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Factors Affecting Smallholder Farmers' Marketing Channel Choice in China with Multivariate Logit Model

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Abstract: Facing the changes in China's agricultural products marketing channel, smallholder farmers with different characteristics choose various strategies to obtain more benefits. To analyze factors affecting smallholder farmers' marketing channel choice, we classify four types of channels—Broker Channel, Farmers' Retailing Channel, Wholesale Market Channel, and Cooperative Channel—and inspect 14 variables based on the survey data of 317 households from four provinces. We use a principal components analysis (PCA) to simplify these 14 variables into seven common factors and a multivariate logit model to study how the factors influence smallholder farmers' choices. We find that compared with the Broker Channel, the Farmers' Retailing Channel is mainly affected by the logistics factor, skill factor, risk factor, and size factor; the Wholesale Market Channel is influenced by the logistics factor and age factor; and the Cooperative Channel is mainly influenced by the age factor, logistics factor, and price factor. In conclusion, the logistics factor has a significant positive effect on each channel choice, and the improvement of the market and transportation conditions has a general promoting effect.

Keywords: smallholder farmer; marketing; channel; choice

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1. Introduction

Agricultural product marketing is undergoing rapid changes in China. With the emergence of e-commerce, knowledge about the farmers' online purchasing behavior is becoming more important [1–3]. Some new forms of supply chain channels, such as the direct link of farmers to supermarkets (DLFS) and community group buying [4,5], are accounting for an increasing share [6]. Information and communication technologies (ICTs), such as big data and the internet of things, are reforming agriculture in every aspect [7–9]. In general, all these trends are affecting the food marketing structure.

Faced with the new marketing channels and patterns, how to survive and maximize their benefits is a vital problem for smallholder farmers, and how to support them is a key focus for policymakers. Smallholder farmers are in a precarious position; they are more vulnerable to cost increases, price volatility, changes in the state of the market, and challenges in securing fair benefits [10–12]. Analyzing the traits and factors that influence smallholder farmers who participate in various marketing channels is therefore extremely important.

As the largest vegetable producer and consumer, China's vegetable distribution channel has become more and more diversified over the last four decades [13]. Traditional village fairs with a circulation pattern of local products and local trade started to come back in the 1980s [14]. The Chinese government started to construct the infrastructure of wholesale markets and transportation facilities, and cross-regional and multi-level circulation patterns developed and gradually occupied the dominant position [15]. It has increased the circulation radius and broken through time and location constraints but also

contributed to information asymmetry and high transaction costs. The central government has tried a lot to shorten the circulation lengths and increase farmers' income, encouraging the development and application of ICTs, so e-commerce has grown rapidly and derived B2C (business-to-customer), C2C (customer-to-customer), and O2O (online-to-offline) models [16–19].

Many scholars have performed studies about the marketing channel of agricultural products and concluded that age, education, expertise, asset, and the scale of farms are essential factors for smallholder farmers' choice. In general, more elder groups have better marketing performance [20,21]. Bigger farm sizes will increase farmers' participation [13,22]. Farmers with good assets are more likely to improve their market situation [20], and with better education and expertise, they will select market channels with high values [21,23]. Family labor availability and previous benefits encourage more participation in collective marketing [24].

Except for the traits of farmers, there are other factors affecting farmers' participation in new marketing channels. Contracts and cooperatives play a positive role in the primary market channel [25–30]. Costs and benefits are also important for participating in various channels, especially for innovative markets [31] and cold supply chains [32]. Producers are more concerned about transaction costs [33–35], through which farmers try to maximize their profits [36]. Access to information has a statistically significant influence on farmers' participation [33,37,38]. Market infrastructure, especially ICT, could increase the circulation of agricultural products, and even help to export [38,39].

With the emergence of some new channels, such as electronic marketing, the pattern is evolving all over the world. New technologies, such as big data, the internet of things, and blockchains, are reforming the agricultural products marketing networks [40,41]. In the US, more and more people are now marketing through various direct marketing channels, and buyers [42], such as restaurants, are also featuring locally sourced foods [43]. In Europe, the Agri-Food sector is embracing digitalization and getting more access to digital transformation [44]. In China, electronic commerce, such as online-to-offline food delivery, is gaining more popularity and accounting for an increasing share [45].

