Chapter 37
Evolution Analysis of Standardization Production Behavior in GI Agricultural Product Enterprise Cluster

Zhi-fang Li and Tong Chen

Abstract GI agricultural products, as the typical representative of quality agricultural products, play an important role in promoting the development of rural economy. However, in recent years, some GI agricultural products enterprises did not process agricultural products according to the standards, so the accidents occurred frequently. Based on the problems, with the premise of sharing the collective revenue, this paper uses the evolutionary game theory to analyze the behaviors of standardization strategy of GI agricultural product enterprise cluster. The research shows that it must be properly introduced the supervision of the local government and the association and the construction of the mechanism of punishment, which can promote the development of GI agricultural product enterprises cluster.

Keywords Enterprise cluster · Evolutionary game · GI agricultural product · Standardized production

37.1 Introduction

In terms of the definition in "Trade related intellectual property rights agreement" (TRIPS), Geographical indications(GI) refers to the commodities in the origin, which has specific quality, reputation or other characteristics, are determined by the natural or cultural factors in the region. According to the definition of geographical indications, geographical indication of agricultural products is identification marking of agricultural products, which is naive to a particular country, region or in a particular place, the quality characteristics, flavor and reputation of

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E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_37,

agricultural product completely or mainly depends on the geographic environment, natural conditions, human factors and so on in this area (Ren and Huang 2007). Based on the protection of geographical indications of the agricultural products, it is conducive to the development of the local leading industry, regional brand; but also can improve the added value of agricultural products, increase the income of the farmers, and promote rural economic development (He 2010).

According to "Geographical indications products protection regulations" in China, in the registration process, there must be detailed plant (production, cultivation) specification, local and national standards, which is to ensure that the quality characteristics of GI agricultural products, but also to make the sustainable development (Wang and Du 2011). But in recent years, geographical indications agricultural products appeared more malignant events, such as 2010, "consumer advocate" in CCTV reported the massive fraud of Heilongjiang Wuchang rice, the reason mainly lies in the adulteration of Wuchang rice processing enterprises in origin. These events seriously disturbed the stability of agricultural product market and violated consumer rights. The fundamental reason lies in the "free riding" behaviors under sharing collective reputation, processing businesses, which belongs to small and medium enterprises, do not strictly enforce the standards of production and processing (Sun 2012).

From production to processing, to enter the market, GI agricultural products involve multiple bodies. At the same time, processing as the most important link, multiple small and medium-sized processing enterprises distribute in the origin, which is consisted of a fully competitive market (Wang and Liu 2008). Therefore, in view of the current literature on the standardized production of GI agricultural products being not studied, this paper uses evolutionary game theory and method, under the premise of the collective revenue sharing, builds behavior evolution model on using standardized strategy in the processing of GI agricultural products enterprise clusters in the processing link, analyzes the stability of evolution process and identifies the key factors to adopt standardized strategy, in order to provide decision-making references on promoting the GI agricultural product standardization production.

37.2 Methodology

Evolutionary game theory takes the group behavior as the research object, from the bounded rational individual as the starting point, thinks that individual decision-making behavior is not always optimal, it is often not possible to find the optimal strategy in the beginning. Individual decision-making is through individual mutual imitation, learning in dynamic process to achieve, stepwise finds the better strategy (Sun et al. 2003; Wu et al. 2004).

One of the most important dynamic behavior analysis models in evolutionary game theory is replicator dynamic model. Replicator dynamics is a dynamic differential equation which describes adopted frequency of a particular strategy (behavior) in a group. It can well describe the change trend of bounded rational individual in groups and predict individual behavior in groups. Replicator dynamic model can be expressed as:

$$dx(t)/_{dt} = x(t) * \left[u_t(\alpha) - \bar{u}_t(g)\right],$$

where $x(t)$ is the proportion of the involved members in the groups who adopt pure strategy α during the time t involved in groups; $u_t(\alpha)$ is the expected utility of the involved members who use the pure strategy α in the period t; $\bar{u}_t(g)$ is the group's average expected utility (Friedman 1991; Taylor and Jonker 1978; Friedman 1998). Evolutionary game theory provides good analysis methods and tools for analyzing the mutual game behavior of cluster members in GI agricultural product cluster enterprises who adopt standardization strategy (Hu 2010).

