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Predictive Study of Factors Influencing Farmers' Satisfaction with Transgenic Technology Based on Probit Model and Factor Analysis

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Abstract

Transgenic technology is the product of scientific and technological progress, using modern biotechnology, one or more of the known functional genes will be expected to be transferred into the genome of the organism after artificial modification, thereby achieving the purpose of changing the characteristics of the body. Now it has been widely applied in agriculture and food. The genetically modified crops showed the characteristics of resistance to insect pests and drought, and the quality of genetically modified foods was also different from that of traditional foods. Although the transgenic technology has its advantages, but attitudes of transgenic technology is mixed in real life, farmers, as growers and consumers, are more cautious about genetically modified technology. In this paper, probit model and structural equation model are used to explore the main factors affecting the satisfaction of farmers, with a view to provide reference for the future research of transgenic technology.

Keywords*: GM technology; farmers; Probit Model; Factor analysis*

1. Introduction

Since the first case of the industrialization of genetically modified crops in 1996, the global technology research and application of genetically modified technology has been developed rapidly. In 2008, China launched a major project to cultivate new varieties of genetically modified organisms, and in the "Twelfth Five-Year Plan" period, 137 key genes with significant breeding value were obtained, and the total number of new varieties of transgenic patents ranked second in the world. Transgenic cotton and transgenic papaya has been grown commercially in China, however, transgenic soybean was still in the basic research level. In view of the high cost of soybean planting and growing domestic demand, the spike in demand for GM soybean import to China is at an all-time high. Transgenic soybean mainly used for oil extraction, so it is more closely related with people's life. Taking the farmers as the research object, the research on the satisfaction of the farmers to the transgenic technology can be transformed into the farmers' willingness to plant genetically modified soybeans.

Many scholars have focused on ethical concerns and safety problems of genetically modified crops. However, farmers have a major role in production. For example, farmers in Heilongjiang Province raise transgenic soybeans illegally because they provide a quality product that is for its good quality and easy to management in 2005 which reflects farmers' attitude to GM soybeans. The main policy document from the central government states that "Strengthening the agricultural transgenic technology research and development and regulation, to ensure safety on the basis of careful promotion". This mention of the GM soybeans cultivation promotion shows that the government is

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committed to promoting GM crops. Research of farmers' cognitive and planting willingness of GM crops is needed.

Domestic scholars have launched a detailed study of many aspects around the farmers on genetically modified technology cognition and production willingness. Xujiapeng and Yanzhenyu [1]found farmers' knowledge of transgenic technology was very scarce in a survey of farmers in Hubei province, the individual characteristics and subjective expectation are the important factors influencing farmers to plant transgenic staple food. Xueyan [2]studied the maize and rice transgenic insect-resistant varieties and disease-resistant varieties through field investigation in Heilongjiang, Jilin, Shandong, Henan and Fujian provinces, finding that many farmers were concerned about economic benefits in addition to safety issues. In other words, it is more difficult to promote GM technology commercialization at the producer level compared with the demand-side. One suite of factors affecting farmers' willingness to plant GM crops is related to the farmers themselves, including: education background[3], source of income[4], cognitive level of GM technology[5-6], crop planting history[7] cultivation area[6], risk preference[8] and the behavior of economic - moral man[9]. Another suite of factors is external to the farmers, including: crop production forecast[1,4] , prospective crop quality and nutritional value[7],sales expected[1], food security[1,4,10],ecological outcomes[10], input expected[1,6],market liberalization[11], information dissemination[12]. According to a survey of genetically modified soybean planting, Xu Shenxian concluded that famers are not passionate about growing herbicide-resistant soybeans [10].

