Game Analysis and Countermeasures on Increasing Prices of Agricultural Products under Triple Supply Chain

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Abstract From the perspective of supply chain of agricultural products, by establishing Stackelberg game model based on triple supply chain, this paper researches the price formation and profit distribution mechanism of agricultural products under circumstance of non-cooperation and cooperation. The results show the main factors responsible for the hiking of prices of agricultural products as follows: the cost of agricultural products climbs incessantly; the circulation cost hovers at high level; the factor inputs of agricultural products are short; inflation pressure is incessantly mounting; the profit distribution of supply chain is irrational. Finally, corresponding countermeasures are put forward.

Key words Triple supply chain, Stackerlberg game model, Price formation mechanism, China

Price formation mechanism of agricultural products, farmers' profit and benefit, have a close relationship with supply chain of agricultural products. The supply chain of agricultural products is a network chain that the agricultural products move along farmers, cooperatives, processing enterprises, logistics center, retailers, and consumers. It is a logistics chain of product connecting suppliers, producers and consumers, and also a value-added chain that the agricultural products add value in supply chain, which can not only strengthen connection among farmers, distributors, retailers and consumers in the process of production and circulation of agricultural products, but also promote industrialization degree of production, processing and circulation of agricultural products, thus it is an important means for operators of agricultural products to acquire market competitive advantage[1-3]. From the perspective of supply chain of agricultural products, this paper establishes Stackelberg model of triple supply chain including " farmers – distributors – retailers", discusses prices formation of agricultural products and profit distribution mechanism under non-cooperative and cooperative game situation respectively, analyses the main factors responsible for rise in price of agricultural products in China, and further proposes countermeasures and suggestions for addressing rise in price of agricultural products currently in China.

1 Stackelberg model of agricultural products under triple supply chain

1.1 Establishment of basic hypothesis and model Supply chain, taking leading enterprises as core, is a network integrating a series of functional activities, from raw material procurement and production, to finally delivering products to end-users. In terms of production and circulation of agricultural product, it is in general consistent with the supply chain model of " farmers – distributors – consumers". As China's production areas of agricultural products are far away from sales areas of agricultural products, the farmers are mainly small-scale farmers who conduct decentralized management, unable to bear high distribution costs of processing, storage, and transportation of agricultural products; although the retailers has some advantages in final pricing of agricultural products, owing to dearth of perfect purchase, transportation and marketing network of agricultural products, coupled with high cost of self-built distribution center, in the existing triple supply chain of agricultural products, the distributors are in a dominant position. Under the circumstance of taking into account response of farmers and retailers, the distributors first determine the purchase price and the wholesale price of agricultural products, then the farmers and retailers immediately respond to the relevant prices, and finally determine the market retail price.

Assuming that the retailers sell agricultural products at the price P_3; C_3 is the average retail cost; α is the loss rate of agricultural products in the retail part (including natural and man-made losses); let $\xi = 1/(1-\alpha)$; Q is consumers' demand for agricultural products; m is consumer income levels, $Q = m - bP_3$; the distributors provide agricultural products for retailers at the price P_2; C_2 is the average distribution costs; β is the loss rate of agricultural products in the distribution part (including natural and man-made losses); let $\rho = 1/(1-\beta)$; based on relevant information, the farmers produce $Q\xi\rho$ agricultural products; C_1 is the average production costs; the products are sold to distributors at the price P_1, $Q\xi\rho = e - dP_1$, that is, the purchase price of agricultural products is inversely proportional to the yield of agricultural products. The farmers' profit is $\pi_1 = (P_1 - C_1)\ Q\xi\rho$; distributors' profit is $\pi_2 = (P_2 - P_1\rho - C_2\rho)\ Q\xi$; retailers' profit is $\pi_3 = (P_3 - P_2\xi - C_3\xi)\ Q$; the total profit of supply chain is $\pi = \pi_1 + \pi_2 + \pi_3 = (P_3 - C_1\xi\rho - C_2\xi\rho - C_3\xi)\ Q$.

