Quality Improvement of Agricultural Products Supply Chain Under Social Preference and CSR by Big Data Analysis

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ABSTRACT

The aim of this study is to analyze the effect of corporate social responsibility (CSR) and social preference on quality improvement of the agricultural products supply chain composed of agricultural products, producer, and processor (A3P) and supermarket by theoretical analysis and empirical evidence. This paper sets Stackelberg game model under A3P's CSR by considering the supermarket's altruistic reciprocity and A3P's fairness concern, respectively. By comparative analysis, the authors study the effect of CSR, altruistic reciprocity, and fairness concern on the quality improvement of the agricultural products supply chain. Then, they adopt the empirical evidence to analyze the correlation between CSR, altruistic reciprocity (fairness concern), and quality improvement and the mediating effect of altruistic reciprocity (fairness concern) by investigating the agricultural enterprises.

KEYWORDS

Agricultural Products Supply Chain, Altruistic Reciprocity, CSR, Fairness Concern, Mediating Effect

INTRODUCTION

With the rapid economic development and material enrichment, consumers' demand for agricultural products has changed from quantity satisfaction to quality improvement. In recent years, quality and safety incidents caused people to worry about the quality and safety of agricultural products, such as "Lean meat powder" incident (Zheng and Zhang, 2015), "Poisonous ginger" incident (Pu et al., 2014), "Unclear labeling" incident (Chen et al., 2014), "Fake wine" incident (Lin et al., 2015), "Saccharin jujube" incident (Li, 2017), "Poisonous bean sprout" incident (Shi et al., 2019), and so on. Incomplete legal system, inadequate supervision, and asymmetry information are certainly important, but the root of the problem is the lack of corporate social responsibility (CSR) and the poor quality control of agricultural products. When enterprise actively fulfill CSR, they will not only pay attention to their own interests, but also improve the interests of other relative stakeholders, such as consumers, cooperative partners, and so on (Pino et al. 2016). Some researches proved that enterprises with strong consumer awareness and active CSR commitment can obtain greater enterprise value (Liu et al. 2019), and especially can improve quality efforts by increasing quality input, which can not only ensure the supply and circulation of high-quality agricultural products, but also publicize and establish corporate image and improve market share by big data analysis based on internet.

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So far, many behavior game experiments proved the decision maker has the fairness concern, altruistic reciprocity, sympathy, jealous, guilty, etc., and the fairness concern and altruistic reciprocity is the most important and popular type of social preference (Loch and Wu, 2008). These experiments proved the decision makers are bounded rationality, i.e. when they make decision, they not only consider to maximize the own profit, but also care the benefit of other relative entities (Ho and Su, 2009). On the one hand, an important reason for the quality of agricultural products is that some supply chain members perceive the unfair distribution of channel profit and make decision that may impair the quality of agricultural products, so the fairness concern is very important for the supply chain operation (Zheng and Zhang, 2012; Chen et al., 2014). On the other hand, there exists so much cooperation and altruistic reciprocity in the supply chain so as to keep long-term cooperation and stable supply chain operation. It is important to consider social preference in the agricultural products supply chain. Besides, the big data technology can help us to obtain the relative information of the social preference to optimize the quality decision and supply chain operation. Therefore, it is necessary to study the influence mechanism of CSR and social preference (altruistic reciprocity and fairness concern) on the quality of agricultural products by big data analysis, so as to provide a new perspective and theoretical basis of micro motivation for further improving the quality of agricultural products, ensuring the long-term stable supply of high-quality agricultural products, and optimizing the operation of agricultural products supply chain.

Our work intends to study quality improvement of agricultural products supply chain under CSR and social preference by big data analysis. For the main operating mode of agricultural products supply chain is made up of A3P& supermarket, so we focus on the quality improvement of A3P& supermarket under CSR and social preference. For the altruistic reciprocity and fairness concern is the most important and popular type of social preference, and thus we focus on the effect of altruistic reciprocity and fairness concern on the bilateral quality decision, respectively. First, we set the Stackelberg game model under A3P's CSR by considering the A3P's altruistic reciprocity and supermarket's fairness concern, respectively. By comparative analysis, we study the effect of CSR, fairness concern and altruistic reciprocity on the quality improvement of the agricultural products supply chain. Secondly, we adopt the empirical evidence to analyze the correlation between CSR, altruistic reciprocity (fairness concern) and quality improvement, and illustrate the mediating effect of altruistic reciprocity (fairness concern) by investigating the agricultural enterprises.

The rest of the paper is organized as follows. Section 1 will review the research relative to our topic. Section 2 will set Stackelberg model under only A3P's CSR, both A3P's CSR and altruistic reciprocity, both A3P's CSR and supermarket' fairness concern, and adopt backward induction to solve the equilibrium solution to analyze the effect of CSR, altruistic reciprocity and fairness concern on the quality improvement. Section 3 will adopt the SPSS 22.0 and AMOS 22.0 to analyze the correlation between CSR, altruistic reciprocity (fairness concern) and quality improvement, and illustrate the mediating effect of altruistic reciprocity (fairness concern). Section 4 will provide the discussions according to the theoretical analysis and empirical evidence. Section 5 will conclude our research and provide some future directions.

1. Literature Review

The quality and safety of agricultural products has always been an important issue that has attracted much attention in practice, and it is also a hot issue in academic research (Sun et al., 2015; Sun et al., 2017). However, the research related to the quality improvement under CSR or altruistic reciprocity (fairness concern) by big data analysis mainly includes: (1) quality control of agricultural products supply chain by big data analysis;(2) agricultural products supply chain under altruistic reciprocity or fairness concern; (3) agricultural products supply chain under CSR. We will conduct the literature review in terms of these three aspects.

(1) Quality Control of Agricultural Products Supply Chain By Big Data Analysis

- ① The unilateral quality control from supplier. Henson et al. (2005) pointed out that the key to ensure quality is to strengthen the control of the source links in the production and processing of agricultural products. Cai et al. (2010) and Cai et al. (2015) designed an incentive mechanism to improve the fresh-keeping effort of agricultural enterprise in order to realize the coordination of the agricultural products supply chain. Peng (2012) proved that source control of supply chain could efficiently ensure the quality and safety of agricultural products. Baert et al. (2015) proved that the willingness to control quality and safety of supplier was significantly affected by media perception. Seo et al. (2017) further pointed out that proper media supervision had a positive impact on the quality and safety control behavior of agricultural supplier. Yang and Liu (2018) proposed the revenue-sharing contract based on effort cost sharing could effectively encourage agricultural producer to work hard to coordinate the supply chain. Yu et al. (2020) studied the price decision and coordination mechanism by evaluating agricultural products processing quality in terms of supplier.
- ② The unilateral quality control from retail link. Blackburn and Scudder (2009) suggested that the supermarket should formulate the quality standard test of agricultural products and be responsible for the cold chain distribution so as to ensure the quality of agricultural products efficiently. Bosona and Gebresenbet (2013) proposed the retailer's quality effort was more important to improve the food quality in agricultural products supply chain. Pu et al. (2014), Ding (2015) proved that the quality inspection and control of agricultural products in retail link could effectively improve the quality and safety of agricultural products. Aidonis et al. (2015) proved that the supermarket's quality inspection effort had positive impact on the quality and safety. Bottani et al. (2018) not only emphasized the importance of quality inspection effort level at seller link, but also set up reverse logistics channel to recover food waste by retailer to improve the economic profitability of agricultural products supply chain.