Farmers' willingness to grow GM crops varies over time and geography. Variation is likely related to information availability and differences in national policy and advocacy. Statistical research methods, including Probit and/or Tobit models, help show that farmers value economic benefits. Farmers are beginning to become more aware of GM crops, with the help of popular science. Three provinces in Northeast China and Inner Mongolia provide a pilot region to evaluate soybean price subsidy policies. The sample areas mentioned below are also selected from the pilot region based on the soybean planting area, yield and other indicators. The general distribution of the situation is shown in Figure 1,2.Farmers are willing to grow GM soybeans in these major soybean-producing areas. We surveyed farmers in the main production areas to understand farmers' knowledge of GM soybeans and how they cultivate soybeans in various regions. To analyze factors influencing farmers' willingness to grow GM soybeans, we used a Probit model and Factor analysis respectively.

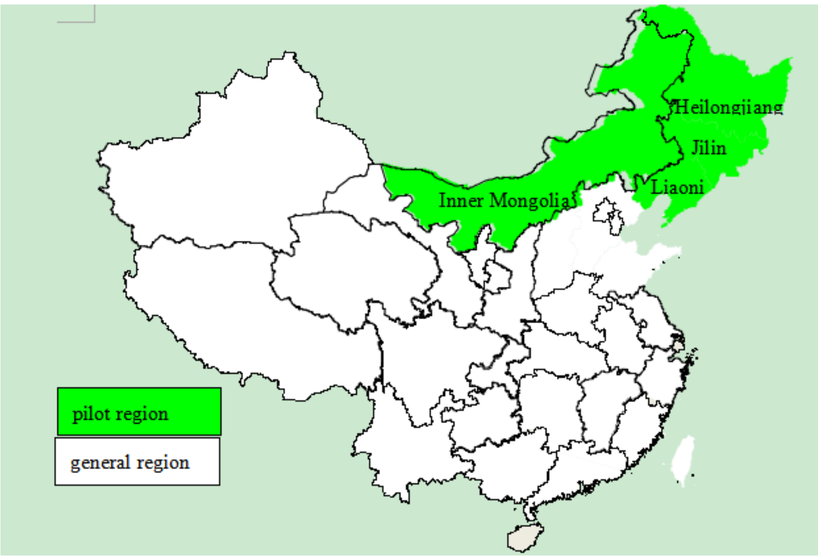

Figure 1. Pilot Areas

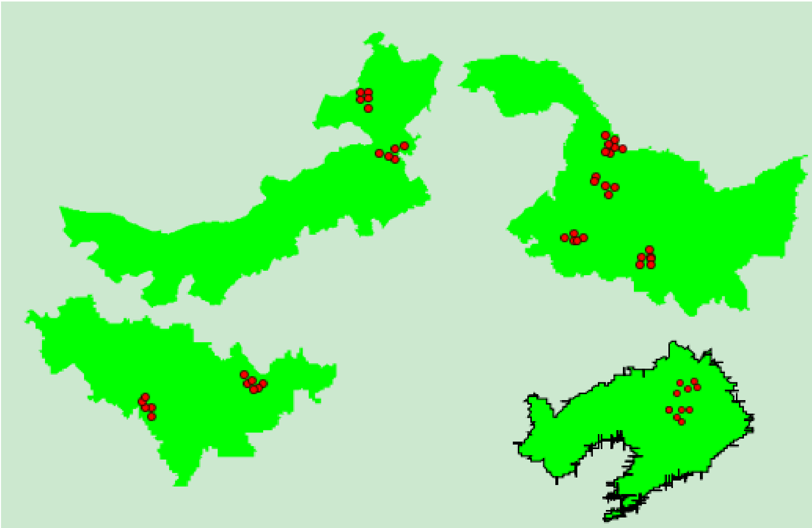

Figure 2. Sample Distribution

2. Research Background

2.1. Sample Selection

(A)Research objectives and locations

According to the statistical material about China's main soybean producing areas, four provinces were selected as the target price of soybean subsidies in 2014: Heilongjiang, Jilin, Liaoning and Inner Mongolia. Cities, including farm management districts, included: Qiqihar city, and Suihua city, Heihe city and the nine three Bureau of reclamation, Heilongjiang province; Dunhua city and liaoyuan city, Jilin province; Tieling city and Shenyang city, Liaoning province; Ulanhot city and Hulun Buir city, Inner Mongolia. A total of 10 cities in 22 counties (area, administration, and flag) and 53 villages were selected as the research location. Ten households were selected in each village, resulting in a total of 530 questionnaires, of which 520 valid questionnaires were returned. The research team included graduate and undergraduate students from Northeast Agricultural University, and work was completed from July to September 2015.