However, for some countries and regions, the traditional channel is still the major market for smallholder farmers [46–48]. Jia et al. [49] showed that marketing farmer professional economic cooperatives in China rely primarily on the wholesale market. Mgale and Yunxian [50] demonstrated that most farmers in rural Tanzania still sell their rice to neighborhood collectors because they are afraid or unable to enter markets. Blandon et al. [51] discovered that a majority of farmers favor conventional marketing strategies in Honduras. Plakias et al. [42] discovered that in the US, vegetable growers and new farmers are less inclined to sell to intermediaries.

In general, scholars have conducted in-depth studies on how farmers choose their distribution channels. In addition, a variety of specific influences are identified by them. However, most of these studies focus on some specific factors and analyze their effect. The variables discussed in the empirical analysis are generally strongly correlated. The main contribution of this paper is that we conduct research on new channels with 14 variables, then simplify them into seven common factors, and conclude how each channel is affected by these common factors.

To study the smallholder farmers' participation in marketing channels, in this paper, we classify these channels into four types. The first is the Broker Channel, which means that the farmer sells the vegetables directly to the brokers on the farmland. In this channel, farmers are not involved in the distribution. The second is the Farmers' Retailing Channel, referring to farmers transporting vegetables to local markets nearby and selling them mainly through retailing. The next is the Wholesale Market Channel, which indicates that farmers transport vegetables to wholesale markets to sell products. The last is the Cooperative Channel, in which farmers sell products through cooperatives, and products could be transported directly to buyers, such as supermarkets and e-commerce platforms.

The rest of this paper is organized as follows. In Section 2, we present the details of the data sources and methodologies. Section 3 provides the results about the farmers' characteristics and factors about participating in different marketing channels. In Section 4, how the factors affect farmers' channel choice is discussed to conclude this article.

2. Materials and Methods

This study applied principal component analysis (PCA) and multinomial logit regression model to questionnaire survey data. The data were collected in 2019 from 4 Chinese provinces (Beijing, Hebei, Shandong, and Liaoning), 10 counties, and 29 townships. At first, we intended to study the factors affecting smallholder farmers' marketing channels and track the pattern changes from 2019 to 2021 for three years. Because of the COVID-19 pandemic, we could not collect data in 2020 and 2021, so we only addressed the first problem.

2.1. Data Sources

In the questionnaire, we tried to cover all possible variables affecting smallholder farmers' choices, and 14 variables were collected, including the characteristics of farmers (age, education, household size, motor vehicle ownership) and farm (production, farm size), access to markets, training, cooperatives, etc. We chose Beijing, Shandong, Liaoning, and Hebei to carry out field surveys about tomatoes, cucumbers, peppers, eggplants, and other fruit vegetables. We did not consider the difference between different vegetables. The 4 provinces are located in the main producing areas of vegetables in China. According to the National Bureau of Statistics, these 4 provinces produced more than 20% of vegetable output in 2019. To perform the survey, at first, we chose 2 or 3 main producing counties in each province, so 10 counties were selected in total. We randomly selected 2 or 3 townships in each county and 10–25 households in each township. Finally, we obtained 317 valid items from 439 questionnaires, with a 72.2% response rate. Figure 1 describes the survey regions.

