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Differentiation Management of Green Agricultural Products Based on Utility Analysis

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Abstract

This paper studies the differentiation management of green agricultural products problem of "Farmer supermarket connection" mode. The "Farmer supermarket connection" mode is a direct connection between supermarkets and farmers (or cooperatives), what the supermarket needs and what the farmers produce. The green degree is used to indicate the quality level of health, safety and nutrition of agricultural products. The greater the green degree, the better the quality of agricultural products. In order to meet the needs of all consumers, the supermarket decided to differentiate one kind of agricultural products, namely, the supermarket which operates both ordinary and green agricultural products. It builds on the consumer utility function for ordinary agricultural products and green agricultural products. Based on utility function, it analysis the consumers choice behavior of ordinary agricultural products and green agricultural products. It is concluded that the general demand for agricultural products and the demand of green agricultural products. It is discussed the optimal decision based on Stackelberg game of supermarket choosing one farmer to purchase of common agricultural products and green agricultural products at the same time and supermarket to choose two farmers to purchase of common agricultural products and green agricultural products. It can be seen from the comparison that the supermarket chooses the two farmers to order separately, which is more profitable than the purchase of one. Finally, a "wholesale price + ordering subsidy" coordination mechanism is proposed to realize supply chain coordination. An example is given to verify the rationality of the model and conclusion.

Keywords: *Differentiation, Management, Green-Agriculture, Products and Analysis.*

Introduction

Nowadays, with the improvement of people's living standard and the frequent occurrence of food safety problems, people pay more and more attention to food safety. Therefore, green agricultural products are becoming more and more concerned. Green agricultural products follow the principles of sustainable development, produce according to specific production mode, such as no pollution, safety, high quality, nutrition and so on. But the production of green fresh agricultural products need to strictly control the production environment, the need of human and in need of some modern science and technology and so on, compared with ordinary fresh agricultural products, green agricultural products cost will be relatively high a lot. So the sales price of green agricultural products will be higher than normal fresh agricultural products. For almost all commodities, the sale price is one of the main factors that affect the purchase of consumers. Although in terms of health and safety nutrition, consumers will tend to buy green agricultural products, but the sales prices of green agricultural products would be much higher compared to ordinary agricultural products, it is now the biggest factor that hinder the consumers to buy the green agricultural products. In the middle of the economic pressure, when buying a product, consumers weigh the price and demand for health, choose to buy common fresh produce or green produce. In this paper, the concept of green degree is introduced and the green degree is used to indicate the safety and health of agricultural products. The higher the green degree of agricultural products, the higher the safety degree, the better the quality.

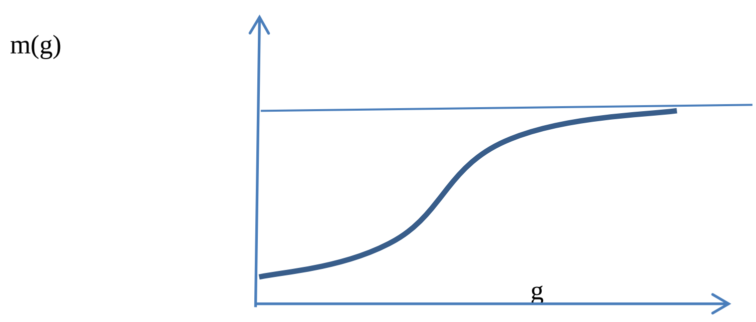
Consumers' preference for green agricultural products varies depending on consumers' perceptions of green agricultural products, as well as economic conditions, knowledge levels, age, gender and so on. In order to meet the needs of most customers, retain more customers, the supermarkets carry out differentiated agricultural products, in other words, supermarket sales not only common agricultural products, but also sell green agricultural products. It is assumed that the average agricultural products and green agricultural products have their respective green ranges. The green degree g_0 is the cut-off point of common agricultural products and green agricultural products. When $g < g_0$, it is common products, when $g \geq g_0$, it is green produce. Everyone has a position on the green value of agricultural products. When consumers buy agricultural products, there will be an estimate of the value of the agricultural products. If they are satisfied with their own requirements, consumers will choose to buy them. Therefore, this paper constructs a consumer utility function and consumers choose to purchase ordinary agricultural products or green agricultural products or give up the purchase of the agricultural products directly according to the utility function.

The farmers and supermarket connecting supply chain is the special application of agriculture in the supply chain. With the development of agricultural modernization, the trading mode of agricultural products is also improving. "Farmer supermarket connection", refers to the farmers and supermarkets direct docking, farmers and merchants intention agreement, from farmers to supermarkets, markets and convenience stores for new ways of distribution of agricultural products, market needs, farmers will produce what, so to avoid the blindness of peasant household production, stable sales channels for agricultural products, at the same time, through direct purchase, can across the middlemen, reduce circulation, reduce the circulation and transaction costs and supermarket can also provide technical guidance to farmers, set up the supervision system, strictly control the green degree of fresh agricultural products, ensure food safety. From the beginning of the farmer to sell, agricultural products trading mode is mainly a large number of scattered farmers, to a variety of trading patterns. Reardon, Timmer & Barrett, et al.(2003) found that in the central part of the Americas, some countries in Asia and the east of Europe, the supply and marketing model of "agricultural super docking" was widely used. Reardon & Swinnen (2004) through the study of fresh agricultural products supply chain, it obtained with the mode of operation of agricultural products supermarkets, traditional farmers' market will be gradually replaced by a supermarket, small agricultural producers and business operators will gradually eliminated by the market. Reardon, Timmer, & Minten (1981) found that there was a "supermarket revolution" in developing countries. The cooperation between farmers and supermarkets increased, and farmers strengthened their cooperation with supermarkets by setting up cooperatives and companies. Since our country energetically implemented the "agricultural super docking" supply and marketing model, Chinese scholars have conducted a lot of research on "agricultural super docking". According to the supermarket and cooperative whether or not integration mode, Li (2009) divided that into two modes: one kind is the supermarket and cooperatives as a continuum to pursue the overall profit maximum; Secondly, in the premise of the cooperation between the supermarket and the cooperative, through the signing of the contract, to pursuit of profit maximization. Jiang (2009) believes that the "agricultural super-connection" is of great significance to improve the quality of agricultural products, the circulation of agricultural products and the increase of farmers' income. Hu & Yang (2010), this paper expounds the concept and development of farmers and process, from improving the quality of agricultural products, increase farmers' income and reduce the transaction cost, it expounds the significance of the farmers and think that it can promote the process of agricultural modernization in our country. In recent years, with food and health safety accidents occur frequently, as well as people living standard rise, green agricultural products is more and more attention by people. (Jiang & Li 2015) The four green supply chain game models are established to consider the green degree of products. Based on the Stackelberg game model, Li, Zhu, & Jiang, et al. (2016) can obtain optimal pricing and the decision of optimal green product in the case of concentration and decentralization. Liu & Ji (2017) studied the influence of consumers' green preference and horizontal competition degree on the operation of green supply chain. Zhang & Wang (2017) studied the supply chain efficiency analysis when the product demand was related to the green degree of the product. Liu (2012) studied the horizontal bidding game and pricing strategy of the supply chain under consideration of product greenness. But the research on supermarkets for agricultural product differentiation is not much, because the price of green agricultural products relative levels of the buyer are still too high, for the average agricultural products and green agricultural products, due to the economic level of consumers and the degree of attention to health is different, different consumers to common agricultural products and green agricultural products have different needs. This article puts forward the differential operation of agricultural products, supermarket sales of common agricultural products and green agricultural products at the same time. It can meet the requirements of most consumers, supermarket can also help retain more customers. Fu, Deng, Wei & Xu (2014), such as buying behavior based on Probit regression forecasting model, studies have shown that in addition to the traditional economic variables, such as income and price, the consumer awareness、 trust and willingness to pay will also influence the purchasing behavior; Information asymmetry, insufficient consumer confidence and high levels of premium are the main reasons that why they refuse to buy green agricultural products. This paper assumes that consumers' preference for green degree of agricultural products is a random variable, subject to uniform distribution on a certain interval.

