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Climate Perception and Adaptation Decision of Apple Growers in Guanzhong Plain Region Based on Structural Equation Model

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Abstract

It is important to clarify the influence path of farmers' climate change perception and adaptation behavior decision-making for the further effective implementation of rural revitalization strategy. Based on structural equation model, SPSS and Amos software were used to import survey data, and then the influence path of climate change perception and adaptation behavior of apple farmers in the study area was discussed. The results showed that: (1) The individual characteristics of farmers had a significant positive effect on their objective adaptation ability, but had a negative effect on their climate change perception ability and household economic characteristics. (2) The family characteristics of farmers had a negative and significant effect on objective adaptation. (3) Farmers' climate perception had a significant positive effect on their objective adaptation ability. The indicators of each potential variable can reflect itself well and have significant representativeness. Finally, according to the test results of structural equation model, some effective suggestions are put forward for individual, family and perception.

Keywords: structural equation model, Guanzhong plain, apple farmers, climate perception, adaptive behavior

1. Introduction

Climate change has had a profound impact on all walks of life. Among them, farmers, as micro-subjects of agricultural production, have the strongest perception and sensitivity to climate change (Ren et al., 2015). In order to reduce the adverse effects of climate change, farmers often take a series of measures to cope with it. Perception is the premise of adaptive decision-making, and accurate perception can help people better adopt appropriate measures to deal with meteorological disasters and minimize losses. It is crucial for the agricultural sector to formulate effective policies on agriculture and agriculture and for farmers to adopt effective strategies to identify the influencing factors of climate change perception and identify the influencing paths of "perception-adaptation"(Luo et al., 2017). At present, the academic community has carried out a wealth of studies on climate change and adaptation behavior, mainly focusing on climate suitability assessment, climate perception, and influencing factors of adaptation behavior (Song et al., 2024; Song et al., 2022; Wang et al., 2021). This provides experience for the study of this paper. This paper takes Guanzhong Plain as a research area and uses structural equation model to clarify the relationship between attribute, perception and adaptation based on questionnaire survey data of apple growers.

2. Study Area Profiles and Data Sources

2.1 Profile of The Study Area

In this paper, Guanzhong Plain is selected as the research region, which is located in the middle of Shaanxi Province, starting from Baoji in the west, Tongguan in the winter solstice, reaching the Loess Plateau of northern Shaanxi in the north and the Qinling mountain system in the south. Guanzhong Plain is flat with fertile soil, formed by the alluvial action of Weihe River and rich in water resources. The climate is a temperate monsoon climate with four distinct seasons. Here, agricultural production conditions are superior, The land type is mainly cultivated land, mainly planting apple, wheat, corn and other crops. It is one of the important agricultural production areas in China. The agricultural development of Guanzhong region is related to the economic and social development of Shaanxi Province, and its ecosystem service function plays a crucial role in the ecological environment and agricultural production of the whole Weihe River basin(Ren et al., 2015).According to its natural resource endowment advantages, the fruit industry in this region is very developed, especially the apple industry with excellent quality and high market recognition, forming a complete industrial chain.Among them, Qianyang apple has been sent into space four times, taking the lead in introducing foreign high-quality seedlings and working technology, and the unique Qianyang model of dwarfization cultivation has become a national model. Under the background of climate change, it is of urgent practical significance to study and analyze the influence path of the perception and adaptation behavior of apple growers to climate change in Guanzhong Plain for the improvement and upgrading of agricultural industry and the further implementation of the national rural revitalization strategy.

2.2 Questionnaire Survey and Data Sources

The questionnaire survey in this paper adopts the investigation mode of online and offline integration, with offline as the main and online as the auxiliary. The offline survey is conducted by a combination of random sampling questionnaire and semi-structured interview, while the online survey is conducted by sending electronic questionnaires to the target subjects through computers, mobile phones and other devices.The survey was conducted in October and November 2024.The survey sites were Fenggeling Town in Chencang District of Baoji City and Nanzhai Town, Zhangjiayuan Town, Caobi Town, Chengguan Town, Cuijiatou Town and Shuigou Town in Guanzhong area of Shaanxi Province. A number of villages in each town were randomly selected for questionnaire survey and case interview. As can be seen from Table 1, the survey contents include: (1) household attribute data of growers. It is composed of demographic attribute data (gender, age, educational background) and socio-economic characteristic data (income, distance from town, planting area, crop type). (2) Perceived data of climate change in recent 10 years, including temperature and precipitation (winter and summer), floods, pests and diseases, etc. (3) Objective adaptation to climate change (technical behavior=1~7 kinds; economic behavior=1~4 kinds; migratory behavior=1~2 kinds).

