Research on Construction and Analysis of Supply Chain Model of Agricultural Special Products in Yunnan Area

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Abstract
Supply chain integration is the management method of higher level cooperation between supply chain partners in order to provide higher value and competitive advantage for customers. In this paper, the authors analyze the construction and analysis of supply chain model of agricultural special products in yunnan area. Through the strategic cooperation between enterprises and supply chain partners, the efficient operation of product flow, service flow, information flow and capital flow can be realized, and the maximum value can be created for customers with low cost and high efficiency. Through the supply chain integration, it can provide more advantageous conditions for the development of advantageous agricultural products in yunnan province.

Keywords: Agriculture supply chain, Service flow, Information network, Supply chain collaboration

1. INTRODUCTION

The area of mountain of Yunnan Province, the province accounted for more than 95% of the area, the unique geographical advantages, the species has obvious advantages, location advantages and favorable conditions richly endowed by nature advantages in the development of agricultural products, gave birth to the rich and colorful of the plateau characteristics of agricultural industry, fruit, vegetables, clouds cloud plateau animal husbandry etc.. In 2016, the total amount of agricultural economy in Yunnan increased steadily, with a total output value reaching 336 billion 300 million yuan, with an added value of 224 billion 200 million yuan. However, a long time Yunnan plateau agriculture has been using the traditional mode of operation, and is located in the border area, relatively closed to traffic and information, scattered operation mode limits the market space and development potential, has had a great impact on the development of agricultural economy and increase the income of peasants. Supply chain integration is the management method of higher level cooperation between supply chain partners in order to provide higher value and competitive advantage for customers. Through the strategic cooperation between the enterprise and the supply chain partners, the product flow, service flow, information flow, capital flow and the efficient flow of the decision flow are achieved, which creates the maximum value for the customers at low cost and high efficiency.

Domestic and foreign scholars have made some achievements in the research of green agricultural product supply chain. Joseph (2003) and Samir (2007) studied the implementation strategy of green agricultural products supply chain management. Liu Weihua (2010) et al., through the study of the present situation of closed supply chain, put forward the significance of green agricultural product closed transformation. Lu Bin (2012) studied the situation under the condition of symmetric information game and reputation mechanism under the condition of asymmetric information finite game based on the situation, and points out the factors of the establishment and perfection of agricultural products supply chain trust mechanism. Wang Chong (2013) and others studied on the problem of huge loss in the circulation of fresh agricultural products. Liang Peng (2013) and others analyzed the profit distribution mechanism of agricultural products supply chain alliance with alliance game in Shapley value. Li Xiaoyu (2014) studied the dynamic game model of agricultural products supply chain under asymmetric information. Research on reservoir Chengbing and Li Pingzhen (2014) management pattern of new agricultural products the supply chain of agricultural super docking, the key to success lies in the strength of the parties involved in balanced development. Wu Rong and Bai Shizhen (2014) through the establishment of the system of production and consumption of green agricultural products in the volume of business scale to achieve dynamic stability, ease the conflict between the two information system, put forward mode and guarantee the stable cooperative measures of green agricultural product supply chain. Zhao Jingwen and Yang Honglin (2015) established the game model between the government, enterprises and consumers in the low carbon environment, and analyzed the income of each subject under different circumstances, and obtained the optimal solution under the mixed strategy. Zhang Hanjiang (2015) studied the optimal emission reduction problem of the vertical supply chain under the background of low carbon. Lin Ting (2015) and others studied on the evolutionary game of knowledge sharing between upstream and downstream nodes in edible agricultural products supply chain. Deng Bin (2015), in order to improve the quality of agricultural products management system for the protection of the circulation of agricultural products, the degree of organization innovation, to contract management as the criterion, with full information sharing as the link and other aspects of continuous improvement, to ensure that agricultural products supply chain flow, prevent the fracture, achieve win-win interests between nodes as much as possible.
To sum up, although the research of green agricultural products supply chain has made some achievements, but there are few studies on the interests of the government, enterprises and consumers in the green agricultural products supply chain. On the basis of the traditional supply chain operation, this paper analyzes the operation of green agricultural products supply chain, and establishes the game model between the government, enterprises and consumers in the three party. This paper analyzes benefits of pure strategy equilibrium and mixed strategy equilibrium of each subject under different conditions and equilibrium, and the equilibrium results and related parameters were analyzed, to provide theoretical reference and decision support for the government and enterprises to implement green supply chain management.