Based on this, it studies the farmer supermarket connection cases in order to meet the needs of most consumers, supermarket take pricing strategy that operate differential for the common agricultural products and green agricultural products. It obey the Stackelberg game between farmers and supermarkets under decentralized decision making, farmers is the leader and the supermarket is following. This can avoid the farmer blindly planting the breeding and solve the difficult problem of the sale, expands the supermarket customer source and has certain significance for the convenience consumer. It discussed the supermarket to choose one farmer to order general situation of agricultural products and green agricultural products at the same time and then discusses the supermarket to choose two farmers were ordered general situation of agricultural products and green agricultural products and finally compares the two kinds of situations, it is concluded that the supermarket to choose two farmers than it is to choose one farmer to get income more. It also proposes a "wholesale price + ordering subsidy" coordination mechanism, which can maximize the benefit of the whole supply chain and realize the coordination of supply chain. It also gives an example analysis to verify the above conclusions.

Model Construction

With the improvement of people's living standard, consumers' health and safety consciousness will gradually be improved, consumers in the purchase of agricultural products are more and more attention in the process of agricultural products contain pesticides, fertilizers, hormones and other health nuisances. It introduced the concept of green degree level refers to crops contain poisonous and harmful material such as pesticides, hormones, chemical fertilizer level, the higher the green degree, the less agricultural products contain harmful substances. For any commodity, the sale price is one of the most important factors that affect its demand. As consumers with green requirements, as well as based on considerations of the price, as far as possible in order to meet the needs of all consumers, improve market competitiveness, supermarket decided to differentiation of the agricultural products, that is, for the agricultural products, supermarket management common agricultural products and green agricultural products at the same time. It assume that consumers can only choose one of the common agricultural products and green agricultural products and assumes that the consumer utility function is related to the green degree of agricultural products and prices. The consumer utility function can be assumed to be the multiplication of green and price : $u(g,p) = \theta m(g) \cdot n(p)$. It can also be assumed to be the additive form of green and price : $u(g,p) = \theta m(g) - n(p)$. In this paper, consumer utility function is used to the form of : $u(g,p) = \theta m(g) - n(p)$. Among them, $m(g)$ is the consumer utility of green degree of agricultural products, and $n(p)$ is the consumer utility of the price of agricultural products, and θ is the degree of green preference of consumers. Due to different cognitive level of consumers of green agricultural products and consumer levels of knowledge, such as age, gender, income is different, every consumer's green appetite is not the same. So let's say that θ is a random variable, obeying the uniform distribution on $[0,1]$. From real life can be concluded that the increase of the degree of green agricultural products, agricultural products safety degree is higher, the consumer demand for safety of agricultural products is more and more satisfied, therefore, agricultural product green degree of consumer utility is increased. In addition, with the increase of green degree, the growth rate of the green degree of consumer utility are also on the increase, but when the green degree is increased to a certain extent, the safety of agricultural products indicators reached almost all the requirements of consumers, consumers to the requirement of agricultural product green degree further pursuit is less, so the growth rate of agricultural product green degree of consumer utility in decreasing and with the increase of green degree, agricultural product green degree of consumer utility approach a constant value. It is explained by mathematical knowledge: when the green degree of agricultural products is relatively small , $\frac{d^2 m(g)}{dg^2} > 0$, But when g gets to a certain value, it's going to be , $\frac{d^2 m(g)}{dg^2} < 0$. The general trend of the consumer utility function of the green degree of agricultural products can be expressed as below :



According to the above figure, the consumer utility of the green degree of agricultural products is roughly an s curve, which conforms to the logistic model. Therefore, we assume that the consumer utility function m(g) of the green degree of agricultural products is subject to the logistic model. Namely $m(g) = \frac{k}{1 + ae^{-bg}}$ 。

Now let's look at the utility function of the price of agricultural products $n(p)$.In this paper, we assume that $n(p) = p$.

So, the consumer utility function is： $\mu(g,p) = \theta \frac{k}{1+ae^{-bg}} - p$ 。

In "Farmer supermarket connection" mode, the farmers (or cooperative) direct docking with the supermarket, so farmers from planting (breeding) into a single production, the supermarket need what and how much, what farmers from production and production how much. In the product before the start of trading activities, sign a contract with farmers, supermarket stipulated in the contract order quantity from farmers, farmers decided the unit wholesale price of agricultural products, supermarket decision unit sales price of agricultural products sold to consumers. For the agricultural products produced by the farmers, the supermarkets will compensate the farmers with $c_s g$, which can improve the green degree of agricultural products.

As a result of the common agricultural products and green agricultural products green degrees and selling price are different, based on the former in the face of consumer utility function hypothesis, ordinary consumer utility function of agricultural products and green agricultural products, respectively：

$$\begin{cases} \mu_1 = \theta \frac{k}{1+ae^{-bg_1}} - p_1 \\ \mu_2 = \theta \frac{k}{1+ae^{-bg_2}} - p_2 \end{cases} \quad (1)$$

μ_1 is the consumer utility function of ordinary agricultural products, μ_2 is the consumer utility function of green agricultural products. The turning point in the consumer utility of green products is $g' = -\frac{1}{b}\ln\frac{1}{a}$, According to the real life common sense, it can be inferred that this turning point should occur on the green agricultural product range. Suppose the green degree of agricultural products g_0 is the cut-off point of common agricultural products and green agricultural products. So when $g < g_0$, it's a common agricultural product, and when $g \geq g_0$, it's a green agricultural product $g' = -\frac{1}{b}\ln\frac{1}{a} \geq g_0$.

The consumer's choice behavior of the agricultural product is based on the comparison of the above consumer utility function.

When the utility of ordinary agricultural products is greater than that of green agricultural products, consumers will choose to purchase ordinary agricultural products.

