Tripartite Game Analysis of Zunyi Pepper Industry Chain Based on Game Theory

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Abstract: Zunyi is a very important pepper producing area in China today, and the pepper industry plays a very important role in local economic development and farmers' income increase. However, in the current pepper industry chain, the interest connection between leading enterprises, intermediary organizations and farmers is not close, and contradictions and conflicts occur from time to time. This situation seriously hinders the healthy and sustainable development of the chili industry in Zunyi, and poses a threat to the stability and growth of farmers' income. This article is based on the framework of game theory, and analyzes the interest linkage mode of Zunyi pepper leading enterprises, intermediary organizations and farmers. The paper summarized the problems existing in the current pepper industry chain, and put forward the corresponding solutions, in order to promote the development of Zunyi pepper industry and increase the interests of farmers to provide theoretical reference and practical guidance.

1. Introduction

In recent years, the research on the interest linkage model among leading enterprises, intermediary organizations and farmers in the agricultural industry chain has become the focus of academic attention. However, the existing research on the interest linkage of Zunyi pepper industry chain is still insufficient. The current research mainly focuses on three aspects: first, the role positioning and responsibility analysis of various stakeholders in the pepper industry chain; The second is to use game theory to discuss the interest relationship and game strategy between the parties; Third, it puts forward the countermeasures and suggestions to optimize the interest linkage mode and solve the problems in the industrial chain. However, the existing research on the specific issues of the pepper industry chain in Zunyi City, such as the game behavior between leading enterprises, intermediary organizations and farmers, and the benefit distribution mechanism, still needs to be deepened [1]. Based on the existing results and field investigation, this study intends to conduct an in-depth analysis of the interest linkage mode of Zunyi pepper industry chain, in order to provide useful theoretical reference and practical guidance for the development of the industry and the protection of farmers' interests [2].

2. Stakeholder

2.1 Chili Leading Enterprise

Pepper leading enterprises refer to enterprises that occupy a leading position in the pepper industry chain and have greater influence and control ability on the production, processing and sales of pepper. These enterprises usually have strong market competitiveness and scale advantages, and play a leading and promoting role in the entire pepper industry chain. Pepper leading enterprises are not only simple processing enterprises, but also generally bear the functions of pepper planting technology guidance, resource integration, market development and brand building, which has an important impact on the development and stability of the entire industrial chain [3].

2.2 Pepper Farmers

Pepper farmers refer to farmers or peasant families engaged in pepper cultivation and production. They are key players in the pepper industry chain, taking responsibility for planting, management, picking and sales. Pepper farmers usually own or lease land, and carry out the cultivation and maintenance of pepper, while bearing the costs and risks of the cultivation process. Farmers' income is often affected by market conditions, policy support and technical guidance.

2.3 Intermediary Organization

Based on the research of Ye Leilei (2020), this paper refers to agricultural cooperatives, large agricultural households, agricultural associations and bases as intermediary organizations. The intermediary organization plays a very important role in the interest linkage mechanism between the leading chili enterprises and farmers. On the one hand, the intermediary organizations establish contact with the leading enterprises of pepper, supervise and restrict the agricultural operation activities of enterprises, and reduce the behavior of pepper enterprises in breach of contract or cheating farmers; On the other hand, they are closely integrated with farmers. Most intermediary organizations are spontaneously formed or voluntarily joined by scattered farmers, who share the same interest base and cultural values, and understand and trust each other. In agricultural production and management activities, the transaction cost between intermediary organizations and farmers is low, and the organizational operation is relatively fair and transparent. Therefore, farmers are willing to cooperate with intermediary organizations for a long time and form a stable contract relationship. In this case, farmers and intermediary organizations have established a community of interests and formed a cooperative and supportive relationship between them. The existence of intermediary organizations helps facilitate better transactions between farmers and leading enterprises [4]. Through the supervision and restraint mechanism, the intermediary organization ensures the fairness of the transaction and protects the rights and interests of farmers, and farmers are willing to cooperate with the intermediary organization in a long-term stability. The two are no longer in a game state, but a community of interests, and the intermediary organization will represent the interests of farmers to negotiate with the leading chili enterprises. Under the interest connection mode of "pepper leading enterprises + intermediary organizations + farmers", this paper only considers the game between intermediary organizations and pepper leading enterprises [5].