37.3 Results

37.3.1 Model Building

GI agricultural products processing enterprises are the core bodies who can add the value of agricultural products, the process of adopting standardized production is directly related to the GI agricultural product reputation and the economic interest of relevant interest persons. In the processing link of GI agricultural products, this paper takes adopting standardized production behavior in GI agricultural products processing enterprise cluster as an example, analyzes the dynamic behavior evolution (Zhang 2011).

Hypothesis 1 GI agricultural product enterprise cluster has n similar enterprises in scale. At one time t, each enterprise in clusters is faced with the same set of strategies $S_i = \{s_1, s_2\}$, where is named {adopting the standards, not adopting the standards}. Thus, it assumes that in the period t, the percentage of adopting standards in cluster is $x(t)$, so the percentage of not adopting standards is $1 - x(t)$.
Hypothesis 2 The amount of resources which each enterprise has is 1, the amount of resources which can be put into the standardized production is ε.
Hypothesis 3 R is the benefit of standardization production in GI agricultural product enterprises cluster, which is a regional sharing, for all enterprises sharing. Here, it assumes that $R(\varepsilon, n, x(t)) = (\varepsilon n x(t))^{1/\alpha}$, here $0 \leq \varepsilon \leq 1$, $\alpha \geq 0$. In the above formula, the benefit R is decided by the numbers $nx_t(t)$ of enterprises who adopt standardization strategy in cluster and the amount ε of resource which is put into the standardized production, and both size is proportional to R; where α is the productivity parameters of the standardized production, in this article α is assumed to be valued 2.

Hypothesis 4 The income π^c of the enterprises who adopt standardized strategy is composed of two parts, one part $1-\varepsilon$ is devoted by the profits of other agricultural products, another part is the benefit of the standardized production, $R(\varepsilon, n, x(t))$. Therefore,

$$\pi^c = 1 - \varepsilon + R(\varepsilon, n, x(t)).$$

Hypothesis 5 The income π^b of the enterprises who do not adopt standardized strategy is composed of two parts, one part is the original resource 1, another part is the overflow profit of the enterprises who use standardized production, overflow value coefficient is λ, so $\pi^b = 1 + \lambda R(\varepsilon, n, x(t))$.

Taking into account all enterprises using the standardization production being randomly paired into the game, at a time t, it can establish the following 2×2 asymmetric game model, as shown in Fig. 37.1 (Shen and Wang 2011).

37.3.2 Model Solution

Assume that in a certain period t, u_c is the expect profit of the enterprises which use standardized strategy, u_b is the expect profit of the enterprises which do not use standardized strategy, $\bar{u}$ is the average expected returns of GI agricultural product enterprises cluster. According to Fig. 37.1, it can concluded that

$$\begin{aligned} u_c &= x(t)[1-\varepsilon + R(\varepsilon, n, x(t))] \\ &\quad + (1 - x(t))[1 - \varepsilon + R(\varepsilon, n, x(t))] \\ &= 1 - \varepsilon + R(\varepsilon, n, x(t)) \end{aligned} \tag{37.1}$$

		Enterprise 1	
		adopting the standards	**not adopting the standards**
Enterprise 2	**adopting the standards**	$1-\varepsilon+R(\varepsilon,n,x(t))$, $1-\varepsilon+R(\varepsilon,n,x(t))$	$1-\varepsilon+R(\varepsilon,n,x(t))$, $1+\lambda R(\varepsilon,n,x(t))$
	not adopting the standards	$1+\lambda R(\varepsilon,n,x(t))$, $1-\varepsilon+R(\varepsilon,n,x(t))$	$1+\lambda R(\varepsilon,n,x(t))$, $1+\lambda R(\varepsilon,n,x(t))$