Besides, some literatures applied the big data technology to improve the quality control of agricultural products. Akhtar et al. (2016), Accorsi et al. (2018) applied the big data and cloud technology to investigate the global agri-food supply chains connected with emerging markets, and proposed some effective strategies to improve the quality of fresh agricultural products in terms of seller. Zimon et al. (2020) proved that standardized quality management systems were useful in supply chain management (SCM) regardless of the role that the organization played in the supply chain. Mohammadreza and Alireza (2020) performed a big data analysis-based review of sustainable agricultural supply chain, and emphasized the importance of bilateral quality control in agricultural products supply chain. Dellana et al. (2020) studied the compact of cost performance and quality performance on the overall firm performance and supplier under ISO 9001 under big data condition. Cao (2021) applied big data analysis to prove that e-commerce platforms (such as Taobao, Jingdong, Pinduoduo) could improve quality and freshness of agricultural products by reducing the middle links to shorten the distance between farmers and consumers

(2) Agricultural Products Supply Chain Under Altruistic Reciprocity or Fairness Concern

- ① The research under altruistic reciprocity. Shi and Ma (2016) proved that altruistic reciprocity could alleviate the channels conflict. Dong et al. (2017) found that retailer was more willing to cooperate with altruistic manufacturer when market demand was large. Gu et al. (2018) established a bilateral adverse selection model with the principal as the coordination agent, and studied the influence of altruistic reciprocity on supply chain coordination. Xu and Wang (2018) established a competitive cooperation strategy model under altruistic reciprocity to improve the channel efficiency. Sun et

- al. (2017) proved that wholesale price contract could coordinate the agricultural products supply chain only by considering the altruistic reciprocity of cooperative enterprises. Qin et al. (2017) set game model between farmer and supermarket under altruistic reciprocity, and they proved altruistic reciprocity had obvious effect on the coordination of supply chain. Liu et al. (2018) found that only when both logistics service integrator and functional logistics service provider had altruistic reciprocity, supply chain coordination could be achieved. Li et al. (2020) applied dynamic game theory to prove that only when both members had altruistic reciprocity, the quality of agricultural products and operation efficiency of supply chain could be improved effectively.
- ② The research under fairness concern. Hong et al. (2014) proved that fairness concern would reduce the profit of all members in the agricultural products supply chain. Sun et al. (2015) proved that when supplier cared about fairness, the revenue sharing contract could effectively coordinate dual channel supply chain. Zhang and Zhang (2016) studied the bilateral decision-making behavior of “enterprise + farmer” and two-level certification of agricultural products supply chain, and then they proved that the fairness concern was good to farmer’s effort and achieved more fair profit distribution of the supply chain. Busch and Spiller (2016) proved that if the profit distribution was unfair to farmer compared to whole supply chain, it was bad to operation of supply chain. Parvathi and Waibel (2016), Markova and Wätzold (2017) applied the case study method to study the fresh agricultural products supply chain under fairness concern, and they found that the higher fairness concern intensity of wholesaler would lead to a significant decline in the overall competitiveness of the agricultural products supply chain. Zhang and Wang (2018) proved that vertical fairness concern could improve supply chain efficiency, while horizontal fairness concern would reduce supply chain efficiency. Tang et al. (2018) proved that the retailer’s fairness concern would obviously affect the equilibrium pricing decision of the members in a two-level supply chain. Liu et al. (2019) proved that the retailer’s fairness concern had a significant impact on the coordination of revenue sharing contract in three-level model, which may lead to the quality reduction and the quality decline of agricultural products.

(3) The Effect of CSR On Agricultural Products Supply Chain

Cruz (2013) pointed out the supermarket chain enterprises should first undertake the CSR, form the advantages of scale and logistics network, and ensure the timely listing of high-quality agricultural products. Komodromo and Melanthiou (2014) pointed out that the fresh supermarket should strengthen the quality inspection of agricultural products by checking the product packaging and using professional detection technology to eliminate the pollution risk. Shen et al. (2018) proved that the quality control of agricultural processing enterprises must consider the requirements of consumers for agricultural products. Pietro (2018) proved that the retailer could encourage the upstream to increase green investment by undertaking CSR so as to improve the overall revenue of the supply chain. Zhang (2019) proved that the green production and processing technology could reach or even exceed the green standard of agricultural products when the processing enterprises perform CSR. Li et al. (2020) proved that agricultural products processing enterprises attached importance to CSR and actively adopted new agricultural technology and equipment, which was conducive to improving the quality of agricultural products and improving the utilization rate of agricultural resources. Xiao and Tang (2019) suggested that agricultural processing enterprises and sellers should share CSR and improve the processing depth and the proportion of high-end products and end products, which could promote the sustainable development of high-quality agricultural products.

The above literature studied effect of fairness concern, altruistic reciprocity and CSR on agricultural products supply chain, but there are several shortcomings as following:

Firstly, the above researches on quality control of agricultural products put forward some strategies and suggestions for improving the quality of agricultural products, but only two literatures referred to quality control by considering social preference, i.e. Li et al. (2020) considered the altruistic

reciprocity, and Liu et al. (2019) considered the fairness concern. No research studied the compact of both fairness concern and altruistic reciprocity on the quality improvement of agricultural products.

Secondly, although some research referred to the effect of CSR on the quality control, no research consider the social preference. In reality, there exists close relationship between CSR and social preference. For the altruistic reciprocity, if the members of agricultural products supply chain have CSR awareness, they will take account their own interests and the welfare of stakeholders, and at the same time, altruistic reciprocity requires them not only to pursuit maximizing their own profit but also to improve the benefits of partners. So it is necessary to study the relation between social preference and CSR and the effect of social preference and CSR on the quality improvement.

Thirdly, all the researches were based on mathematical model to study the quality control of agricultural products supply chain and the effect of social preference and CSR on quality improvement. The theoretical math model is the abstraction and simplification of reality. It is necessary to conduct empirical study the influence mechanism of social preference and CSR on the quality improvement of agricultural products supply chain by empirical evidence. By theoretical analysis and empirical evidence, we can conduct the research more in line with the actual decision-making psychology in advance, and further improve the quality of agricultural product.

2. THEORETICAL ANALYSIS

2.1 Model Description

We consider two stage of agricultural products supply chain including agricultural products producer and processor (A3P) and supermarket (we call A3P as he, and call supermarket as she), and they take Stackelberg game. The A3P is leader and decides his production effort e and wholesale price w , and then supermarket decides CSR input effort t and retail price p .

According to Pietro (2018), the enterprise dominating the supply chain is more willing to be responsible for integration and operation of supply chain and is more likely to fulfill CSR, so A3P will take social consumer surplus as a part of pursuing the utility maximization which means A3P has CSR awareness. For example, A3P would actively provide farmers with high-quality varieties, agricultural technology training, purchase advanced and efficient agricultural machinery and equipment, implement a good job in the field operation records of agricultural products, and reduce the improper use of pesticides and fertilizers as far as possible. At the same time, the subordinate supermarket will invest in CSR to ensure that consumers actively buy the agricultural products, such as seasonal vegetables discount, and directly donate part of the profits to the relevant social welfare organizations, so as to bring good reputation for themselves, thus indirectly affecting and expanding the market demand for agricultural products. For example, in online shopping, Agricultural Taobao directly uses eye-catching words on the front page of the online store to explain that each unit of product sold will donate a certain amount to schools in poor areas, showing its CSR efforts and effectively stimulating the sales of products.

The notations used in our model are shown in Table 1.

- (1) For the quality of agricultural products is mainly determined by A3P, we assume all the quality effort cost is happened at A3P. When A3P pursuits for higher quality effort e , he will pay more for the high-quality seed fertilizer, more human training and processing technology. So with the increase of A3P's quality effort, the cost of quality effort will increase rapidly. For model

simplification, the A3P's cost can be denoted as $c_s(e) = \frac{1}{2}e^2$, subjected to $c'_s(e) > 0$ and

$$c''_s(e) > 0.$$

- (2) For the supermarket is in the terminal of supply chain and serves customers directly, she would try her best to prevent consumers' complaints, compensation and goodwill damage caused by

Table 1. Notations

Symbol	Description
a	Market demand scale of agricultural products
w	The unit wholesale price of agricultural products ordered by supermarket at A3P
c_s, c_r	The A3P's quality effort cost and the supermarket's CSR cost
p	Retail price of agricultural products
q	Order quantity from A3P
e	A3P's quality effort
t	Supermarket's effort to better fulfill CSR
α	The influence coefficient of product price on demand
β	The influence coefficient of quality and CSR on demand
θ	The A3P's CSR awareness
π_X^i, Π_X^i	The profit and utility of the subject X under the model i . $i = \{C, D, A, F\}$ denotes model of the centralized mode, decentralized mode, A3P's altruistic reciprocity and supermarket's fairness concern. $X = \{s, r, sc\}$ denotes the A3P, supermarket and supply chain.
CSR	The superscript " CSR " indicates the condition under CSR
*	Equilibrium solution

the inflow of problem agricultural products into the market, so she always fulfill the CSR and let customers feel the CSR effort t of supply chain to improve the quality of agricultural products by increasing the number of spot checks, improving the frequency of agricultural products on shelves, and introducing advanced automatic detection equipment. Besides, the supermarket would often stimulate customer demands by promotion, discount, direct price reduction, and so on. Similar to A3P's cost function, the supermarket's cost can be denoted as $c_r(t) = \frac{1}{2}t^2$, subjected

to $c_r'(t) > 0$ and $c_r''(t) > 0$.

