm products from the view of the game theory, we utilized choice behavior of the government which influences the purchaser (market) and the producer (farmers) by the combination of the compensation mechanism and the quality rating mechanism in Chinese quality safety management of farm products to enhance the quality of farm products, analyzed the reason why the quality safety of farm products is hard to be enhanced by the game tools, and further redesigned the behavior combination of the government according to the game results.

Keywords: Quality safety of farm products, Game, Choice behavior, Mechanism design

1. Introduction

The quality safety of farm products is the need of the development of the market economy and the need to ensure the safe consumption, and it involves many parts such environment, production, transportation, sale and market, and no matter which part is in trouble, the consumers' healthy consumption can not be ensured. The quality safety of farm products can not only decide the development of the agriculture and the agricultural economy and the competitive ability of Chinese farm products in the international market, but also influence the normally running of the party, the country and the society. So it is very meaningful to study the quality safety of farm products, and foreign and domestic scholars have devoted much attention, and relative research results are emerging in an endless stream.

About the reason to induce the unsafe quality of farm products, Zhang Lifu et al (2002) thought that many situations including the agricultural production environment is being destroying continually, the environment pollution is being aggravating increasingly, the technology is lagged, the market test and quarantine mechanism is not perfect, and the laws and regulations are not complete make the quality of farm products hard to be guaranteed. From the views of weak detection ability, low quality of quality control personnel and bad performance of quality equipment, Lv Qiaozhi (2007) analyzed the reasons of unsafe quality of farm products in detail. Zheng Fengtian and Zhaoyang (2003) selected the emphasis of analysis in the layer of the quality safety supervision, and they thought the main reasons to induce the low quality of farm products included that Chinese government blanked off the information of the epidemic region and rarely supervise and manage the food safety and sanitation powerfully, the manufacturers blindly pursued the business profits, and the agricultural management institutions were overstaffed. For the countermeasure analysis of the quality safety management of farm products, some scholars emphasized to start from the headstream pollution management, largely push the standardization of the quality of farm products, establish and perfect the quality test and checking mechanism of farm products, perfect the quality safety management mechanism of farm products, realize the integrated management, strengthen the quality consciousness, and attach importance to the function of technical factors to the quality safety of farm products (Xu Jing, et al, 2007), and the government should pay attention to the information channel construction in many parts such as the production, circulation and sale, and reduce the "Lemon Problems" in the market of farm products (Wu Jianping, et al, 1999). Starting from the legislation, other scholars appealed to the government for establishing the universal and strict market admittance system as soon as possible (Zhang Lifu, et al, 2002), quickening the step of the legal construction, strengthening the power of law execution (Lv Qiaozhi, 2007), and

finally actualizing putting the quality safety of farm products on a legal basis (Li Yuwen, et al, 2003).

To be sure, existing theories have made large amounts of research for the reasons and countermeasures of the quality problems of farm products, and they have offered some theoretical approaches to solve the quality safety problem of farm products, but undeniably, these researches more start from the exterior environment and the restriction mechanism of the production and management of farm products, and few of them deeply studied the interior behaviors of relative subjects such as government, purchaser and farmers in the quality safety management of farm products. However, in practical economic running, above economic subjects would continually adjust their own behavior choices surrounding the objective function which presents the amount of their benefits in deed, and this dynamic behavior adjustment process will compose of the mutual game relationship among subjects on the meaning of economics to some extent. So we can say that it is not effective to look for the measures to solve the quality problems of farm products without these interior behaviors. Based on that, aiming at the behavior choice of the government in the macro management of farm product quality safety and the dynamic change of the benefits among subjects induced by the choice, in this article, we utilize the game theory to analyze the reason why the quality of farm products is hard to be enhanced, and further make corresponding mechanism design innovation for how to improve the quality of farm products.

2. Theoretical analysis of the reason why the quality of farm product is hard to be enhanced

The game model established in the article is based on three subjects including government, purchaser (market) and farmer. As the macro management subject of farm product quality, the government's behavior choice is understood as the appointed exterior limitation in the analysis of the model, which will largely influence farmers and purchasers' choice behaviors. In this article, the behavior choice of the government is mainly embodied in the compensation mechanism (strong compensation or weak compensation) to the farms who plant the crops and the rating service (strong rating or weak rating) to the quality of farm products. The weak compensation means that that the government gives same common compensation (the compensation value is U_0) according to the planting area, and doesn't give the difference compensation (including direct money compensation, and indirect compensations such as tax preference or derating, loan preference, rating charge preference and free technology) according to the quality class of farm products planted by farmers. Strong compensation means that the government gives higher special compensation for the high-quality farm precuts (such as healthy and safe organic farm products) (the compensation value is U_1 , and $U_1 > U_0$) and gives lower general compensation U_0 for traditional low-quality products. Strong rating means that the government gives fully rating to the quality of farm products, which are the references for farmers when they sale the products. By contraries, if the government doesn't rate the quality of farm products or doesn't give fully rating, that is regarded as weak rating. For the charging of the rating, in this article, we adopt the mode of "who requires rating, who assumes the charge". Generally speaking, the rating charge is assumed by the farmer and computed into the production cost. The purchaser's behavior choice set is {high price, low price}, and the farmer's corresponding behavior choice set is {high quality, low quality}. The cost that farmers plant traditional low quality farm products is C_0 , and the cost that they plant high quality farm products is C_1 , (in practice, $C_1 > C_0$), and the outputs respectively are Q_0 and Q_1 ($Q_0 > Q_1$), and the prices respectively are P_0 and P_1 ($P_0 < P_1$). As the purchaser, the consumer's benefit is W_1 when he consumes farm products with high quality, and his benefit is W_0 when he consumes farm products with low quality, and the corresponding costs respectively are $P_0 \cdot Q_0$ and $P_1 \cdot Q_1$.