The task force selected the research area to focus on GM soybeans because the northeast is China's main soybean producing area, where farmers have a long, rich history of producing soybeans. Moreover, researchers were trained in the sensitivities involved in the topic of GM soybeans.

2.2. Soybean Planting in the Research Area

2.2.1. The Overall Characteristics of the Research Area

The terrain dominated by plains and hills in Heilongjiang Province is the largest soybean planting area, followed by Inner Mongolia. Soybeans in Liaoning Province are mainly used as food. Soybean planting in Jilin Province is mainly concentrated in Dunhua City, a lower proportion of Liaoning Province and Jilin Province planting soybean. In the labor distribution of soybean planting, middle-aged women are major labour force in Jilin and Liaoning province, the proportion of men and women in the labor force is considerable, while in Inner Mongolia, the labor force is dominated by the elderly. The proportion of men and women in the labor force is considerable. Research areas were not restricted to “no tillage” technology, so farm lands are typically trimmed once every autumn, with some farmers trimming the land in spring.

2.2.2. Behavior Choice and Reasons of Regional Farmers' Soybean Planting

(A) Unwilling to grow soybeans. The reasons why the farmers do not want to grow soybean have the national convergence, mainly exists in two aspects. On the one hand, based on the input and output perspective, although the investment cost of corn is higher, but the output value is much higher than soybean. as “rational economic men”, when the yield of corn is higher than the yield of soybean, farmers will be biased in favor of planting corn. Figure 3 shows an income analysis of soybean and corn, indicating that corn profits are higher than soybean; On the other hand, based on the perspective of national policy, At present, the target price subsidy policy is an important policy of for the implementation of soybean. However, some problems in the implementation of the policies have weakened the farmers' willingness to grow soybeans. For example, market price monitoring points set unreasonable, making the market monitoring prices high. Moreover, farmers are mainly selling crude soybeans at home, while the market price monitoring points monitor soybeans according to the quality classification, purchased by enterprise. The price of latter soybean is higher 0.2-0.4yuan/kg than the crude soybean. Besides, there is a deviation between real area and the area identified by the country, as a basis for the subsidy. So, farmers receive relatively small subsidies. In 2014 the target price of the domestic soybean was 4800 yuan per ton, which did not have much impact on farmers growing enthusiasm. Soybeans are likely to be replaced by crops with higher efficiency such as corn and rice.