- (3) The market demand of agricultural products is mainly affected by retail price, A3P's quality effort and supermarket's CSR effort. On the one hand, the demand of agricultural products will decrease with the retail price and increase with the quality of agricultural products. On the other hand, the quality of agricultural products is often influenced by the CSR effort, and the enterprise with more CSR awareness will not provide poor quality products, so the market demand increases with the degree of CSR effort. At the same time, because consumers are more aware of the price and thus more sensitive to the price, but the consumers often can't clearly distinguish the impact between product quality and CSR. So the market demand function of agricultural products can be denoted as $q = a - \alpha p + \beta(e + t)$, where the impact of quality and CSR on demand is assumed to be the same β . In order to ensure the concavity of the profit function, we assume $\alpha > 2\beta^2$.

- (4) Social welfare can be measured by customer surplus (CS). For given demand function $q = a - \alpha p + \beta(e + t)$, CS can be denoted as

$$CS = \int_{p_{\min}}^{p_{\max}} q dp = \int_{\frac{a+\beta(e+t)-q}{\alpha}}^{\frac{a+\beta(e+t)}{\alpha}} q dp = \frac{[a - \alpha p + \beta(e + t)]^2}{2\alpha}.$$

2.2 Basic Model

According to the assumptions and notations, we can get the profit function as following:

$\pi_s^D = wq - \frac{1}{2}e^2$, $\pi_r^D = (p - w)q - \frac{1}{2}t^2$, $\pi_{sc}^D = \pi_s + \pi_r = pq - \frac{1}{2}t^2 - \frac{1}{2}e^2$. In the basic model, we only study the compact of A3P's CSR on the quality and profit of supply chain.

When the A3P's CSR awareness is θ ($0 \leq \theta \leq 1$), and thus A3P's utility is $\Pi_s^D = wq - \frac{1}{2}e^2 + \theta \frac{q^2}{2\alpha}$, so the decision of supply chain is $\text{Max}_{e,t,p} \Pi_{sc}^C = p(a - \alpha p + \beta(e + t)) - \frac{1}{2}t^2 - \frac{1}{2}e^2 + \theta \frac{q^2}{2\alpha}$. It is easy to obtain the optimal decision as $e^{C*} = \frac{\beta a}{2\alpha - 2\beta^2 - \alpha\theta}$, $p^{C*} = \frac{(1 - \theta)a}{2\alpha - 2\beta^2 - \alpha\theta}$, $t^{C*} = \frac{\beta a}{2\alpha - 2\beta^2 - \alpha\theta}$, and $q^{C*} = \frac{\alpha a}{2\alpha - 2\beta^2 - \alpha\theta}$, $CS^{C*} = \frac{\alpha a^2}{2(2\alpha - 2\beta^2 - \alpha\theta)^2}$, and $\Pi_{sc}^{C-CSR*} = \frac{a^2}{2(2\alpha - 2\beta^2 - \alpha\theta)}$.

In decentralized mode, the A3P decides (w, e) to maximize the total utility including his own profit and social welfare in advance, and then the supermarket decides the (p, t) to maximize her own profit. So the Stackelberg game model can be denoted as:

$$\begin{aligned} \text{Max}_{e,w} \Pi_s^D &= wq - \frac{1}{2}e^2 + \theta \frac{q^2}{2\alpha} \\ \text{s.t. } \text{Max}_{p,t} \pi_r^D &= (p - w)(a - \alpha p + \beta e + \beta t) \end{aligned}$$

We can apply backward induction method to compute the supermarket's response function is $p^{D*}(w, e) = \frac{a + \beta e + (\alpha - \beta^2)w}{2\alpha - \beta^2}$ and $t^{D*}(w, e) = \frac{\beta(a + \beta e - \alpha w)}{2\alpha - \beta^2}$, so the equilibrium solution is $e^{D*} = \frac{\beta a}{\alpha(4 - \theta) - 3\beta^2}$, $w^{D*} = \frac{(2\alpha - \alpha\theta - \beta^2)a}{\alpha^2(4 - \theta) - 3\alpha\beta^2}$, $p^{D*} = \frac{(3\alpha - \alpha\theta - \beta^2)a}{\alpha(4\alpha - \alpha\theta - 3\beta^2)}$, $t^{D*} = \frac{\beta a}{\alpha(4 - \theta) - 3\beta^2}$, $q^{D*} = \frac{\alpha a}{\alpha(4 - \theta) - 3\beta^2}$, $CS^{D*} = \frac{\alpha^2 a}{2(4\alpha - \alpha\theta - 3\beta^2)^2}$. The profit and utility of supply chain is: $\pi_s^{D*} = \frac{(4\alpha - 2\alpha\theta - 3\beta^2)a^2}{2(4\alpha - \alpha\theta - 3\beta^2)^2}$, $\pi_r^{D*} = \frac{(2\alpha - \beta^2)a^2}{2(4\alpha - \alpha\theta - 3\beta^2)^2}$, $\Pi_s^{D*} = \frac{a^2}{2(4\alpha - \alpha\theta - 3\beta^2)}$, $\pi_{sc}^{D*} = \frac{(3\alpha - \alpha\theta - 2\beta^2)a^2}{(4\alpha - \alpha\theta - 3\beta^2)^2}$, $\Pi_{sc}^{D*} = \frac{(6\alpha - \alpha\theta - 4\beta^2)a^2}{2(4\alpha - \alpha\theta - 3\beta^2)^2}$.

So we can get the effect of CSR as shown in Property 1 and Proposition 1.

Property 1 ① $\frac{\partial e^{C*}}{\partial \theta} > 0$, $\frac{\partial p^{C*}}{\partial \theta} < 0$; $\frac{\partial t^{C*}}{\partial \theta} > 0$; $\frac{\partial q^{C*}}{\partial \theta} > 0$, $\frac{\partial CS^{C*}}{\partial \theta} > 0$;
 $\frac{\partial e^{D*}}{\partial \theta} > 0$, $\frac{\partial w^{D*}}{\partial \theta} < 0$; $\frac{\partial p^{D*}}{\partial \theta} < 0$, $\frac{\partial t^{D*}}{\partial \theta} > 0$; $\frac{\partial q^{D*}}{\partial \theta} > 0$, $\frac{\partial CS^{D*}}{\partial \theta} > 0$.

$$f \frac{\partial \pi_s^{D*}}{\partial \theta} < 0, \frac{\partial \Pi_s^{D*}}{\partial \theta} > 0; \frac{\partial \pi_r^{D*}}{\partial \theta} > 0; \frac{\partial \pi_{sc}^{D*}}{\partial \theta} > 0, \frac{\partial \Pi_{sc}^{D*}}{\partial \theta} > 0, \frac{\partial \Pi_{sc}^{C*}}{\partial \theta} > 0$$

According to Property 1① and ,, A3P's quality effort, supermarket's CSR effort, sale quantity and social welfare is positively correlated with A3P's CSR awareness except retail price. The stronger A3P's CSR awareness, the more A3P's effort, and thus the higher quality of agricultural products. Besides, As the leader of the agricultural products supply chain, A3P will take initiative to reduce the wholesale price so as to benefit the stakeholders and increase social welfare. So A3P's CSR awareness plays "Double incentive" role for supermarket. The unit wholesale price decreases, the supply quality of agricultural products improves, which greatly encourages supermarket to increase

the order quantity. Besides, For $\frac{\partial t^{C*}}{\partial \theta} > 0$ and $\frac{\partial t^{D*}}{\partial \theta} > 0$, A3P's CSR awareness can also effectively motivate supermarket to improve CSR input effort, further ensure the quality assurance of agricultural products in the sales link, and stimulate more consumers to buy agricultural products. According to Property 1f, A3P's CSR awareness will reduce her own profit, but will improve the supermarket's profit, social welfare and total profit of supply chain.