According to above analysis and hypothesis, we can explore the root that the quality of Chinese farm products is lower from the general compensation system (weak compensation) and few rating (weak compensation) implemented by the government at present to certain extent. First, we can establish the following model.

INSERT MATRIX 1 ABOUT HERE

Through the beneficial analysis of the matrix 1, we can see that the exclusive pure strategic Nash Equilibrium (low quality, low price) exists in the model. The analysis result indicates that without the effective rating mechanism, the general compensation system implemented by the government is hard to stimulate farmers' behaviors and hard to enhance the quality of farm products. Thus result accords with the present actuality of China, and it requires that if the government wants to improve the quality of farm products, the rational measure is to change its behavior choice, and adjust the existing system arrangement, i.e. implement the innovation of the system design on the macro layer.

3. Innovation of macro system design for the farm product quality management

In above analysis, we found that the deficiencies contained in the government compensation mechanism and rating mechanism were the important reasons that the quality of farm products is hard to be enhanced. In the second part of the article, we suppose the behavior choice set of the government in the quality management of farm products mainly includes compensation (weak compensation, strong compensation) and rating (strong rating, weak rating), so we can easily obtain three sets of behavior combination which can be selected by the government, i.e. {strong compensation, weak rating}, {weak compensation, strong rating} and {strong compensation, strong rating}. In fact, the combination of {strong compensation, weak rating} could not exist, because since the fully rating offered by the government to the

quality of farm products doesn't exist, the base to implement difference compensation system doesn't exist. So we mainly analyze the latter two sets of behavior combination.

3.1 Game analysis of the choice behavior combination (weak compensation and strong rating) of the government

Before analyzing, it should be appointed out that when the government offers the service of strong rating, farmers will assume higher rating charge because of offering farm products with high quality, and make their planting costs rise from C_1 to C_2 . At the same time, to make the theoretical analysis more approaching the actuality, we add the hypothesis that the government will punish the fake behaviors to prevent farmers sell seconds at best quality prices (the value is e). Under thus background, to analyze the behavior combination (weak compensation, strong rating), the following situation will be presented in Matrix 2.

INSERT MATRIX 2 ABOUT HERE

In Matrix 2, from the beneficial analysis of the model, {low quality, low price} is still the exclusive pure strategic Nash Equilibrium. In fact, there are two hypotheses concealed here. First, when the purchaser selects the strategy of high price, farmers can sell seconds at best quality prices to obtain a better beneficial value of $(P_1 \cdot Q_0 - C_0 + U_0)$ which is higher than the benefit of $(P_1 \cdot Q_1 - C_2 + U_0)$ when they offer the farm products with high quality. But in practice, because of the existence of the punitive penalty e of the government, farmers will suffer severe punishment when their cheating behaviors are found, which will reduce the beneficial anticipation of farmers to carry through moral risk and give up the behavior selling seconds at best quality prices, and choose to offer the products with high quality. Second, when farmers sell the farm products with high quality in the market, purchasers will give lower price, which doesn't accord with the practice obviously, so farmers will not sell their products then, and the purchaser can obtain the farm products with high quality only paying for higher price. Above analysis indicates that two behavior combinations of {low quality, high price} and {high quality, low price} are not the dynamically stable combinations, so the combination of {high quality, high price} seems to compose of the Nash Equilibrium, so two sorts of equilibrium will exist in Matrix 2. But if we dynamically consider the stability of these two sorts of equilibrium, we can further find that the combination of {high quality, high price} possesses the instability under the dynamic condition comparing with the combination of {low quality, low price}. We can first compare farmers' benefits, $(P_0 \cdot Q_0 - C_0 + U_0)$ and $(P_1 \cdot Q_1 - C_2 + U_0)$, under two sorts of combination, because many risks brought by the fluctuant prices of farm products, uncertain production and sales amount, and immature technology when farmers plant the crops with high quality, and the compensation that farms obtain from the government is limited, so farmers tend to avoid the fluctuant risk of income and choose to plant traditional crops with low risk and low quality. For the purchaser, because the price of the farm products with high quality is always higher than the price of common farm products, which may make his income present $W_1 - P_1 \cdot Q_1 < W_0 - P_0 \cdot Q_0$, so the purchaser's rational choice is to buy the farm products with low price, and farmers also tends to choose to plant traditional crops with low quality because of the narrow high price farm products market and above risks, so the combination of {low quality, low price} becomes into the exclusive Nash Equilibrium. Obviously, the behavior combination of {weak compensation, strong rating} doesn't accord with the requirement of the model.