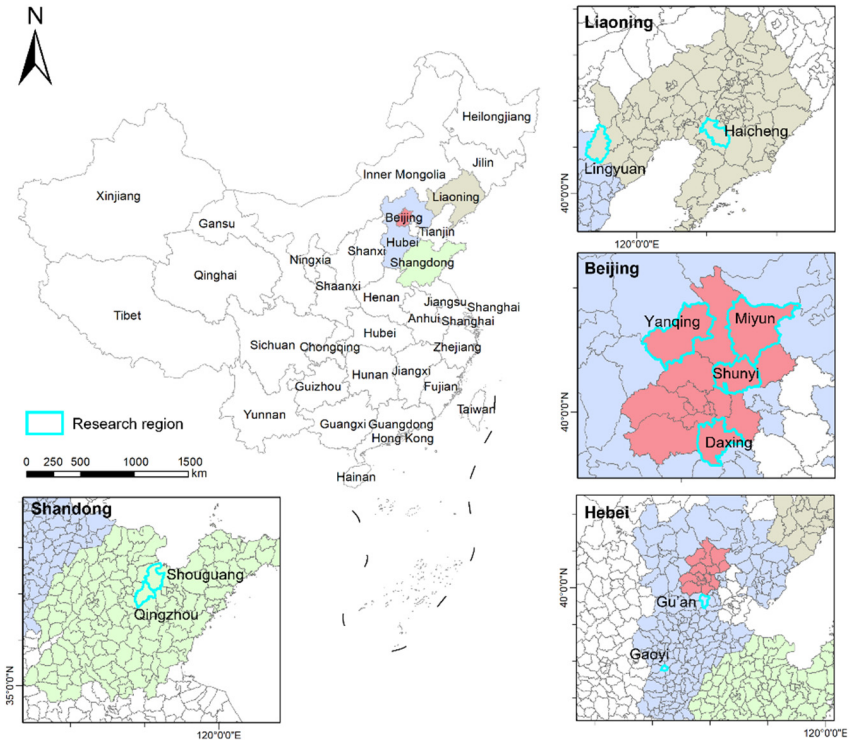

Figure 1. A description of the survey regions.

2.2. Methods

In this paper, we employed PCA and a multinomial logit regression model to analyze the factors influencing smallholder farmers' channel choice. The multiple variables examined are combined into a limited number of principal components or factors. Let $X = (X_1, X_2, \ldots, X_p)'$ denote the variable to be discussed, $F = (F_1, F_2, \ldots, F_m)'$ denote the extracted primary components or factors, $\varepsilon = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_p)'$ denote the residual items, A denote the factor loading matrix, a_{ij} denote the factor load. The relationship between variable X and factor F is captured by the factor loading matrix A, and the relationship between the factors and the variables of interest can be presented by Equation (1).

$$\begin{cases} X_1 = a_{11}F_1 + a_{12}F_2 + \cdots + a_{1m}F_m + \varepsilon_1 \\ X_2 = a_{21}F_1 + a_{22}F_2 + \cdots + a_{2m}F_m + \varepsilon_2 \\ \cdots\cdots \\ X_p = a_{p1}F_1 + a_{p2}F_2 \ldots + + a_{pm}F_m + \varepsilon_p \end{cases}, \; A = \begin{bmatrix} a_{11} & a_{12} & \ldots & a_{1m} \\ a_{21} & a_{22} & \ldots & a_{2m} \\ \ldots & \ldots & \ddots & \ldots \\ a_{p1} & a_{p2} & \ldots & a_{pm} \end{bmatrix} \quad (1)$$

The 14 variables are selected from 3 aspects, external environment, individual characteristics, and performance gains, combined with the data information obtained from the survey. Table 1 demonstrates a detailed description of these variables. Through PCA, we could transfer these variables to fewer factors.

Table 1. Variables used in this paper.

Factor	Variable	Implication	Value
External environment	Wholesale Market	Access to wholesale markets in the township	Yes = 1; No = 0
	Cooperative	Access to professional cooperatives in the village	Yes = 1; No = 0
	Training	Times of attending technical training	Specific times
	Insurance	Access to insurance in the county	Yes = 1; No = 0
Individual characteristics	Age	Age of respondent	Specific age
	Planting year	Planting years of respondent	Specific year
	Education	Education level of respondent	Below Primary School = 1; Primary School = 2; Junior High School = 3; High School = 4; College and above = 5
	Information channel	Available number of information channel	Based on farmers' multiple-choice statistics
	Transportation	Availability of motor vehicles	Yes = 1; No = 0
	Areas	The planting area of vegetable	Specific area
	Labor Force	Household labor force engaged in production	Specific number
	Cultivar	Plantingspecial vegetable varieties	Yes = 1; No = 0
Performance gains	Relative price	Ratio of the selling price to the local average price of the same vegetable	By cultivar
	Stagnant situation	Encounter unsalable situation	Yes = 1; No = 0