1.2 Nash noncooperative equilibrium In the above model

Received: September 1, 2011 Accepted: October 2, 2011

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I establish, the distributors are dominant, while the farmers and retailers are in a subordinate position, but the goal they pursue is to maximize their own interests, realizing Nash noncooperative equilibrium. Therefore, we can use Stackelberg model to conduct reverse solving. At first, the retailers respond to the price P_2 set by distributors, to determine the optimal retail price P_3^*, meeting the first-order condition: $\partial\pi_3/\partial P_3 = (m - bP_3) - (P_3 - P_3\xi - C_3\xi) = 0$, namely $P_3^* = [m + b\xi(P_2 + C_3)]/2b$; farmers' realization of maximum self-interests meets the first-order condition $\partial\pi_1/\partial P_1 = (e - dP_1) - d(P_1 - C_1) = 0$, namely $P_1^* = (e + dC_1)/2b$; secondly, by virtue of core status in entire supply chain, the distributors fully take into account the response of farmers and retailers, and then determine the final distribution price P_2^*, meeting the first-order condition $\partial\pi_2/\partial P_2 = \xi\{[m - b\xi(P_2 + C_3)] - b\xi[P_2 - (e + dC_1)\rho/2d - C_2\rho]/2\}/2 = 0$, namely $P_2^* = 2[m/b\xi - C_3 + (e + d\ C_1)\rho/4d + C_2\rho]/3$; the profit of all main body in supply chain is as follows respectively: $\pi_1^* = (e - dC_1)^2/4d$; $\pi_2^* = b(2m/b - e\xi\rho/d - C_1\rho\xi - 2C_2\rho\xi - 2C_3\xi)/36$; $\pi_3^* = b(2m/b - e\xi\rho/d - C_1\rho\xi - 2C_2\rho\xi - 2C_3\xi)/144$.

1.3 Pareto cooperative equilibrium Cooperative equilibrium of agricultural products means that all subjects in supply chain unite together, unify prices by decision-making, to realize maximum holistic benefits of supply chain system: Max $\pi = (P_3 - C_1\xi\rho - C_2\xi\rho - C_3\xi)\ Q$, meeting the first-order condition $\partial\pi/\partial P_3 = m - bP_3 - b(P_3 - C_1\xi\rho - C_2\xi\rho - C_3\xi) = 0$, namely $P_3^{**} = m/2b + (C_1\xi\rho + C_2\xi\rho + C_3\xi)/2$, and the total profit $\pi^{**} = (m - C_1\xi\rho b - C_2\xi\rho b - C_3\xi b)^2/4b$.

By comparing Nash noncooperative equilibrium and Pareto cooperative equilibrium, we can draw the following conclusions: first, the total profit of supply chain under cooperative game is greater than the total profit of supply chain under noncooperative game, namely $\pi^{**} > \pi^*$; second, the retail price under cooperative game is greater than the retail price under noncooperative game, namely $P_3^{**} > P_3^*$; third, the market demand of agricultural products under cooperative game is smaller than the market demand of agricultural products under noncooperative game, namely $Q^{**} < Q^*$. These conclusions are in line with economic theory. As agricultural products are generally necessities, and their price elasticity of demand $e_d < 1$, the total profits of supply chain and market demand price should meet the following condition: $\partial\pi/\partial P_3 = Q(1 - e_d) > 0$, that is, in order to increase total profit of supply chain, it is appropriate to adopt strategy of increasing price, and consumer demand drops with the rising prices of agricultural products, but the dropping amplitude is smaller than the rising amplitude, so as to achieve the overall increase in profits.

1.4 Profit distribution on the basis of ability to bargain Through strategy of internal cooperation in the supply chain to achieve the overall profit increase, the increase parts are distributed according to the status and bargaining power of different subjects in the supply chain. We establish the following bargaining model: Max $(\pi_1^{**} - \pi_1^*)^X(\pi_1^{**} - \pi_1^*)^Y(\pi_1^{**} - \pi_1^*)^Z$ *s. t.* $\pi_1^{**} + \pi_2^{**} + \pi_3^{**} = \pi^{**}$, $\pi_1^* + \pi_2^* + \pi_3^* = \pi^*$.

Where X is bargaining ability of farmers, Y is bargaining ability of distributors, Z is bargaining ability of retailers, and $X + Y + Z = 1$.

By using Lagrangian method, we get equilibrium solution as follows: $\pi_1^{**} = \pi_1^* + X(\pi^{**} - \pi^*)/(X + Y + Z)$; $\pi_2^{**} = \pi_2^* + Y(\pi^{**} - \pi^*)/(X + Y + Z)$ $\pi_3^{**} = \pi_3^* + Z(\pi^{**} - \pi^*)/(X + Y + Z)$. The equilibrium result shows that under cooperative game, farmers, distributors and retailers get more profits than under noncooperative game, and profit of all subjects in supply chain, is positively correlated with total profit and bargaining ability. As farmers are at a disadvantage in the distribution of profits, they get meagre profits and their enthusiasm for production is baffled, resulting in reduced quantity of agricultural products and rising prices.

2 Reason of rise in price of agricultural products

Based on the above game model analysis, we can draw the following reasons for rise in China's agricultural prices.