3.2 Game analysis of the choice behavior combination (strong compensation and weak rating) of the government

According to the former definition in the article, the government choice behavior combination of "strong compensation, strong rating" means that the government offers sufficient quality rating to the farm products produced by the farmers plant farm products with different classes, and give farmers difference compensation based on that. In fact, this sort of strong rating behavior of the government also offers the references for the purchaser in the market to choose the price. In addition, because the government gives higher compensation to the farmers who plant the modern crops with high quality, which will compensate farmers' production costs to some extent, and make the price when farmers sell the farm products with high quality change, i.e. reduce the sales price of the high quality farm products to the level which is not too greatly different with the price of common farm products, which will make the sale of the high quality farm products extended to make farmers acquire the same income of the common farm crops when they plant the high quality farm crops. We can suppose the price is P_{11} ($P_0 < P_{11} < P_1$) here, and for the purchasers, their benefits $W_1 - P_{11} \cdot Q_1$ when they consume the high quality farm products may exceed their benefits $W_0 - P_0 \cdot Q_0$ when they consume the low quality farm products, so we can establish the following model.

INSERT MATRIX 3 ABOUT HERE

Through analyzing the Matrix 3 by the same method with Matrix 2, we can see that, because of the existence of higher government compensation U_1 , the $P_{11} \cdot Q_1 - C_2 + U_1 > P_0 \cdot Q_0 - C_0 + U_0$ exists, which make farmers who plant modern high quality crops more profitable than planting traditional low quality crops, and their behavior choice is be limited in the strategy of high quality. But the change of the purchaser's benefit induced by the decrease of the price of high quality farm products under strong compensation makes $W_1 - P_{11} \cdot Q_1 > W_0 - P_0 \cdot Q_0$ possible, which will strengthen that the purchasers by the high quality farm products. Obviously, whether for the purchaser or for farmers, the behavior combination of {low quality, low price} here is not the rational choice, and which may finally make {high quality,

hypo-high price} be the exclusive Nash Equilibrium under the mechanism of {strong compensation, strong rating}. As viewed from the actual angle, because the cost of organic farm products is far higher than the cost of green farm products, and the price of green farm products is hypo-higher than the price of organic farm products, so it is strongly operational to encourage and lead farmers to engage in the production of green farm products (not organic farm products).

4. Conclusions

The game behavior of various subjects exists broadly in the economic activity. In the quality management of farm products, the behavior game of relative subjects will also occur. On the theoretical layer, in this article, we simply analyze the problem that the general compensation system implemented by the government to plant farm products can not enhance the quality of farm products under the condition of the effective rating mechanism is deficient by the game theory, which is based on the reality that existing literatures about the analysis of farm products quality have not highly noticed these problems. The problem that the quality of farm products is low can be analyzed from the game view, because we think the application of the game theory in this problem can embody the objective functions of government, purchaser (market) and farmer and their limitations, and the theoretical analysis of the game theory can accord with the general description of the actuality to large extents. But we should point out that the choice and enactment of the game model and its variables are all based on the practice. In addition, the emphasis of the article is to utilize the game model to find the efficiency that the government redesign the compensation mechanism and rating mechanism aiming at enhance the quality of farm products, and the result indicates that the government behavior choice of {strong compensation, strong rating} is the effective strategy combination which may realize the equilibrium between the high quality of farm products and the hypo-high price which can be accepted by the market.

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The behavior choice of the government is {weak rating, weak compensation}

		Purchaser	
		High price	Low price
Farmers	High quality	$(P1 \cdot Q1 - C1 + U0, W1 - P1 \cdot Q1)$	$(P0 \cdot Q1 - C1 + U0, W1 - P0 \cdot Q1)$
	Low quality	$(P1 \cdot Q0 - C0 + U0, W0 - P1 \cdot Q0)$	$(P0 \cdot Q0 - C0 + U0, W0 - P0 \cdot Q0)$

Matrix 1

The behavior choice of the government is {weak compensation, strong rating}

		Purchaser	
		High price	Low price
Farmers	High quality	$(P1 \cdot Q1 - C2 + U0, W1 - P1 \cdot Q1)$	$(P0 \cdot Q1 - C2 + U0, W1 - P0 \cdot Q1)$
	Low quality	$(P1 \cdot Q0 - C0 + U0 - e, W0 - P1 \cdot Q0)$	$(P0 \cdot Q0 - C0 + U0, W0 - P0 \cdot Q0)$

Matrix 2

The behavior choice of the government is {strong compensation, strong rating}

		Purchaser	
		Hypo-high price	Low price
Farmers	High quality	$(P11 \cdot Q1 - C2 + U1, W1 - P11 \cdot Q1)$	$(P0 \cdot Q1 - C2 + U1, W1 - P0 \cdot Q1)$
	Low quality	$(P11 \cdot Q0 - C0 + U0 - e, W0 - P11 \cdot Q0)$	$(P0 \cdot Q0 - C0 + U0, W0 - P0 \cdot Q0)$

Matrix 3