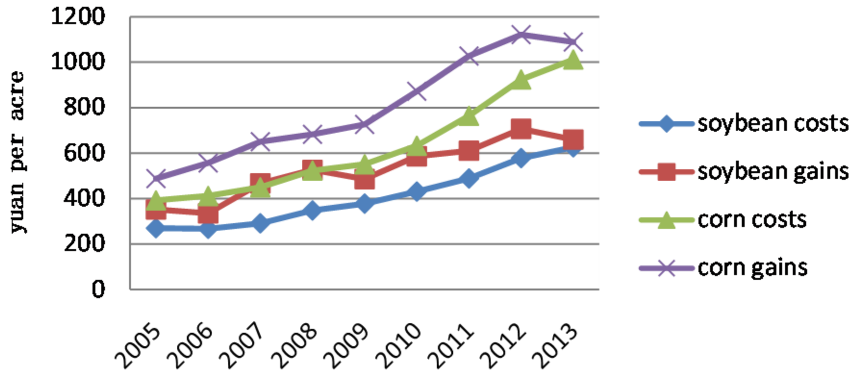

Figure 3. Comparison of Soybean and Maize Yield Analysis

(B)Choose to grow soybeans

Of course, there are other reasons in addition to profit that farmers will choose to plant soybeans. In Heilongjiang Province, since the farmers in Nenjiang county are close to the Jianshan farm, their selections of major species follows the farm. Farmers who choose to grow soybeans believe that the risk of planting soybeans is small and early production inputs are lower than corn, and also perceive that soybeans are not labor intensive. Farms choose to plant soybeans because of crop rotation in Baiquan County, some lands are suitable for continuous cropping of corn, and some of the land can be placed in corn - soybean rotation. Planting soybeans in Wangkui Country is based on the consideration of base temperature and restricted natural environment. In short, given the presence of comparative income, farmers will abandon soybeans for corn. Considering base temperature, the planting habits, crop rotation, labor, cultivation time, risk and other aspects, the farmers will likely choose to plant a portion of their land as soybean crops.

3. Survey Results

3.1. Households Surveyed

3.1.1. Based On the Individual Characteristics of Households

In the survey of 520 valid samples of farmers: terms of gender, there were 463 male, 57 female; for age, a minimum of 21 years and a maximum of 74 years, of which a total of 25 people aged 20-30, 96 persons aged 31-40, a total of 216 persons aged 41-50, 131 persons aged 51-60, 42 persons aged 61-70, a total of 10 persons aged 71-80, average age was 47 years old; for years of education, 0-5 years a total of 88 persons, 6-10 years a total of 283 people, 11-15 years for a total of 141 persons, 16-20 years a total of 8 persons, people with the lowest qualifications did not receive formal education, the highest level of education was college degree, average years of schooling for 8.96; for employment status, there were 407 pure farmers, concurrently industry farmers of 113 persons.

3.1.2. Based On Regional Differences

By comparing each sample area, we found more female respondents in Jilin province and Liaoning Province and more men chose to go out to work, so the degree of part-time farming was higher. Farmers' education level is higher than other regions in nine three Bureau of reclamation, with an average 12 years of schooling. The least number of farmers were surveyed in Nenjiang County, Heilongjiang province: a total of 10 farmers interviewed from three villages. Because the development of land scale management was better, the number of farmers engaged in agricultural production was less in each village. The respondents in Inner Mongolia were older and the new generation of migrant workers did not want to return to farming. As a result most of the land was managed by the old people in the countryside.

3.2. Farmers ' Perceptions of Biotechnology and Genetically Modified Foods

From Table 1, the gender, age, years of education and occupation of the farmer will affect their awareness of transgene. The overall understanding of genetically modified GMfood was higher than that of GM technology; a large part of the reason might come from the identification of genetically modified soybean oil in supermarkets. Specifically speaking: the proportion of males who heard about transgene was higher than that of females, 85% male farmers had heard of genetically modified food, while female farmers heard of genetically modified food accounted for 72%; the older the farmer was, access to GM information might be narrower.58% of farmers aged between 51 and 70 years had heard about GM technology, while, farmers aged pver 70,the ratio was only 21%.The higher the level of education, the more sensitive to capture new things, the greater the possibility of acquiring GM technology or GM food knowledge. If farmers had other occupation except for agriculture, such as working in the factory, he or she was more likely to have access to GM information, and this possibility is 13 percentage points higher than in agriculture alone. Although farmers had heard of transgene, but really did not know much. Table 2 shows that the number of people who could answer the six questions was about 144, accounting for the proportion of people heard about 32%.