2.1 The incessantly increasing agricultural production cost sends price of agricultural products up First, with the massive outflow of rural labour, shortage of rural labor resources occurs, and there is a rapid increase in the cost of employing agricultural labour forces. In addition, the demand of urbanization, and industrialization building for rural labor forces are incessantly increased, and non-agricultural incomes are incessantly increased, increasing the existing opportunity cost of agricultural labour forces. Second, the dramatic rise in cost of international means of agricultural production, international energy and other agricultural raw materials, pushes up the cost of production of agricultural materials company and drives the prices of means of agricultural production to hike up. Second, the government's inputs to rural infrastructure building are insufficient, which cannot meet the development needs of the agricultural economy, so the farmers can only rely on their ability to carry out irrigated production, increasing farmers' burden. Finally, due to the generally small scale of agricultural operation in China, it is difficult to get effective financial and insurance support, and farmers have to bear the cost with great uncertainty and blindness, thus reducing the farmers' expectations for agricultural production earnings, and leading to their insufficient enthusiasm for production[4].

2.2 The circulation cost is high and there is a serious loss in the process of circulation of agricultural products As China has a vast territory, combined with far distance from producing areas of agricultural products to sale areas of agricultural products, so in order to meet consumer demand, and realize the value of agricultural products, we must rely on circulation system of agricultural products. At present, China's logistics infrastructure building of agricultural products lags behind, with too many circulation links. From production to consumption, the agricultural products have to at least pass five to six different links, and the cost of each link increases link by link, coupled with the government protectionism, leading to higher final retail price than purchase price. According to statistics, 82% of the world's toll roads are in China. In retail price of China's agricultural products, the circulation cost accounts for

50% –70% approximately, more than twice that of Europe. In addition, due to weak logistics management of agricultural products, scant building inputs of processing, storage, transport and other infrastructure of agricultural products, and vulnerability and perishable characteristic of agricultural products, it results in serious natural and man-made losses in the process of circulation after production of agricultural products[5]. According to statistics, every year, 80 million tons of fruits in China suffer losses in the process of procurement, storage, and transportation, with loss rate of 25 –30%, while the loss rate of fruit and vegetable in developed countries is below 5%, and it is strictly controlled within 2% in America.

2.3 The supply of agricultural production cost is short and the production of agricultural products decreases With China's rapid economic development, the growing income gap between urban and rural areas looms large, coupled with low added – value of agricultural production, causing a large number of rural labour forces, especially young workers to transfer to towns and industrial sectors. Most of farmers in cities have become accustomed to city life, reluctant to return to rural areas for farming, thereby agricultural working population decreases year by year, and even in many places, the phenomenon of arable land being abandoned due to lack of labour forces, occurs. And the people who stay in rural areas for farming, in a large measure, are the older women or the women who have difficulties to leave home. With the flow of rural labour forces to cities, the problems of agricultural part-time work, hollow rural areas, and aging of farmers, become increasingly obvious, seriously affecting sustainable development of agricultural production. In addition, as industrialization and urbanization continue to increasingly accelerate, there is an increasing land use demand of urban construction, and large areas of land, even the cultivated land is occupied, and expropriated. The area of farmland decreases incessantly, and increasing land supply and demand contradiction, are responsible for inadequate supply of agricultural products, and rapid rise in prices.

2.4 The macro factors of increasing residents' income, mounting pressure of inflation and so on send price of agricultural products up In recent years, with rapid and continuous economic development in China, urban-rural residents' income increases significantly. According to statistics, in the first half of the year, the income growth rate of urban and rural residents in 29 provinces, districts and cities of China is more than 10%. The income growth rate of urban and rural residents in 31 provinces, districts and cities of China, exceeds growth rate of CPI, which makes the residents' consumption structure of agricultural products change, so that the residents have a huge demand for agricultural products, especially the protein, directly driving the prices of agricultural products to climb. Along with increase in residents' income, the expected inflationary pressure is also rising. In July of this year, the consumer index continues to rise, an increase of 6.5%, chain increase of 0.5%, 0.2 percentage point more than in June. There is an overall increase in domestic consumer prices, along with soaring prices of the international crude oil, and raw material, forcing up the prices of agricultural products[6-7].

2.5 The profit distribution of supply chain is irrational impairing production enthusiasm of rural households Currently, agricultural production in China still adopts the small-scale agricultural production and management mode taking the family as unit. This decentralized, small-scale, and low-organization agricultural production, makes farmers lack effective discourse power in profit distribution in supply chain of agricultural products, with poor bargaining ability, at a disadvantage, so that farmers have a limited impact on the purchase price of agricultural products, and fail to fully enjoy the benefits brought by the circulation link. Taking tomato as an example, according to the survey of Market Information Division in Ministry of Agriculture, it indicates that from the producing area (Shouguang) to Beijing's supermarkets, the price per kilogram of tomatoes rises from 2.42 to 7.63 yuan, wherein farmers' profit per kilogram is just 0.334 yuan, agricultural fair's profit per kilogram is just 0.864 yuan, first-level wholesaler's profit is 0.710 yuan, second-level wholesaler's profit is 0.876 yuan, and retailers' profit in supermarkets is 2.30 yuan[8]. It can be clearly seen that farmers obtain the least profit in the whole supply chain, which can not mobilize the enthusiasm of farmers for production, not conducive to healthy and stable development of agriculture.