Therefore, the consumer chooses to buy common agricultural product to have the necessary condition is：

$$\begin{cases} \mu_1 \geq 0 \\ \mu_1 \geq \mu_2 \end{cases} \quad (2)$$

From equation (2), we have: $\begin{cases} \theta \geq \dfrac{p_1}{\dfrac{k}{1+ae^{-bg_1}}} \\ \theta \leq \dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}} \end{cases}$, In order to make the study meaningful, it should be $\dfrac{p_1}{\dfrac{k}{1+ae^{-bg_1}}} \leq \dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}}$, That is $p_1 \dfrac{k}{1+ae^{-bg_2}} - p_2 \dfrac{k}{1+ae^{-bg_1}} \leq 0$. Under the condition of $p_1 \dfrac{k}{1+ae^{-bg_2}} - p_2 \dfrac{k}{1+ae^{-bg_1}} \leq 0$, When $\theta \in \left[\dfrac{p_1}{\dfrac{k}{1+ae^{-bg_1}}}, \dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}} \right]$, consumers will choose to buy ordinary produce.

Similarly, we have the necessary and sufficient condition：

$$\begin{cases} \mu_2 \geq 0 \\ \mu_2 \geq \mu_1 \end{cases} \qquad (3)$$

From equation (3) , we have $\begin{cases} \theta \geq \dfrac{p_2}{\dfrac{k}{1+ae^{-bg_2}}} \\ \theta \leq \dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}} \end{cases}$. When $p_1 \dfrac{k}{1+ae^{-bg_2}} - p_2 \dfrac{k}{1+ae^{-bg_1}} \leq 0$, we have $\dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}} \geq \dfrac{p_2}{\dfrac{k}{1+ae^{-bg_2}}}$. In order to make the study meaningful, it should be $\dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}} \leq t$, namely $p_2 - p_1 - t\left(\dfrac{1}{1+ae^{-bg_2}} - \dfrac{1}{1+ae^{-bg_1}}\right) \leq 0$.

Under the condition of $\begin{cases} p_1 \dfrac{k}{1+ae^{-bg_2}} - p_2 \dfrac{k}{1+ae^{-bg_1}} \le 0 \\ p_2 - p_1 - t(\dfrac{1}{1+ae^{-bg_2}} - \dfrac{1}{1+ae^{-bg_1}}) \le 0 \end{cases}$, When $\theta \in \left[\dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}},\ t \right]$, consumers will choose to buy green produce.

To sum up, under the premise of this condition $\begin{cases} p_1 \dfrac{k}{1+ae^{-bg_2}} - p_2 \dfrac{k}{1+ae^{-bg_1}} \le 0 \\ p_2 - p_1 - t(\dfrac{1}{1+ae^{-bg_2}} - \dfrac{1}{1+ae^{-bg_1}}) \le 0 \end{cases}$, consumers are likely to buy ordinary agricultural products or green agricultural products. In this way, supermarkets have the need to differentiate between ordinary produce or green produce.① When $\theta \in \left[0, \dfrac{p_1}{\dfrac{k}{1+ae^{-bg_1}}} \right]$ consumers, whether ordinary produce or green produce, will not choose to buy it and may switch to other produce. ; ② When $\theta \in \left[\dfrac{p_1}{\dfrac{k}{1+ae^{-bg_1}}}, \dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}} \right]$, consumers choose to buy common agricultural products. ; ③ When $\theta \in \left[\dfrac{p_2 - p_1}{\dfrac{k}{1+ae^{-bg_2}} - \dfrac{k}{1+ae^{-bg_1}}},\ t \right]$, consumers choose to buy green agricultural products.

To discuss convenience, let $G_1 = \dfrac{k}{1+ae^{-bg_1}}, G_2 = \dfrac{k}{1+ae^{-bg_2}}$

The demand for ordinary produce is. : $Q_1 = \begin{cases} \int_{\frac{p_1}{G_1}}^{\frac{p_2 - p_1}{G_2 - G_1}} \dfrac{1}{t} d\theta = \dfrac{p_2 G_1 - p_1 G_2}{t G_1 (G_2 - G_1)}, p_1 G_2 - p_2 G_1 \le 0 \\ 0, others \end{cases}$

The demand for green agricultural products is：

$$Q_2 = \begin{cases} \int_{\frac{p_2 - p_1}{G_2 - G_1}}^{t} \dfrac{1}{t} d\theta = \dfrac{t(G_2 - G_1) - p_2 + p_1}{t(G_2 - G_1)}, p_1 G_2 - p_2 G_1 \le 0 \text{且} \\ \qquad p_2 - p_1 - t(G_2 - G_1) \le 0 \\ 0, others \end{cases}$$

The cost of producing ordinary produce and green produce is respectively c_{f1} , c_{f2} , Because the production cost of green produce is higher than the raw product of ordinary produce, so $c_{f1} < c_{f2}$. The wholesale prices of ordinary agricultural products and green agricultural products are respectively w_{f1}、 w_{f2} .For farmers to produce agricultural products with g green degree, the supermarket gives the green degree subsidy of $c_s g$ per unit, so as to encourage farmers to improve their green level.

Therefore, under this premise $\begin{cases} p_1G_2 - p_2G_1 \le 0 \\ p_2 - p_1 - t(G_2 - G_1) \le 0 \end{cases}$, if the supermarket ordered ordinary agricultural products and green agricultural products from two farmers separately, the farmers' income function with ordinary agricultural products would be：

$$\pi_{f1}(w_{f1}) = (w_{f1} - c_{f1} + c_s g_1)Q_1 = (w_{f1} - c_{f1} + c_s g_1)\frac{p_2G_1 - p_1G_2}{tG_1(G_2 - G_1)} \quad (4)$$

The income function of farmers producing green agricultural products is:

$$\pi_{f2}(w_{f2}) = (w_{f2} - c_{f2} + c_s g_2)Q_2 = (w_{f2} - c_{f2} + c_s g_2)\frac{t(G_2 - G_1)\text{-}p_2 + p_1}{t(G_2 - G_1)} \quad (5)$$

The revenue function of the supermarket is：

$$\begin{aligned}\pi_s(p_1, p_2) &= (p_1 - w_{f1} - c_s g_1)Q_1 + (p_2 - w_{f2} - c_s g_2)Q_2 \\ &= (p_1 - w_{f1} - c_s g_1)\frac{p_2G_1 - p_1G_2}{tG_1(G_2 - G_1)} + (p_2 - w_{f2} - c_s g_2)\frac{t(G_2 - G_1)\text{-}p_2 + p_1}{t(G_2 - G_1)}\end{aligned} \quad (6)$$

The profit function of the whole supply chain is:

$$\begin{aligned}&\pi_{sc}(p_1, p_2) = (p_1 - c_{f1})Q_1 + (p_2 - c_{f2})Q_2 \\ &= (p_1 - c_{f1})\frac{G_1p_2 - G_2p_1}{tG_1(G_2 - G_1)} \\ &+ (p_2 - c_{f2})\frac{t(G_2 - G_1)\text{-}p_2 + p_1}{t(G_2 - G_1)}\end{aligned} \quad (7)$$