Table 1. Sample description Statistics and variable description

Variate		Serial Number	Assignment Specification	Mean Value	Standard Deviation
Individual	Gender	XB	1=Male; 2=Female	1.23	0.42
	Age	NL	1=Under 18 years old; 2=18 to 25 years old; 3=26 to 30 years old; 4=31 to 40 years old; 5=41 to 50 years old; 6=51 to 60; 7=Over 61 years old	5.88	1.29
	Education Background	XL	1=Junior high school and below; 2=High school/technical secondary school; 3=Junior college; 4=Undergraduate college; 5=Postgraduate and above	1.51	0.71
	Number of farmers	WNRS	1=1 or 2 people; 2=3 or 4 people; 3=5 people and above	1.31	0.61
Family	Family income	JTSR	1=10, 000 to 50, 000 yuan; 2=60, 000 to 100, 000 yuan; 3=more than 100, 000 yuan	2.15	0.41
	Distance from town	JZJL	1=0~5km; 2=6~10km; 3=11~15km; 4=16~20km; 5=20km 以上	1.86	1.04
	Planting area	ZZMJ	1=Less than 5 acres; 2=6 to 10 acres; 3=11 to 15 acres; 4=16~20 acres; 5=Over 21 acres	2.23	1.12
	Crop type	ZWZL	1=One kind; 2=Two kinds; 3=Three kinds; 4=Four kinds	1.79	0.75
Climate perception	The average temperature (summer)	QWXJ	1=Decrease a lot; 2=Decrease some; 3=Basically unchanged; 4=Increase some; 5=Increase a lot	3.65	1.39
	The average temperature (winter)	QWDJ	1=Decrease a lot; 2=Decrease some; 3=Basically unchanged; 4=Increase some; 5=Increase a lot	3.40	1.12

	Precipitation (Summer)	JSXJ	1=Decrease a lot; 2=Decrease some; 3=Basically unchanged; 4=Increase some; 5=Increase a lot	3.67	1.38
	Precipitation (Winter)	JSDJ	1=Decrease a lot; 2=Decrease some; 3=Basically unchanged; 4=Increase some; 5=Increase a lot	3.49	1.07
	flood	HL	1=Decrease a lot; 2=Decrease some; 3=Basically unchanged; 4=Increase some; 5=Increase a lot	3.51	1.02
	Diseases and insect pests	BCH	1=Decrease a lot; 2=Decrease some; 3=Basically unchanged; 4=Increase some; 5=Increase a lot	3.49	0.96
Objective adaptation	Climate access	TQTJ	1=One kind; 2=Two kinds; 3=Three kinds; 4=Four kinds; 5=Five kinds	3.75	0.70
	Reason for action	CQYY	1=One kind; 2=Two kinds; 3=Three kinds; 4=Four kinds; 5=Five kinds	3.26	0.72
	Assumption problem	CSWT	1=One kind; 2=Two kinds; 3=Three kinds; 4=Four kinds; 5=Five kinds; 6=Six kinds	3.66	0.91
	Decision influencing factors	XSYS	1=One kind; 2=Two kinds; 3=Three kinds; 4=Four kinds; 5=Five kinds;6=Six kinds;7=Seven kinds; 8=Eight kinds	4.65	1.42
	Type of behavior	CSSL	1=One kind; 2=Two kinds; 3=Three kinds; and so on until 13= Thirteen kinds	7.21	2.00

A total of 300 paper and electronic questionnaires were distributed this time. After eliminating invalid questionnaires such as those with incorrect or incomplete answers(Zhang et al., 2018), 265 valid questionnaires were finally collected, with an effective rate of 88.33%. Among the surveyed farmers, the proportion of males was the highest, at 76.60%, while that of females was only 23.40%. The age group of 51 to 60 years old had the largest proportion, at 41.13%, followed by those over 61 years old, accounting for 36.23%. The proportion of those with junior high school education was the highest, at 61.13%, followed by those with high school or technical secondary school education, accounting for 26.79%. Regarding household income, the proportion of those with an income of 60, 000 to 100, 000 yuan was the largest, at 80.76%. In terms of distance from the town, the proportions of those within 0 to 5 kilometers and 6 to 10 kilometers were 45.28% and 36.60% respectively. The number of farmers with a planting area of 6 to 10 acres was the largest, accounting for 58.11%. Besides growing apples, many farmers also grow crops such as wheat and corn. The types of crops grown are diverse, and the proportion of those growing two types of crops is 40.00%.