Property 1 illustrates that A3P's CSR awareness can not only improve the quality of agricultural products and realize the stable supply of high-quality agricultural products, but also improve the overall profit and utility of agricultural products supply chain.

Proposition 1 $e^{D*} < e^{C*}, p^{D*} > p^{C*}, t^{D*} < t^{C*}; q^{D*} < q^{C*}, CS^{D*} < CS^{C*}; \Pi_{sc}^{D*} < \Pi_{sc}^{C*}$

In Proposition1, the A3P's quality effort, supermarket's CSR effort, sale quantity, social welfare is lower in decentralized model except the retail price, so there exists the "Double marginalization effect" in decentralized mode.

2.3 The model Under CSR and Social Preference

Because A3P dominates the supply chain, he can make the optimal decision according to the supermarket's response, so he has the first mover advantage in the game. Therefore, A3P is in a strong position of game and can get more profit of supply chain, and he will more likely has fairness concern. While supermarket is in the weak position of game and can get less profit in the agricultural products supply chain, and she will more likely has fairness concern. So the effect of A3P's altruistic reciprocity and supermarket's fairness concern on the quality effort and CSR effort will be studied respectively.

2.3.1 The Model Under CSR and Altruistic Reciprocity

When we consider the A3P's altruistic reciprocity, A3P will make decision to maximize total utility including his own profit, social welfare and improve the supermarket's profit, and the supermarket is still perfect rationality to maximize her own profit. According to Ge et al. (2012), the A3P's utility

function is $\Pi_s^A = \pi_s^D + \theta \frac{q^2}{2\alpha} + \lambda_s \pi_r^D$ under altruistic reciprocity. λ_s denotes the intensity of A3P's

altruistic reciprocity, and A3P will be more likely to improve his own profit, so $0 \leq \lambda_s \leq \frac{1}{2}$ (Qin et

al., 2015). Combined with $\pi_s^D = wq - \frac{1}{2}e^2$, $\pi_r^D = (p - w)q - \frac{1}{2}t^2$ and $\pi_{sc}^D = pq - \frac{1}{2}t^2 - \frac{1}{2}e^2$, so the game model under A3P's altruistic reciprocity can be denoted as:

$$\begin{aligned} \text{Max}_{e,w} \Pi_s^A &= wq - \frac{1}{2}e^2 + \theta \frac{q^2}{2\alpha} + \lambda_s(pq - wq - \frac{1}{2}t^2) \\ \text{s.t. } \text{Max}_{p,t} \pi_r^D &= (p-w)(a - \alpha p + \beta e + \beta t) \end{aligned}$$

Similar to the computation only under CSR, equilibrium solution is as following:

$$\begin{aligned} e^{A*} &= \frac{\beta a}{\alpha(4 - 2\lambda_s - \theta) - (3 - \lambda_s)\beta^2}, w^{A*} = \frac{[\alpha(2 - 2\lambda_s - \theta) - (1 - \lambda_s)\beta^2]a}{\alpha[\alpha(4 - 2\lambda_s - \theta) - (3 - \lambda_s)\beta^2]}, \\ p^{A*} &= \frac{[\alpha(3 - 2\lambda_s - \theta) - (1 - \lambda_s)\beta^2]a}{\alpha[\alpha(4 - 2\lambda_s - \theta) - (3 - \lambda_s)\beta^2]}, t^{A*} = \frac{\beta a}{\alpha(4 - 2\lambda_s - \theta) - (3 - \lambda_s)\beta^2}, \\ q^{A*} &= \frac{\alpha a}{\alpha(4 - 2\lambda_s - \theta) - (3 - \lambda_s)\beta^2}, CS^{A*} = \frac{\alpha a^2}{2[\alpha(4 - 2\lambda_s - \theta) - (3 - \lambda_s)\beta^2]^2} \\ \pi_s^{A*} &= \frac{[2\alpha(2 - \theta - 2\lambda_s) - \beta^2(3 - 2\lambda_s)]a^2}{2[\beta^2(3 - \lambda_s) - \alpha(4 - \theta - 2\lambda_s)]^2}, \pi_r^{A*} = \frac{(2\alpha - \beta^2)a^2}{2[\beta^2(3 - \lambda_s) - \alpha(4 - \theta - 2\lambda_s)]^2} \\ \Pi_s^{A*} &= \frac{a^2}{2[(4 - 2\lambda_s - \theta)\alpha - (3 - \lambda_s)\beta^2]}, \Pi_{sc}^{A*} = \frac{[(6 - 2\lambda_s - \theta)\alpha - (4 - \lambda_s)\beta^2]a^2}{2[(4 - 2\lambda_s - \theta)\alpha - (3 - \lambda_s)\beta^2]} \end{aligned}$$

So we can get the effect of altruistic reciprocity as shown in Property 2 and Proposition 2.

Property 2 ① $\frac{\partial e^{A*}}{\partial \lambda_s} > 0, \frac{\partial w^{A*}}{\partial \lambda_s} < 0, \frac{\partial p^{A*}}{\partial \lambda_s} < 0, \frac{\partial t^{A*}}{\partial \lambda_s} > 0, \frac{\partial q^{A*}}{\partial \lambda_s} > 0, \frac{\partial CS^{A*}}{\partial \lambda_s} > 0;$
 $\frac{\partial \pi_s^{A*}}{\partial \lambda_s} < 0, \frac{\partial \pi_r^{A*}}{\partial \lambda_s} > 0, \frac{\partial \Pi_s^{A*}}{\partial \lambda_s} > 0, \frac{\partial \Pi_{sc}^{A*}}{\partial \lambda_s} > 0.$

Property 2 ① denotes that A3P's altruistic reciprocity can improve the A3P's quality effort, supermarket's CSR effort, sale quantity and social welfare except the wholesale price and retail price, so A3P's altruistic reciprocity can encourage himself to improve quality effort so as to reduce the keep cost and difficulty for supermarket, and then the better quality of agricultural products can stimulate customers to buy more agricultural products. Besides, A3P's altruistic reciprocity can be shown as improving the supermarket's profit, stimulating the supermarket's sale enthusiasm and thus increasing the purchase quantity of agricultural products. Property 2, illustrate that only A3P's profit is decreasing with altruistic reciprocity, but all the supermarket's profit, A3P's utility and total utility of supply chain is increasing with the altruistic reciprocity.

Proposition 2:①

$$\begin{aligned} e^{D*} &< e^{A*} < e^{C*}, p^{C*} < p^{A*} < p^{D*}, t^{D*} < t^{A*} < t^{C*}, q^{D*} < q^{A*} < q^{C*}, CS^{D*} < CS^{A*} < CS^{C*}; \\ \pi_r^{A*} &> \pi_r^{D*}, \pi_s^{A*} < \pi_s^{D*}, \Pi_s^{A*} > \Pi_s^{D*}, \Pi_{sc}^{D*} < \Pi_{sc}^{A*} < \Pi_{sc}^{C*}. \end{aligned}$$

Proposition 2 illustrates that A3P's altruistic reciprocity can help to alleviate the “Double marginalization effect” in decentralized decision, improve the social welfare and optimize the operation of supply chain.