Table 1. Respondents Heard about GM

		Gene	GM technology	GM food
Total sample(a)		460	442	448
Often heard		215	191	183
Occasionally heard		245	251	265
Gender(%)				
Male		89	80	85
Female		81	68	72
Years of schooling(%)				
0~5		71	32	45
6~10		89	63	74
11~15		98	79	86
16~20		100	95	97
Age(%)				
21~30		93	86	89
31~50		81	78	71
51~70		63	58	42
Over 70		40	21	14
Engaged in other occupations(%)	Yes	92	84	86
	No	80	72	73

Table 2. Respondents' True Knowledge of GM

	Respondents' answers		
Questions	YES	NO	NOT SURE
People eating genetically modified food will be transferred to genes.(NO)	274	157	16
GM foods contain genes, and ordinary foods (non GM foods) do not contain genes.(NO)	285	141	22
Boys' sex is determined by paternal genes.(YES)	182	251	13
Animal genes cannot be transferred to plants.(NO)	293	143	9
Fish genes transferred into tomatoes, tomatoes will have fish flavor(NO)	287	145	11
Small tomato is a genetically modified food.(NO)	266	146	35

3.3. Farmers' Understanding of GM Soybeans

In 520 questionnaires, nearly 59% of the farmers indicated they had heard of GM soybeans, but didn't fully understand the issue. Nearly 28% of the farmers said they understood a little, showing that farmers' awareness of GM soybeans was generally low. Many farmers indicated lack of knowledge of GM technology and GM soybean cultivation. Their willingness to grow was likely limited by a lack of scientific background.

Farmers did not pay much attention to the quality of soybeans planted now, whether insect, disease resistance, anti-grass or other capabilities, but were more concerned about the production and sale price. In the attention of soybean quality, the top three are: yield, stress resistance and security. Four hundred and thirty-five farmers were most concerned about the yield of soybeans, 304 farmers believed that the resistance was very important, and 141 farmers thought that the security of the species was of great importance. In addition, 39 households selected high oil, 35 farmers chose high protein, 25 farmers selected lodging-resistant and 11 farmers chose precocity. Farmers did not fully understand the characteristics of their own soybean, the factors deciding to which kind of soybean mainly include: the experience of others (neighbors grow effect and dealer recommended), whether it had a good sales, a high yield, a suitable growth period, or whether it was precocious or lodging-resistant. The yield of soybean was the most concern of farmers. For soybean inputs, farmers generally believed that the seeds, fertilizers, and pesticides had a greater impact on soybeans, (respectively, 354,354 and 276 farmers to choose, followed by a total of 127 people chose “save labor”, 117 persons chose “field management”).

3.4. Farmers' Perception and Willingness to Grow GM Soybeans

3.4.1. Farmers' Perception of GM Soybeans

As can be seen from Table 3, farmers are still lack of substantial understanding of GM soybeans.

Table 3. Cognitive Statistics of Transgenic Soybean

Name	Options (multiple choice)	(a)
Obvious superiority of resistance	Herbicide tolerance	78
	Insect-resistant	31
Yield characteristics	High yield	107
	Low yield	14
	High yield, but not stable	23
Seed price	Higher than common seed	83
Saving drug costs	Herbicide cost savings	69
	Pesticide cost savings	47
Labor saving	Reduce pesticide	92
	Less tillage	11
Oil content	High	90
	Low	35
Nutritional value	Low protein content	59
Security	"Super weeds", pests increase	44
	May be detrimental to health	126
Market prospect	Fine	57
	Poor, need for government guidance	103
Macro level	Increase social welfare	9
	Safeguarding national food security	28
Resources and Environment	Reduce carbon emissions	13
	Protection of cultivated land	19

Farmers were rational economic people, and they paid more attention to yield, cost and income, while less attention was paid to the benefits of resources, environment and national macro-level.GM soybean is beneficial to promote the reform of cropping system and reduce soil erosion. Although its protein content is less than that of non-transgenic soybean, its nutrient components such as hard fatty acid and flavonoids occupy a great advantage. Farmers paid more attention to what was visible on the surface and did not understand deep information. It was easy to see that farmers generally believe that genetically modified soybean can increase production, save drug costs, may have adverse effects on human health. Specific performance: Farmers heard about potential high yields of GM soybean from television, neighborhood friends and seed dealers, but realized GM soybeans were harmful to the human from the network and the media, including worries they could lead to abortion or infertility. Some believed that GM soybeans could only grow one year and they would not grow seedlings in the second year. These negative messages were based on hearsay and the lack of in-depth understanding of GM soybeans. Most people said GM soy would cause risks to human health, but if the state issued a statement saying GM soy was harmless, farmers would believe the government. It could be seen that channel for farmers to obtain genetically modified knowledge was narrow; they lacked scientific training and did not use their own perspective to determine the accuracy of information.