Fig. 37.1 The 2×2 asymmetric game model of the standardization production in GI agricultural products cluster

$$\begin{aligned} u_b &= x(t)[1 + \lambda R(\varepsilon, n, x(t))] \\ &\quad + (1 - x(t)) \times [1 + \lambda R(\varepsilon, n, x(t))] \\ &= 1 + \lambda R(\varepsilon, n, x(t)) \end{aligned} \tag{37.2}$$

$$\begin{aligned} \bar{u} &= x(t)u_c + (1 - x(t))u_b \\ &= x(t)[1 - \varepsilon + R(\varepsilon, n, x(t))] \\ &\quad + (1 - x(t))[1 + \lambda R(\varepsilon, n, x(t))] \end{aligned} \tag{37.3}$$

Therefore, according to the references (Rosenberg 1983), the changed proportion of choosing standardization strategy in cluster enterprises every period can be used to describe by the following discrete dynamical system:

$$x(t+1) = \frac{x(t)u_c}{x(t)u_c + (1 - x(t))u_b} \tag{37.4}$$

The equation shows that if the profits of using standardized strategy is greater than the average expected return of GI agricultural product enterprise cluster, then it will increase the probability of using standardized strategy in the next period; otherwise, the cluster will reduce the proportion of using standardized strategy in the next period.

Subtracting $x(t)$ from the Formula (37.4) in both sides, then, introducing the Formulae (37.1), (37.2, (37.3) into the Formula (37.4), it can be obtained as follows a discrete dynamical system:

$$\begin{aligned} x(t+1) &= x(t) + \frac{x(t)(1 - x(t))(u_c - u_b)}{x(t)u_c + (1 - x(t))u_b} \\ &= x(t) + \frac{x(t)(1 - x(t))\left((1 - \lambda)(n\varepsilon x(t))^{\frac{1}{2}} - \varepsilon\right)}{1 - \varepsilon x(t) + x(t)(n\varepsilon x(t))^{\frac{1}{2}} + \lambda(1 - x(t))(n\varepsilon x(t))^{\frac{1}{2}}} \end{aligned} \tag{37.5}$$

Commanding $x(t+1) = x(t)$, when $0 < \lambda < 1$, there are three equilibrium points in the discrete system, respectively 0,1, $\frac{\varepsilon}{n(1-\lambda)^2}$; when $\lambda = 1$, the Formula (37.5) changes into $x(t+1) = \frac{x(t)(1-\varepsilon)}{1 + x(t)(1-\varepsilon)}$, there are two equilibrium points, respectively 0,1.

37.3.3 Stability Analysis

According to the discrete dynamic system theory, it can get the following conclusion:

Conclusion 1 when $0 < \lambda < 1$, the Formula (37.5) can change into (Shen and Wang 2011)

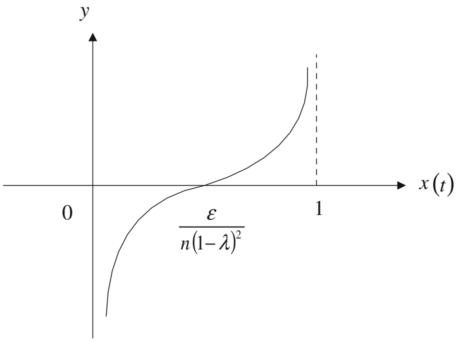

Fig. 37.2 The behavior evolution of the standardization production in GI agricultural products cluster

$$\begin{aligned} y &= \frac{dx(t)}{dt} = \frac{x(t+1)-x(t)}{x(t)} \\ &= \frac{(1-x(t))(u_c-u_b)}{x(t)u_c+(1-x(t))u_b} \\ &= \frac{(1-x(t))\left((1-\lambda)(n\varepsilon x(t))^{\frac{1}{2}}-\varepsilon\right)}{1-\varepsilon x(t)+x(t)(n\varepsilon x(t))^{\frac{1}{2}}+\lambda(1-x(t))(n\varepsilon x(t))^{\frac{1}{2}}} \end{aligned} \tag{37.6}$$

