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RESEARCH ARTICLE

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The impact of business relationships on safe production behavior by farmers: Evidence from China

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Abstract

This paper focuses on the impact of business relationships on safe production behavior by farmers in China. Data collected from 410 vegetable farmers were used with a propensity score matching model for estimating. We found that the co-operative membership without marketing transactions had no significant effect on whether farmers had vegetable certification, whereas the membership did positively affect farmers' attention to pesticide toxicity and the application of soil-testing results to fertilization compared with farmers who participated in market exchanges. These results show that farmers who participate in co-operative membership with marketing transactions are more likely to own certifications, attend to toxicity and apply soil-testing results. We also found that contract farming has a positive effect on whether farmers have certification, whereas no significant effect was observed on the attention paid to toxicity and the application of soil-testing results.

KEYWORDS
business relationship, contract farming, co-operative, safe production behavior, vegetables

JEL CLASSIFICATION
L140, Q130

1 | INTRODUCTION

Major changes are taking place in the agriculture sector in China, with food safety issues becoming major concerns in the case of fresh food products. Currently, consumers in China prefer safe, nutritious, fresh, low-fertilizer, and low-pesticide food, especially for young and highly educated people. However, the status of food safety in China is

still unsatisfactory; hundreds of food safety incidents have occurred in China in the past decade, particularly in the vegetable sector because they receive the highest application of pesticides and have higher pesticide residues than other crops (Ngowi, Mbise, Ijani, London, & Ajayi, 2007). Moreover, because China has the second highest annual per-capita consumption of vegetables in the world, food safety issues in the vegetable sector poses a great risk to consumers' health (Zhou & Jin, 2009). Thus, the food safety issues urgently need to be solved.

The large number of dispersed, small-scale, rural households in China, and their traditional production and transaction model are considered to be the main causes of food safety (Hu, 2006; Zhou & Jin, 2011). The economic strength of the dispersed smallholders is relatively weak. They often lack access to high-quality fertilizer, to pesticides with low persistence or no persistence, and to soil-testing (Royer, Bijman, & Abebe, 2017; Stringer, Sang, & Croppenstedt, 2009; Swinnen & Maertens, 2007; B. Zhang et al., 2017). Smallholders are also faced with many challenges that hinder them from safe production, including high certification costs, the complex requirements of documentation, limited access to productive assets, and a lack of management skills (H. R. Barret, Browne, Harris, & Cadoret, 2001; Blanc, 2009; Nordlund & Egelyng, 2008). Furthermore, the upstream agrofood market in China is dominated by a vast number of small farmers and traders. It includes the poor, with the lack of vertical coordination in the agrofood chain posing tremendous challenges for food safety standards compliance (Jia, Huang, & Xu, 2012). Very few farmers in the upstream of the agrofood market have their fresh agricultural products tested for pesticide residue before or after sale (Huang et al., 2008; Huang, Zhi, Huang, Jia, & Rozelle, 2009). After selling their output on the spot in the market, farmers are free of all accountability. They have less inclination to improve the product quality and safety. Given these complex issues, improving the business relationship between farmers and their buyers is important, which includes, for example, the introduction of higher levels of managed coordination between farmers and agribusiness firms, as well as different forms of co-operation among farmers. Coordination or co-operative relationships can offset the inability of individual farmers to deal with safety issues in the agricultural sector. These kinds of relationships provide farmers with high-quality inputs, safe production training, standardized production and a safety management system (C. B. Barrett et al., 2012; X. Y. Guo & Zhang, 2010; Zhou & Jin, 2011). Studying the impact of different relationships between farmers and buyers on safe production behavior by the farmers provides an effective way to improve food safety situations in China. However, the impact and influence of such a mechanism are still far from being properly explored.

Thus, we tried to make up for the gaps and study the impact of different business relationships on safe production behavior by farmers. The current situation in the Chinese vegetables sector and the different kinds of business relationships of vegetable farmers, including market exchange, co-operative membership without marketing transactions, co-operative membership with marketing transactions and contract farming were described. The impact mechanisms of business relationships on safe production behavior by farmers are illustrated, followed by the application of a propensity score matching model to the data of 410 farmers in Hebei and Zhejiang provinces to analyze the effects empirically. Based on the empirical results, conclusions and implications are discussed in the final part.