Based on the factors, we then used multinomial logistic regression model to analyze multiple behavioral choices that are non-sequential and non-degree varying. This model was used because it is the standard method for estimating unordered, multi-category dependent variables. It also assumes independence across the choices, that is, it does not allow correlation or substitution between them [52]. The multinomial logistic regression model is also chosen because it is widely used in studies involving multiple choices and easier to compute than its alternative, the multinomial probit [53].

Before that, one certain channel needs to be specified as a control group. $i - 1$ equations will be generated if there are i channels.

Let P_i be the probability that the farmer chooses channel i, P_0 be the probability that the control channel is chosen. F_1, F_2, …, F_m be the probability that each factor is extracted from the factor analysis, β_{1i}, β_{2i}, …, β_{mi} be the regression coefficient of each factor when channel i is chosen.

In this study, Broker Channel is used as the control group. The probabilities of farmers choosing Farmers' Retailing Channel, Wholesale Market Channel, and Cooperative Channel are denoted by P_1, P_2, and P_3. Equation (2) presents the specific model form. The regression coefficients of the equations are estimated using the great likelihood method.

$$\ln\left(\frac{P_i}{P_0}\right) = \beta_{0i} + \beta_{1i}F_1 + \beta_{2i}F_2 + \cdots + \beta_{mi}F_m + \varepsilon_i \quad (2)$$

3. Results

3.1. A Description of the Survey Data

In this survey, 91.2% of the respondents are male. The average age of the respondents is 53.29 years of age, with only 4 people below 30 and 38 farmers above 65. The average cultivation time length is 19.48 years, and more than 85% of the farmers have more than 10 years of planting experience.

The farmers operate on a small scale, with an average of 6.52 mu (15 mu equal to 1 hectare) of vegetables per household and an average of 2.59 laborers in the household engaged in vegetable planting. The respondents generally have a low level of education, with only a small share of high school and above. The average quantity of skills training is 4.77 times in one year, and the average number of channels to acquire information is 2.23. Nearly 70% of the farmers live in towns with wholesale markets, with over 40% professional cooperatives in their villages. Most farmers possess motor vehicles, making market and circulation conditions better. Despite this, nearly 30% of the farmers said they have experienced stagnant sales in recent years. Most farmers, about 88.3%, chose the Broker and Wholesale Market channels; only a few farmers, about 11.7%, chose the Farmers' Retailing and Cooperative channels (see Table 2).

Table 2. A description of the survey data.

Characteristics	Explication	Regions				
		Beijing	**Shandong**	**Hebei**	**Liaoning**	**Total**
Sample size	—	94	76	45	102	317
Gender	Number of male respondents	80	73	44	92	289
Age	Average age	56.61	53.25	51.64	50.99	53.29
Education	Below Primary School	5	0	1	1	7
	Primary School	15	11	8	20	54
	Junior High School	59	49	30	68	206
	High School	14	14	6	11	45
	College and above	1	2	0	2	5
Area	Average planting area of vegetable	5.72	6.09	7.37	7.20	6.52
Labor Force	Average household labor force engaged in production	2.60	2.64	2.80	2.44	2.59
Planting years	Average planting years of respondents	20.30	22.75	15.36	18.12	19.48
Transportation	Availability of motor vehicles	91	76	28	100	295
Information channel	Available number of information channel	2.21	2.78	2.62	1.67	2.23
Skill training	Average times of attending technical training	7.17	4.91	1.87	3.75	4.77
Market	Access to wholesale markets in the township	49	76	8	86	219
Professional Cooperative	Access to professional cooperatives in the village	63	7	23	49	142
Insurance supply	Access to insurance in the county	94	32	37	102	265
Cultivar	Household planting special varieties	6	11	1	1	19
Channel	Broker Channel	57	16	38	43	154
	Farmers' Retailing Channel	14	5	0	0	19
	Wholesale Market Channel	17	43	7	59	126
	Cooperative Channel	6	12	0	0	18