2. PROBLEMS EXISTING IN THE DEVELOPMENT OF AGRICULTURAL PRODUCTS LOGISTICS IN YUNNAN

2.1. Logistics infrastructure backward

Although the logistics infrastructure of Yunnan has been greatly improved, the overall level is still not high compared with the whole country, and it is difficult to meet the needs of the development of agricultural logistics. The railway transportation has the transportation speed, long distance transport, high safety, large transport capacity, low transportation cost, little pollution, affected by weather conditions and other advantages, agricultural products are generally relatively large size, but compared to industrial products, the value is relatively low, so it is suitable for railway transportation. So it can be said that railway transportation is the most important mode of transportation of agricultural products logistics. Yunnan, however, is at a peripheral position in the national rail network. The operating mileage of Yunnan railway accounts for only 2.2% of the total national railway mileage. There are only 7 through railways in 16 cities and counties in the whole province, but there is no railway in most areas of southwest and northwest china. In addition, the rural roads in Yunnan also exist low grade, poor road conditions and other issues, leading to long transit time of agricultural products, low fresh activity, transportation loss, high logistics costs, low logistics efficiency.

2.2. The informatization construction of agricultural products lags behind

In the construction of new countryside, informatization construction is the key and the important sign of modern agriculture development. Through the information network, farmers can understand the market information through the rapid information channels. However, the informatization construction of agricultural products logistics in Yunnan is lagging behind. There is no public information platform, and the application level of informatization is low. Especially in the wholesale market of agricultural products, most of them are not equipped with information equipment, the market information function is not fully developed, and the degree of information sharing is low. Farmers, enterprises and the government do not have a common information platform, through the inquiry, publish and master the production of agricultural products information, market demand information. Although Yunnan is carrying out the "rural circulation project" construction, improve the rural information network, agriculture related departments have also established the rural information network, but in general, the rural informatization environment in Yunnan is not perfect

2.3. More logistics links, high loss rate

At present, Yunnan agricultural products logistics link is generally "breeding - harvesting - transportation to wholesale market - wholesalers - transport to consumption - retailers - consumers". From the whole logistics process, the link is too much and too cumbersome, which led to the overall benefits of agricultural logistics is low. Agricultural products usually have the characteristics of perishable, so in order to maintain the freshness of agricultural products, agricultural products logistics operations must be carried out at low temperature. However, the logistics of agricultural products in Yunnan province conducted at room temperature, only some of the links,
sometimes at low temperatures, resulting in low level of preservation technology, agricultural products in Yunnan province in the picking, storage, transportation and logistics link losses. This traditional logistics mode extends the controllable logistics time and increases the logistics loss.

Figure 2. Integration of agricultural products

3. ESTABLISHMENT AND SOLUTION OF GAME MODEL

3.1. Basic Assumption and Parameter Setting of Game Model

Follow the classical game model about the hypothesis of “rational person”, the subject will participate in the game as the pursuit of the interests of the individual, have an accurate grasp of the future judgment, do not make a wrong decision. In order to facilitate the analysis, it is assumed that the whole chain consists of three parts: government, enterprise and consumer. Among them, the government refers to the local government, to guide the environmental protection and publicity of enterprises and consumers, including the formulation of relevant environmental laws and regulations; The enterprise covers more and larger range of subjects including all aspects of agricultural production, processing and circulation. Consumer refers to the purchase of agricultural products from one side of the enterprise and its primary processing consumer groups. It is assumed that the three sides of the game are aware of each other’s strategic space and the corresponding gains in the short-term equilibrium, so we deal with it according to the static game of complete information, and obtain the Nash equilibrium solution.