As shown in Fig. 37.2, when $0 \le x(t) < \frac{\varepsilon}{n(1-\lambda)^2}$, which meets $u_c < u_b$, at this time, GI agricultural product enterprises are all not using standardized strategy; when $\frac{\varepsilon}{n(1-\lambda)^2} \le x(t) \le 1$, which meets $u_c > u_b$, at this time, GI agricultural product enterprises are all using standard strategy; $x^*(t) = \frac{\varepsilon}{n(1-\lambda)^2}$, it means that said the proportion, $\frac{\varepsilon}{n(1-\lambda)^2}$, of GI agricultural product enterprises in the period is using standardized strategy, which is a non steady state (Shen 2008).

Conclusion 2 When $\frac{\varepsilon}{n(1-\lambda)^2} \le x(t) \le 1$, the probability of using standardized strategy decreases (increases) as the amount of resources required increases (decreases), as the spillover coefficient of adopting standardized strategy increases (decreases), as the cluster size increases (decreases).

Conclusion 3 When $\lambda = 1$, $x^*(t) = 0$, no GI agricultural product enterprise in the period uses standardized strategy, which is a pure strategy equilibrium; $x^*(t) = 1$, all GI agricultural product enterprises in the period have adopted standardized strategy, which is a pure strategy equilibrium.

37.4 Discussion

According to the above, it can be known that the initial state of the GI agricultural product enterprise clusters, the amount of resource of the enterprise using standardized strategy, the spillover coefficient of standardization strategy, the efficiency of standardized strategy and the size of GI agricultural product enterprise cluster and other factors play important roles on the formation, evolution and stability of GI agricultural product enterprise cluster.

(1) The amount of resource of the enterprise using standardized strategy ε. On the condition that a certain amount of resources needed by standardized strategy, the less the enterprises using standardized strategy, the more resources invested by every enterprise. In addition, the more the resource required to invest, the higher the ratio threshold of using standardized strategy by GI agricultural product enterprise clusters is. Therefore, reducing ε through the construction of government subsidies mechanism, improving the agricultural science and technology extension system and other measures are contribute to the evolution and stability of adopting standardized strategy of the GI agricultural product enterprise clusters generally.
(2) The spillover coefficient λ. When λ closes to 1, spillover effect is obvious, which will lead to more "free-riding" behaviors, so it leads to a decrease in the quality of agricultural products, and even endanger the collective reputation. So, only by cluster internal or local government to improve the punishment system, the "free-riding" acts will be reduced.
(3) The efficiency α. The size of α directly affects the threshold of using standardized strategy in GI agricultural product enterprise clusters. Thus, in reality, planning the industrial structure and the coordination of organizational settings and designing management mechanism can effectively influence the standardized popularization efficiency.
(4) The scale n. From the Fig. 37.2, when the initial area is in $\frac{\varepsilon}{n(1-\lambda)^2} \leq x(t) \leq 1$, the smaller clusters, the popularization rate of using standardized strategy is higher, thus more stable. It means that, in reality, it should control the number of enterprises, ensure the effective supervision and management, being combined with the above measures at the same time.

37.5 Conclusion

This paper constructs the evolutionary game model of using standardized strategy in GI agricultural product enterprise clusters, and focuses on the analysis of behavior evolution of cluster members in different conditions. The results show that using standardized strategy may be influenced by a variety of key factors, so local government, industry associations and other coordination organization which are used to control these factors should play an important role. Establishing the supervision and punishment mechanism of standardized strategy implementation, through the improvement of the initial state, reducing the burden of cluster members, thereby improving the popularity efficiency of standardization, reducing the exterior effect of standardized popularization, making standardization to carry out effectively, safeguarding the characteristics and market competitive advantage of GI agricultural product.

Acknowledgments This paper is supported by the Humanities and Social Sciences Program of the Ministry of Education of China (10YAJ630014).

The authors thank the editor and the anonymous referees for their comments and suggestions.

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