2 | VEGETABLE SECTOR IN CHINA

2.1 | Vegetable sector

The economy in China has experienced high-speed growth since the 1980s, a result of a series of reforms and opening-up policies. Even in recent years, the annual growth rate of the GDP is approximately 7%[1], which is among the highest in the world. China's rapidly growing economy has great influenced the vegetables sector. The vegetable sector holds an important position in China's agricultural industry. China is the largest vegetable-producing country, providing up to 51.46% of the world yield in 2013; the export of vegetables from China also

[1]Data source: China Statistical Yearbook of 2015.

accounts for a large share (42.98% in 2013) of the world's exports[2]. The vegetable industry is the second largest agricultural industry in China, just behind the grain industry. The total vegetable land area was 21.4 million hectares in 2014, making up 12.94% of the whole cultivated land area. In addition, the total vegetable yield was 7.6 billion ton in 2014, accounting for 46.32% yield of the whole agriculture industry[3]. Vegetables also serve as the main source of agricultural cash income for farmers (Y. Liu, Chen, Zhang, & Kamphuis, 2004). Most vegetable farmers in China are smallholders. Our survey, for example, showed the average scale of vegetable production per household as being 4.12 ha. However, the average scale that is ≥1 ha accounts for 74.63% of the total. In areas outside the main production region, the production scale is even much smaller.

These smallholders are dispersed and less specialized. These smallholders are unable to meet the strict quality and safety requirement of consumers (Royer et al., 2017; B. Zhang et al., 2017). However, vegetables are high-quality and perishable products, receiving the highest application of pesticides than other crops. Therefore, these crops require stringent management for safe production. To deal with the contradiction between smallholders and high safety requirements in the vegetable sector, high levels of specialization, and vertical coordination are needed.

2.2 | Business relationships in vegetable sector

In the vegetable sector in China, we define a business relationship as a series of interactions between farmers and their direct customers, including the selling of farm products, the purchase of inputs, and the use of services. Those customers include private traders, vegetable co-operatives, and investor-owned firms (IOFs). We distinguish among four dominant business relationships between farmers and transaction actors that coexist in the vegetable markets in China, based on Cui and Wang (2012), H. D. Guo and Li (2014), C. Y. Li and Zhou (2009), and X. C. Xu, Shao, Liang, Guo, and Huang (2011). These four business relationships are as follows:

(1) Market exchange: It refers to the seller–buyer relationship between farmers and private traders. These farmers serve as independent producers in the supply chain. The partners in the market exchange relationship are farmers and private traders.

(2) Co-operative membership without marketing transaction: It refers to the seller–buyer relationship between farmers and private traders and the membership relationship that exists between farmers and a cooperative. These farmers are co-operative members. The partners in co-operative membership without marketing transactions are farmers, private traders and the co-operative.

(3) Co-operative membership with marketing transaction: It refers to the seller-buyer and membership relationship between farmers and a co-operative. These farmers are co-operative members. The partners in a co-operative membership with marketing transactions are the farmers and the co-operative.

(4) Contract farming: It refers to the marketing contractual relationship between farmers and an IOF. These farmers sign marketing contracts with an IOF. The partners in the contract farming relationship are farmers and the IOF.

The market exchange represents a pure market mechanism between independent farmers and buyers. Farmers have full autonomy in deciding on production issues. In this business relationship, farmers often lack access to high quality inputs, technical assistance, and market information (Stringer et al., 2009; Swinnen & Maertens, 2007), which constrains them in improving product quality, applying safe production methods, and anticipating changes in the market demand. Independent farmers generally sell their vegetables to private traders in low-end markets, such as in traditional wet markets or wholesale markets. Hardly any inspection occurs during production and pesticide residue testing before the sale. These kinds of vegetables generally sell to consumers who pay more

[2]Data source: FAO Reports of 2015.

[3]Data source: China Rural Statistical Yearbook of 2015.

attention to price rather than quality and safety (Q. F. Zhang & Pan, 2013). Thus, farmers are not concerned about safe production, such as using low toxic pesticide or having soil-testing done before fertilizer application. This approach causes several safety issues in the traditional spot markets, which in turn brings consumers a high uncertainty in quality, making them less inclined to pay a premium for quality (Akerlof, 1970).

