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Relationship quality in the vertical collaboration of vegetable farmers: evidence from the North China Plain

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Close collaboration between vegetable farmers and downstream stakeholders is crucial for integrating farmers into modern agricultural supply chains, helping them manage market uncertainties and improving their economic outcomes. Based on the Stimulus - Organism - Response (SOR) model and social embeddedness theory, this study adopts a moderated mediation model and utilizes survey data from 1,014 farmers in the North China Plain to analyze how relationship quality influences vegetable farmers' participation in the vertical collaboration. Our findings indicate that relationship quality significantly enhances farmers' willingness to engage in the vertical collaboration, particularly in production contract arrangements. Furthermore, relationship quality promotes collaboration through enhancing farmers' perceived value, with the business environment significantly moderating this effect. Heterogeneity analyses reveal notable differences, particularly among Chinese cabbage growers and members of agricultural cooperatives, highlighting targeted opportunities for strengthening vertical collaboration. This study emphasizes the need for building robust interpersonal networks among farmers, creating a favorable business environment, optimizing collaboration mechanisms, and implementing targeted policies for different vegetable categories, thereby providing both theoretical insights and practical guidance for agricultural modernization.

KEYWORDS

vertical collaboration, relationship quality, perceived value, business environment, vegetable farmers

1 Introduction

Upgrading the production structure is a global trend in agricultural development, as well as an important aspect of China's efforts to modernize this sector. Accordingly, determining how to integrate small-scale farmers into modern supply chain systems and fully connecting production, supply, and sales is a key path for promoting such upgrades (Zhang and Aramyan, 2009). Enhancing farmers' enthusiasm for participation in the vertical collaboration within the supply chain is the key to their integration in modern supply chains (Yang et al., 2022), along with forming a community of interests with downstream stakeholders. Especially in the vegetable industry, crop production is confronted with frequent price fluctuations, rising production costs, and increasing market demand uncertainty, among other challenges (Xaba and Masuku, 2013a,b), which makes it difficult for farmers to cope with multiple pressures independently. Farmers need to diversify risks and increase profits through vertical collaboration with supply chain entities. Vertical collaboration can provide stable market channels for farmers through order contracts, reducing information asymmetry risks,

promoting technology exchange and resource sharing, and increasing the added value of agricultural products. Such activities fundamentally improve farmers' market position and provide notable economic benefits (Widadie et al., 2021). Consequently, exploring how vegetable farmers participate in the vertical collaboration and the factors that influence this participation would be of great theoretical and practical significance for optimizing and upgrading the agricultural supply chain and organically integrating farmers into modern agricultural development.

Academic research on farmers' vertical collaboration and the factors that influence it mainly focuses the following dimensions. The first dimension is the precise meaning and connotation of farmers' vertical collaboration. The concept of vertical collaboration originated from the idea of vertical integration in industrial organization theory (Tirole, 1988), emphasizing the reduction of transaction costs and improvement of efficiency through the integration of upstream and downstream links in the supply chain. With the development of supply chain management theory, vertical collaboration has gradually been endowed with a more explicit connotation. Martins et al. (2019) define vertical collaboration as the collaboration between suppliers and purchasers. Wang et al. (2023) describe vertical collaboration as the behavior of upstream and downstream stakeholders working together to reduce costs and improve efficiency by optimizing the supply and demand chain.

The second dimension is the analysis of the specific models of vertical collaboration. Most studies specifically categorize the vertical collaboration model into sales collaboration, production collaboration, strategic alliance, and vertical integration, among others (Liang and Wang, 2023; Zhang et al., 2014). Among them, the sales collaboration model belongs to loose collaboration. The vertical integration model is characterized by close collaboration and the highest level of control intensity (Gong et al., 2023). Additionally, the strategic alliance model, as an emerging form of vertical collaboration, emphasizes long-term collaborative relationships between upstream and downstream enterprises, achieving win-win results through resource and information sharing (Bai et al., 2024). The choice of these models depends on transaction costs, market conditions, and the specific needs of farmers (Li et al., 2024; Liu et al., 2024).

The third dimension is the investigation of the influencing factors of farmers' participation in the vertical collaboration. Some scholars have analyzed the influences of asset specificity and uncertainty from the perspective of transaction costs. Farida et al. (2024) found through quantitative research that asset specificity has a significant positive correlation with supply chain collaboration. Uncertainty, by influencing farmers' market expectations, further affects their willingness to collaborate (Rolfe et al., 2022). Other scholars have extended this research to include the internal subjective factors and found that emotional attachment significantly affects farmers' vertical collaboration. Farmers with a strong sense of emotional attachment are more inclined to choose the collaboration model involving farmers' cooperatives (Guo et al., 2024). This issue has also been explored from the perspective of exogenous driving forces; in a favorable business environment, factors such as policy transparency (Chen et al., 2019) and convenient market access (Hung-Anh and Bokelmann, 2019) provide farmers with stable market expectations, directly influencing their participation in the vertical collaboration.

Collaboration within the supply chain is often not merely based on institutional incentives and shared economic interests, but is also

influenced by social networks, particularly when imperfect competition is widespread in rural markets of developing countries and personal relationships may provide an important function of credit and insurance provision (Osborne, 2005). Therefore, scholars have expanded their research by focusing on the relationship quality between farmers and stakeholders in the supply chain. Fynes et al. (2008) defined relationship quality as the relationship atmosphere composed of relationship dimensions such as trust, adaptation and communication. Regarding the interaction between relationship quality and vertical collaboration among farmers, existing studies have affirmed the positive role of relationship quality. Ahmed et al. (2024) hold that the farmers' economic behavior is embedded in their social networks. The high-quality relationships formed between farmers and other market participants enhance their social capital, fostering good communication, trust, and collaboration among members (Hien and Kim, 2024). These relationships can also influence farmers' market participation behavior through three mechanisms: promoting information sharing, reducing transaction costs, and strengthening constraints (Xu et al., 2017). Then, some studies have specifically analyzed the influence of relationship quality on farmers' vertical collaboration participation behavior (VCPB). Research has shown that when the existing collaborative relationship between supply chain members tends to be stable, the probability of vertical collaboration is relatively high (Yu et al., 2024; Renko, 2011). Relationship network density and centrality between members are particularly important influencing factors. Wang et al. (2021) found through empirical research that a high-density relationship network can enhance the interaction frequency among supply chain entities, and farmers in the central position of the network can obtain more resources and information (Song et al., 2024), thereby strengthening their willingness and ability to collaborate. Existing studies have confirmed the direct effect of relationship quality on farmers' VCPB, especially in the agricultural product supply chain, where high-quality relationships can significantly enhance farmers' market participation and collaboration stability (Benitez-Altuna et al., 2024).

This provides a reference for exploring the behavioral mechanism of farmers' VCPB, but there are still some deficiencies. Regarding variable selection, many scholars have started from the transaction cost theory in economics, have focused on its effect on farmers' organizational behavior (Bijman et al., 2020; Jraisat et al., 2023). These theories have certain limitations when explaining the organizational behavior of farmers in developing countries, especially in the context of China's "acquaintance society." Previous research on the effect of relationship quality on farmers' VCPB remain inadequate. When VCPB encompasses multiple modes, comparative analyzes on the role of relationship quality across different modes are insufficient. In terms of the relationship between variables, scholars have primarily focused on elucidating the direct effects of explanatory variables on farmers' market behavior (Hung-Anh and Bokelmann, 2019; Al-Omoush et al., 2023), often neglecting the potential interaction effect and the influence of external factors on farmers' internal perceptions. To address these gaps, we used survey data from 1,014 vegetable farmers of Hebei province, employing a multiple linear regression model with considering the potential moderated mediation effect to explore the following research questions: Can the relationship quality affect vegetable farmers' VCPB? If so, what are the differences in the effect on different modes of collaboration? Can the effect of relationship

quality be strengthened by improving perceived value? Can this mechanism be regulated by optimizing the business environment?