3 Countermeasures and suggestions for stabilizing price of agricultural products

3.1 Increase government support for agriculture and effectively reduce farmers' production costs China is a big agricultural country, and the development of agriculture plays an important supporting role for China's economic growth, and social stability. Government should increase inputs to agriculture and support for agriculture, and effectively reduce farmers' production costs. First, it should speed up building of rural infrastructure, improve investment efficiency, focus on supporting farmland irrigation infrastructure, irrigation and drainage system, rural power grids and communications network, and urban and rural road construction for agricultural transportation. Second, it should emphasize agricultural development, increase the proportion of finance in agricultural inputs, improve the agricultural development policy, increase direct subsidies to farmers, stabilize prices of means of agricultural production through macro-control, vigorously support agricultural technology innovation and promotion, promote the coverage of public services, such as agricultural market information, and weather forecasts, and avoid blind production. Third, it should expand financing channels for agricultural production, use economy to guide social investment, establish agricultural financial support system, improve the agricultural micro-credit system, and reduce the credit limitations for farmers. In the mean time, it should strengthen the construction of agricultural insurance and expand coverage of rural policy insurance, and reduce the farmers' empirical risk.

3.2 Establish modern agricultural circulation system and reduce loss rate of agricultural products as well as circulation costs The price of agricultural products continues to

rise, increasing the daily consumption expenditure of urban residents, but farmers complain that they do not make money and get more benefits, the main reason of which is that at present, the cost of circulation in China is too high, and distributors and retailers get excessive profits, generating a phenomenon of "the two ends vociferating but the middle end laughing". Therefore, first, we should establish modern agricultural circulation system, accelerate the infrastructure building of circulation of agricultural products, open up the green channel for agricultural products, abolish all kinds of unreasonable charges, integrate the existing transportation resources of roads, railways, ports and so on, coordinate interest relations of all regions, and reduce the circulation costs of agricultural products to the extreme. Second, we should strengthen the supply chain management in the circulation process of agricultural products, establish modern digital information-based and technology-based distribution system of agricultural products, promote efficiency of processing, refrigeration, storage, transportation, and distribution, and effectively reduce natural and man-made loss rate of agricultural products in circulation links after production.

3.3 Better organize agricultural cooperation and strengthen farmers' market price game ability Through the establishment of various types of agricultural cooperative organizations, we are to change the existing decentralized, small-scale, and non-organization state of agricultural production, organize farmers, connect small rural households and big supermarkets, promote farmers' market price bargaining and negotiating power, and reduce the risk losses arising from information asymmetry and irresistible power of agricultural production. In the mean time, the government should encourage and support rural cooperative organizations, offer preferential policies for rural cooperative organizations in the process of self-built distribution channels, guide the farmers to build direct marketing connection of terminal supermarket, simplify and shorten the circulation link, and reduce distribution costs, so that farmers fully enjoy the returns brought by the circulation appreciation of agricultural products, and the farmers organized truly become market game subject with competitiveness, to promote healthy and rapid development of agriculture.

3.4 Vigorously promote agricultural technology, reinforce agricultural technology training and reduce reliance of agricultural production on labour forces At present, a large number of young labour forces in rural areas flow out, and supply and demand contradiction of agricultural labour is increasingly prominent. We should vigorously promote agricultural science and technology, change the extensive mode of production that China's agriculture excessively depends on inputs of labour forces, and rely on agricultural technology to change agricultural growth mode. Through the development of vocational education, adult education and a variety of short-term trainings, we should improve farmers' agricultural professional skills, fully use agricultural technical schools and other agricultural training resources as well as modern information network, disseminate information of agricultural technology, organize scientific and technological personnel to go to rural areas to impart scientific knowledge, carry out various forms of popular culture and education, science and technology popularization activities, improve the quality of agricultural workers, and improve technological content in agricultural products. We should truly realize taking science and technology as the first agricultural productivity, improve agricultural productivity, gradually change the status quo of "eating dependent on the weather, farming dependent on human", achieve stable and continuous increase in farmers' income, change the status of urban-rural dual structure, and achieve balanced regional development.

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