Cooperatives arose in China in the 1980s and began to grow rapidly after the implementation of the "Law on Farmer Specialized Cooperatives" in 2007, which created new ways for farmers to do business with their buyers (Chen & Scott, 2016). Cooperatives are expected to provide individual farmers with high-quality input, market information, and assistance with new technologies to help them address problems of small-scale production challenges, food safety, pesticide residue testing, and supervision during production (Song, Qi, Zhang, & Vernooy, 2014; Zheng, Wang, & Awokuse, 2012). Cooperatives can be effective organization carriers for achieving quality and safe production in agriculture. Cooperatives play essential roles in food product safety control among farmer members through training, group input purchasing, inspection during production, mutual supervision among members, and pesticide residue testing before sale (Kirezieva, Bijman, Jacxsens, & Luning, 2016; Narrod et al., 2009; Royer et al., 2017; X. Xu et al., 2013). Food safety control by the co-operatives is quite important, as the co-operative controls food safety problems from the beginning to upstream of the food supply chain.

Two types of relationships between a farmer and a co-operative can be distinguished: a co-operative membership with or without the marketing transaction. In both relationships, vegetable farmers have membership with the co-operative, and receive assistance from the cooperative. The difference between co-operative membership with and without marketing transactions is the marketing/transaction relationship. For co-operative membership without marketing transactions, the farmers sell their vegetables to private traders. That is, independent farmers have a flexible transaction relationship with private traders. Farmers have a high autonomy on production issues. The co-operatives, however, provide these farmer members with high-quality inputs, low toxic pesticide, soil-testing services, and fertilizer and pesticide application guidance, whether or not the farmer-members use these services offered by co-operatives. The farmers do not have to comply with the safety requirements made by co-operatives. The private traders do not supervise the safe production of vegetables by the farmers. Similar to the market exchange relationship, this membership requires no pesticide residue testing, as long as vegetables are in good condition in appearance. Farmers in the co-operative membership without marketing transaction do not promote safe production behavior.

In co-operative membership with marketing transactions, co-operative members deliver their vegetables to the co-operative. Farmers in this business relationship have lower autonomy on production issues. They need to obey the regulations set by the cooperative. In this kind of business relationship, the co-operatives provide farmer members with safety production training to meet the requirement of standardization and food safety (Robinson et al., 2017). It is an effective channel to meet the need of food safety. In addition, individual farmers in China are faced with high costs when implementing safe production. Co-operatives save the implement cost, by scale economy, through centralized testing, unified and low-price input provisioning, training and technique services, and scientific and unified production management in applying safety production. Moreover, co-operatives carry out inspection processes during vegetable production more effectively because they build operative and restrictive inspection mechanism (X. Y. Guo & Zhang, 2010). Because the safety regulations and requirements of cooperatives are jointly decided by all members, these decisions are still in the farmers' hands. More important, the cooperative shares the ownership and control of the members and maximizes the interests of all members (Hansmann, 1996; Sexton & Iskow, 1993). The benefits of cooperative and farmer members are closely interrelated. If the cooperative gets more market opportunities for high-end markets through standardized production and several safety controls, farmers also gain more price-improved incomes because of co-operative benefits and qualified production. These benefits motivate farmers to obey the regulations made by the co-operatives and avoid farmers' optimistic behavior in safe production.

Contract farming arose in China in the early 1980s. It is the contractual relationship between a farmer and an IOF. The IOF provides contract farmers with easy access to agricultural inputs, technical support, and output

markets to minimize quality and safety risks and improve safe production by the farmers (C. B. Barrett et al., 2012; Zhou, Kai, & Qiao, 2015). Contract farmers have low autonomy on production issues. IOFs control the product quality and safety strictly, through input control, supervision during production and pesticide residue testing before sale. Farmers need to follow production regulations to meet the strict quality requirements specified in the contracts. Otherwise, IOFs are entitled to reject farmers' vegetables or to reduce the price. Though the strict regulations are quite advantageous for safe production, space remains for optimistic behavior by the IOF. For example, the IOF may reject a farmer's vegetables or reduce the selling price deliberately and unfairly.