Compared with existing literature, the marginal contributions of this paper are reflected in three aspects. First, the motivation of vegetable farmers for participating in the vertical collaboration is explored from the perspective of relationship quality, thereby expanding the research on the antecedents of farmers' economic participation behavior. Second, endogenous perceived value and exogenous business environment are incorporated into the research scope. Based on the integrated framework of the stimulus-organism-response (SOR) model and social embeddedness theory, a comprehensive theoretical model is constructed to analyze the mediating role of perceived value and the moderating role of business environment, further revealing the relationship between relationship quality and vegetable farmers' VCPB under different circumstances. Third, through an empirical study of 1,014 vegetable farmers in the North China Plain, empirical data are used to reveal the positive role of relationship quality in VCPB within rural society. Furthermore, the heterogeneous effect of relationship quality on different modes of vertical collaboration is considered. This paper provides scientific support for integrating farmers into modern agricultural product supply chains and sharing more industrial value-added benefits, in addition to playing a certain exploratory role in enriching the theoretical understanding of farmers' behavior.

The rest of this paper is organized as follows. Section 2 presents the theory and hypotheses. Section 3 describes the materials and methods used in the study, including data collection, variable description, and research methods. Section 4 analyzes the research results, including model evaluation, hypothesis testing, and heterogeneity analyses. Section 5 includes the interpretation and discussion of the model results. Section 6 presents the research conclusions, including model conclusions, policy implications, and research limitations.

2 Theoretical framework

Previous studies mainly adopt transaction cost theory and principal-agent theory to analyze the organizational behavior of farmers (Adaku and Amanor-Boadu, 2023; Arcas-Lario et al., 2014), but these theories have certain limitations when explaining the organizational behavior of farmers in developing countries, especially in the context of China's "acquaintance society." For instance, transaction cost theory mainly focuses on the cost-benefit trade-offs in collaboration (Cuypers et al., 2021), while principal-agent theory emphasizes the incentive and supervision mechanisms (Poulton and Macartney, 2012). These theories struggle to explain how relationship networks and market environments influence farmers' VCPB and fail to reflect the impact paths of external factors on farmers' psychological cognition. In contrast, social embeddedness theory highlights the constraints and empowerment of social relations on farmers' behaviors (Czyżewski et al., 2025), and the SOR theory reveals how external stimuli affect farmers' psychological cognition and decision-making, making it suitable for analyzing farmers' decision-making logic in complex social environments (Xu et al., 2024). Therefore, we combine the social embeddedness theory with SOR theory to construct an integrated framework, elaborating on the influencing factors and mechanism of farmers' VCPB.

2.1 Theoretical foundations

2.1.1 Social embeddedness theory

The social embeddedness theory was first proposed by economic historian Karl Polanyi in 1944. He argued that economic behavior does not exist in isolation but is embedded in social relations, and there is no market that is detached from social relations (Polanyi, 2001). On this basis, Granovetter, from a micro-level perspective of interpersonal interaction, further subdivided embeddedness into relational embeddedness and structural embeddedness to analyze the relationship between economic actions and social structures (Granovetter, 1985). Social embeddedness theory holds that an individual's economic behavior mainly depends on their social relationships, the network structure to which they belong, and the institutional framework, which together form a path dependence (Chaudhuri et al., 2021; Aji, 2016). The social embeddedness theory is mainly applied in fields such as agricultural social capital and sustainable agricultural development. Its research content involves the construction of farmers' social networks, the development of new agricultural organizations, and the promotion of green agriculture (Duan et al., 2024; Yan et al., 2025). From the perspective of social embeddedness theory, the vegetable farmers' VCPB is embedded in the relationship network formed with purchasers and the external institutional environment.

2.1.2 Stimulus-organism-response theory

The stimulus-organism-response (SOR) theoretical model aims to dissect the influence of external stimuli on human organism responses and their operational mechanisms, providing a theoretical basis for individual behavioral responses (Mehrabian and Russell, 1974). According to this theoretical framework, the stimulus (S) encompasses various external stimuli, including social environments and interpersonal interactions; the organism (O) refers to the psychological feelings resulting from exposure to external stimuli; and the response (R) represents the behavioral choices made by the organism after integrating the external stimuli and the psychological feelings (Sultan et al., 2021). The SOR theory does not necessarily strictly follow the action path of "S-O" and "O-R." External stimuli (S) can directly act on the psychological processes of the organism (O), or directly produce behavioral responses (R) (Dong X. et al., 2022; Dong H. et al., 2022). The SOR theory is applicable to analyzing the organizational behavior of farmers and is mainly used in fields such as agricultural technology adoption, digital agriculture application, and rural finance (Hou and Wang, 2023). The research content involves farmers' green production decisions, e-commerce adoption, and access to financial credit and other behaviors (Dong X. et al., 2022; Dong H. et al., 2022). When examining farmers' VCPB, it is imperative to note that their judgments are influenced by many external conditions and internal feelings. Consequently, the SOR model is suitable for analyzing how various mechanisms influence vegetable farmers' VCPB and can fully reveal the roles of both internal and external factors.

2.2 Conceptual framework and hypotheses

Based on the logic of the SOR model and combined with social embeddedness theory, we constructed a framework for theoretical analysis of the influence of relationship quality on the VCPB of

vegetable farmers. Accordingly, we further link the external stimuli, internal psychological mechanisms, and behavioral choices of vegetable farmers to analyze how relationship quality, business environment, and perceived value influence the VCPB in depth. Relationship quality reflects the depth of collaboration among vegetable farmers in their social network (Liu and Lv, 2023), while the business environment encompasses the external environmental conditions that vegetable farmers encounter (Wang et al., 2024). These two factors form the stimulus for farmers' decision-making from the perspective of social embeddedness, while the perceived value, as a psychological mechanism, reflects farmers' internal evaluation of the value obtained from participating in the vertical collaboration (Luo et al., 2022). Therefore, relationship quality and business environment are the stimulus variables (S), perceived value is the organism variable (O), and VCPB is the response variable (R). This paper explores the factors influencing vegetable farmers' VCPB and the mechanisms for that influence from the perspective of social embeddedness. The theoretical framework is shown in Figure 1.

2.2.1 Direct effect of relationship quality on the vegetable farmers' VCPB

Relationship quality refers to the status of interaction and degree of collaboration among the members of a social network. In the vegetable supply chain, relationship quality is reflected in the degree of connection between upstream and downstream stakeholders (Lu et al., 2008). Relationship quality is improved through relationship management methods, which promote the transformation of social relationships from loose and conflictive to close and collaborative (Beske et al., 2014). Improving the relationship quality between vegetable farmers and downstream stakeholders in the vegetable supply chain can effectively prevent opportunistic risks, reduce frictions during the implementation of control rights (Karaman and Yigit, 2022), and promote long-term and stable vertical collaboration among supply chain members. Specifically, relationship quality affects VCPB in three ways. First, the level of trust serves as the foundation of vertical collaboration. Sahara et al. (2011) note that only when there is sufficient trust within the supply chain will stakeholders be willing to adopt a cooperative strategy. As the initial level of trust among farmers increases, the trust difference sensitivity coefficient also increases, and the probability of vertical collaboration between

farmers and fixed buyers will increase (Ayari and Boulila, 2023). Second, the level of communication is the key to vertical collaboration. Smooth and effective communication can ensure information symmetry along the supply chain, form an effective conflict resolution mechanism, and facilitate deeper collaboration (McNally and Griffin, 2006; Widadie et al., 2023). Finally, the level of commitment is the core of vertical collaboration. The commitment level of purchasers fully leverages the advantage of personal relationships, resultantly reducing negotiation and coordination costs during transactions (Suvanto and Lähdesmäki, 2023). When there is a strong commitment between vegetable farmers and purchasers, both parties are more willing to invest and work toward common goals and long-term interests, which is conducive to forming a stable collaborative relationship.

As relationship quality improves, vegetable farmers' demands for stability, trust, and information sharing also increase. Vertical collaboration, through closer ownership or management ties, can provide more certain income expectations, reducing transaction costs and risks (Xaba and Masuku, 2013a,b), thereby better meeting the higher-level demands for collaboration created by high-quality relationships. Given such high-quality relationships, vegetable farmers' VCPB will significantly increase. The following hypothesis is therefore proposed.