According to a random sampling survey, over 80% of the farmers believe that the average temperatures in summer and winter have changed, but the extent of the change varies. 66.42% of the farmers think that the average temperature in summer has increased (including a slight increase and a significant increase, the same below), while 22.27% of the farmers hold the opposite view. As for the average temperature in winter, only 58.12% of the farmers believe that it has increased, and 25.29% think it has decreased (including a slight decrease and a significant decrease, the same below). In the farmers' view, the temperature in summer has generally increased, while in winter, there seems to be a trend of getting colder. Regarding the perception of changes in precipitation, the proportions of farmers who think precipitation has increased, remained unchanged, and decreased in summer are 58.12%, 22.64%, and 19.24% respectively; in winter, the proportions are 53.21%, 32.08%, and 14.71% respectively. The perception of changes in precipitation is not significant, with the proportion of farmers who think precipitation has increased being the largest, and it is higher in summer than in winter. In terms of the perception of changes in natural disasters, the proportion of farmers who think that floods have increased is the highest, at 61.89%. The proportion of farmers who think that the occurrence of pests and diseases has slightly increased is the highest, at 60.00%. The farmers' ability to obtain information and objectively adapt needs to be improved. In terms of the choice of adaptation measures, the top three measures are all technical behaviors, indicating that farmers tend to use scientific and technological means to solve problems encountered in agricultural production.

Economic behaviors have a lower proportion of adopters because when taking such measures, they need to consider the cost and effect of the measures as well as the family's economic conditions. However, the proportion is not low. Few farmers choose to migrate, indicating that agricultural production holds an important position in the local development.

3. Research Hypothesis and Research Method

3.1 Research Hypothesis

Through literature search on topics such as "climate change", "perception", and "adaptation", it was found that the earliest research in this field in China appeared in 2002, which was later than that in foreign countries. Since 2008, the number of studies has gradually increased. The early research was relatively simple, mainly focusing on climate perception and adaptation. Later, it gradually diversified, covering aspects such as risk perception of climate change, influencing factors, and adaptation efficacy. (Song et al., 2024; Song et al., 2022; Wang et al., 2021). Existing studies have shown that farmers' adaptation decisions to climate change are the result of the joint effect of individual internal factors and external environmental factors, including gender, age, knowledge reserves, experience, information acquisition, weather changes, social economy, and policy systems, etc. In the theoretical model, these factors can be attributed to the personal characteristics of farmers, family economic characteristics, climate perception, and the objective adaptation ability of farmers, all of which play an important role in farmers' climate perception and adaptation perception. Individual characteristics belong to the category of population characteristics, usually including gender, age, education level, etc. Family economic characteristics have the dual characteristics of population characteristics and social economic characteristics, usually including family size, income, transportation distance, occupation category, etc. Climate perception refers to the degree of cognition of climate change, including temperature and precipitation, various meteorological disasters, etc. Objective adaptation ability can be defined as the adaptation ability composed of natural, information, economic, technical, management, and institutional resources, and is reasonably allocated in the adaptation decision-making process to achieve an effective response, manifested as the effectiveness of these resources for adaptation. Based on this, this paper proposes the following hypotheses and constructs a path model of the effects of individual characteristics, family characteristics, and climate perception on the objective adaptation of farmers (see Figure 1). The selection and assignment of variables are shown in the above table. Due to the small degree of discrimination between indicators, the model fitting effect is poor. Based on professional knowledge, the correlation relationships between variables are debugged and the direction of effect is selected to make the model fit the observed data, which is statistically significant and consistent with theoretical knowledge.

Assumption H1: The individual characteristics of farmers influence their perception ability regarding climate change.

Assumption H2: The individual characteristics of farmers affect their objective adaptability.

Assumption H3: The individual characteristics of farmers influence the changes in their family and socio-economic characteristics.

Assumption H4: The family characteristics of farmers affect their perception ability regarding climate change.

Assumption H5: The family characteristics of farmers influence their objective adaptability.

Assumption H6: The perception ability of farmers regarding climate change affects their objective adaptability.