In the market exchange and cooperative membership without marketing transactions, the transactional relationship between farmers and downstream traders is based on pure market mechanisms (Williamson, 1991). These kinds of transactions are always one-time, unstable transactions. The transaction mode is relatively primitive. Most transactions adopt a spot trading mode of "seeking goods–bargaining–picking–buying." Compared with the other two kinds of business relations, farmers in market exchange and co-operative membership without marketing transaction are more inclined to have opportunistic behavior and take no initiative to adopt safe production behavior as long as no supervision or punishment occurs. In co-operative memberships with marketing transactions and contract farming, the transactional relationships between the farmers and the co-operatives or IOFs are based on co-operative or contractual relationships, which are long-term relationships (H. Guo & Jolly, 2008; L. Li, Guo, Bijman, & Heerink, 2018). Through repeated transactions, a relationship becomes more symbiotic and trustworthy (Hill, 1990; Yaqub, 2009). This relationship reduces a farmers' possibility for opportunistic behavior and makes farmers more willing to adopt safe production behavior. In addition, these two relationships have more stringent controls on inspection and punishment. The relationships always have explicit regulations on the use of chemical fertilizer and pesticide, requirements of structural inspection and testing, penalty clauses, and so on (Bijman, 2008; Otsuka, Nakano, & Takahashi, 2016). These controls of product quality and safety compel farmers to emphasize safe production.

3 | METHODOLOGY

3.1 | Data

The data used in the econometric analysis were obtained from a survey of 420 farmers in 2015 in the Hebei and Zhejiang provinces in China. A multistage sampling procedure was used for the data selection. First, Hebei and Zhejiang provinces were purposively selected based on the national intensity of vegetable production and consumption. Second, 13 county-level districts where vegetables are intensively produced at the provincial level were chosen in the two provinces. Third, 20 vegetable co-operatives and 10 vegetable agribusiness firms were randomly selected from those 13 districts. The number of vegetable co-operatives and agribusiness firms was proportional to their shares in the list of registered vegetable co-operatives and agribusiness firms. Fourth, one village affiliated to each vegetable co-operative or agribusiness firm in the selected district was randomly selected. Finally, three co-operative members or contract farmers of agribusiness firms and four independent farmers in each village were randomly selected, resulting in a total of 420 farmers. Of the 420 farmers surveyed, 410 provided observations included in the analysis. The other ten were omitted because of missing values or as obvious outliers for one or more major variables.

3.2 | Model

A propensity score matching model is established. Farmers in the experimental group (co-operative membership without marketing transaction, co-operative membership with marketing transaction, and contract farming) and the control group (market exchange) are matched in a certain way. In the case of same conditions, the differences in safe production behaviors between the experimental group and the control group were used to determine the

causal relation between the business relationships and the farmer's safe production behavior. Farmers' safe production behavior is designated as dependent dummy variable y. $y = 1$ means a farmer adopts this kind of production behavior, whereas $y = 0$ indicates nonadoption. The independent variables of the four business relationships are denoted as $X_1, X_2, X_3,$ or X_4.

When the experimental group-co-operative membership without marketing transaction is taken as an example, the propensity score is

$$PS(X_2) = Pr(BR_2{=}1 \mid X_2) = \frac{e^{\alpha X_2}}{1+e^{\alpha X_2}} \tag{1}$$

where $BR_2 = 1$ represents the experimental group, and farmers in this group choose co-operative membership without marketing transaction; $BR_2 = 0$ represents the control group, and farmers in this group choose market exchange; $e^{\alpha X_2}/(1 + e^{\alpha X_2})$ represents the cumulative distribution function.

The average treatment effect (take the experimental group-co-operative membership without marketing transaction as an example) is as follows:

$$ATT = E(y_2 - y_1|BR_2 = 1) = E(E[y_2|BR_2 = 1, P[X_2]) - E[y_1 BR_2 = 0, P[X_2]|BR_2 = 1]), \tag{2}$$

where y_2 and y_1 represents the safe production behavior of farmers with the co-operative membership without marketing transactions and market exchange. The other two experimental groups (co-operative membership with marketing transaction and contract farming) can also be written as Equation (2).

3.3 | Variables

Our model has three dependent variables. y_1 is whether a farmer owns pollution-free certification, green certification, or organic vegetable certification. y_2 is whether a farmer pays attention to pesticide toxicity when applying pesticide. y_3 is whether a farmer uses the soil-testing results to guide his/her vegetable production to avoid fertilizer overuse and the influence of soil pollution. The value of farmer's safety production behavior is denoted as 1 if a farmer adopts it, and 0 otherwise.