H1: The relationship quality positively affects vegetable farmers' VCPB. The vegetable farmers with higher-quality relationships are more inclined toward vertical integration collaboration.

2.2.2 Mediating effect of perceived value

The concept of perceived value originated in the field of product marketing and indicates the trade-off between gains and losses for customers—that is, the overall evaluation of the utility of a product or service made by customers after weighing the costs they have to pay and the benefits they perceive when obtaining the product or service (Blut et al., 2024). Perceived value is also regarded as an important basis for actions in the study of farmers' economic behavior (Cao et al., 2022). During vegetable production and sales, farmers' decisions to participate in the vertical collaboration are mainly based on rational judgments of the perceived benefit and cost. On the one hand, if vegetable farmers perceive that vertical collaboration would reduce the information, negotiation, and implementation costs incurred

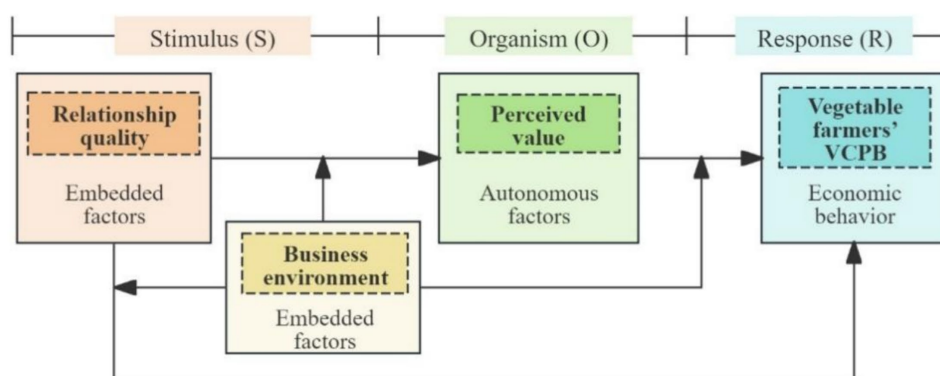


FIGURE 1
Theoretical framework.

during transactions (Zeweld et al., 2017) and provide more favorable market opportunities, they are more likely to engage in the vertical collaboration with purchasers to sell their vegetable products. On the other hand, if the perceived benefit of vertical collaboration exceed their psychological expectations, their behavioral intentions would be more positive (Li et al., 2021). Meanwhile, relationship quality can influence the perceived value of vegetable farmers. It can effectively alleviate the information constraints on vegetable farmers, enabling them to obtain and share information more accurately and conveniently. Their acceptance and understanding of information affect their perception of value, so relationship quality is an important antecedent variable of perceived value. The following hypothesis is therefore proposed.

H2: Perceived value mediates the effect of relationship quality on vegetable farmers' VCPB.

2.2.3 Moderating effect of the business environment

The business environment refers to the external environmental conditions for economic entities to engage in market operations (Wang et al., 2024). Within the framework of social embeddedness theory, the optimization of the business environment facilitates the exchange of materials, information, and services between vegetable farmers and other stakeholders, thereby enhancing the efficiency of social exchanges (Zhang and Xu, 2024) and promoting the stability of vertical collaborative relationships. The business environment, as a contextual variable, theoretically does not have a direct effect on the economic behavior of vegetable farmers. Its internal logic lies in building a resource platform or in optimizing the transaction environment to gather the core elements for collaboration between vegetable farmers and purchasers (Li et al., 2023), which leads to the platform aggregation of resources, in which resources serve the subjects. As a result, the business environment should be regarded as a moderating variable rather than a predictive variable for promoting vegetable farmers' behavior. Empirically, Wang and Wu (2024) argued that as the transparency and standardization of the business environment improve, actors are more likely to identify and select suitable partners when establishing social relationships, thus reducing uncertainty risks. We therefore posit that the business environment positively moderates the direct effect of relationship quality on vegetable farmers' VCPB. Specifically, regions with a favorable business environment will have built a bridge of communication for vegetable farmers and downstream entities through policy support, improved infrastructure, and the continuous optimization of the trading environment, thereby stimulating market vitality and internal development momentum. The following hypothesis is therefore proposed.

H3: The business environment moderates the process by which relationship quality affects vegetable farmers' VCPB.

A favorable business environment can enhance market transparency, which can make it easier for vegetable farmers to obtain higher perceived value through social relationships; resultantly, they are more inclined to engage in the vertical collaboration such as contractual transactions and collaborative alliances (Yu, 2020). As such, the business environment is a moderator in the framework

relationship quality → perceived value → vegetable farmers' VCPB. The business environment moderates the relationship between relationship quality and perceived value. When the policy system is sound and the business environment is stable, the communication ability and trust level of supply chain members are strengthened, promoting resource and risk sharing between vegetable farmers and downstream members. This structural embedding enhances farmers' perception of the potential benefits of social relationships (Patnayakuni et al., 2006). The business environment also moderates the relationship between perceived value and vegetable farmers' VCPB. In a favorable business environment, the market is more open and active, thereby allowing farmers to have a clearer understanding of market demand, price fluctuations, and the credibility of purchasing organizations (German et al., 2020). This enhances their perception of the benefits that may come from collaboration, reduces uncertainties and risks in collaboration, and makes farmers more willing to participate in the vertical collaboration. The following hypothesis is therefore proposed.

H4: The business environment moderates the mediating path through which relationship quality affects vegetable farmers' VCPB via perceived value.

Our hypothesized model is illustrated in Figure 2.

3 Materials and methods

3.1 Data collection

Our data were derived from a questionnaire survey of vegetable farmers conducted in Hebei Province, a highly representative region within the North China Plain, spanning from June 2023 to July 2024. The selection of the research area was based on the following considerations: First, Hebei Province is a major vegetable-producing area in China and one of the regions with the highest output of vegetables in the country. According to the "2024 China Rural Statistical Yearbook," Hebei's total vegetable output in 2023 was 54.98 million tons, contributing 6.63% to the national total output, and playing a crucial role in ensuring a stable supply of vegetables throughout the year. Second, Hebei Province is surrounded by Beijing, one of the most economically developed regions in China, and serves as the primary vegetable supplier to the city. Since 2015, Hebei has become the top province supplying vegetables to Beijing, with a year-round market share of around 41% of vegetables in Beijing's wholesale markets. Hence, Beijing attaches great importance to the development of Hebei's vegetable industry and has introduced policies to support the joint construction of large-scale vegetable production bases for Beijing with Hebei. Currently, the two regions have jointly established 158 vegetable bases and promoted diverse supply chain modes such as online direct sales, farm-to-supermarket connections, central kitchens, community group buying, and pre-prepared food processing. This has led to a closer vertical collaborative relationship between vegetable farmers and downstream supply chain members. These details ensure the typicality of our sample.