Centralized decision model

The profit function of the whole supply chain is：

$$\begin{aligned}&\pi_{sc}(p_1, p_2) = (p_1 - c_{f1})Q_1 + (p_2 - c_{f2})Q_2 \\ &= (p_1 - c_{f1})\frac{G_1p_2 - G_2p_1}{tG_1(G_2 - G_1)} \\ &+ (p_2 - c_{f2})\frac{t(G_2 - G_1)\text{-}p_2 + p_1}{t(G_2 - G_1)}\end{aligned} \quad (7)$$

From the previous analysis, if you want the supermarket to differentiate between ordinary agricultural products and green agricultural products, it needs to be satisfied

$$\begin{cases} p_1 \dfrac{k}{1+ae^{-bg_2}} - p_2 \dfrac{k}{1+ae^{-bg_1}} \le 0 \\ p_2 - p_1 - t(\dfrac{1}{1+ae^{-bg_2}} - \dfrac{1}{1+ae^{-bg_1}}) \le 0 \end{cases}$$

Therefore, the optimal benefit of the whole supply chain can be expressed by the following model：

$$\pi_{sc}\left(p_1, p_2\right) = \left(p_1 - c_{f1}\right)Q_1 + \left(p_2 - c_{f2}\right)Q_2$$

$$= \left(p_1 - c_{f1}\right)\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)} + \left(p_2 - c_{f2}\right)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right) \quad \text{s.t. } p_1 G_2 - p_2 G_1 \le 0$$

$$p_2 - p_1 - t\left(G_2 - G_1\right) \le 0 \quad (8)$$

Let：

$$L_1\left(p_1, p_2\right) = \left(p_1 - c_{f1}\right)\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)} + \left(p_2 - c_{f2}\right)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right) \quad (9)$$

$$+\delta\left(p_1 G_2 - p_2 G_1\right) + \mu\left[p_2 - p_1 - t\left(G_2 - G_1\right)\right]$$

The K-T condition of the above planning problem is：

$$\begin{cases} \dfrac{-2G_2 p_1 + 2G_1 p_2 + G_2 c_{f1} - G_1 c_{f2} + tG_1\left(G_2 - G_1\right)\left(\delta G_2 - \mu\right)}{tg_1\left(g_2 - g_1\right)} = 0 \\ \dfrac{2p_1 - 2p_2 - c_{f1} + c_{f2} + t\left(G_2 - G_1\right) + t\left(G_2 - G_1\right)\left(-\delta G_1 + \mu\right)}{t\left(g_2 - g_1\right)} = 0 \\ \delta\left(p_1 G_2 - p_2 G_1\right) = 0 \\ \mu\left[p_2 - p_1 - t\left(G_2 - G_1\right)\right] = 0 \\ \delta \ge 0, \mu \ge 0 \end{cases} \quad (10)$$

To solve the model (10),

when $\begin{cases} G_2 c_{f1} - G_1 c_{f2} \le 0 \\ c_{f2} - c_{f1} - t\left(G_2 - G_1\right) \le 0 \end{cases}$, the optimal solution for planning problem (8) is

$$\begin{cases} p_1^* = p_1^{3*} = \dfrac{c_{f1} + tG_1}{2} = \dfrac{c_{f1} + t\dfrac{k}{1+ae^{-bg_1}}}{2} \\ p_2^* = p_2^{3*} = \dfrac{c_{f2} + tG_2}{2} = \dfrac{c_{f2} + t\dfrac{k}{1+ae^{-bg_2}}}{2} \end{cases} \quad (11)$$

It can be known from the analysis of the above. Relative to the supermarkets sell only common agricultural products or green agricultural products, the income of the supermarket which sell common agricultural products and green agricultural products at the same time gained more by the entire supply chain. It is advantageous for the supermarket to differentiate the common agricultural products and green agricultural products, so it is necessary for the supermarket to carry out the differential operation.

Property1. When $\begin{cases} G_2 c_{f1} - G_1 c_{f2} \le 0 \\ c_{f2} - c_{f1} - t(G_2 - G_1) \le 0 \end{cases}$, the optimal decision under centralized decision is

$$\begin{cases} p_1^* = p_1^{3*} = \dfrac{c_{f1} + tG_1}{2} = \dfrac{c_{f1} + t\dfrac{k}{1+ae^{-bg_1}}}{2} \\ p_2^* = p_2^{3*} = \dfrac{c_{f2} + tG_2}{2} = \dfrac{c_{f2} + t\dfrac{k}{1+ae^{-bg_2}}}{2} \end{cases} \quad (12)$$

The whole supply chain has the benefit of $\pi_{sc}^* = \frac{tG_1 - c_{f1}}{2} \cdot \frac{G_1 c_{f2} - G_2 c_{f1}}{2tG_1(G_2 - G_1)} + \frac{tG_2 - c_{f2}}{2} \cdot \frac{t(G_2 - G_1) + c_{f1} - c_{f2}}{2t(G_2 - G_1)}$

(13)

Property2. When $\begin{cases} G_2 c_{f1} - G_1 c_{f2} \le 0 \\ c_{f2} - c_{f1} - t(G_2 - G_1) \le 0 \end{cases}$, in a centralized decision.

(1) Common agricultural products sales price only with ordinary agricultural production cost and common agricultural product green degree, have nothing to do with the green agricultural products, and when ordinary farm production costs and ordinary agricultural product green degree rise, ordinary sales of agricultural products prices will rise.

(2) Green agricultural products sales price only with the cost of production of green agricultural products and green degree of green agricultural products, has nothing to do with ordinary agricultural products, and as the green agricultural production costs and the rise of green degree of green agricultural products, green agricultural products sales price will rise.

Decentralized decision model

Assume that supermarkets for this differential operation, the supermarkets which purchase agricultural products have two kinds of decision making, choosing one farmer is a kind of supermarket purchasing common agricultural products and green agricultural products at the same time and there is a supermarket to choose two farmers purchasing common agricultural products and green agricultural products. Under the discussion of decentralized decision, the supermarket adopts the optimal decision of these two kinds of decisions based on Stackelberg game and compares the choice which the supermarket adopts to its advantage.

Supermarket choosing one farmer

This section assumption for the differentiation of the agricultural products to the supermarket to choose one farmer (or cooperative), supermarkets and farmers intention agreement has been signed, for farmers to grow both common agricultural products and green agricultural products, in this way, the supermarket need common agricultural products and green agricultural products ,it can be order from the farmer.