Independent variables are shown in Table 1. C. Liu (2011) finds that the most common safety problems in production in China are the inappropriate use of fertilizers and pesticides and the resulting agroecological environmental pollution. Thus, we include the variable of whether farmers receive the pesticide and fertilizer application guidance by local government into our model. Product characteristics also influence farmers' safety

TABLE 1 Independent variables and descriptive statistics

Variables	Mean	Std. Dev.	Min.	Max.
Age	48.99	10.50	25	75
Education	0.65	0.48	0	1
Vegetable production years	15.63	10.73	1	50
Vegetable land area	62.45	182.60	0.2	1500
Proportion of greenhouse land area	0.49	0.48	0	1
Proportion of leafy vegetables	0.16	0.31	0	1
Proportion of fruit vegetables	0.72	0.38	0	1
Pesticide application guidance by local government	0.04	0.19	0	1
Fertilizer application guidance by local government	0.03	0.16	0	1
Hebei province	0.49	0.50	0	1

production practices. For example, if farmers plant more leafy vegetables, more pesticides will be needed than planting root vegetables. Therefore, the proportion of the leafy vegetables and fruit vegetables are included in the analysis. Farmers' personal endowment and production characteristics are also included into the model.

4 | RESULTS

4.1 | Descriptive statistics

In our sample, 57 farmers chose cooperative membership without marketing transactions, 62 farmers chose co-operative membership with marketing transactions, 41 farmers chose contract farming, and 250 farmers chose the market exchange. Of the farmers, 205 were in Zhejiang province, and 205 were in Hebei province. In Table 1, we found that the average age and years of vegetable production of farmers in the sample was 48.99 and 15.63, respectively. These averages showed that vegetable farmers in these two provinces are mature and experienced. In our sample, 65% of the farmers had obtained an education beyond junior high school, illustrating that most of the farmers are highly educated. We also found that only 0.04 and 0.03 of the farmers receive pesticide and fertilizer application guidance from the local government, respectively. This finding demonstrates that the guidance for safe production from the government is lacking. Table 1 also shows that the mean value for the proportion of fruit vegetable is 0.72, which means that fruit vegetables are more popular than leafy and root vegetables among farmers in Hebei and Zhejiang provinces.

From Table 2, we show that of the total sample, 29% of the farmers have vegetable certification, 28% of the farmers pay attention to pesticide toxicity when applying pesticide, and 57% of the farmers apply soil-testing and use the results when they fertilize. Among these four business relationships, the co-operative membership with marketing transaction relationship has the largest proportion of farmers that have adopted the three safe production practices, whereas the market exchange has the smallest proportion. The proportions of farmers adopting safe production behavior in one of the other two business relationships are almost the same. Among these three kinds of safety production practices, attention to pesticide toxicity when applying pesticide has the highest frequency, whereas vegetable certification has the lowest.

4.2 | Empirical results

To analyze the effect of the different business relationships on farmers' safe production behavior, we defined three dependent variables: whether farmers have vegetable certification, attention to pesticide toxicity when applying pesticide, and the application of soil-testing results to fertilization. For each dependent variable, we used a propensity score matching model (PSM). The three experimental groups include a co-operative membership without marketing transactions, co-operative membership with marketing transactions, and contract farming, and

TABLE 2 Percentage of food safety practices adopted by farmers

	Vegetable certification	Attention to toxicity when applying pesticide	Application of soil-testing results to fertilization
Total	0.29	0.28	0.57
Market exchange	0.36	0.51	0.38
Cooperative membership without marketing transaction	0.37	0.67	0.44
Cooperative membership with marketing transaction	0.67	0.69	0.52
Contract farming	0.43	0.67	0.33

TABLE 3 The empirical results of propensity score matching (PSM)—whether the farmer has vegetable certification

Matching method	Co-operative membership without marketing transactions	Market exchange	Average treatment effect (ATT)
Before matching	0.368	0.148	0.220***
Nearest neighbor matching ($k = 4$)	0.346	0.198a	0.148
Kernel matching	0.346	0.220	0.126
Radius matching	0.346	0.213	0.133
Matching method	**Co-operative membership with marketing transactions**	**Market exchange**	**ATT**
Before matching	0.672	0.148	0.524***
Nearest neighbor matching ($k = 4$)	0.692	0.160	0.532***
Kernel matching	0.692	0.159	0.533***
Radius matching	0.692	0.156	0.536***
Matching method	**Contract farming**	**Market exchange**	**ATT**
Before matching	0.428	0.145	0.283***
Nearest neighbor matching ($k = 4$)	0.414	0.152	0.262**
Kernel matching	0.351	0.194	0.157
Radius matching	0.351	0.185	0.166