The Chinese cabbage and cucumbers of Hebei Province were selected as the main research varieties. First, Chinese cabbage and cucumbers are characteristic and advantageous industries in Hebei Province, with relatively large planting areas. In 2023, the Chinese

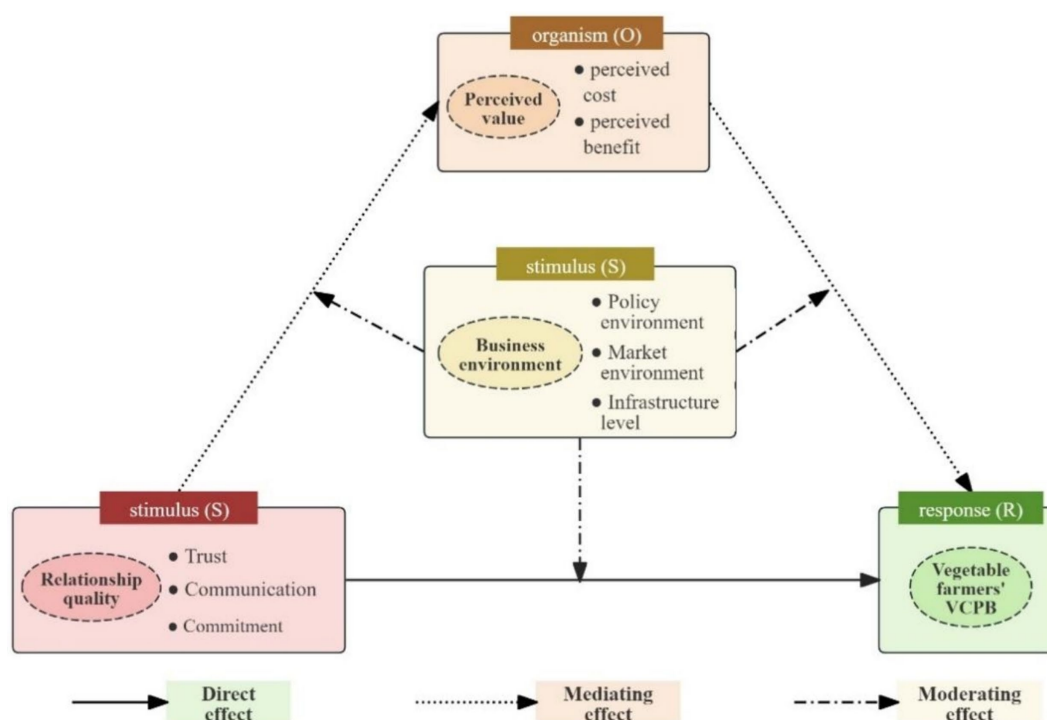


FIGURE 2
Diagram of hypothesized model.

cabbage covered 185,500 hectares in Hebei Province and cucumbers 81,700 hectares, accounting for 30% of the total vegetable planting area. Second, the Chinese cabbage from Zhangjiakou in summer and that from Tangshan in autumn and winter are staples of the national vegetable market and directly affect vegetable price fluctuations. Cucumbers from Hebei Province have achieved year-round balanced supply in the Beijing market, consequently providing a stable supply for the national market. The farmers' VCPB of these two vegetable varieties is stable. Third, both cucumber farmers and Chinese cabbage farmers have a high demand for vertical collaboration. Cucumbers involve high-investment, high-value, and high-technology-demand vegetable varieties, and farmers need to reduce costs and increase efficiency through vertical collaboration. Chinese cabbage is a bulk low-value vegetable and is resultantly more sensitive to market price fluctuations, so farmers need to obtain stable sales prices through vertical collaboration. The selection of these two products thus ensures typicality.

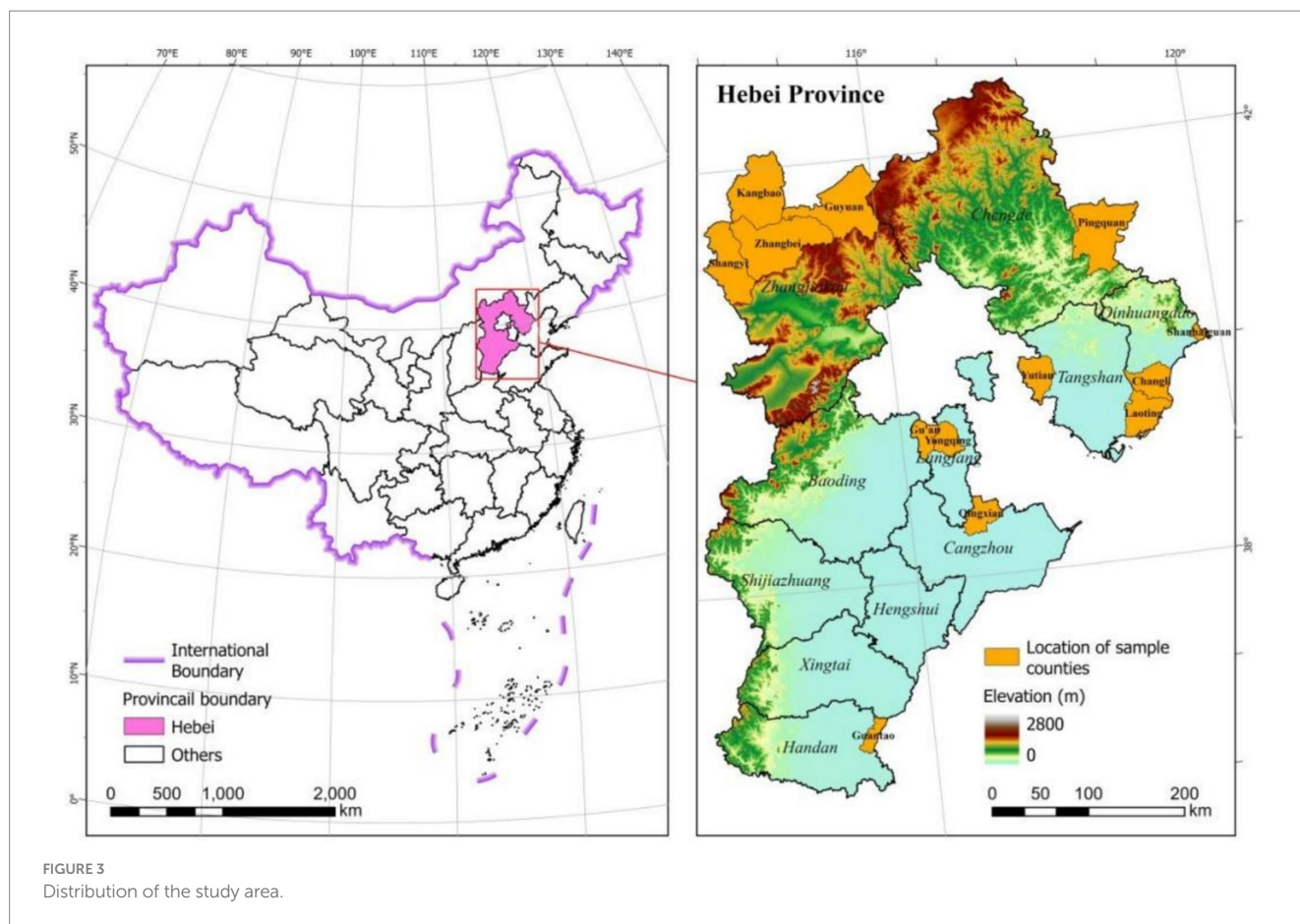
Stratified sampling was adopted to collect data. First, the main production counties (districts) of cucumbers and Chinese cabbages in Hebei Province were selected as the primary sampling units, including eight cucumber production regions—the counties of Guantao, Gu'an, Yongqing, Qingxian, Changli, and Laoting, as well as Shanhaiguan District and the city of Pingquan—and five Chinese cabbage production regions: the counties of Yutian, Zhangbei, Shangyi, Kangbao, and Guyuan. Figure 3 shows the regional distribution of the research. The planting conditions for cucumbers and Chinese cabbages in these 13 counties (districts) basically represent the overall situation of Hebei Province. Second, 30 vegetable supply bases for Beijing were randomly selected from these counties (districts). One village mainly served by each vegetable supply base was also randomly

selected. Finally, 15 farmers participating in the construction of the vegetable production bases for Beijing and 20 independent vegetable farmers were randomly selected from each village, totaling 35 farmers. The research team interviewed a total of 1,050 farmers, and after excluding questionnaires with inconsistent responses and missing data, a total of 1,014 valid questionnaires were ultimately obtained, with an effective recovery rate of 96.57%.