3. Analysis of Current Situation

Zunyi, also known as Bozhou, is located in an important transportation hub in southwest China, in the north of Guizhou Province and the northeast of the Yunnan-Guizhou Plateau. It is the second

largest city in Guizhou Province. The main producing area of the pepper industry in Guizhou province is the Qianbei pepper belt, which is dominated by Zunyi City. Zunyi has a long history of planting pepper. From the 1980s to the present, the scale of pepper is constantly expanding. The scale of the city's pepper from output value to planting area accounts for about 40% of the province's pepper industry, and the area accounts for about 10% of the country's planting area. As the city with the largest planting area and the largest number of pepper processing enterprises in Guizhou Province, Zunyi has cultivated many brands with the overall layout of "one center, two important regions and multiple radiation regions", such as "spicy Sanyang", "Zunspicy" and "GUI SAN Hong", etc., and also created China Pepper City, becoming one of the largest pepper trading and distribution centers in the country [6]. Zunyi city is currently mainly planting Chaotian pepper, thread pepper, millet pepper and other varieties, of which the largest planting area is the moderate spicy Chaotian pepper. In the process of the development of the pepper industry, the local government has provided strong support policies. The implementation of these policies and the support of the government have played an important role in the rapid development of Zunyi pepper industry. By promoting brand building, expanding sales channels, improving planting technology and processing level, Zunyi pepper industry continues to grow, and the output value increases year by year. At the same time, the chili industry in Zunyi City has also driven the increase of local farmers' income and the prosperity of rural economy. In recent years, the development of Zunyi pepper industry is as follows: Figure 1.

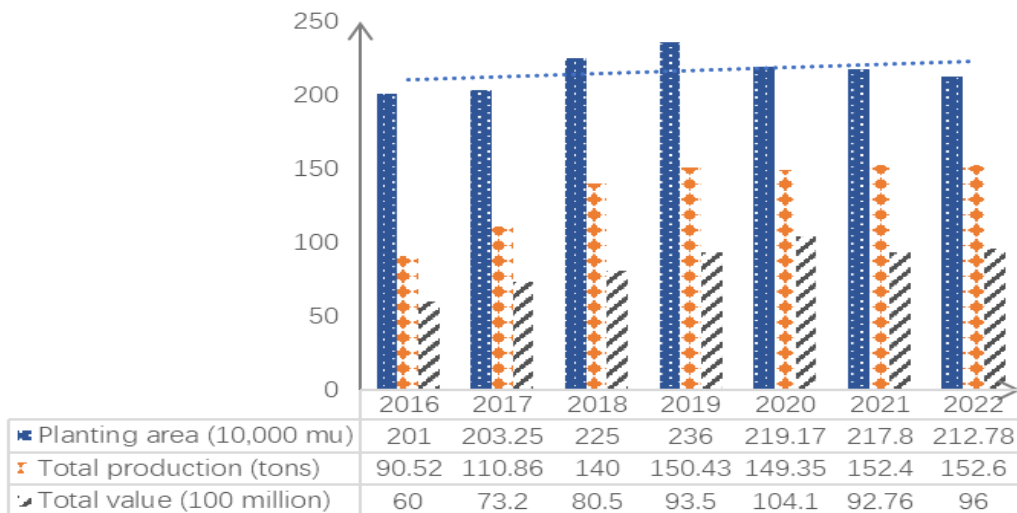|	2016	2017	2018	2019	2020	2021	2022
Planting area (10,000 mu)	201	203.25	225	236	219.17	217.8	212.78
Total production (tons)	90.52	110.86	140	150.43	149.35	152.4	152.6
Total value (100 million)	60	73.2	80.5	93.5	104.1	92.76	96

Figure 1: Development of pepper industry in Zunyi City from 2016 to 2022

4. Game Analysis

4.1 The Construction of Game Model

Player hypothesis: In this game model, the participants are assumed to be a leading chili enterprise, an intermediary organization and a farmer.