2.3.2 The Model Under CSR and Fairness Concern

When we consider the supermarket's fairness concern, supermarket will make decision to maximize her own total utility including her own profit and negative fairness utility, but A3P is still perfect rationality to maximize his own utility including his own profit and consumer surplus. According to Cui et al. (2007), supermarket's utility function can be denoted as $\Pi_r^F = \pi_r^D - \lambda_r(\pi_s^D - \pi_r^D) = (1 + \lambda_r)\pi_r^D - \lambda_r\pi_s^D$ ($0 \leq \lambda_r \leq 1$). The game model under supermarket's fairness concern can be denoted as

$$\begin{aligned} \max_{e,w} \Pi_s^F &= wq - \frac{1}{2}e^2 + \theta \frac{q^2}{2\alpha} \\ \text{s.t. } \max_{p,t} \Pi_r^F &= (1 + \lambda_r)[(p - w)q - \frac{1}{2}t^2] - \lambda_r(wq - \frac{1}{2}e^2) \end{aligned}$$

Similar to the computation only under CSR, we can get the supermarket's response function is $p^{F*}(w, e) = \frac{a + \beta e + (1 + \lambda_r)(\alpha - \beta^2)w}{2\alpha - \beta^2}$ and $t^{F*}(w, e) = \frac{\beta[a + \beta e - \alpha(1 + \lambda_r)w]}{2\alpha - \beta^2}$, so we can obtain the equilibrium solution under supermarket's fairness concern as following:

$$\begin{aligned} e^{F*} &= \frac{\beta a}{2(1 + \lambda_r)[4 - (1 + \lambda_r)\theta] - (3 + 2\lambda_r)\beta^2}, w^{F*} = \frac{[2\alpha - \beta^2 - \alpha\theta(1 + \lambda_r)]a}{2\alpha(1 + \lambda_r)[4 - (1 + \lambda_r)\theta] - (3 + 2\lambda_r)\alpha\beta^2} \\ p^{F*} &= \frac{(1 + \lambda_r)[(3 - (1 + \lambda_r)\theta) - \beta^2]a}{(1 + \lambda_r)\alpha[4 - (1 + \lambda_r)\theta] - (3 + 2\lambda_r)\alpha\beta^2}, t^{F*} = \frac{(1 + \lambda_r)\beta a}{(1 + \lambda_r)\alpha[4 - (1 + \lambda_r)\theta] - (3 + 2\lambda_r)\beta^2} \\ q^{F*} &= \frac{(1 + \lambda_r)\alpha a}{(1 + \lambda_r)\alpha[4 - (1 + \lambda_r)\theta] - (3 + 2\lambda_r)\beta^2}, \mathcal{CS}^{F*} = \frac{(1 + \lambda_r)^2 \alpha a^2}{2[(1 + \lambda_r)\alpha(4 - (1 + \lambda_r)\theta) - (3 + 2\lambda_r)\beta^2]^2} \\ \pi_s^{F*} &= \frac{[(1 + \lambda_r)(2 - (1 + \lambda_r)\theta)\alpha + (3 + 2\lambda_r)\beta^2]a^2}{2[(1 + \lambda_r)\alpha(4 - (1 + \lambda_r)\theta) - (3 + 2\lambda_r)\beta^2]^2}, \\ \pi_r^{F*} &= \frac{(1 + \lambda_r)[(1 + 3\lambda_r)(2\alpha - \beta^2) - \alpha\lambda_r(1 + \lambda_r)\theta]a^2}{2[(1 + \lambda_r)\alpha(4 - (1 + \lambda_r)\theta) - (3 + 2\lambda_r)\beta^2]^2} \\ \Pi_s^{F*} &= \frac{a^2}{2[(1 + \lambda_r)\alpha(4 - (1 + \lambda_r)\theta) - (3 + 2\lambda_r)\beta^2]}, \\ \Pi_r^{F*} &= \frac{[(2\alpha - \beta^2)(1 + \lambda_r^2) + \lambda_r(4\alpha - \beta^2)]a^2}{2[(1 + \lambda_r)\alpha(4 - (1 + \lambda_r)\theta) - (3 + 2\lambda_r)\beta^2]^2} \\ \Pi_{sc}^{F*} &= \frac{2[(1 + \lambda_r)\alpha(4 - (1 + \lambda_r)\theta) - (3 + 2\lambda_r)\beta^2]^2}{2[(1 + \lambda_r)\alpha(4 - (1 + \lambda_r)\theta) - (3 + 2\lambda_r)\beta^2]^2}. \end{aligned}$$

So we can get the effect of fairness concern as shown in Property 3 and Proposition 3.

Property 3: ① $\frac{\partial e^{F*}}{\partial \lambda_r} < 0, \frac{\partial w^{F*}}{\partial \lambda_r} < 0, \frac{\partial p^{F*}}{\partial \lambda_r} > 0, \frac{\partial t^{F*}}{\partial \lambda_r} > 0, \frac{\partial q^{F*}}{\partial \lambda_r} < 0, \frac{\partial CS^{F*}}{\partial \lambda_r} < 0;$
 $\frac{\partial \pi_s^{F*}}{\partial \lambda_r} < 0, \frac{\partial \pi_r^{F*}}{\partial \lambda_r} > 0, \frac{\partial \Pi_s^{F*}}{\partial \lambda_r} < 0, \frac{\partial \Pi_r^{F*}}{\partial \lambda_r} > 0, \frac{\partial \pi_{sc}^{F*}}{\partial \lambda_r} < 0, \frac{\partial \Pi_{sc}^{F*}}{\partial \lambda_r} < 0.$

When the supermarket cares about fairness, she will increase the retail price $\frac{\partial p^{F*}}{\partial \lambda_r} > 0$ so as to increase unit profit, and increase her own CSR effort to avoid the demand shrinking caused by price increasing. For $\frac{\partial e^{F*}}{\partial \lambda_r} < 0$ and $\frac{\partial w^{F*}}{\partial \lambda_r} < 0$, A3P's quality effort and wholesale price will decrease with supermarket's fairness concern. The dominant A3P would reduce the wholesale price to overcome the supermarket's negative fairness utility. Given A3P's CSR awareness θ , the A3P would reduce his quality effort to reduce the cost. Facing the lower quality of agricultural products, supermarket has no choice but to improve the CSR effort by increasing the frequency of spot check so as to avoid the consumer complaints and loss of goodwill. On the one hand, A3P reduce the quality and thus reduce the quality of agricultural products. On the other hand, supermarket increase the retail price. Property 3, illustrates that supermarket's fairness concern only help her to obtain lower wholesale price and more profit and utility, but it would reduce the A3P's quality and profit, so supermarket's fairness concern would squeeze the consumer surplus and is unfavorable to improve the quality and sales of agricultural products.

Proposition 3 ①

$$e^{F*} < e^{D*} < e^{C*}, p^{C*} < p^{D*} < p^{F*}, t^{D*} < t^{F*} < t^{C*}, q^{F*} < q^{D*} < q^{C*}, CS^{F*} < CS^{D*} < CS^{C*};$$

$$\pi_r^{F*} > \pi_r^{D*}, \pi_s^{F*} < \pi_s^{D*}, \Pi_s^{F*} < \Pi_s^{D*}, \Pi_r^{F*} > \Pi_r^{D*}, \Pi_{sc}^{F*} < \Pi_{sc}^{D*} < \Pi_{sc}^{C*}$$

Proposition 3 illustrate that supermarket's fairness concern is unfavorable to improve quality of agricultural products and social welfare. For $\pi_r^{F*} > \pi_r^{D*}, \pi_s^{F*} < \pi_s^{D*}, \Pi_s^{F*} < \Pi_s^{D*}$, and $\Pi_{sc}^{F*} < \Pi_{sc}^{D*} < \Pi_{sc}^{C*}$, the supermarket's fairness concern only improve her own profit and utility at the cost of A3P's profit and supply chain, so supermarket's fairness concern is bad to operation of agricultural products supply chain and aggravates the "Double marginalization effect".

To sum up, we can get Conclusion 1 as following:

Conclusion 1 A3P's altruistic reciprocity will improve the quality of agricultural products, increase social welfare and mitigate the double marginal effect of supply chain. However, supermarket's fairness concern will reduce the quality of agricultural products, reduce social welfare and aggravate the double marginal effect of supply chain.

3. EMPIRICAL EVIDENCE

Although we adopt the mathematic model to analyze the effect of A3P's CSR awareness, A3P's altruistic reciprocity and supermarket's fairness concern on the quality improvement, social welfare and supply chain. For simplifying the computation and obtaining the obvious conclusions, we just consider unilateral CSR awareness, altruistic reciprocity and fairness concern, and do not study the relationship between CSR and altruistic reciprocity (fairness concern). So the empirical evidence method can be applied to verify the bilateral effect of CSR, altruistic reciprocity and fairness concern on the quality improvement and analyze the relationship between CSR and altruistic reciprocity (fairness concern).