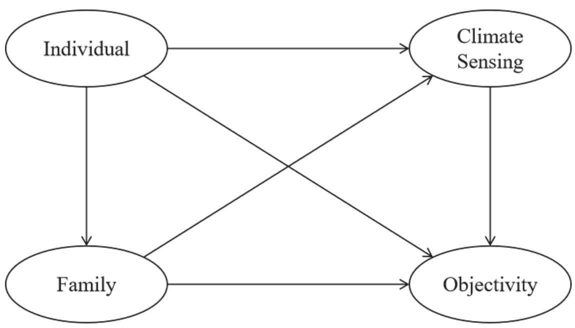

Figure 1. Model of the influence mechanism of farmers' climate perception and adaptation behavior (Hypothetical model)

3.2 Research Methods

In order to clarify the above-mentioned action paths, this study established a sample database in SPSS software, and then imported it into Amos software to construct a structural equation model (SEM) for analysis. This model is based on factor analysis and linear regression methods, and is used to represent the relationships among complex variables. Structural equation models can be divided into measurement models and structural models. The measurement model describes the relationship between indicators and latent variables, while the structural model describes the relationship between latent variables (Li et al., 2019). Indicators are observable variables, while latent variables cannot be directly observed and can only be inferred from indicators. Its analytical formula is:

$$x = \Lambda_x \varepsilon + \alpha \tag{1}$$

$$y = \Lambda_y \eta + \beta \tag{2}$$

$$\eta = A_\eta + B_\varepsilon + \xi \tag{3}$$

Equation (1) and (2) represent the measurement relationship, and equation (3) represents the structural relationship. x and y are exogenous and endogenous indicators, and α and β are errors in x and y measurements.Λ_x is the factor load matrix of x index on ε latent variable.Λ_y is the factor load matrix of y index on η latent variable.η is an endogenous latent variable.ξ is an exogenous latent variable.A is the relationship between endogenous latent variables.Bis the influence of exogenous variables on endogenous variables (Li et al., 2019).ξ is the error term in the model that fails to explain the part of the equation.

4. Research Results and Analysis

4.1 Reliability and Validity Test Results

This study employed SPSS software to conduct reliability tests on the scale data. The results indicated that the Cronbach's α coefficient value was 0.704, suggesting that the reliability of this questionnaire was good and acceptable. Due to the influence of the dimensional differences of the data variables, the standardized Cronbach's α coefficient was slightly lower than the non-standardized value, at 0.684. However, the two values were close, which further confirmed the consistency and stability of the indicator data. For the validity test of the data, the KMO test results showed that the KMO value was 0.75, which was within the acceptable range and the numerical suitability was good. At the same time, the Bartlett's sphericity test results indicated that the significance P value was 0.000***, which rejected the null hypothesis. This result further supported the rationality of factor analysis.

4.2 Confirmatory Factor Analysis Results

This study employed Amos software to conduct confirmatory factor analysis (CFA) on the indicator data to characterize the degree of association between test items and variable factors. It should be noted that during the measurement process, the first item of the same variable factor would be regarded as the reference item, and thus its significance (p-value) would not be displayed. In the individual characteristic factor, XB was not shown as the reference variable, while the standardized loading coefficient of NL was 0.743, indicating a significant positive contribution of this variable to individual characteristics, with a p-value < 0.01, and XL presented a significant negative loading, with a p-value < 0.01. In the family characteristic factor, WNRS was used as the reference variable, and it showed significance based on the levels of JTSR, JZJL, ZZMJ, and ZWZL. The standardized loading coefficients ranged from 0.583 to 0.737, and the p-values were all less than 0.01, indicating that these variables had a strong and significant positive influence on the family characteristic factor. In the climate perception factor, QWXJ was used as the reference, and QWDJ, JSXJ, JSDJ, and BCH variables all presented significant positive loading, with loading coefficients ranging from 0.681 to 0.918, and p-values all less than 0.01, indicating that these variables had a significant positive contribution to the climate perception factor in terms of statistics. In terms of objective adaptation, TQTJ was used as the reference variable, and CQYY, CSWT, XSYS, and CSSL variables had positive loading coefficients, but the standard loading coefficients were relatively low and had a large distinction (ranging from 0.489 to 0.822), with p-values all less than 0.01, indicating that their influence intensity was not as strong as the variables in the climate perception factor, but their contribution to the objective adaptation factor was still not negligible. Based on these variables, it can be considered that each measurement indicator shows a reasonable and effective presentation on the corresponding factor.