At this point, the income function of the farmer is：

$$\begin{aligned} \pi_f(w_{f1}, w_{f2}) &= (w_{f1} - c_{f1} + c_s g_1)Q_1 + (w_{f2} - c_{f2} + c_s g_2)Q_2 \\ &= (w_{f1} - c_{f1} + c_s g_1)\frac{G_1 p_2 - G_2 p_1}{tG_1(G_2 - G_1)} + (w_{f2} - c_{f2} + c_s g_2)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right) \end{aligned} \quad (14)$$

Similarly, the premise that the supermarket undertakes differentiating operation is $\begin{cases} p_1G_2 - p_2G_1 \le 0 \\ p_2 - p_1 - t\left(G_2 - G_1\right) \le 0 \end{cases}$. Moreover, farmers and supermarkets are based on Stackelberg game and the farmers are the leaders of the game, the followers of the supermarket and the game model is：

$$max\pi_f\left(w_{f1}, w_{f2}\right) = max\{\left(w_{f1} - c_{f1} + c_s g_1\right)\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)} + \left(w_{f2} - c_{f2} + c_s g_2\right)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right)\}$$

$$\text{s.t. } \max\pi_s\left(p_1, p_2\right) = \max\{\left(p_1 - w_{f1} - c_s g_1\right)\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)} + \left(p_2 - w_{f2} - c_s g_2\right)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right)\}$$

$$p_1G_2 - p_2G_1 \le 0$$
$$p_2 - p_1 - t\left(G_2 - G_1\right) \le 0 \qquad (15)$$

The model (15) was solved by inverse method， First, solve the planning problem：

$$\max\pi_s\left(p_1, p_2\right) = \max\{\left(p_1 - w_{f1} - c_s g_1\right)\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)} + \left(p_2 - w_{f2} - c_s g_2\right)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right)\}$$

$$\text{s.t. } p_1G_2 - p_2G_1 \le 0$$
$$p_2 - p_1 - t\left(G_2 - G_1\right) \le 0 \qquad (16)$$

let：

$$L_2\left(p_1, p_2\right) = \left(p_1 - w_{f1} - c_s g_1\right)\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)} + \left(p_2 - w_{f2} - c_s g_2\right)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right) + \delta\left(p_1G_2 - p_2G_1\right) + \mu\left[p_2 - p_1 - t\left(G_2 - G_1\right)\right] \qquad (17)$$

The K-T condition of the above planning problem is：

$$\begin{cases} \frac{-2G_2 p_1 + 2G_1 p_2 + G_2 w_{f1} - G_1 w_{f2} + c_s g_1 G_2 - c_s G_1 g_2 + tG_1\left(G_2 - G_1\right)\left(\delta G_2 - \mu\right)}{tG_1\left(G_2 - G_1\right)} = 0 \\ \frac{2p_1 - 2p_2 - \left(w_{f1} + c_s g_1\right) + \left(w_{f2} + c_s g_2\right) + t\left(G_2 - G_1\right) + t\left(G_2 - G_1\right)\left(-\delta G_1 + \mu\right)}{t\left(G_2 - G_1\right)} = 0 \\ \delta\left(p_1G_2 - p_2G_1\right) = 0 \\ \mu\left[p_2 - p_1 - t\left(G_2 - G_1\right)\right] = 0 \\ \delta \ge 0, \mu \ge 0 \end{cases} \qquad (18)$$

The solution model (18) is solved and the result is substituted into the model (15). The optimal solution is obtained.

So for the whole model (15), the best wholesale price is：

$$\begin{cases} w_{f1}^{**} = \dfrac{c_{f1} + tG_1 - 2c_s g_1}{2} \\ w_{f2}^{**} = \dfrac{c_{f2} + tG_2 - 2c_s g_2}{2} \end{cases} \quad (19)$$

By substituting (19) into (18), the best selling price of the whole model (15) is obtained. :

$$\begin{cases} p_1^{**} = \dfrac{c_{f1} + 3tG_1}{4} = \dfrac{c_{f1} + 3t\dfrac{k}{1+ae^{-bg_1}}}{4} \\ p_2^{**} = \dfrac{c_{f2} + 3tG_2}{4} = \dfrac{c_{f2} + 3t\dfrac{k}{1+ae^{-bg_2}}}{4} \end{cases} \quad (20)$$

Property 3. Under decentralized decision making based on Stackelberg game , when supermarket choose one farmers to order common agricultural products and green agricultural products at the same time, contrast to supermarkets sell only ordinary or green agricultural products, supermarket will choose differential operation to carried out on the common agricultural products and green agricultural products.

Property4. Under the decentralized decision, when $\begin{cases} G_2 c_{f1} - G_1 c_{f2} \le 0 \\ c_{f2} - c_{f1} - t(G_2 - G_1) \le 0 \end{cases}$ and the supermarket selects the same farmers and orders the common agricultural products and green agricultural products, the optimal decision of the decision model based on Stackelberg is :

$$\begin{cases} p_1^{**} = \dfrac{c_{f1} + 3tG_1}{4} = \dfrac{c_{f1} + 3t\dfrac{k}{1+ae^{-bg_1}}}{4} \\ p_2^{**} = \dfrac{c_{f2} + 3tG_2}{4} = \dfrac{c_{f2} + 3t\dfrac{k}{1+ae^{-bg_2}}}{4} \\ w_{f1}^{**} = \dfrac{c_{f1} + tG_1 - 2c_s g_1}{2} \\ w_{f2}^{**} = \dfrac{c_{f2} + tG_2 - 2c_s g_2}{2} \end{cases}$$

Property 5. In decentralized decision-making, when $\begin{cases} G_2 c_{f1} - G_1 c_{f2} \le 0 \\ c_{f2} - c_{f1} - t(G_2 - G_1) \le 0 \end{cases}$, and the supermarket selects one farmer to order both ordinary and green agricultural products.

(1) Common agricultural products sales price only with ordinary agricultural production cost and common agricultural product green degree, have nothing to do with the green agricultural products, and when ordinary farm production costs and ordinary agricultural product green degree rise, ordinary sales of agricultural products prices will rise.

(2) Green agricultural products sales price only with the cost of production of green agricultural products and green degree of green agricultural products, has nothing to do with ordinary agricultural products,

and as the green agricultural production costs and the rise of green degree of green agricultural products, green agricultural products sales price will rise.

Decentralized decision making, when the supermarket selects one farmer to order ordinary produce and green produce, the profit of the supermarket is：

$$\pi_s^{**}=\frac{tG_1-c_{f1}}{4}\cdot\frac{G_1c_{f2}-G_2c_{f1}}{4tG_1\left(G_2-G_1\right)}+\frac{tG_2-c_{f2}}{4}\cdot\frac{t\left(G_2-G_1\right)-c_{f2}+c_{f1}}{4t\left(G_2-G_1\right)} \quad (21)$$

The benefit of the whole supply chain is：

$$\pi_{sc}^{**}=\frac{3\left(tG_1-c_{f1}\right)}{4}\cdot\frac{G_1c_{f2}-G_2c_{f1}}{4tG_1\left(G_2-G_1\right)}+\frac{3\left(tG_2-c_{f2}\right)}{4}\cdot\frac{t\left(G_2-G_1\right)+c_{f1}-c_{f2}}{4t\left(G_2-G_1\right)} \quad (22)$$

Property 6. Under the decentralized decision, when $\begin{cases} G_2c_{f1}-G_1c_{f2}\le 0 \\ c_{f2}-c_{f1}-t\left(G_2-G_1\right)\le 0\end{cases}$ and the supermarket selects one farmer and orders the ordinary agricultural products and green agricultural products, the situation is compared with the centralized decision：

(1) The selling price of common agricultural products and green agricultural products under decentralized decision making is higher than that of ordinary agricultural products and green agricultural products；
(2) The benefit of the whole supply chain is greater than that of the whole supply chain.