At present, China’s green agricultural products supply chain is still in the primary stage of development, the relevant concepts and measures are not in place, consumers and enterprises for green agricultural products to enhance the level of awareness and acceptance. In view of this phenomenon, as the representative of all environmental protection organizations and associations, the government is necessary to monitor the behavior of the main body of agricultural products supply chain. Control measures include the implementation of green supply chain management, enterprises participate in the green agricultural products purchase consumer subsidies and implement the green supply chain management, the enterprise does not participate in the green agricultural products consumers in the purchase of punishment, the probability hypothesis of government surveillance for \( x \), no monitoring probability is \( 1 - x \), namely the government space strategy for \( G \) no monitoring, monitoring); Enterprises implement green supply chain management and implementation of the two aspects of green supply chain management in supply chain management, including the production, processing and circulation of the link is the green technology is processing agricultural products, chemical fertilizer with green food regulations and standards, whether to adopt energy saving planting technology and so on. If the probability of implementing green supply chain management is \( y \), the probability of not implementing green supply chain management is \( 1 - y \), that is to say, the strategic space of the enterprise is \( E \) (implemented, not implemented); Consumer choice is not controlled by the government and the enterprises, can participate in the purchase of green agricultural products, also cannot participate in the purchase of green agricultural products, green agricultural products consumer participation probability hypothesis for the purchase of \( z \), the consumer
does not participate in the probability of green agricultural products for the purchase of \(1 - \varepsilon\), namely the strategy space for \(C\) (consumer participation, not participate in). When the government to monitor the supply chain of agricultural products, the monitoring and promotion costs for the \(C_G\), the implementation of green supply chain management of agricultural products and participate in the green agricultural products purchase consumers get from the government subsidies were \(A_E, A_C\), the environmental benefits for the government is \(M_1\). If the enterprise does not implement the green supply chain management of agricultural products, consumers do not participate in the purchase of green agricultural products, the two was a result of the government to punish \(P_E, P_C\), the government obtained at this time the environmental benefits of \(M_2\) \((M_1 > M_2)\); When the enterprise does not implement the green agricultural products supply chain management, the profit is \(R_{E}, E\), and the investment cost is negligible. Because the government is not in place to monitor the social benefits of \(M_3\), the implementation of green agricultural products supplies management income of \(R_{E1}\), this time due to increased investment in technology, personnel, resulting in cost increased to \(C_{E1}\); When consumers participate in the green agricultural products purchase, advocacy and control of green agricultural products of the government and enterprises to a certain extent, consumers get utility for \(U_{C2}\), do not participate in the green agricultural products purchase utility for \(U_{C1}\).

3.2. Strategy Combination and Revenue Matrix of Game Theory

Based on the above assumptions and analysis of green agricultural products supply chain, the establishment of the government, enterprises and consumers in the game model of the payoff matrix, as shown in Table 1.

<table>
<thead>
<tr>
<th>Strategy selection</th>
<th>Consumer participation</th>
<th>Consumer nonparticipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government monitoring</td>
<td>Enterprise implementation</td>
<td>(M_1 - A_E - A_C - C_G)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{E1} - C_{E1} + A_E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(U_{C1} - A_C)</td>
</tr>
<tr>
<td>Enterprises nonperformance</td>
<td></td>
<td>(M_3 + P_E - A_C - C_G)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-P_E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(A_C)</td>
</tr>
</tbody>
</table>

Without Government monitoring

| Enterprise implementation | \(M_1\) | \(M_2\) |
| | \(R_{E1} - C_{E1}\) | \(-C_{E1}\) |
| | \(U_{C1}\) | 0 |

| Enterprises nonperformance | \(M_1\) | \(M_3\) |
| | 0 | \(R_{E2}\) |
| | 0 | \(U_{C2}\) |