3.2 Variable description

3.2.1 Dependent variable

VCPB was the dependent variable. Vegetable farmers' VCPB refers to the behavior of farmers establishing collaborative relationships with upstream and downstream members in the supply chain during the production and sales of vegetables to achieve coordinated management and resource sharing in this process (Bijman and Wollni, 2009). The measurement of the vegetable farmers' VCPB covered two issues: whether farmers participated in the vertical collaboration and the choice of vertical collaboration mode. Drawing on relevant research (Zhang and Wu, 2023; Ying and Wang, 2009), the modes of vertical collaboration was categorized into three types: sales contract, production contract, and vertical integration collaboration. Sales contract collaboration refers to the signing of sales contracts by both parties involving transaction quantity, price, and quality (Schipmann and Qaim, 2011). Production contract collaboration means that both trading parties provide production input factors and sign production contracts involving production, management, and procurement (Huang et al., 2019). Vertical integration collaboration involves integrating production, circulation, and other links into a single



organizational structure for supervision and control, internalizing transactions (Dong et al., 2020). The analysis revealed that 43.00% of vegetable farmers participate in the vertical collaboration. Among the three vertical collaboration modes, sales contract collaboration had the highest proportion at 27.91%, followed by production contract collaboration (10.06%). Vertical integration collaboration had the lowest proportion at 5.03%.

3.2.2 Core independent variable

The core independent variable was relationship quality. The relationship quality reflects the degree of connection between the subjects (Lu et al., 2008). Morgan and Hunt (1994) held that the core of relationship marketing was trust and commitment, which were important components of relationship quality. Dlamini-Mazibuko et al. (2019) showed that smooth communication enhanced trust and cohesion among supply chain members, thereby improving relationship quality. This paper characterized relationship quality based on three dimensions: trust, communication, and commitment. A 5-point Likert scale was adopted, ranging from “strongly disagree” to “strongly agree.” The items are shown in Table 1. Factor analysis was used to measure relationship quality, and three common factors with eigenvalues greater than 1 were obtained. The comprehensive value of the relationship quality variable was calculated based on the standardized factor scores and the corresponding variance contribution rates of each factor. The calculation formula is: relationship quality = (variance contribution rate of trust factor × trust score + variance contribution rate of communication factor ×

communication score + variance contribution rate of commitment factor × commitment score) ÷ cumulative variance contribution rate.

3.2.3 Mediating variable

Perceived value was the mediating variable. The perceived value of vegetable farmers refers to their subjective assessment of the benefits and costs brought about by participating in the vertical collaboration (Li et al., 2020). Drawing on the research of Soane et al. (2010), we divided perceived value into two dimensions: perceived cost and perceived benefit. A 5-point Likert scale was adopted, ranging from “strongly disagree” to “strongly agree.” The items are shown in Table 2. Factor analysis was used to measure perceived value, and two common factors with eigenvalues greater than 1 were obtained. The comprehensive value for this variable was calculated based on the standardized factor scores and the corresponding variance contribution rates. The calculation formula is: perceived value = (variance contribution rate of perceived cost factor × perceived cost score + variance contribution rate of perceived benefit factor × perceived benefit score) ÷ cumulative variance contribution rate.

3.2.4 Moderating variable

The business environment was the moderating variable. The business environment refers to the external institutional and market conditions that affect the operation and development of the supply chain (Ren, 2024). Following Tse-Alan et al. (2003) and Liu et al. (2015), and in light of the characteristics of the vegetable industry, we characterized this variable in terms of the policy environment,

TABLE 1 Relationship quality items and descriptive statistics.

Variable	Items	Mean	Standard deviation
Trust	I believe in the information provided by the purchaser.	3.850	0.913
	I believe the purchaser will adhere to the principle of fair trade.	3.501	0.874
	I believe the purchaser will seriously consider and handle my reasonable demands.	3.591	1.011
Communication	The purchaser will communicate with me about the transaction time.	3.837	0.813
	The purchaser will communicate with me about the delivery method.	3.829	0.843
	The purchaser will communicate with me about market demand information.	3.637	0.986
	In case of disagreement, the purchaser will communicate with me candidly.	3.552	0.988
Commitment	The purchaser will pay the purchase price on time.	3.837	0.748
	The purchaser will fulfill the oral or written contract agreement.	3.604	0.979
	I am willing to spend time and energy maintaining the collaborative relationship.	3.544	0.854

TABLE 2 Perceived value items and descriptive statistics.

Variable	Items	Mean	Standard deviation
Perceived cost	I believe vertical collaboration reduces information costs.	3.532	1.230
	I believe vertical collaboration reduces negotiation costs.	3.996	0.993
	I believe vertical collaboration reduces implementation costs.	3.163	1.284
Perceived benefit	I believe vertical collaboration increases vegetable output.	3.746	0.889
	I believe vertical collaboration boosts sales revenue.	3.859	0.866
	I believe vertical collaboration expands product sales channels.	3.792	0.898

market environment, and infrastructure level based on three items: “I am satisfied with the local support policies for the vegetable industry,” “I am satisfied with the services provided for local vegetable market transactions,” and “I am satisfied with the infrastructure conditions of the local vegetable industry.” These items were rated on a 5-point Likert scale. Factor analysis was conducted, and one common factor with an eigenvalue greater than 1 was extracted and named as the business environment.

3.2.5 Control variables

Existing studies have shown that variables such as the personal and family characteristics of vegetable farmers affect their behavioral choices regarding supply chain organization modes (Wardhana et al., 2020; Romero-Granja and Wollni, 2018). We selected relevant control variables based on these personal and family characteristics. The items are shown in Table 3. Descriptive statistical analysis revealed that most interviewed farmers were male (71.2%). Those with junior high school education or below accounted for 64.4%, and the overall education level was relatively low. The farmers had an average of 16 planting years. The average number of agricultural laborers in the family was 2.

3.3 Methods

3.3.1 Logit model

We built binary logit and multinomial logit models to investigate vegetable farmers’ VCPB and, if so, the specific modes chosen. The expression of the binary logit model is:

$$\ln \frac{P_i}{1 - P_i} = a_0 + \alpha_1 X_i + \alpha \text{Control} + \mu \quad (1)$$

To further examine the mode selection, we assumed that farmers would choose one of three modes: sales contract collaboration, production contract collaboration, and vertical integration collaboration ($j = 1, 2, 3$); the reference group was recorded as 0. The expression of the multinomial logit model is:

$$\ln \frac{P(Y = j|X)}{P(Y = J|X)} = a_0 + \alpha_1 X_i + \alpha \text{Control} + \mu \quad (2)$$

In Equations 1, 2, P is the probability of the event occurrence, Y is the dependent variable, X_i is the independent variable, Control captures the control variables, and a_0, α_1, α are the parameters to be estimated, while μ is the random error. Coefficient estimation was carried out using the maximum likelihood estimation (MLE) method.

3.3.2 Moderated mediation effect model

The bootstrap method was used to test the mediating effect of perceived value and the moderating effect of the business environment on the relationship between relationship quality and vegetable farmers’ VCPB. Compared with the traditional stepwise regression method commonly used in the tests of mediation and moderating effects, this method has several advantages. First, it can be applied to tests of mediation effects in various complex situations. For example, perceived value can be divided into two dimensions, perceived cost and perceived benefit, for analysis, and the mediating effect of perceived value can be tested under the moderation of the business environment, among

TABLE 3 Variable descriptions and descriptive statistics.

Variable	Variable description	Mean	Standard deviation
Dependent variable			
Vertical collaboration participation behavior (VCPB)	0 = no; 1 = yes	0.430	0.495
Vertical collaboration participation mode	0 = reference group; 1 = sales contract collaboration; 2 = production contract collaboration; 3 = vertical integration collaboration	-	-
Core independent variable			
Relationship quality	The standardized result of factor score	0.624	0.175
Trust	The standardized result of factor score	0.588	0.174
Communication	The standardized result of factor score	0.532	0.157
Commitment	The standardized result of factor score	0.607	0.172
Mediating variable			
Perceived value	The standardized result of factor score	0.600	0.245
Moderating variable			
Business environment	The standardized result of factor score	0.667	0.238
Control variables			
Individual characteristics			
Gender	0 = Female; 1 = Male	0.712	0.453
Age	Actual survey results	47.825	10.905
Education level	1 = Never attended school; 2 = Primary school; 3 = Junior high school; 4 = High school/technical secondary school; 5 = College and above	2.800	1.326
Years of cultivation	Actual survey results	15.983	11.989
Cultivated varieties	0 = Chinese cabbage; 1 = Cucumber	0.633	0.482
Production training	0 = no; 1 = yes	0.447	0.497
Member of cooperative organization	0 = no; 1 = yes	0.278	0.448
Family characteristics			
Number of laborers	Actual survey results	2.395	1.404
Cultivated area	Actual survey results (mu)	7.701	8.144
Proportion of cultivation income	1 = Less than 20%; 2 = 20–40%; 3 = 40–60%; 4 = 60–80%; 5 = 80–100%	3.331	1.315
Cadre identity	0 = no; 1 = yes	0.051	0.221
Employment situation in vegetable service industry	0 = no; 1 = yes	0.598	0.491

other options. Second, this method compares the differences in the mediating effect of perceived value under three levels (high, medium, and low) for the business environment, avoiding the problem of omitted variables. Third, this method can also test the mediating and moderating roles of the binary dependent variable of farmers' VCPB, which compensates for the deficiency that the stepwise regression can only analyze continuous dependent variables (Hayes, 2013).