Supermarkets select two farmers

Assumptions for the differentiation of the agricultural products to the supermarket to choose two farmers (or cooperative),one planting common agricultural products, another planting green agricultural products and the information is completely symmetrical, supermarket order common agricultural products and green agricultural products from the two farmers.

At this point, the income function of farmers 1 with ordinary agricultural products is：

$$\pi_{f1}\left(w_{f1}\right)=\left(w_{f1}-c_{f1}+c_sg_1\right)Q_1=\left(w_{f1}-c_{f1}+c_sg_1\right)\frac{G_1p_2-G_2p_1}{tG_1\left(G_2-G_1\right)} \quad (23)$$

The income function of farmers 2 producing green agricultural products is:

$$\pi_{f2}\left(w_{f2}\right)=\left(w_{f2}-c_{f2}+c_sg_2\right)Q_2=\left(w_{f2}-c_{f2}+c_sg_2\right)\frac{1}{t}\left(t-\frac{p_2-p_1}{G_2-G_1}\right) \quad (24)$$

Decisions of supermarkets and farmers are assumed to Stackelberg game, farmers 1 and 2 is the leader in the Stackelberg game, farmers between 1 and 2 in a fully equal information and know each other's information, the followers of supermarket as a Stackelberg game.

The game model is：

$$max\pi_{f1}\left(w_{f1}\right)=\max\left\{\left(w_{f1}-c_{f1}+c_sg_1\right)\frac{G_1p_2-G_2p_1}{tG_1\left(G_2-G_1\right)}\right\}$$

$$max\pi_{f2}\left(w_{f2}\right)=\max\left\{\left(w_{f2}-c_{f2}+c_sg_2\right)\frac{1}{t}\left(t-\frac{p_2-p_1}{G_2-G_1}\right)\right\}$$

$$\text{s.t. } \max\pi_s\left(p_1,p_2\right)=\max\{\left(p_1-w_{f1}-c_s g_1\right)\frac{G_1p_2-G_2p_1}{tG_1\left(G_2-G_1\right)}$$
$$+\left(p_2-w_{f2}-c_s g_2\right)\frac{1}{t}\left(t-\frac{p_2-p_1}{G_2-G_1}\right)\}$$
$$p_1G_2-p_2G_1\le 0$$
$$p_2-p_1-t\left(G_2-G_1\right)\le 0 \qquad (25)$$

By solving the model (25), the optimal wholesale price is as follows:

$$\begin{cases} w_{f1}^{***}=\dfrac{2G_2c_{f1}+G_1c_{f2}+tG_1\left(G_2-G_1\right)-c_s g_1\left(4G_2-G_1\right)}{4G_2-G_1} \\ w_{f2}^{***}=\dfrac{G_2c_{f1}+2G_2c_{f2}+2tG_2\left(G_2-G_1\right)-c_s g_2\left(4G_2-G_1\right)}{4G_2-G_1} \end{cases} \qquad (26)$$

The formula (26) is substituted into the formula (25). The optimal sales price of ordinary agricultural products and green agricultural products is respectively：

$$\begin{cases} p_1^{***}=\dfrac{2G_2c_{f1}+G_1c_{f2}+tG_1\left(5G_2-2G_1\right)}{2\left(4G_2-G_1\right)} \\ p_2^{***}=\dfrac{G_2c_{f1}+2G_2c_{f2}+3tG_2\left(2G_2-G_1\right)}{2\left(4G_2-G_1\right)} \end{cases} \qquad (27)$$

Property 7. Under the decentralized decision, when $\begin{cases} \left(tG_1-c_{f1}\right)\left(G_2-G_1\right)+G_1c_{f2}-G_2c_{f1}\ge 0 \\ 2\left(tG_2-c_{f2}\right)\left(G_2-G_1\right)-G_1c_{f2}+G_2c_{f1}\ge 0 \end{cases}$, and the supermarket selects two farmers to order the ordinary produce and fresh produce separately, the optimal decision is：

$$\begin{cases} p_1^{***}=\dfrac{2G_2c_{f1}+G_1c_{f2}+tG_1\left(5G_2-2G_1\right)}{2\left(4G_2-G_1\right)} \\ p_2^{***}=\dfrac{G_2c_{f1}+2G_2c_{f2}+3tG_2\left(2G_2-G_1\right)}{2\left(4G_2-G_1\right)} \\ w_{f1}^{***}=\dfrac{2G_2c_{f1}+G_1c_{f2}+tG_1\left(G_2-G_1\right)-c_s g_1\left(4G_2-G_1\right)}{4G_2-G_1} \\ w_{f2}^{***}=\dfrac{G_2c_{f1}+2G_2c_{f2}+2tG_2\left(G_2-G_1\right)-c_s g_2\left(4G_2-G_1\right)}{4G_2-G_1} \end{cases} \qquad (28)$$

Under the decentralized decision, When $\begin{cases} \left(tG_1 - c_{f1}\right)\left(G_2 - G_1\right) + G_1 c_{f2} - G_2 c_{f1} \ge 0 \\ 2\left(tG_2 - c_{f2}\right)\left(G_2 - G_1\right) - G_1 c_{f2} + G_2 c_{f1} \ge 0 \end{cases}$ and the supermarket selects two farmers to order ordinary produce and green agricultural products respectively. The revenue of supermarket is：

$$\pi_s^{***} = \frac{3tG_1G_2 - 2G_2c_{f1} - G_1c_{f2}}{2\left(4G_2 - G_1\right)} \cdot \frac{G_2\left(G_1 - 2G_2\right)c_{f1} + G_1G_2c_{f2} + tG_1G_2\left(G_2 - G_1\right)}{2tG_1\left(G_2 - G_1\right)\left(4G_2 - G_1\right)}$$
$$+ \frac{tG_2\left(2G_2 + G_1\right) - G_2c_{f1} - 2G_2c_{f2}}{2\left(4G_2 - G_1\right)} \cdot \frac{G_2c_{f1} - \left(2G_2 - G_1\right)c_{f2} + 2tG_2\left(G_2 - G_1\right)}{2t\left(G_2 - G_1\right)\left(4G_2 - G_1\right)} \qquad (29)$$

Property 8. When $\begin{cases} G_2 c_{f1} - G_1 c_{f2} \le 0 \\ c_{f2} - c_{f1} - t\left(G_2 - G_1\right) \le 0 \end{cases}$ the supermarket income which choose two farmers to order the general agricultural products and green agricultural products is greater than the supermarket income of choosing one farmers at the same time ordering the general agricultural products and green agricultural products.