4. EQUILIBRIUM ANALYSIS OF GAME THEORY

4.1. Pure Strategy Nash Equilibrium Analysis

Table 2. Pure Strategy Nash Equilibrium and Its Conditions

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Pure Strategic Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R_{E1} - C_{E1} &gt; 0, U_{C1} &gt; 0)</td>
<td>(enterprises implement, participation, not monitoring)</td>
</tr>
</tbody>
</table>
and $U_{C1} < 0$, which means that benefits for enterprises to implement green agricultural product supply chain management are higher than the cost, and they participate in green agricultural product supply chain construction in order to gain profits. Customers get positive utility by participating in purchasing green agricultural products and they are willing to participate in purchasing green agricultural products, which is the development trend of future game among subjects of agricultural product supply chain. With the improvement of green agricultural product planting technologies, enterprises need to pay lower cost to implement green agricultural product supply chain management, and customers’ improved awareness of environmental protection and health drive them to participate in purchasing green agricultural products, enterprises sell products in the right channels and gain improved profits, and they will necessarily vigorously promote green agricultural product supply chain management. But to generate this mode, customers’ awareness and enterprises’ production and management technologies must reach certain degree of maturity; the established condition of strategic combination (enterprises implement, not participation, not monitoring) is $-C_{E1} > R_{E2}$ and $U_{C1} < 0$, which means enterprises pay less cost in implementing green agricultural product supply chain management, leading to the loss of enterprises and customers are not satisfied with the purchased green agricultural products, which may be that due to the improved cost in implementing green agricultural product supply chain management in actual production and sales, enterprises give a high price and fail to achieve customers’ desired effect, thus customers do not participate in purchasing green agricultural products. In addition, if enterprises implement green agricultural product supply chain management and in order to reduce expenditure, the government tends to adopt the measure of not monitoring, and strategic combination (enterprises implement, participate, monitor) and (enterprises implement, not participating and monitoring) will not become pure strategic combination equilibrium. Therefore, there is no only Nash equilibrium solution in Table 2, and in the supply chain, the government, enterprises and customers will adopt mixed Nash equilibrium strategy.

4.2. Mixed strategy Nash equilibrium analysis

Under the condition that the pure strategy Nash equilibrium does not exist, the government, enterprises and consumers will adopt a strategy with a certain probability, i.e., mixed Nash equilibrium.

When the possibility $y$ for enterprises to implement green agricultural product supply chain management and the possibility $z$ for customers to purchase green agricultural products are fixed, the benefits for the government to adopt the monitoring strategy and not adopt the monitoring strategy are $M_{G1}$ and $M_{G2}$, besides:

$$M_{G1} = x[yz(M_1 - A_E - A_C - C_G) + y(1 - z)(M_2 + P_t - A_E - C_G)] + (1 - y)z(M_3 + P_t - A_E - C_G) + (1 - y)(1 - z)(M_4 + P_t + P_c - C_G)$$

$$M_{G2} = (1 - x)y z M_1 + y(1 - z)M_2 + yz M_3 + (1 - y)(1 - z)M_4$$

Besides, only when the benefits for the government to monitor and not monitor are the same, the status of equilibrium game can be achieved, i.e., $M_{G1} = M_{G2}$, and then:
When the possibility $x$ of government monitor and the possibility $y$ of implementing green agricultural product supply chain management are fixed, the benefits for enterprises to implement or not implement green agricultural product supply chain management are $M_{E1}$ and $M_{E2}$ respectively. Besides, only when the benefits enterprises to implement or not implement green agricultural product supply chain management are the same, the status of equilibrium game can be achieved, i.e., $M_{E1} = M_{E2}$, and then:

$$y^* = \frac{1}{1 + \frac{x\bar{C}_{E1} + xU_{C1}A_{E} - \bar{C}_{E1}U_{C1}^2}{zR_{E2}U_{C1} + xP_{E}U_{C1} - R_{E2}U_{C1}^2}}$$

When the possibility $x$ of government monitor and the possibility $y$ of implementing green agricultural product supply chain management are fixed, the benefits for customers to be engaged or not to be engaged in purchasing green agricultural products are $M_{C1}$ and $M_{C2}$. Besides, only when the benefits for customers to be engaged in or not to be engaged in purchasing green agricultural products are the same, the status of equilibrium game can be achieved, i.e., $M_{C1} = M_{C2}$, and then:

$$z^* = \frac{1}{1 + \frac{U_{C1} + xA_{E} + xU_{C1} + xyU_{C1}}{U_{C2} - xP_{E} - yU_{C2}}}$$

Therefore, $x^*$, $y^*$ and $z^*$ represent the equilibrium solutions of the government, enterprises and customers in the game of green agricultural product supply chain.