4 Results

4.1 Model evaluation

4.1.1 Common method bias and collinearity test

A combined approach of pre-control and post-examination was adopted to manage the issue of common method bias. First, the questionnaire included some reverse-coded questions to prevent the

respondents from falling into a continuous scale-filling pattern. Second, the control unmeasured single method latent factor method recommended by Xiong et al. (2012) was adopted to test for common method bias. Exploratory factor analysis was conducted on all items of the three latent variables using the extraction method of not making any selection and with eigenvalues greater than 1. The results showed that the variance explained by the first factor was 32.779%, which was lower than the critical value of 40%, indicating that there was no obvious common method bias in the data used. The variance inflation factor (VIF) of each measurement item ranged from 1.03 to 1.49, so it can be determined that there was no problem of multi-collinearity among the variables.

4.1.2 Reliability test

The reliability of the scale was assessed from two dimensions: Cronbach's alpha coefficient and composite reliability (CR). The values for the Cronbach's alpha coefficient for all latent variables were greater than the recommended value 0.7 (relationship quality: Cronbach's

alpha coefficient = 0.878; perceived value: Cronbach's alpha coefficient = 0.732; business environment Cronbach's alpha coefficient = 0.791). The CR values for all latent variables exceeded the recommended value of 0.7, which indicates that the measurement scales in this paper have high reliability.

4.1.3 Validity test

The validity of the scale was assessed in three ways. First the Kaiser–Meyer–Olkin (KMO) values of all latent variables were above the threshold of 0.6. Second, all factor loadings of the latent variables were greater than the threshold of 0.5, and most exceeded the ideal value of 0.7. Finally, the average variance extracted (AVE) of each latent variable was higher than the recommended value of 0.5. The test results are shown in Table 4. Based on these results, the measurement scales appear to have high validity.

4.2 Hypothesis testing

4.2.1 Direct effect test of relationship quality

From the regression results of Model 1 in Table 5, the influence of relationship quality on vegetable farmers' VCPB passed the significance test at the 1% statistical level, and the coefficient is positive. Therefore, H1 is partially verified. A good relationship appears to be the driving force for vegetable farmers to strengthen collaboration. The regression results of Model 2 show that trust positively affects vegetable farmers' VCPB at the 5% significance level, communication, and commitment positively affect vegetable farmers' VCPB at the 1% significance level. In a comparison of marginal effects, commitment has the most obvious effect in promoting VCPB.

Looking at the effect of control variables on vegetable farmers' VCPB, in Model 1 and Model 2, the individual characteristics of education level, training, and participation in agricultural cooperative organizations have significant effects on the vegetable farmers' VCPB. For family characteristics, the number of family vegetable laborers and the employment situation for vegetable distribution work in the family have significant effects on VCPB.

A multinomial logit model was employed to analyze the effect of relationship quality on vegetable farmers' choice of different vertical collaboration modes. As shown in Table 6, relationship quality between farmers and purchasers has a significant positive influence on the choice of long-term vertical collaboration modes by vegetable farmers. From the perspective of marginal effects, vegetable farmers are more likely to choose production contract collaboration. For every one-unit increase in relationship quality, the probability that farmers

will choose production contract collaboration will increase by 0.321. Accordingly, the second half of H1 was not verified.

4.2.2 Mechanism test: perceived value

The deviation-corrected non-parametric percentile bootstrap method was used to test the mediating effect of perceived value. The SPSS Process macro program was employed, with 5,000 repeated samplings conducted at a 95% confidence interval. The results are shown in Table 7. The total mediating effect of relationship quality on vegetable farmers' VCPB through perceived value was 2.626 (CI = [1.995, 3.535]); the confidence interval does not include zero. The total mediating effect of perceived value holds true, and H2 is verified. After introducing the mediating variable of perceived value, the direct effect of relationship quality on farmers' VCPB is 2.499 (CI = [1.291, 3.708]); the confidence interval does not include zero. Thus, even after including the mediating variable, the direct effect of relationship quality on vegetable farmers' VCPB remains significant, indicating that perceived value plays a partial mediating role. In the specific mediation effect, the confidence intervals of the indirect effects of perceived cost and perceived benefit do not include 0, and both mediation paths are significant, but the influence coefficient of perceived cost is larger. This indicates that relationship quality can enhance the perceived value of vegetable farmers, thereby promoting their VCPB.

4.2.3 Moderating effect test: business environment

The Process macro program in SPSS was used to test the moderating effect of business environment among different variables, with 5,000 repeated samplings. The relationships among the variables are shown in Table 8. The results indicated that the interaction term of relationship quality and business environment ($\beta = 3.684, p = 0.112$) had no significant effect on VCPB, so H3 was not verified. A possible explanation for this is that when the relationship quality is already high, vegetable farmers and purchasers have established a good trust, communication, and commitment mechanism, and their collaborative behavior may no longer be affected by the moderating effect of the business environment.

The bootstrap method was adopted to test the moderated mediation model. Specifically, the business environment was divided into groups based on the mean plus or minus one standard deviation, and the mediating effect of perceived value was tested at different business environment levels. As shown in Table 9, the mediating role of perceived value varied with the moderating variable of business environment, and the confidence intervals do not include 0, which indicates significant test results. H4 is therefore verified. This suggests

TABLE 4 Results of reliability and validity tests.

Latent variable	Factor loadings	Cronbach's alpha coefficient	Kaiser–Meyer–Olkin	Bartlett's test of Sphericity			Composite reliability	Average variance extracted
				Chi-square test	Degree of freedom	Significance level		
Relationship quality	0.678–0.858	0.878	0.868	4,663.446	45	0.000	0.943	0.623
Perceived value	0.632–0.908	0.732	0.672	1,858.752	15	0.000	0.919	0.655
Business environment	0.788–0.869	0.791	0.687	962.616	3	0.000	0.879	0.708

TABLE 5 Test results on the effect of relationship quality on vegetable farmers' VCPB.

Variable	Model 1		Model 2	
	Coefficient	Marginal effect	Coefficient	Marginal effect
Relationship quality	4.715*** (0.693)	0.515*** (0.071)		
Trust			1.257** (0.615)	0.137** (0.066)
Communication			3.141*** (0.669)	0.341*** (0.071)
Commitment			3.860*** (0.656)	0.420*** (0.068)
Gender	0.219 (0.214)	0.024 (0.023)	0.189 (0.215)	0.021 (0.023)
Age	−0.006 (0.009)	−0.001 (0.001)	−0.007 (0.009)	−0.001 (0.001)
Education level	0.149** (0.076)	0.016** (0.008)	0.155** (0.076)	0.017** (0.008)
Years of cultivation	0.011 (0.008)	0.001 (0.001)	0.013 (0.009)	0.001 (0.001)
Cultivated varieties	−0.204 (0.202)	−0.022 (0.022)	−0.206 (0.203)	−0.022 (0.022)
Production training	0.575*** (0.220)	0.063*** (0.024)	0.574*** (0.221)	0.062*** (0.024)
Member of cooperative organization	3.627*** (0.395)	0.397*** (0.037)	3.656*** (0.396)	0.397*** (0.036)
Number of laborers	0.680*** (0.094)	0.074*** (0.009)	0.692*** (0.095)	0.075*** (0.009)
Cultivated area	0.005 (0.012)	0.001 (0.001)	0.005 (0.012)	0.000 (0.001)
Proportion of cultivation income	0.115 (0.077)	0.013 (0.008)	0.122 (0.078)	0.013 (0.008)
Cadre identity	0.479 (0.443)	0.052 (0.048)	0.407 (0.450)	0.044 (0.049)
Employment situation in vegetable service industry	1.051*** (0.231)	0.115*** (0.024)	0.999*** (0.233)	0.109*** (0.025)
Constant term	−5.292*** (0.886)		−7.055*** (1.078)	
County fixed effects	Under control	Under control	Under control	Under control
LR chi ²	670.721***		676.046***	
Log likelihood	−357.515		−354.853	
Pseudo R ²	0.484		0.488	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 6 Effect of relationship quality on the choice of vertical collaboration mode.