Note. ***, **, and *, significant at 1%, 5%, and 10%, respectively.

the control group is the market exchange. To ensure the robustness of the estimation results, three matching methods—nearest neighbor matching, kernel matching, and radius matching—were used to conduct the matching. The common support of propensity score (Appendix A) shows that the choice of variables meets the balance requirements. The results of the first step of the PSM model are shown in Appendix B. We focused on the impact of business relationships on farmers' safe production behavior; thus, primarily the results of the second steps of the PSM model are discussed (see Tables 3, 4 and 5).

From Table 3, we found that no matter which matching method was used, the co-operative membership without marketing transactions had no significant effect on whether the farmer had vegetable certification, whereas farmers who participate in a co-operative membership with marketing transactions are more likely to have vegetable certification at the 1% level compared with the market exchange relationship. The differences of the results among the three matching methods are relatively small, which shows that the estimation results are robust. Contract farming also has a positive effect on farmers' ownership of vegetable certification. Even though the significance of the average treatment effect decreases when compared with nonmatching, after the influence of observable factors has been removed, contract farming has a positive significant effect on whether a farmer has vegetable certification.

We show in Table 4 that co-operative membership with and without marketing transactions have a positive effect on farmers' attention to pesticide toxicity compared with the market exchange relationship. As long as farmers participate in co-operatives, no matter whether farmers transact with the co-operatives, they are more likely to pay attention to toxicity when applying pesticide. The estimation results are also robust according to the small differences among the three matching methods. However, contract farming showed no significant effect on farmers' attention to pesticide toxicity in the estimation of any matching method in comparison with the market exchange.

TABLE 4 The empirical results of propensity score matching (PSM)—attention to pesticide toxicity

Matching method	Co-operative membership without marketing transactions	Market exchange	Average treatment effect (ATT)
Before matching	0.666	0.496	0.170**
Nearest neighbor matching ($k = 4$)	0.693	0.403	0.290***
Kernel matching	0.693	0.408	0.285***
Radius matching	0.693	0.403	0.290***
Matching method	**Co-operative membership with marketing transactions**	**Market exchange**	**ATT**
Before matching	0.688	0.496	0.192***
Nearest neighbor matching ($k = 4$)	0.717	0.474	0.243*
Kernel matching	0.717	0.498	0.219**
Radius matching	0.717	0.503	0.214
Matching Method	Contract Farming	Market Exchange	ATT
Before matching	0.666	0.495	0.171**
Nearest neighbor matching ($k = 4$)	0.658	0.475	0.183
Kernel matching	0.651	0.496	0.155
Radius matching	0.651	0.499	0.155

Note. ***, **, and *, significant at 1%, 5%, and 10%, respectively.

TABLE 5 The empirical results of propensity score matching (PSM)—application of soil-testing results to fertilization

Matching method	Co-operative membership without marketing transactions	Market exchange	Average treatment effect (ATT)
Before matching	0.438	0.172	0.450***
Nearest neighbor matching ($k = 4$)	0.428	0.209	0.225**
Kernel matching	0.428	0.218	0.210**
Radius matching	0.428	0.211	0.217**
Matching method	**Co-operative membership with marketing transactions**	**Market exchange**	**ATT**
Before matching	0.524	0.172	0.352***
Nearest neighbor matching ($k = 4$)	0.538	0.192	0.346*
Kernel matching	0.538	0.189	0.349
Radius matching	0.538	0.191	0.347
Matching method	**Contract farming**	**Market exchange**	**ATT**
Before matching	0.333	0.188	0.145***
Nearest neighbor matching ($k = 4$)	0.341	0.306	0.035
Kernel matching	0.300	0.315	−0.015
Radius matching	0.300	0.308	−0.008

From Table 5, we found that farmers participating in co-operative membership with and without marketing transactions are more likely to apply soil-testing results when fertilizing compared to farmers in the market exchange. For co-operative membership with marketing transactions, only the nearest neighbor matching method shows a significantly positive effect. Contract farming also shows no significant effect on farmers' application of soil-testing results to fertilization compared with the control group.