From the property of 6, it can know that the income of supermarket which choose two farmers to order the general agricultural products and green agricultural products is greater than the supermarket income of choosing one farmers at the same time ordering the general agricultural products and green agricultural products. Supermarket choose two farmers, ordering common agricultural products and green agricultural products and let the two farmers to competition, the supermarkets can get greater benefits. In general the output of agricultural products are greatly influenced by the weather and so on, if there are any hail, drought and other bad weather, the output of agricultural products may be affected, supermarket to choose two farmers order ordinary agricultural products and green agricultural products will also reduce the risk of the supply of agricultural products affected by weather.

Supply chain coordination

From the above analysis, the above contract cannot realize the whole supply chain coordination. Therefore, this part proposes a "wholesale price + ordering subsidy" coordination mechanism. In order to reduce the economic burden of farmers and to improve the green degree of agricultural products before the transaction starts, supermarkets will subsidize $c_s g$ per unit for each unit. In order to improve the quantity of the supermarket, also in order to make the supermarkets and farmers become a more closely the interests of the community, make the supermarket and closer cooperation between farmers, at the end of the deal, farmers will take out part of their income to the supermarket order certain subsidies, it is assumed that the supermarket order subsidies for farmers： $\varphi_1 w_{f1} Q_1 + \varphi_2 w_{f2} Q_2$. One of them φ_1 is the proportion of the farmers' ordering subsidy for the ordinary agricultural of the supermarket and the proportion φ_2 of the purchase subsidy for the green agricultural products from the farmers to the supermarket.

Under the "wholesale price + ordering subsidy" contract, the profit function of the supermarket becomes：

$$\pi_s\left(p_1, p_2\right) = \left(p_1 - w_{f1} - c_s g_1\right)\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)} + \varphi_1 w_{f1}\frac{G_1 p_2 - G_2 p_1}{tG_1\left(G_2 - G_1\right)}$$
$$+\left(p_2 - w_{f2} - c_s g_2\right)\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right) + \varphi_2 w_{f2}\frac{1}{t}\left(t - \frac{p_2 - p_1}{G_2 - G_1}\right) \qquad (30)$$

The planning problem of the supermarket is：

$$\max\pi_s\left(p_1,p_2\right)=\max\{\left(p_1-w_{f1}-c_s g_1\right)\frac{G_1p_2-G_2p_1}{tG_1\left(G_2-G_1\right)}+\varphi_1 w_{f1}\frac{G_1p_2-G_2p_1}{tG_1\left(G_2-G_1\right)}$$
$$+\left(p_2-w_{f2}-c_s g_2\right)\frac{1}{t}\left(t\text{-}\frac{p_2-p_1}{G_2-G_1}\right)+\varphi_2 w_{f2}\frac{1}{t}\left(t-\frac{p_2-p_1}{G_2-G_1}\right)$$
$$\text{s.t}\quad G_2p_1-G_1p_2\le 0$$
$$p_2-p_1-t\left(G_2-G_1\right)\le 0 \qquad (31)$$

By using the same programming method, we can get:

Property 9. **I**n the "wholesale price + purchase subsidy" contract, the optimal sales price of ordinary agricultural products and green agricultural products is：

$$\begin{cases} p_1^{****}=\dfrac{\left(1-\varphi_1\right)w_{f1}+tG_1+c_s g_1}{2} \\ p_2^{****}=\dfrac{\left(1-\varphi_2\right)w_{f2}+tG_2+c_s g_2}{2}\end{cases} \qquad (32)$$

Property 10. When $\begin{cases} G_2c_{f1}-G_1c_{f2}\le 0 \\ c_{f2}-c_{f1}-t\left(G_2-G_1\right)\le 0\end{cases}$ and the contract parameter $(w_{f1},\varphi_1,w_{f2},\varphi_2)$ satisfies the following relationship, the "wholesale price + subscription subsidy" contract can coordinate the whole supply chain：

$$\begin{cases} w_{f1}=\dfrac{c_{f1}-c_s g_1}{1-\varphi_1} \\ w_{f2}=\dfrac{c_{f2}-c_s g_2}{1-\varphi_2}\end{cases} \qquad (33)$$

Proof: To make the whole supply chain coordination, "wholesale price + order subsidy" under the contract of ordinary optimal sale price of agricultural products and green agricultural products should be equal to the centralized decision making ordinary optimal sale price of agricultural products and green agricultural products, namely $\begin{cases} p_1^{*}=p_1^{****} \\ p_2^{*}=p_2^{****}\end{cases}$, So to solve it ,it can get $\begin{cases} w_{f1}=\dfrac{c_{f1}-c_s g_1}{1-\varphi_1} \\ w_{f2}=\dfrac{c_{f2}-c_s g_2}{1-\varphi_2}\end{cases}$.

5 Numerical example

Based on the assumption $\begin{cases} G_2c_{f1}-G_1c_{f2}\le 0 \\ c_{f2}-c_{f1}-t\left(G_2-G_1\right)\le 0\end{cases}$, let $\text{k}=1,\text{a}=3,\text{b}=1,G_1=0.4\left(g_1=0.69\right),.G_2=0.8\left(g_2=2.48\right),c_{f1}=2,c_{f2}=5,c_s=1,t=10$

Table 1.

	Centralized decision-making	One farmer	Two farmers
p_1	3	$7/2$	$45/14$
p_2	$13/2$	$29/4$	$48/7$
π_s	*	$5/64$	$73/392$
π_{sc}	$5/16$	$15/64$	$116/392$

Table 1 respectively to calculate the concentration of decision making and decentralized decision making, 1 or 2 farmers and three cases of normal optimal sale price of agricultural products and green agricultural products, the optimal income of supermarket and the optimal benefits of entire supply chain. By comparison, the benefits of the entire supply chain under centralized decision making are more than the benefits of the whole supply chain under decentralized decision making, so supermarkets and farmers choose cooperation by coordination mechanism (this paper put forward a "wholesale + order subsidy coordination mechanism"), such gains can be higher than gains that non-cooperative condition. Under centralized decision making, the average selling prices of agricultural products and green agricultural products are lower than the selling price under decentralized decision making. If supermarkets and farmers cooperation, consumers can buy products at a lower price. Therefore, when supermarkets cooperate with farmers, supermarkets, farmers and consumers can benefit from it.

Under decentralized decision making, as supermarkets choose two farmers ordering common agricultural products and green agricultural products will get more than choosing one farmer at the same time ordering the general agricultural products and green agricultural products. The two farmers are competing with each other, and supermarkets can benefit from the competition between the two farmers.

Let's take a look at the impact of green levels on sales prices.