In this empirical study, the research data are collected through the electronic questionnaire, mainly through the member enterprises of typical agricultural products supply chain including A3P and supermarket. At the same time, for both altruistic reciprocity and fairness concern is typical social preference, we conduct two questionnaires so as to avoid the confusion about altruistic reciprocity and fairness concern. The first questionnaire is designed to investigate the relationship between CSR awareness, altruistic reciprocity and quality effort, and the second questionnaire is designed to investigate the relationship between CSR awareness, fairness concern and quality effort.

3.1 The Framework of Relation

3.1.1 The Relations Between CSR Awareness, Altruistic Reciprocity and Quality Effort

(1) The relation between CSR and altruistic reciprocity

If the members of agricultural products supply chain have CSR awareness, they will take account their own interests and the welfare of stakeholders, and at the same time, altruistic reciprocity requires them not only to pursuit maximizing their own profit but also to improve the benefits of partners. LV et al.(2015)pointed out that the beneficiary of CSR is the public, including donation for disaster relief, environmental protection, etc., and thus CSR is conducive to enhance the reputation of enterprises and reduce the overall risk faced by enterprises. Tan and Xu (2015) proposed that CSR could encourage enterprises to invest social projects so as to keep long-term cooperation with stakeholders. Zhang et al. (2021) proved that CSR's altruistic reciprocity can positively moderate the influence of CSR on production efficiency. For members of agricultural products supply chain have CSR awareness, and optimize their own invest decision by improving the benefits of other stakeholders, so we propose Hypothesis HA1 as following:

Hypothesis HA1: CSR has a significantly positive impact on altruistic reciprocity.

(2) The relation between CSR and quality effort

According to Proposition 1 and Property 1, CSR awareness has a positive impact on the quality effort of agricultural products and CSR effort, and thus has a positive impact on the quality of agricultural products, we propose Hypothesis HA2a and HA2b as following:

Hypothesis HA2a: A3P's CSR awareness has a significantly positive impact on quality effort.

Hypothesis HA2b: Supermarket's CSR awareness has a significantly positive impact on quality effort.

(3) The relation between altruistic reciprocity and quality effort

According to Proposition 2 and Property 2, altruistic reciprocity has a positive impact on the quality effort of agricultural products, and thus we propose Hypothesis HA3a and HA3b as following:

Hypothesis HA3a: A3P's altruistic reciprocity has a positive impact on the quality effort.

Hypothesis HA3b: Supermarket's altruistic reciprocity has a positive impact on the quality effort.

(4) The mediating effect of altruistic reciprocity

CSR includes the use of environmental protection materials to alleviate environmental pollution, which may not directly lead to the improvement of quality efforts, but may increases the cost due to the adoption of special measures. However, by performing CSR, the members of agricultural products supply chain can improve the welfare of stakeholders, enhance their own positive altruistic utility,

and further have a positive impact on the balanced decision-making, so as to improve quality efforts. Therefore, the influence of CSR on quality effort also has an indirect effect formed by altruistic reciprocity as a mediating variable. So we propose the Hypothesis HA4.

Hypothesis HA4: Altruistic reciprocity has mediating effect between CSR and quality effort.

To sum up, we can propose the research framework under altruistic reciprocity, as shown in fig.1A. In fig.1A, the solid line indicates the direct effect (HA1), the effect path of CSR on quality effort (HA2a and HA2b), the effect path of altruistic reciprocity on quality effort (HA3a and HA3b), and the dotted lines indicate indirect effect: the mediating effect of altruistic reciprocity between CSR and quality effort (HA4). Altruistic reciprocity plays direct and mediating effect on the quality effort of agricultural products, so the variables and influence paths of altruistic reciprocity are represented by both solid line and dotted line at the same time.

3.1.2 The Relations Between CSR Awareness, Fairness Concern and Quality Effort

The fairness concern will cause the member to care about the profit difference with other partners. Rupp et al. (2006) pointed out that the CSR could be the external form of fairness judgement for third party. Wang et al. (2017) proposed CSR awareness could expand the profit share to all stakeholders and transform the evaluation index into comprehensive evaluation index of CSR, which was conducive to the realize equity in enterprise distribution activities. Yan et al. (2020) proved that CSR awareness could improve the overall sense of organizational justice. So CSR awareness can improve the profit of other members to influence the profit difference, and thus we propose the Hypothesis HF1 as following:

Hypothesis HF1: CSR has a significantly negative impact on fairness concern.

Similar to altruistic reciprocity, we can propose the following Hypothesis and research framework under fairness concern, as shown in fig.1F.

Hypothesis HF2a: A3P's CSR awareness has a significantly positive impact on quality effort.

Hypothesis HF2b: Supermarket's CSR awareness has a significantly positive impact on quality effort.

Hypothesis HF3a: A3P's fairness concern has a negative impact on the quality effort.

Hypothesis HF3b: Supermarket's fairness concern has a negative impact on the quality effort.

Hypothesis HF4: Fairness concern has mediating effect between CSR and quality effort.

Figure 1. A Framework under altruistic reciprocity

Figure 2. F Framework under fairness concern

3.2 Data sorting and analysis under altruistic reciprocity

300 electronic questionnaires were sent out and 217 were returned under altruistic reciprocity. After eliminating the questionnaires with missing answers, 205 valid questionnaires were obtained.

3.2.1 Reliability and Validity Analysis

We use Likert 5-point scale, the interviewees were asked to answer according to their own work experience. “1” means “totally disagree”, “3” means “uncertain”, and “5” means “totally agree”. The measurement items are shown in Table 2A and the correlation analysis of variables is shown in Table 3A. Most of the measurement items come from the existing research, and few measurement items are modified according to the actual needs of the survey. For example, CSR reflects the social contribution in the agricultural products supply chain, and the measurement item comes from Chen (2011). Altruistic reciprocity reflects that members attach importance to the improvement of partners’ profits. The measurement items come from Wuyts (2019) and Ma (2019), and they proposed that quality effort input can improve the product quality in the agricultural products supply chain.

SPSS22.0 and AMOS22.0 are used to test the reliability and validity of the scale data. It can be seen from table 2A that the Cronbach’s α scores of all variables are significantly higher than 0.9, reaching the standard 0.7, indicating that the scale data has good reliability. The overall measurement model fitting indicators: TLI = 0.913, CFI = 0.922, RMSEA = 0.061, and these indicators meet the range recommended by Hu and Bentler (1999), indicating that the scale is acceptable. All standard loads are greater than 0.6, AVE is greater than 0.5, indicating that the scale has good convergence validity. Through the observation of Table3A, it indicates that the correlation coefficients are lower than the square root of AVE, so the discriminant validity test of the scale is passed.