3.2. Results of Principal Component Analysis

After standardizing the data, the PCA is applied to calculate the factor loading matrix. The common factors are selected based on the covariance characteristic roots of the variable. Seven public factors are extracted, with a combined variance contribution of 69.7%. The extracted public factors contain nearly 70% of the information of the original variables, which can be a good substitute for the original variables. After that, a factor rotation is performed using the orthogonal method to provide a clearer meaning to the common factors. The factors are no longer linearly correlated after the factor rotation. According to the relationship between the factors and variables, the rotated public factors are defined as age factor, logistics factor, price factor, skill factor, risk factor, protection factor, and size factor (see Table 3).

Table 3. Factor analysis results of variables.

Variable	Age Factor	Logistics Factor	Price Factor	Skill Factor	Risk Factor	Protection Factor	Size Factor
External environment							
Market	0.00	0.81 *	0.07	−0.07	−0.14	0.09	−0.19
Cooperative	0.05	0.07	−0.14	0.07	0.67 *	−0.15	−0.31
Skill training	−0.04	0.00	0.07	0.83 *	0.08	−0.04	−0.02
Insurance supply	0.12	−0.42	0.03	0.22	0.22	−0.61 *	−0.11
Individual characteristics							
Age	0.81 *	−0.14	−0.13	0.19	−0.03	−0.02	0.01
Planting year	0.53 *	0.13	−0.05	0.58 *	−0.17	0.20	0.08
Education	−0.72 *	−0.02	−0.04	0.36	−0.14	0.12	0.00
Information channel	0.00	−0.12	−0.04	0.12	0.15	0.85 *	−0.09
Transportation	−0.06	0.76 *	0.03	0.16	0.21	−0.10	0.17
Vegetable planting area	−0.44	0.00	−0.09	−0.19	−0.02	0.02	0.62 *
Household labor force	0.17	−0.01	−0.03	0.10	−0.05	−0.04	0.77 *
Cultivar	−0.07	0.11	0.81 *	0.18	−0.07	−0.02	−0.11
Circulation performance							
Relative price	−0.01	−0.01	0.84 *	−0.10	0.10	−0.03	0.02
Stagnant situation	−0.01	−0.04	0.15	−0.04	0.81 *	0.18	0.14
Eigenvalue	1.70	1.48	1.44	1.39	1.33	1.22	1.20
Contribution	12.18	10.54	10.30	9.90	9.50	8.70	8.57
Cumulative contribution rate %	12.18	22.71	33.01	42.91	52.41	61.12	69.68

Note: The coefficients marked with * in the table indicate that the factor loadings are greater than 0.5 and the variable of interest has a significant effect on the corresponding factor.

The age factor is highly positively relevant to age and years of planting and negatively related to education level. In reality, the older the farmer, the longer the years of vegetable farming and the lower the level of education. The study is briefly summarized by age.

The logistics factor is highly related to market construction and transportation, reflecting the logistics conditions, such as facilities and equipment circulating by farmers. The better the logistics conditions, the higher the factor scores.

The price factor is highly connected to relative prices and cultivars. Special vegetable varieties are generally sold at higher prices than common varieties. Cultivar and channel revenue differences are largely reflected by this factor.

The skill factor is highly related to the respondents' skill training and years of experience in farming. The availability of technical services and farming experience are reflected by this factor. Therefore, the factor scores are higher for farmers who had participated in more training and had more experience in cultivation.

The risk factor is highly related to the variables of the stagnation situation and the cooperative situation. It reflects the market risk faced by farmers and the possibility of participating in cooperatives. In our survey, we found that stagnation has disastrous results

for farmers, while cooperatives will decrease this risk. Moreover, the greater the risk of stagnation, the stronger the demand for farmers' cooperation.

The protection factor is highly related to the number of information channels and the supply of insurance. Farmers' access to information and insurance could help to protect their benefits.