Variable	Sales contract collaboration		Production contract collaboration		Vertical integration collaboration	
	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect
Relationship quality	3.500*** (0.726)	0.053 (0.079)	7.809*** (1.051)	0.321*** (0.059)	7.238*** (1.383)	0.122** (0.047)
Control variable	Under control	Under control	Under control	Under control	Under control	Under control
County fixed effects	Under control	Under control	Under control	Under control	Under control	Under control
No. of observations	283		102		51	
LR chi²	826.093***					
Log likelihood	−659.749					
Pseudo R²	0.385					

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; the control variables are the same as those in Table 3.

that in the process where relationship quality influences VCPB, the mediating role of perceived value strengthens as the business environment improves.

4.3 Robustness test

To verify the reliability of the above data analysis results, a robustness test was conducted by changing the measurement methods

of independent variables, mediating variables, and moderating variables. Specifically, the latent variables of relationship quality, perceived value, and business environment were generated by summing the original variables and taking their average. The above moderated mediation analysis process was then repeated using the newly generated variables, and the estimation results showed no significant difference from the existing analysis. The estimation results are shown in Table 10. Therefore, the empirical results of this paper are robust.

TABLE 7 Influence mechanism of perceived value.

Type of effect	Estimated coefficient	Standard error	Lower limit of the confidence interval	Upper limit of confidence interval
Direct effect of channel relationship quality	2.499	0.617	1.291	3.708
Total mediating effect of perceived value	2.626	0.394	1.995	3.535
Relationship quality → perceived cost → vertical collaborative participation behavior	2.390	0.368	1.790	3.232
Relationship quality → perceived benefit → vertical collaborative participation behavior	0.236	0.121	0.017	0.499

TABLE 8 Moderating effect of the business environment.

Variable	Coefficient	Standard error
Relationship quality	2.573***	0.621
Business environment	1.785***	0.423
Relationship quality × business environment	3.684	2.320
Control variable	Under control	
–2 log likelihood	794.037	
Co & Snell R ²	0.442	
Nagelkrk R ²	0.593	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.4 Endogeneity test

The relationship quality and vegetable farmers' VCPB may suffer from endogeneity issues due to reverse causality and omitted variables. On the one hand, vegetable farmers engaged in the vertical collaboration may inherently possess higher relationship quality, potentially leading to an overestimation of the impact of relationship quality (Liu, 2015). On the other hand, there may be unobserved variables that affect both relationship quality and VCPB being omitted, such as farmers' personality traits (Qian et al., 2020). Therefore, we employ the geographical distance between vegetable farmers and purchasers as an instrumental variable to address the potential endogeneity problem (Ding and Wan, 2023). The rationale behind this choice is that geographical proximity can improve the efficiency of information transmission and is conducive to improving the relationship quality between vegetable farmers and downstream entities. More importantly, geographical distance is an exogenous factor and does not directly affect VCPB; instead, it is expected to affect VCPB indirectly through its influence on relationship quality (Wang, 2017).

An effective instrumental variable should simultaneously satisfy the criteria of exogeneity and relevance. The exogeneity test results are shown in Model 3 of Table 11. As shown in Model 3, the influence of the instrumental variable, geographical distance, on the VCPB of vegetable farmers did not pass the significance test, meeting the exogeneity condition. The relevance test results are shown in Model 4. The Wald test indicates that the hypothesis of no endogeneity is rejected at the 1% level. The results of the first stage show that the instrumental variable, geographical distance has a significant correlation with the relationship quality, and the F value is greater than 10, indicating that there is no weak instrumental variable problem. In addition, the instrumental

variable should also satisfy the exclusivity. Geographical distance may theoretically affect farmers' VCPB through relationship quality or transportation cost. The test of the channel mechanism found that the impact of geographical distance on transportation cost is not significant,¹ satisfying the exclusivity. The results are shown in Supplementary Table 1. The results of the second stage are shown in Model 5. After introducing the instrumental variable to address the potential endogeneity of relationship quality, the regression coefficient of relationship quality on vegetable farmers' VCPB is positive at the 1% significance level, confirming that relationship quality positively affects the VCPB of vegetable farmers. Therefore, the instrumental variable simultaneously satisfies exogeneity, relevance, and exclusivity.

4.5 Heterogeneity analyses

4.5.1 Heterogeneity analysis of varieties cultivated

Based on the differences in the main surveyed vegetable varieties, the samples were divided into Chinese cabbage and cucumber groups for group regression to test the differences in the effect of relationship quality on farmers' VCPB for different vegetable varieties. The empirical results are shown in Model 6 and Model 7 in Table 12. The promoting effect of the improvement of relationship quality on farmers' VCPB in the Chinese cabbage group is greater than in the cucumber group. This indicates that for vegetable varieties with relatively low returns and significant price fluctuations, such as Chinese cabbage, reducing transaction costs through vertical collaboration with purchasers and ensuring stable returns through contractual connections are more necessary.

4.5.2 Heterogeneity analysis of participation in agricultural cooperative organizations

The sample was then divided based on the differences in the participation in cooperative organizations into those participating in such organizations and those who do not participate. In total, 282 vegetable farmers participate in agricultural cooperative organizations

1 There are two possible reasons for this result. First, our survey reveals farmers generally use electric tricycles for relatively short distances (within 10 kilometers), where marginal transportation costs such as charging fees or travel time are minimal, and the primary cost (vehicle depreciation) remains fixed regardless of small distance variations. Second, many purchasers in the survey area provide door-to-door acquisition services, reducing farmers' transportation costs to nearly zero, further weakening the effect of geographical distance.

TABLE 9 Moderated mediation under the influence of the business environment.

Variable	Business environment	Moderated mediation effect		95% confidence interval	
		Coefficient	Standard error	Lower limit	Upper limit
Perceived value	–Standard deviation	0.626	0.228	0.248	1.137
	Mean	1.801	0.340	1.269	2.601
	+Standard deviation	3.516	0.747	2.351	5.286

TABLE 10 Results of the robustness test.

Variable	Business environment	Moderated mediation effect		95% confidence interval	
		Coefficient	Standard error	Lower limit	Upper limit
Perceived value	–Standard deviation	0.283	0.086	0.142	0.484
	Mean	0.596	0.110	0.425	0.850
	+Standard deviation	0.998	0.218	0.671	1.519

TABLE 11 Results of the endogeneity test.

Variable	Exogeneity test of instrumental variables	First stage	Second stage
	Model 3	Model 4	Model 5
Relationship quality	4.441*** (0.780)		3.064 (0.804)***
Geographical distance	–0.060 (0.080)	–0.049*** (0.003)	
Control variable	Under control	Under control	Under control
County fixed effects	Under control	Under control	Under control
F		24.03***	
Wald			14.53***
No. of observations	1,014	1,014	1,014

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; the control variables are the same as those in Table 3.

(27.81%). The results of the grouped regression are shown in Model 8 and Model 9 in Table 12. The promoting effect of improving the relationship quality on VCPB in the participation group is greater than in the non-participation group. As such, it is evident that participating in agricultural cooperatives promotes the full sharing and mutual penetration of information, technology, and management elements, which is conducive to further enhancing the VCPB.