5. DISCUSSION OF THE THEORETICAL SIGNIFICANCE AND PARAMETER INFLUENCE OF MIXED GAME EQUILIBRIUM SOLUTION

In the absence of pure Nash equilibrium solution, the government, enterprises and customers will adopt mixed Nash equilibrium strategy, i.e., adopt the pure strategy at certain possibility. It can be found from the above mixed Nash solution that it is hard to determine the size of $x^*$, $y^*$ and $z^*$ and their relationship with 0. Because when all of $x^*$, $y^*$ and $z^*$ are smaller than 0, it represents that the government implements strict monitor and publicity of green agricultural product supply chain so as to make sure that enterprises carry out green production and customers adopt green purchase decisions to maximize the social utility; enterprises actively promote management and maintenance of green agricultural product supply chain and adhere to the national and government policies, and invest manpower, materials and wealth to inject green concept into the production, process, transportation and warehousing of agricultural products so as to construct green agricultural product supply chain for the long-term development of enterprises, improve and enhance enterprises’ core competitiveness and achieve the maximum benefits; considering their own health, customers are willing to and capable of purchasing green agricultural products, and in order to support the national policy, customers will also take the initiative to purchase green agricultural products and participate in the construction of green agricultural product supply chain so as to pay for their own health. This is an ideal status of green agricultural product supply chain, but there is still a gap with the real situation, which is mainly manifested in that customers do not have strong awareness to purchase green agricultural products and are unwilling to pay high price. Besides, due to the long production cycle and reducing or not obvious investment return, enterprises will not take the initiative to be engaged in the production and processing of green agricultural products. Besides, as the government’s monitor is not in place, the construction of green agricultural product supply chain in China is slow, and problems in traditional agricultural supply chain have not been improved in green agricultural product supply chain. Therefore, due to the limitation of actual situation, set $x^*, y^*, z^* \in [0, 1]$, and then discuss the influence of parameter variation on the main body of supply chain.

5.1. Significance of Mixed Nash Equilibrium Solution $x^*$ under Government Monitor
Both the possibility $y^*$ of implementing green agricultural product supply chain management and the possibility $z^*$ for customers to adopt green purchase behavior are constants. At this time, the government monitors and promotes green agricultural product supply chain at the possibility $x^*$, expands the coverage of green agricultural supply chain concept, enhances and encourages local leading enterprises to promote green agricultural supply chain management so as to provide customers with quality and effective agricultural products and primary processed products to make sure that customers can purchase and eat safely; meanwhile, advocate the concept of healthy and green food, promote customers’ acceptance and purchase of green agricultural products and achieve the maximum total social efficacy under the government’s monitor and promotion. When $\exists x > x^*$, it shows that the government control and promotion play certain promoting role for enterprises and customers. Under the condition when both policy subsidy and government punishment work enterprises can implement green agricultural products supply chain management and customers can participate in the purchase of green agricultural products.

5.2 Significance of Mixed Nash Equilibrium Solution $y^*$ under Enterprise Management and Mixed Nash Equilibrium Solution $z^*$ with Customer Participation