The size factor is highly related to the planting area and the number of household laborers. The larger the planting area and the number of household laborers, the higher the factor scores.

The results are tested by the KMO (Kaiser–Meyer–Olki) test and Bartlett's sphericity test. The KMO statistic is 0.51 and the Chi-squared statistic for Bartlett's sphericity test is 491.7. The concomitant probabilities are close to 0, indicating that the use of a factor analysis is appropriate.

3.3. Results of Multivariate Logit Model

The factor score is calculated based on the extracted common factor. Based on Equation (2) and the maximum likelihood estimation, we use Eviews 9.0 (Quantitative Micro Software, Irvine, CA, USA) to obtain the correlation results and tests in Tables 4–6. The overall significance of the regression model is tested by the maximum likelihood ratio test (see Table 4). From the test results, the maximum likelihood value decreases from 665.08 to 517.87 after including the factors. In addition, the *p*-value of the maximum likelihood estimation as well as the Chi-square test is close to 0. It indicates that the overall effect of the factors is statistically significant. The results show that the age factor, logistics factor, price factor, and risk factor are significant in relation to channel choice at a 5% level of significance. The skill factor, protection factor, and size factor are statistically insignificant (see Table 5).

Table 4. Maximum likelihood ratio test results of the model.

Model Form	Model Application Criteria	Likelihood Ratio Test		
	2nd Order Maximum Likelihood	Chi-Square Statistic	Degree of Freedom	Statistical Significance
Intercept term only	665.08	—	—	—
Containing each factor	517.87	147.20	21.00	0.00

Table 5. Maximum likelihood ratio test results.

Variable	Symbol	Model Application Criteria	Likelihood Ratio Test		
		2nd Order Maximum Likelihood	Chi-Square Statistic	Degree of Freedom	Statistical Significance
Intercept	-	692.03	174.16	3.00	0.00
Age factor	x_1	534.45	16.58	3.00	0.00
Logistics factor	x_2	602.59	84.72	3.00	0.00
Price factor	x_3	526.59	8.71	3.00	0.03
Skill factor	x_4	522.43	4.56	3.00	0.21
Risk factor	x_5	532.62	14.74	3.00	0.00
Protection factor	x_6	523.64	5.76	3.00	0.12
Size factor	x_7	522.89	5.02	3.00	0.17

Table 6. Estimation results of multivariate selection model.

Channel		β	Standard Error	Wald Statistic	Statistical Significance
Farmers' Retailing Channel	Intercept	−2.45	0.35	50.51	0.00
	Age factor	0.42	0.27	2.36	0.12
	Logistics factor	0.57 *	0.32	3.27	0.07
	Price factor	−0.48	0.43	1.28	0.26
	Skill factor	0.39 *	0.20	3.67	0.06
	Risk factor	0.76 ***	0.26	8.63	0.00
	Protection factor	0.38	0.25	2.27	0.13
	Size factor	−0.49 *	0.28	3.02	0.08
Wholesale Market Channel	Intercept	−0.46	0.17	7.81	0.01
	Age factor	0.40 **	0.15	7.42	0.01
	Logistics factor	1.68 ***	0.26	42.81	0.00
	Price factor	−0.16	0.15	1.18	0.28
	Skill factor	0.03	0.16	0.05	0.83
	Risk factor	0.22	0.15	2.22	0.14
	Protection factor	0.14	0.14	0.98	0.32
	Size factor	−0.21	0.15	2.01	0.16
Cooperative Channel	Intercept	−2.83	0.41	47.61	0.00
	Age factor	1.06 ***	0.32	10.72	0.00
	Logistics factor	1.01 **	0.46	4.77	0.03
	Price factor	0.39 **	0.18	4.83	0.03
	Skill factor	0.31	0.24	1.63	0.20
	Risk factor	−0.52	0.33	2.41	0.12
	Protection factor	−0.44	0.33	1.78	0.18
	Size factor	−0.36	0.30	1.43	0.23

Note: The control channel is Broker Channel, and let *, **, and *** denote factors that are significant at 10%, 5%, and 1% significance levels, respectively.