Strategy hypothesis: The existence of intermediary organizations helps to promote better transactions between farmers and leading enterprises. Through the supervision and restraint mechanism, the intermediary organization ensures the fairness of the transaction and protects the rights and interests of farmers, and farmers are willing to cooperate with the intermediary organization in a long-term stability. The two are no longer in a state of game, but a community of interests.

4.2 Symbol Definition

Table 1 lists the symbols used in the model.

Table 1: Symbol definition

Symbol	Definition
b	Chili leading enterprise
c	Intermediary organization
G	Financial support
R	Income of intermediary organization
H	Intermediary expenses
I	Compensation
C	Cost
D	Default cost

5. Model Building

According to the symbol definition, the probability of supervision and non-supervision of intermediary organizations is Z_c、$1-Z_c$. For pepper leading enterprises, in the game of "leading enterprises + intermediary organizations + farmers", the cost of leading enterprises includes time cost, technology cost and so on. Chili leading enterprises cooperate with intermediary organizations, and will obtain policy and financial support provided by government departments. At this time, as far as leading enterprises and intermediary organizations are concerned, their earnings do not need to consider the number and earnings of peppers.

Based on the above assumptions, the game income matrix of leading chili enterprises and intermediary organizations is shown in Table 2:

Table 2: Chili leading enterprises and intermediary organizations income matrix

Both sides of the game		Intermediary organization	
		Supervise	Without supervision
Chili faucet firm	Performance	$(G-C_b, R+H-C_c)$	$(G-C_b+D, R-D)$
	Default	$(G-D, R+D-I-C_c)$	$(G, R-I)$

In order to test the actual effect and application significance of the model, this paper takes the average market price of Zunyi fresh pepper in June 2023 at 5.2 yuan/catty as the price of pepper in the model for analysis and verification, and uses Matlab to conduct numerical simulation analysis of the strategic behavior of evolutionary game on both sides of the game.
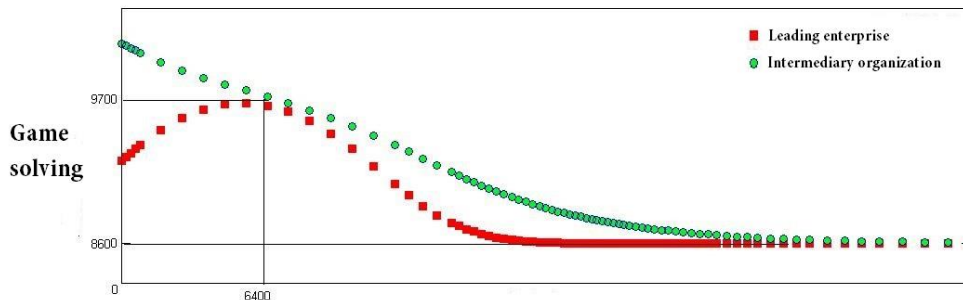

Figure 2: Example diagram

As shown in Figure 2, the optimal solution of the model is when the curves of the equilibrium solution of the leading chili enterprise and the intermediary organization converge. Assuming that the supervision fee of an intermediary organization for farmers is 5,000 yuan, the intermediary fee paid by the leading chili enterprise to the intermediary organization should be 8,600 yuan to 9,700 yuan in order to ensure the performance of the agreement by both parties.

6. Conclusion

It can be concluded that in the interest linkage mechanism of "leading enterprises + intermediary organizations + farmers", the cost of intermediary fees paid by leading enterprises to intermediary organizations is too high, exceeding the transaction cost between enterprises and farmers, leading enterprises may choose to default, because default may reduce their cost and increase their income. On the other hand, whether a leading enterprise will perform the contract depends on the relationship between the performance cost and the penalty cost for breach of contract. If the leading enterprise can obtain higher returns after compliance and the cost of compliance is low, then it may actively comply with the contract. In order to ensure the healthy development of the pepper industry chain, it is necessary to establish an effective regulatory mechanism, increase the punishment for breach of contract, protect the interests of farmers, and reasonably control the principal-agent cost and transaction cost, so as to encourage leading enterprises and intermediary organizations to have the motivation and responsibility to comply with the contract. Only in this way can we realize the stable and sustainable development of the interest linkage mechanism of "leading enterprises + intermediary organizations + farmers".

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