3.2.2 Hypothesis Test

(1) Correlation test

Through the correlation test of variables by SPSS22.0, we can judge the correlation between variables, as shown in table 4A-6A. In table 4A, $\beta = 0.546$ and $p < 0.01$ denotes there is a significant positive correlation between CSR and altruistic reciprocity, so Hypothesis HA1 holds. In table 5A, $\beta = 0.821$ and $p < 0.01$ denotes that A3P’s altruistic reciprocity has significant positive effect on the quality effort, so Hypothesis HA2a holds, and for $\beta = 0.694$ in table 6A, then Hypothesis HA3a holds. Besides, for $0.821 > 0.694$, A3P’s CSR effect on the quality effort is bigger than altruistic reciprocity. Similarly, for $\beta = 0.841$ and $p < 0.01$ in table 6A, Hypothesis HA2b holds, and for $\beta = 0.519$ and

Table 2. A Reliability and validity analysis

Variable	Measurement	Standard loads	t (p)	AVE	Cronbach's α
Altruistic reciprocity	In the transaction, the company will take the initiative beneficial to partners	0.822		0.714	0.939
	Our commitment often exceeds the requirements of partners	0.907	14.426***		
	We would like to actively put in more efforts to improve their performance	0.803	12.666***		
	When we can help partners, we often do more than they expect	0.878	13.853***		
	We will share costs with partners and solve problems of financing	0.756	10.552***		
	We exchange management experience and solve relevant problems timely	0.842	13.652***		
	We actively share our own unique knowledge	0.905	14.383***		
	We take the initiative to promote the timely transmission of information	0.845	13.679***		
	We take the initiative to build logistics system, unified deployment	0.814	13.020***		
	We actively share market research data to further understand market	0.866	13.769***		
CSR	We make effort to reduce the utilization rate of non-recyclable resources	0.760		0.638	0.924
	We try to adopt fresh-keeping spray and other fresh keeping measures.	0.727	10.982***		
	We try to use environmental friendly raw materials	0.817	12.601***		
	We take the initiative to consider the local employment needs	0.798	12.248***		
	We don't use false information when promoting agricultural products	0.851	13.243***		
	We don't use harmful additives when processing agricultural products	0.831	12.873***		
	In the destruction process, we try to reduce environmental pollution	0.800	12.299***		
Quality effort	Conduct regular training on the quality and safety of agricultural products	0.829		0.671	0.934
	New testing technology development and technological innovation	0.778	13.306***		
	Take the initiative to establish standard rules for the quality and safety	0.827	14.601***		
	Strictly keep the use records of chemical preservatives	0.841	15.005***		
	Active control temperature and humidity in transportation environment	0.826	14.576***		
	Active use clean packaging materials for agricultural products	0.817	14.341***		
	Actively participate in training to improve quality of agricultural products	0.813	14.226***		

***. When the confidence level (double test) is 0.001, the correlation is significant.

$p < 0.01$, Hypothesis HA3b holds. $0.841 > 0.519$ denotes the supermarket's CSR effect on the quality effort is bigger than altruistic reciprocity.

(2) Multiple regression analysis

Table 3. A Variable correlation

Type	Altruistic reciprocity	CSR	Quality effort
Altruistic reciprocity	0.845		
CSR	0.546**	0.867	
Quality effort	0.523**	0.822**	0.819

** . When the confidence level (double test) is 0.01, the correlation is significant. The diagonal value is the square root of AVE, and the non-diagonal value is the Pearson correlation coefficient between variables.

Table 4. The relationship between altruistic reciprocity and CSR

Type		CSR
Altruistic reciprocity	Pearson relation	0.546**
	Significance (two tailed)	0.000

** . When the confidence level (double test) is 0.001, the correlation is significant.

Table 5. Correlation between CSR, altruistic reciprocity and A3P's quality effort

Type		Quality effort
CSR	Pearson relation	0.821**
	Significance (two tailed)	0.000
Altruistic reciprocity	Pearson relation	0.694**
	Significance (two tailed)	0.000

*,** denote when the confidence level (double test) is 0.05 and 0.01 respectively,the correlation is significant.

Table 6. Correlation between CSR, altruistic reciprocity and supermarket's quality effort

Type		Quality effort
CSR	Pearson relation	0.841**
	Significance (two tailed)	0.000
Altruistic reciprocity	Pearson relation	0.519**
	Significance (two tailed)	0.000

** . denote when the confidence level (double test) is 0.01,the correlation is significant.

In this section, multiple regression method is used to further study the relationship between the three variables, so as to explore the more exact relationship and significance between the variables, and test the mediating effect of altruistic reciprocity, as shown in fig.2A. For $\beta = 0.822$ and $p < 0.01$, path C is significant, so CSR's total effect on quality effort is significantly positive, which further prove Hypothesis HA2a and 2b hold. Then, for $\beta = 0.546$ and $p < 0.01$, path A is significant, so CSR has significantly positive effect on quality effort. For $\beta = 0.523$ and $p < 0.01$, path B is significant, so altruistic reciprocity as significantly positive effect on quality effort indirectly and Hypothesis HA3a and 3b hold. For $\beta = 0.708$ and $p < 0.01$, path C' is significant, so CSR has direct and significantly positive effect on quality effort. Finally, by comparing the symbol of A, B and C',

Path	A	B	C	C'	Mediating effect
Coefficient	0.546**	0.523**	0.822**	0.708**	Partial Mediating effect

it is easy to see they have the same symbol, so the mediating effect of altruistic reciprocity belongs to partial mediating effect, and the ratio of mediating effect to total effect is $AB / C = 34.7\%$, so Hypothesis HA4 holds.

The results show that: (1) CSR has a significantly positive impact on altruistic reciprocity and quality effort; (2) Altruistic reciprocity has a significantly positive impact on the quality effort; (3) The influence of CSR on quality effort is greater than altruistic reciprocity; (4) Altruistic reciprocity has a partial mediating effect in the compact of CSR on the quality effort of agricultural products.

Figure 3. The mediating effect of altruistic reciprocity

3.3 Data Sorting and Analysis Under Fairness Concern

300 electronic questionnaires were sent out and 238 were returned under fairness concern. After eliminating the questionnaires with missing answers, 201 valid questionnaires were obtained.

3.3.1 Reliability and Validity Analysis

Similar to analysis under altruistic reciprocity, we use Likert 5-point scale, the measurement item of CSR and quality effort is same, but fairness concern reflects the sensitivity of member to profit gap, so the measurement item of fairness concern comes from Ma (2012).

We can also use AMOS22.0 and SPSS22.0 to test the reliability and validity of the scale data under fairness concern, as shown in table 2F and 3F. It can be seen from table 2F that the Cronbach's α scores of all variables are significantly higher than 0.8, reaching the standard 0.7, indicating that the scale data has good reliability. The overall measurement model fitting indicators: TLI = 0.810, CFI = 0.829, RMSEA = 0.074, so the scale is acceptable, and all standard loads are greater than 0.6, AVE is greater than 0.5, indicating that the scale has good convergence validity. Through the observation of table3F, the correlation coefficients are lower than the square root of AVE, so the discriminant validity test of the scale is passed.

3.3.2 Hypothesis test

(1) Correlation test

Through the correlation test of variables by SPSS22.0, we can judge the correlation between variables, as shown in table 4F-6F. In table 4F, $\beta = -0.538$ and $p < 0.01$ denotes there is a significant negative correlation between CSR and fairness concern, so Hypothesis HF1 holds. Besides, for $\beta = 0.768$ and $p < 0.01$, so there is significantly positive relationship between CSR and quality effort and Hypothesis HF2a holds. For $\beta = -0.408$ in table 6F, then Hypothesis HF3a holds. Besides, for $0.768 > 0.408$, A3P's CSR effect on the quality effort is bigger than fairness concern. Similarly, for $\beta = 0.685$ and $p < 0.01$ in table 6F, Hypothesis HF2b holds, and for $\beta = -0.437$ and $p < 0.01$, Hypothesis HF3b holds. $0.685 > 0.437$ denotes the supermarket's CSR effect on the quality effort is bigger than fairness concern.

(2) Multiple regression analysis

In this section, for $\beta = 0.815$ and $p < 0.01$, path G is significant, so CSR's total effect on quality effort is significantly positive, which further prove Hypothesis HF2a and 2b hold. Then, for $\beta = -0.538$ and $p < 0.01$, path E is significant, so CSR has significantly negative effect on fairness concern, so Hypothesis HF1 holds. For $\beta = -0.501$ and $p < 0.01$, path F is significant, so fairness concern has significantly negative effect on quality effort and Hypothesis HF3a and 3b hold. For $\beta = 0.767$ and $p < 0.01$, path G' is significant, so CSR has direct and significantly positive effect on quality effort. Finally, by comparing the symbol of E, F and G', it is easy to see the mediating effect of fairness concern belongs to partial effect, and the ratio of mediating effect to total effect is $EF / G = 33.07\%$, so Hypothesis HF4 holds.

The results show that: (1) CSR has significantly negative impact on fairness concern and significantly positive impact on quality effort; (2) The fairness concern has significantly negative effect on the quality effort; (3) CSR has more influence on bilateral quality effort than fairness concern. (4) Fairness concern has a partial mediating effect in the compact of CSR on quality effort. The agricultural products supply chain can directly and indirectly improve quality effort through CSR, and then further ensure the stable supply of high-quality agricultural products.