4.3 Structural Equation Model Fitting Results

This study employed Amos software to conduct the goodness-of-fit test for the structural equation model based on the questionnaire data. Referring to relevant studies (Li et al., 2015), the chi-square degree of freedom ratio, RMSEA (Root Mean Square Error of Approximation), and CFI (Comparative Fit Index) were selected as the indicators for measuring the overall adaptability of the model. The chi-square degree of freedom ratio was 2.4, which was less than 3, indicating a good fit. The RMSEA was 0.073, which was less than 0.1, and the CFI was 0.917, meeting the general requirement of CFI ≥ 0.9. The model fit was good. The measurement indicators of latent variables were all significant at the 1% level, indicating that each indicator could well reflect the latent variables and had significant representativeness.

4.4 Structural Equation Model Hypothesis Test Results

The test results of the structural model were obtained through Amos software. The results showed that the path coefficient of the H4 hypothesis was not within the range of (-1, +1) and should be discarded. Besides, the other paths (H1-H3, H5-H6) were all verified. Individual characteristics have a negative impact on family characteristics (β = -0.021, P < 0.01***), and climate perception (β = -0.014, P < 0.01***), indicating that different individual characteristics may lead to significant differences in family economic characteristics and climate perception, and this difference is highly statistically significant. Individual characteristics have a significant positive impact on objective adaptation (β = 0.68, P < 0.01***), meaning that factors such as age, gender, and education level of individuals can enhance their adaptability to climate change, emphasizing the importance of individual differences. Family characteristics have a negative and significant impact on objective adaptation (β = -0.518, P < 0.029**), indicating that the adoption of adaptation behaviors is constrained by factors such as the number of family laborers, income, land resources, and geographical location. Climate perception positively and significantly affects objective adaptation (β = 0.447, P < 0.032**), suggesting that growers have perceived climate change and this perception is likely to be transformed into positive adaptation behaviors.

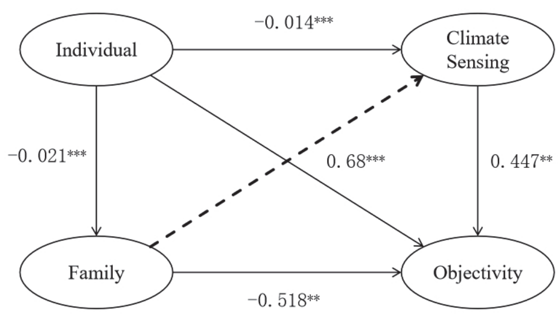

Figure 2. Schematic diagram of structural equation model

Note. *** and ** represent 1% and 5% significance levels respectively, and dotted lines indicate that this path is invalid.

5 Conclusion and Suggestion

5.1 Conclusion

This study applied the structural equation model to the investigation of apple growers' perception of climate change and their adaptation behaviors. This not only broadened the application scope of the structural equation model but also provided new ideas for the research on climate change perception and adaptation behaviors in the face of meteorological disasters. Based on the test results, this paper found that demographic attributes, socio-economic attributes, personal cognitive ability, and perception of climate change all have varying degrees of positive or negative influences on adaptation behaviors. The specific influence paths and magnitudes of influence vary depending on the research subjects (as clarified in the previous part "Research Results and Analysis", this will not be repeated here). This is both consistent with existing research and has innovative findings. For example, during the hypothesis testing of the model, the H4 hypothesis was not verified. This is because there is a possibility that family characteristics may indirectly affect climate cognition through social and cultural backgrounds, rather than directly acting on climate perception factors. In addition, during the process of converting climate perception into adaptation behaviors, it is subject to various factors, and the specific transformation process remains to be discussed.

5.2 Suggestion

Climate change has had a profound impact on agricultural production. Based on research results, personal characteristics and climate perception have significant influence on objective adaptation. Strengthening comprehensive ability training for individuals and enhancing their overall knowledge level should not be limited to agronomy and seed industry. This should be done to enhance the ability to cope with climate change. Continuing to strengthen the publicity of climate change forecasts, diversifying the channels for obtaining weather information, and effectively understanding climate change is the key to adaptation decisions. In agricultural production, more activities that benefit farmers should be carried out, providing technical guidance, financial subsidies, etc., to dispel families' concerns about engaging in agricultural planting. Activities should be carried out in terms of crop varieties, human resources, facilities and equipment, and benefiting farmers and agriculture in the adaptation process. Through structural equation models, the paths of the role of individuals, families and perception on adaptation were analyzed, and targeted suggestions were proposed based on this. However, in actual production, climate perception and adaptation decisions are often the result of multiple influences, involving psychology, disaster science and other aspects (Cao et al., 2021;Xiao, 2014). In future research, the research perspective should be broadened to further explore the interaction relationship between them.

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