Equations (3)–(5) show the regression results, and Table 6 demonstrates the regression equation coefficients, relevant statistics, and significance test results.

$$\ln\left(\frac{P_1}{P_0}\right) = -2.45 + 0.42x_1 + 0.57x_2 - 0.48x_3 + 0.39x_4 + 0.76x_5 + 0.38x_6 - 0.49x_7 \quad (3)$$

$$\ln\left(\frac{P_2}{P_0}\right) = -0.46 + 0.40x_1 + 1.68x_2 - 0.16x_3 + 0.03x_4 + 0.22x_5 + 0.14x_6 - 0.21x_7 \quad (4)$$

$$\ln\left(\frac{P_3}{P_0}\right) = -2.83 + 1.06x_1 + 1.01x_2 + 0.39x_3 + 0.31x_4 - 0.52x_5 - 0.44x_6 - 0.36x_7 \quad (5)$$

Compared with the Broker Channel, better logistics and skills, higher risk preference, and smaller size drive farmers to choose the Farmers' Retailing Channel. The age factor and logistics factor have a positive effect on farmers' choosing the Wholesale Market Channel. The age factor, logistics factor, and price factor drive farmers to choose the Cooperative Channel. The protection factor, which indicates the insurance supply and information source, is not statistically significant for farmers' choices.

4. Conclusions

In this paper, we analyze the characteristics of smallholder farmers and the factors affecting farmers' marketing channel choices. We classify all the channels into the Bro-

ker Channel, Farmers' Retailing Channel, Wholesale Market Channel, and Cooperative Channel and use a PCA to simplify 14 variables into seven factors—age factor, logistics factor, price factor, skill factor, risk factor, protection factor, and size factor. Then, we use a multivariate logit model to test how these factors affect farmers' channel choices.

We conclude that, compared to the Broker Channel, the logistics factor has a significantly positive effect on farmers choosing other channels. That is, improving the market and transportation conditions would encourage farmers to change their choice from the Broker Channel to the other three channels. Our conclusion is consistent with Ma [15], who reports that the improvement of infrastructure helps the development of marketing. We also reveal that the age factor, including the age and education of farmers, has a positive influence on the farmers' choosing the Wholesale Market Channel and Cooperative Channel. Our conclusion is in agreement with Xaba and Masuku [21], who think that aging farmers sell more vegetables in the new channel in Swaziland, and Barham et al. [20], who believe aging farmers have better performance in Tanzania. We also believe that aging and experience accumulation can increase farmers' greater participation in diverse distributions.

We also find some contrary results compared with the previous research. We did not find any significant connections between the number of information sources and farmers' participation, while studies show that access to information is a significant determinant of stallholder farmers' marketing in Peru [39], rice farmers' involvement in association in Vietnam [35], rice farmers' participation in marketing in Ghana [22], and vegetable seeds supply in Bangladesh [54]. The reasons may lie in the difference among countries or varieties. Farmer associations and cooperatives [33] have a significant influence on market participation, but we did not obtain similar conclusions either.

The implication of these results is that, for policymakers, we could provide a reference for policies to guide farmers' marketing strategies. For example, with the improvement of infrastructure, smallholder farmers are expected to change to other channels from the Broker Channel. Governments could also support skill training to help diversify farmers' marketing strategies. Smallholder farmers could diversify their marketing strategies to maximize benefits according to our results. Intermediaries and other related stakeholders could also adjust strategies accordingly.

There are some limitations to be improved. Firstly, the survey data include several types of vegetables, but we did not inspect the influence of different vegetables. Farmers planting different vegetables may have different preferences for channels. Secondly, we did not consider the regional differences among the four provinces, which may affect the results. Beijing is more developed than the other three provinces, and Beijing farmers may also have different marketing strategies. Moreover, the transaction cost is thought to be critical for channel choice by many researchers [31,33,36], but we did not include it. What is more, we classify smallholder farmers' marketing channels into four types, but some new channels keep coming up. Some more specific marketing factors need to be discussed in the future.

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