4. DISCUSSION

So far, we adopt the mathematic model and empirical evidence to study the effect of CSR and social preference on the quality efforts of agricultural products. For simplifying the computation and obtaining the explicit results, we just focus on the effect of unilateral CSR, altruistic reciprocity (fairness concern) on the quality effort of agricultural products supply chain. In empirical study, we design questionnaire to investigate the relationship between CSR, altruistic reciprocity (fairness concern) and quality effort. The relation between mathematic model and empirical evidence is as following:

In mathematical model, we prove that A3P's CSR and altruistic reciprocity will improve the quality of agricultural products, increase social welfare and reduce the double marginal effect of supply chain. However, supermarket's fairness concern will reduce the quality of agricultural products, reduce social welfare and aggravate the double marginal effect of supply chain.

In empirical study, it is difficult to design the questionnaire to reflect the social welfare and coordination, so we don't analyze the effect of CSR and social preference on the social welfare and supply chain coordination, but we can obtain more relationship between CSR, social preference and quality effort. Factually, we not only prove that A3P's altruistic reciprocity will improve the quality of agricultural products and supermarket's fairness concern will reduce the quality of agricultural products, but also find the more interesting conclusions as following:

Table 7. Reliability and validity analysis

Variable	Measurement	Standard loads	t (p)	AVE	Cronbach's α
Fairness concern	What we get is proportional to what we give	0.648		0.561	0.806
	The distribution of income is strictly in accordance with the contract	0.695	8.290***		
	Our revenue is comparable to that of similar enterprises	0.612	7.404***		
	Our effort input is comparable to that of similar enterprises	0.735	6.398***		
	We regularly ask partners about their views on revenue distribution	0.789	6.711***		
	Our partners regularly ask us about our views on revenue distribution	0.652	7.346***		
	We will take the initiative to disclose cost information	0.765	4.493***		
	Agricultural partners will actively disclose cost information	0.899	4.866***		
	If we think the benefits are unfair, we will send this message	0.875	5.638***		
	If we think the benefits are unfair, we will take measures	0.762	5.586***		
CSR	We make effort to reduce the utilization rate of non-recyclable resources	0.781		0.674	0.883
	We try to adopt fresh-keeping spray and other fresh keeping measures.	0.834	7.715***		
	We try to use environmental friendly raw materials	0.774	8.024***		
	We take the initiative to consider the local employment needs	0.814	8.307***		
	We don't use false information when promoting agricultural products	0.875	8.786***		
	We don't use harmful additives when processing agricultural products	0.799	8.580***		
	In the destruction process, we try to reduce environmental pollution	0.863	9.045***		
Quality effort	Conduct regular training on the quality and safety of agricultural products	0.773		0.606	0.915
	New testing technology development and technological innovation	0.815	12.466***		
	Take the initiative to establish standardized rules for the quality and safety	0.790	11.886***		
	Strictly keep the use records of chemical preservatives	0.778	11.731***		
	Active control temperature and humidity in transportation environment	0.766	11.517***		
	Active use clean packaging materials for agricultural products	0.800	12.116***		
	Actively participate in training to improve quality of agricultural products	0.726	10.836***		

***. When the confidence level (double test) is 0.001, the correlation is significant.

Table 8. Variable correlation

Type	Fairness concern	CSR	Quality effort
Fairness concern	0.749		
CSR	-0.538**	0.821	
Quality effort	-0.501**	0.815**	0.778

** . When the confidence level (double test) is 0.01, the correlation is significant. The diagonal value is the square root of AVE, and the non-diagonal value is the Pearson correlation coefficient between variables.

Table 9. The relationship between fairness concern and CSR

		Fairness concern	CSR
Fairness concern	Pearson relation	1	-0.538**
	Significance (two tailed)		.000
CSR	Pearson relation	-0.538**	1
	Significance (two tailed)	.000	

** . When the confidence level (double test) is 0.001, the correlation is significant.

Table 10. Correlation between CSR, fairness concern and A3P's quality effort

Type		Quality effort
CSR	Pearson relation	0.685**
	Significance (two tailed)	0.000
Fairness concern	Pearson relation	-0.437**
	Significance (two tailed)	0.004

** . When the confidence level (double test) is 0.001, the correlation is significant.

Path	E	F	G	G'	Mediating effect
Coefficient	-0.538**	-0.501**	0.815**	0.767**	Partial Mediating effect

Figure 4. The mediating effect test of fairness concern

Path	E	F	G	G'	Mediating effect
Coefficient	-0.538**	-0.501**	0.815**	0.767**	Partial Mediating effect

- (1) Both bilateral CSR and altruistic reciprocity can improve the quality of agricultural products, and bilateral fairness concern will reduce the quality of agricultural products.
- (2) The partial mediating effect of social preference. We prove that CSR has more influence on quality effort than altruistic reciprocity (fairness concern), i.e. altruistic reciprocity (fairness concern) has a partial mediating effect in the impact of CSR on quality effort.
- (3) CSR not only has direct effect on the quality effort, but also has indirect effect on the quality effort through altruistic reciprocity (fairness concern). CSR has significantly positive effect on the altruistic reciprocity and negative effect on fairness concern. On the one hand, the CSR not only has direct positive impact on the quality effort, but also has indirect positive impact on the quality effort by enhancing altruistic reciprocity, which is conducive to maintaining the high-quality standard of agricultural products at each node of the supply chain, so as to obtain profits, and promote the good operation of the agricultural products supply chain. On the other hand, CSR has more positive effect on quality effort than the negative effect of fairness concern, so we can perform better CSR to alleviate the decline of quality caused by fairness concern, and CSR is conducive to alleviate the adverse impact of fairness concern on supply chain operation.

5. CONCLUSION

We set Stackelberg game model under A3P's CSR by considering the A3P's altruistic reciprocity and supermarket's fairness concern, respectively. By comparative analysis, we study the effect of CSR, fairness concern and altruistic reciprocity on the quality improvement of the agricultural products supply chain. Then, we adopt the empirical evidence to analyze the correlation between CSR, altruistic reciprocity (fairness concern) and quality improvement and the mediating effect of altruistic reciprocity (fairness concern) by investigating the agricultural enterprises. ① Through the mathematical model, CSR and altruistic reciprocity are beneficial to improve the quality of agricultural products, but fairness concern will reduce the quality of agricultural products. , Through empirical analysis, both CSR and altruistic reciprocity have positive effect on the quality of agricultural products, but fairness concern has negative effect on the quality of agricultural products. CSR has positive effect on altruistic reciprocity, but negative effect on fairness concern through correlation analysis and multiple regression. The impact of CSR on the quality of agricultural products is greater than altruistic reciprocity (fairness concern), and altruistic reciprocity (fairness concern) has a partial mediating effect on the impact of CSR on the quality of agricultural products.

We first adopt theoretical analysis and empirical evidence to analyze the effect of CSR and social preference on the quality improvement of the agricultural products supply chain, which can enrich the research on quality improvement in agricultural products supply chain, but there still exists some shortcomings. Firstly, we set mathematical model to study the impact of CSR and social preference on the quality effort, but we only consider the unilateral CSR or altruistic reciprocity (fairness concern), and we can consider the bilateral CSR or altruistic reciprocity (fairness concern) of both sides and the cross effect between CSR and altruistic reciprocity (fairness concern), which will be more general and more in line with the reality. Secondly, we first adopt empirical evidence to investigate the relationship between CSR, altruistic reciprocity (fairness concern) and quality effort, but our sample is small, we can expand the sample in the next step. Thirdly, the data of our study can't research the vertical change of the model, so the future research can be longitudinal analyzed through the long-term tracking of the survey enterprises. Finally, in the mathematical model, we study the effect of altruistic reciprocity (fairness concern) on the social welfare, but in the empirical study, wo only design the questionnaire to focus on the relation between CSR, altruistic reciprocity (fairness concern) and quality effort, ignoring the social welfare, so the future research can design the questionnaire to reflect the customer surplus.

Conflict of Interest

We all declare that we have no conflict of interest in this paper.

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