5 Discussion

Vegetable farmers' VCPB is an important way to break the loose connection of the supply chain and promote organic connections between small-scale farmers and modern agriculture. We used micro-level farmer survey data to explore the effect of relationship quality on vegetable farmers' VCPB and its mechanisms. Empirical tests showed that the optimization of relationship quality can enhance VCPB among vegetable farmers, which is consistent with existing research results. For instance, De-Silva et al. (2023) found through a theoretical model that the improvement of the relationship between farmers and suppliers has enhanced farmers' market participation. Additionally, Gajdić et al. (2023) demonstrated that trust significantly influences the effectiveness of collaboration among the subjects in the agricultural food supply chain. This indicates that the problem of information asymmetry in current market transactions is widespread, and the acquisition of information depends on the social capital and relationship networks

formed by kinship, geographical ties, and professional ties among vegetable farmers (Thuo et al., 2014). Good relationships are the driving force for vegetable farmers to strengthen collaboration. Further analysis revealed that, looking at the different collaboration modes, vegetable farmers are more likely to choose production contract collaboration. The reason for this may be that such collaboration usually involves important decisions in the production stage, including production planning, technical guidance, and information sharing (Hong et al., 2023). This form of collaboration helps stakeholders share risks and benefits while allowing vegetable farmers to retain ownership of important production input factors. This result differs from the conclusion of Wan (2008), who argued that enterprises promote vertical integration collaboration between agricultural enterprises and farmers through relationship governance mechanisms such as trust, reciprocity, and effective communication. The difference in research results may stem from the different research subjects. Wan's research mainly focused on large-scale farmers, who, due to their strong production capacity, have a lower threshold for entering vertical integration collaboration and are thus more likely to accept the in-depth collaboration model led by enterprises. In contrast, we mainly focuses on small-scale farmers. For these farmers, the threshold for entering vertical integration collaboration is higher, which limits their enthusiasm for participation and makes them more inclined to choose production contract collaboration.

We also revealed that relationship quality can promote the vegetable farmers' VCPB by enhancing their perceived value. This finding is consistent with the empirical analysis result of Wang and

TABLE 12 Heterogeneity analyses: the effect of relationship quality on the farmers' VCPB.

Variable	Chinese cabbage	Cucumber	Non-member of cooperative organization	Member of cooperative organization
	Model 6	Model 7	Model 8	Model 9
Relationship quality	0.673*** (0.109)	0.416*** (0.094)	0.462*** (0.113)	0.691*** (0.106)
Control variable	Under control	Under control	Under control	Under control
County fixed effects	Under control	Under control	Under control	Under control
No. of observations	372	642	732	282
LR chi ²	274.143***	415.850***	248.518***	108.443***
Log likelihood	−114.529	−232.801	−198.994	−83.500
Pseudo R ²	0.545	0.472	0.384	0.394

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; the control variables are the same as those in Table 3; the reporting result is the marginal effect of the regression result.

Yan (2023) that “social trust indirectly affects farmers’ willingness through perceived benefits.” We find that when vegetable farmers perceive that strengthening the relationship network with downstream stakeholders can bring higher economic or other non-economic benefits, they are more motivated to participate in the vertical collaboration. The mediating role of perceived value is enhanced by improvements to the business environment, which plays a moderating role. This breaks through the limitation of previous studies that “the market environment only directly affects farmers’ collaboration behavior” (Zhang, 2015). This indicates that improving the business environment creates more favorable conditions for collaboration between vegetable farmers and purchasers (Liu et al., 2023). The survey revealed that under continuous policy support, more and more large supermarkets and catering groups in Beijing have started to engage in direct purchasing from bases, which reduces the transaction costs, increases efficiency, and reduces the risks of collaboration. Beijing has also launched the “Vegetable Supply Bus to Beijing,” which has made market access even more convenient. This dynamic change has prompted vegetable farmers to be more inclined to choose vertical collaboration modes.

We also explored the heterogeneous effects of vegetable varieties and participation in cooperative organizations on the effect of relationship quality on farmers’ VCPB. Improving relationship quality had a more significant effect in promoting VCPB among Chinese cabbage farmers and farmers who are members of an agricultural cooperative organization. More targeted measures should be taken to enhance VCPB based on participation modes, resource advantages, and demand differences among farmers (Schrobbach et al., 2023).

6 Conclusion

6.1 Main conclusions

In this study, we constructed a theoretical framework for analyzing farmers’ VCPB from the perspective of social embeddedness and the SOR model. Combining data from 1,014 responses to a survey of vegetable farmers in North China Plain and using the moderated mediation effect model, we empirically analyzed the effect of relationship quality on vegetable farmers’ VCPB and its mechanism of action. The results revealed the influence of the heterogeneity of vegetable farmers. The research shows that: (1) Relationship quality had a significant positive

effect on farmers’ VCPB, and its promoting effect on production contract collaboration was greater than for sales contract and vertical integration collaboration modes; (2) Perceived value plays a partial mediating role in the effect of relationship quality on VCPB, and the mediating effect of perceived cost is more significant than that of perceived benefit; (3) The business environment significantly moderates the mediating effect of perceived value, but does not moderate the direct effect of relationship quality on VCPB; (4) Heterogeneity analyses revealed that improving the relationship quality has a greater effect on promoting the VCPB of Chinese cabbage farmers than that of cucumber farmers, as well as on promoting VCPB among farmers who are members of agricultural cooperative organizations than those who are not.

6.2 Policy implications

Based on the above conclusions, several policy implications can be drawn. First, the social capital of vegetable farmers should be enhanced by leveraging their relationship networks and increasing the density of their interpersonal networks. Farmers should be encouraged to actively participate in community activities organized by local governments, such as training sessions and vegetable production and sales matchmaking events, to build a broader network of interpersonal relationships and gain access to policy support and market resources. Second, the flexible development of various vertical collaboration modes should be supported, and customizable contract forms should be promoted to enhance the flexibility and adaptability of vegetable farmers’ choices of VCPB mode. The barriers to entry for close vertical collaboration modes should be reduced. Third, governments should focus on building sales network systems for major vegetable production and sales areas. By providing policy support and financial assistance, strengthening market regulation, and improving logistics infrastructure, they can stimulate market vitality and create a favorable business environment. Fourth, policies should be tailored based on the differences in vegetable varieties. For low-value vegetables like Chinese cabbage, a performance guarantee mechanism should be established for agricultural contracts to reduce transaction costs for farmers and increase their enthusiasm for VCPB. For high-value vegetables like cucumbers, purchasers should be encouraged to adopt flexible collaboration models and differentiated incentive measures, which would grant farmers greater initiative and choice.

6.3 Limitations

Although our study provides valuable findings and insights, some limitations should be noted. First, the data were obtained from only one region in China, which may lead to sampling bias. Conducting empirical tests with large sample data from all over the country would enhance the credibility and validity of the research results. Second, 1-year cross-sectional data were used, in that we could only use static cross-sectional data to analyze VCPB and its influencing factors, making it difficult to present the long-term dynamic changes in collaboration stability. Future research, given sufficient funding and human resource support, could conduct comprehensive surveys on various types of vegetables across China and use data and information obtained from government agencies, farmer surveys, and interviews, to collect long-term dynamic panel data for in-depth analysis.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because according to the Measures for the Ethical Review of Life Sciences and Medical Research Involving Humans (https://www.gov.cn/zhengce/zhengceku/2023-02/28/content_5743658.htm, accessed on 18 February 2023) jointly issued by Chinese Health Commission, Ministry of Education, Ministry of Science and Technology and Traditional Chinese Medicine Bureau, ethical review and approval were waived for this study due to the absence of sensitive data and to the processing of data with the assurance of the confidentiality and anonymization of the personal information of all the subjects involved in the study. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. YZ: Conceptualization,

Funding acquisition, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. CQ: Conceptualization, Funding acquisition, Methodology, Resources, Writing – review & editing. LB: Funding acquisition, Validation, Writing – review & editing. JN: Investigation, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2025.1567495/full#supplementary-material>

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