When the possibility $x^*$ of government monitor’s balanced solution is a constant, $y^*$ refers to the possibility for enterprises to implement green agricultural product supply chain management and $z^*$ refers to the possibility for customers to purchase green agricultural products. Besides, under this possibility, the two's interests can be maximized. Set $P_{\text{max}} = \max \{y^*, z^*\}$ and $P_{\text{min}} = \min \{y^*, z^*\}$, when both the possibility $y^*$ for enterprises to implement green agricultural product supply chain management and the possibility $z^*$ for customers to purchase green agricultural products are larger than or equal to $P_{\text{max}} = \max \{y^*, z^*\}$, it shows both enterprises and customers can practice the green concept by carrying out green agricultural product supply chain management and purchasing green agricultural products. Besides, both sides can achieve the maximum interests and the construction of the entire green product supply chain is feasible. When both the possibility $y^*$ for enterprises to implement green agricultural product supply chain management and the possibility $z^*$ for customers to purchase green agricultural products are less than $P_{\text{max}} = \max \{y^*, z^*\}$, it shows enterprises are unwilling to carry out green agricultural product supply chain management and customers are unwilling to purchase green agricultural products. When the size of one of $y^*$ and $z^*$ is between $P_{\text{max}} = \max \{y^*, z^*\}$ and $P_{\text{min}} = \min \{y^*, z^*\}$, it shows that one side within the range is willing to carry out green agricultural product supply chain management or purchase green agricultural products, which maybe that enterprises are willing to implement green agricultural product supply chain management and customers are unwilling to purchase green agricultural products, or that customers are willing to purchase green agricultural products while enterprises are unwilling to implement green agricultural product supply chain management. Whatever the situation is, green agricultural supply chain is not successfully constructed.

5.3. Analysis on the influence of parameters $M_1$, $M_2$ and $M_3$

It can be obtained by collating $x^*$ that:

$$x^* = \frac{1}{2 + \frac{C_G - P_E - P_C - z}{2 + \frac{(P_E - C_G - A_C)(2 - z) + A_E + P_E + (P_E + P_C - C_G)z + M_3}{yzM_1 + (1 - z)yM_2 - (1 + y)M_3}}M_3}$$

It can be found from the formula that $x^*$ is the increasing function of $M_1$ and $M_2$, and the decreasing function of $M_3$, i.e., it increases with the increase of $M_1$ and $M_2$, and decreases with the increase of $M_3$. When enterprises implement green agricultural product supply chain management, the possibility $z$ for customers to participate in the construction of green agricultural product supply chain influences the government’s monitor possibility, thus affecting the relative size of social welfare $M_1$ and $M_2$. The most ideal status is that the government does not participate in the monitor and promotion of purchasing green agricultural products, and customers can consciously purchase green agricultural products. At this time, $x \rightarrow 0$, $z \rightarrow 1$ and the size of the
obtain social welfare is $M_1$; the more realistic case is that under the government vigorous promotion and advocacy, customers obtain certain purchase subsidy from the government and pay for the surplus value of green agricultural products so as to be engaged in the activity of purchasing green agricultural products. At this time, $x \rightarrow 1$, $z \rightarrow 0$ and the obtained social welfare is $M_2$, which is in line with customers’ payment willingness. With the increase of people’s health awareness and the improvement of living standard, their acceptance and recognition of green agricultural products are increased, and customers are more willing to purchase and eat green agricultural products and more actively participate in the construction of green agricultural product supply chain without enforced monitor of enterprises. When enterprises do not implement green agricultural product supply chain management, even the government puts a lot of manpower to carry out publicity and monitoring, it can hardly improve social welfare. Besides, the increasing cost of promotion and monitoring can on the contrary reduce the level of social welfare. i.e., all the government does is meaningless, and it can also increase the government’s expenditure and promotion cost, thus reducing the overall level of social welfare $M_3$.

6. CONCLUSIONS

This paper establishes game model of government, enterprises and consumers of the three party in the green agricultural products in the supply chain, and also analyzes the strategies of each subject under pure strategy equilibrium and mixed strategy equilibrium. It is found that the government does not need to supervise the implementation of green agricultural products supply chain, and do not need to promote the purchase of green agricultural products. This shows that the concept of enterprise production technology and consumer environmental protection, awareness has matured, without the supervision and control of the third parties, but there are still many restrictions to achieve this state. For now, the government monitors the behavior of enterprises and consumers, appropriate subsidies and punishment is conducive to the construction and development of green agricultural supply chain.

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