FIG. 2 the trend of the sales price of ordinary agricultural products with the change of green degree g_1

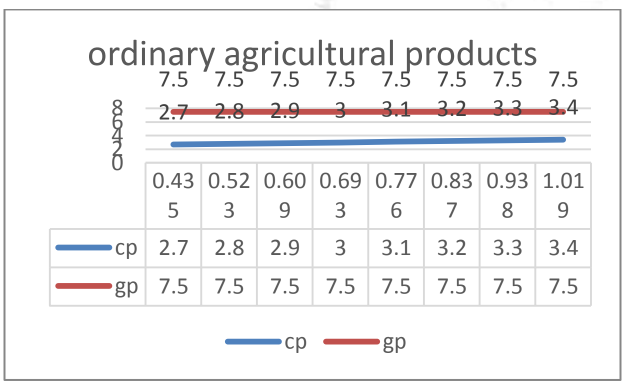


FIG. 2 the trend of the sales price of ordinary agricultural products with the change of green degree g_1 (cp: common agricultural products price; gp: green agricultural products price)

In figure 2, the horizontal coordinate is the green degree g_1 of common agricultural products, and the vertical coordinate is the selling price of agricultural products. In figure 2, $g_2 = 2.48, c_{f1} = 2, c_{f2} = 5, c_s = 1, t = 10$, when the green degree g_1 of common agricultural products changes, the change trend of the optimal sales price of ordinary agricultural products and green agricultural products is concentrated. Can be seen from the figure 2, when ordinary agricultural products green degree increases, the common agricultural products sales price increase, but the green agricultural products sales prices unchanged, ordinary agricultural product green degree has no effect on the sale price of green agricultural products.

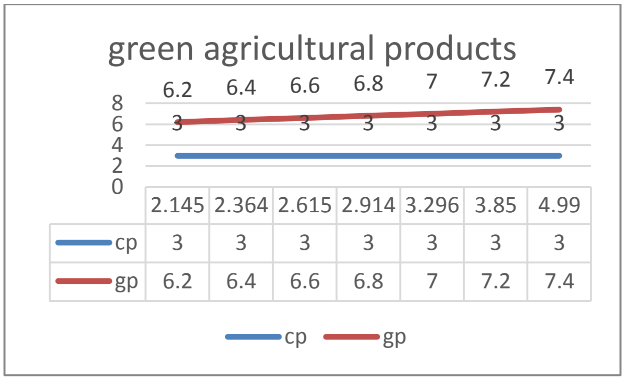


FIG. 3 the trend of the sales price of agricultural products with the green degree g_2 of green agricultural. (cp :common agricultural products price ;gp :green agricultural products price)

In figure 3, the horizontal coordinate is the green degree g_2 of green agricultural products, and the vertical coordinate is the selling price of agricultural products. In figure 3, $g_1 = 0.69, c_{f1} = 2, c_{f2} = 5, c_s = 1, t = 10$, When the green degree g_2 of green agricultural products changes, the change trend of the optimal sales price of ordinary agricultural products and green agricultural products is concentrated. As can be seen from the figure 3, when the green degree of green agricultural products increase, the sales price of green agricultural products increases, but the ordinary agricultural products sales prices unchanged, green degree of green agricultural products has no effect on average sales of agricultural products prices.

Due to different cognitive level of consumers of green agricultural products and consumer's age, gender, education, income of different, different consumer will be different preferences of common agricultural products and green agricultural products, supermarket for differential operation can meet the needs of most consumers, retain more customers. Below, we use the data to verify that the supermarket undertakes differentiating operation is necessary.

Table 4 shows the profitability of supply chain under centralized decision-making.

	Sell only green products	Sell only ordinary products	different operation
g_1 =0.693, g_2 =2.48	$9/32$	$1/4$	$5/16$
g_1=0.898, g_2 =3.296	$4/9$	$25/72$	$13/27$

Table 4 is respectively under centralized decision making supermarkets sell only green agricultural products, supermarkets sell only ordinary agricultural products and supermarkets sell common agricultural products and green agricultural products to carry on the differential operation of the whole supply chain profit. By comparing, table 4 shows that the entire supply chain has the highest income differential operation of earnings in the supermarket.

Table 5 for supermarket under decentralized decision making choosing one farmer of farmers income

	Sell only green products	Sell only ordinary products	different operation
g_1 =0.693, g_2 =2.48	$9/64$	$1/8$	$5/32$
g_1=0.898, g_2 =3.296	$2/9$	$25/144$	$13/54$

Table 5 is decentralized decision making of supermarket choosing one farmers when ordering common agricultural products and green agricultural products at the same time, the supermarket sell only green agricultural products, sell only ordinary agricultural products and operate differential to common agricultural products and green agricultural products, the income gained by the farmer. By comparing table 4, under the supermarket differential operation, the income of the farmer is highest, because the farmer is the leader in the Stackelberg game, farmer will formulate appropriate agricultural wholesale prices to make supermarket choosing differentiation.

Because the supermarket chooses two farmers to order ordinary produce and green produce separately, the supermarket will be operated differential. Through table 4 and table 5, it can be learned that, whether in centralized decision-making or decentralized decision-making, supermarkets can differentiate between ordinary agricultural products and green agricultural products.

Conclusion

This paper studies the agricultural products supply chain problem of farmers and supermarkets connection. The supermarket operates differential of agricultural products, which is of one kind of agricultural products at the same time sales of ordinary and green agricultural products and built a consumer utility function which relate to green agricultural products and prices, assuming that the consumer utility function is about the degree of green agricultural products and the selling price of the combined form $u(g,p)=\theta m(g)-n(p)$. From the analysis of the reality of agricultural products green degree of consumer utility is roughly a s curve, it just conforms to the logistic model, therefore, assuming that agricultural product green degree of consumer utility function $m(g)$ obey the logistic model, namely $m(g)=\dfrac{k}{1+ae^{-bg}}$. According to the green degree of agricultural products, consumers choose their own purchase behavior based on utility function.

Based on the optimal solution of concentrated model and dispersion model, average selling prices of agricultural products and green agricultural products is only related to their own green degree and with the increase of their green degrees, the price increase. In the case of centralized decision making and supermarket only select one farmer to order both ordinary produce and green agricultural products, the supermarket will choose to conduct differentiated operation at last. For the entire supply chain and consumers, the centralized model is better than the dispersion model. Under the decentralized model, it discussed the supermarket order ordinary agricultural products and green agricultural products of choosing one farmer or two farmers respectively. We found that the income of supermarket which chose two farmers to gain more than the income of the supermarket which chose one farmer. Finally, we coordinated the whole supply chain with the coordination mechanism of "wholesale price + ordering subsidy".

It forward a degree of green agricultural products and sales price combined forms of consumer utility function and agricultural product green degree of consumer utility function obey logistic model, but it consider the green degree of agricultural products as a constant, the following research can consider the green degree of products as decision variables, to find the optimal degree of green which make the supermarket to get maximum. Agricultural production is closely related to factors such as weather, the output of agricultural products is not stable, so there is a certain risk. As the following research, risk can also be based on the discussion, in order to take better decisions to deal with risks.

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