5 | CONCLUSIONS AND IMPLICATIONS

The objective of this paper was to gain insights in the effect of business relationships between farmers and buyers on safe production behavior by farmers in the vegetables sector in China. The mechanisms of the impact were also illustrated. The data collected among 410 vegetable farmers in Hebei and Zhejiang provinces were used with the propensity score matching model for estimating these impacts. Cooperative membership without marketing transactions had no significant effect on whether a farmer had vegetable certification, whereas it had a positive effect on farmers' attention to toxicity when applying pesticide and the application of soil-testing results to fertilization compared with the market exchange relationship. These findings illustrated that farmers participating in co-operative membership with marketing transactions are more likely to own vegetable certification, pay attention to pesticide toxicity, and apply soil-testing results when fertilizing. We also found that contract farming has positive effect on whether a farmer has vegetable certification, whereas it has no significant effect on attention to pesticide toxicity when applying pesticide and on the application of soil-testing results to fertilization.

This study shows that co-operative membership with marketing transactions is an effective tool for promoting the improvement of safe production behavior by farmers, whereas the other two business relationships have limited effect. When producing and transacting under cooperatives, farmers are more compliant with safety requirements (Bijman, 2008; Zhou et al., 2015). In a country where the food safety system and food traceability system are not perfect, for example, in China, cooperative membership with marketing transactions is supposed to be supported to make up for the imperfection. This business relationship serves as an important approach for monitoring safety production practices of the numerous smallholder farmers and in turn ensuring food quality in the products produced and transacted by them. Thus, public policy should support the establishment and maintenance of co-operatives that involved smallholder farmers, especially for marketing cooperatives, because in a developing country such as China, several vegetable co-operatives may still not be fully aware of the effectiveness of the food quality and safety standards, particularly in the underdeveloped west-central areas. Guidance and training from the local government is essential. Another implication is to encourage farmer members to transact business with co-operatives, as co-operative membership without marketing transactions has a relatively limited effect. For example, co-operatives may consider increasing the purchasing price, introducing a minimum protective price, or increasing the reward of patronage. Public policy provides some subsidies for co-operatives that have large or increasing transaction with their farmer members. Cooperative can be very effective in improving safe production behavior in farmers, but it is only applicable in certain circumstances.

Possibilities exist for further research. First, the measurement of safe production behavior by farmers may be further improved. For example, the production record is also a kind of safety production behavior (Zhou et al., 2015). However, this record was not included in our analysis due to the lack of suitable data. Second, the safety requirements of the buyers of the co-operatives, IOFs and private traders also play important roles in the safe behavior of the farmers, although they are not included in our analysis and need further research.

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APPENDIX A

TABLE A1 Experimental group: Cooperative membership with marketing transactions

Treatment assignment	Off support	On support	Total
Untreated	0	250	250
Treated	5	56	61
Total	5	306	311

TABLE A2 Experimental group: Contract farming

Treatment assignment	Off support	On support	Total
Untreated	0	250	250
Treated	1	41	42
Total	1	291	292

APPENDIX B

TABLE B1 The first step of the propensity score matching model

Variables	Cooperative membership without marketing transaction	Cooperative membership with marketing transaction	Contract farming
Age	0.022*	0.005	0.041***
	(0.014)	(0.016)	(0.015)
Education	0.354	0.700**	0.192
	(0.294)	(0.337)	(0.288)
Vegetable production years	−0.008	0.030**	−0.022*
	(0.015)	(0.013)	(0.013)
Vegetable land area	0.002*	0.002*	0.003***
	(0.001)	(0.001)	(0.001)
Proportion of greenhouse land area	2.631***	3.133***	1.699***
	(0.353)	(0.402)	(0.271)
Proportion of leafy vegetables	−0.521	−0.003	−0.659
	(0.630)	(0.599)	(0.481)
Proportion of fruit vegetables	−0.295	0.113	−0.801*
	(0.562)	(0.515)	(0.433)
Pesticide application guidance by local government	0.944	0.794	−0.420
	(0.866)	(0.960)	(0.269)
Fertilizer application guidance by local government	−0.604	0.901	0.206
	(1.383)	(0.923)	(0.389)
Hebei province	0.186	−1.136***	−0.135
	(0.319)	(0.318)	(0.312)

Note. Standard errors in parentheses.

***$p < .01$.

**$p < .05$.

*$p < 0.1$.