The cognitive survey of GM soybeans found that men knew more than women, young people knew more than older people, people who grew soybeans knew more than people who did not, farmers with good economic conditions knew more than ordinary farmers, and were more willing to plant them.

3.4.2. Farmers' Willingness to Grow GM Soybeans

Because farmers did not know much about GM soybeans, when asked, "What is a genetically modified soybean," the answer usually was: a kind of new soybean varieties of transgenic technology. There were 144 people who had a certain understanding of GM soybeans, about 28% of the total samples. Eighty-seven of them expressed their willingness to try, hoping the country would allow commercial planting of GM soybeans. 57 people said they did not want to grow GM soybeans. Some farmers had heard some disadvantages of GM soybeans. If the State allowed the commercial planting of GM soybeans, 77 people would choose to grow small areas of GM soybeans in the first years of the commercial planting. If the results were good then the second year of large-scale cultivation. Ten people said that they would not try to grow in the first year, after seeing others grow effect would then decide. When asked about soybean varieties, farmers did not place great emphasis on whether soybean drought, cold, salinity, or resistant to glyphosate herbicide and other characteristics, but generally wanted genetically modified soybeans had high yield, lodging resistance, good sales advantage.

Farmers were sensitive to the risk of new technology, perhaps because of the "cost of technology asymmetric" principle, and could not evaluate the potential risks and benefits. In the case of a lack of understanding of new technologies or completely lack of understanding, farmers' subjective perception would always enlarge the risk, which affected the cultivation of GM soybeans.

4. Analysis of the Factors that Influence Farmers' Willingness to Grow GM Soybeans

4.1. Theoretical Background and Research Hypothesis

Yao & Zheng [13] pointed out that the behavior of farmers would be subject to behavioral attitudes, subjective norms, the perception of behavior control and other factors. Behavioral attitudes include economic rationality, survival rationality, and so on.

Subjective norms mainly concern the opinions of other people around, while perceptive behavior control mainly includes the perception of national policies and risks. Taking the farmer's production characteristics, demographic characteristics, attitude towards GM crops and subjective judgment of their advantages and disadvantages as the main research variables, Darr D A &Chern W S [14] used Tobit model to analyze the impact of various factors on farmers planting herbicide-resistant genetically modified soybean. The results showed that there was a positive relationship between farmers' cultivated area, education level and planting willingness. Payne J, Fernandez-Cornejo J& Daberkow S [15] also found that the farmer's age, farm type, scale of operation, and the degree of rootworm damage would significantly affect farmers' willingness to adopt BT maize seed through research, but the education level and farming way did not have significant influence on willingness. A field survey on rice farmers in Huaian carried by LV Dandan [4] showed that planting time and planting area had a significant positive effect on the willingness of transgenic rice plants. Based on the theories above, to ensure a more scientific conclusion, this paper uses survey data combined with cognitive evaluation of farmers, accounting for individual characteristics of farmers, production characteristics, external factors, self-expectations as the analytic targets of influencing factors. The individual characteristics of farmers include farmers ' age, education level, family size, and part-time farming; Production characteristics include soybean planting area, soybean income share, pesticides use frequency; External factors include safety and health considerations, management convenience, technical guidance, for personal use or not; Self expectations include production expectations and earnings expectations), and put forward the following hypothesis:

a) Individual characteristics of farmers will significantly affect the choice of farmers to plant. Specifically, the farmer's age may be negatively correlated with willingness. The older the farmer is, the more likely it will be to maintain the original habit of cultivating for a long time, in a short time, it is difficult for farmers to accept a new technology; The farmers with long years of education, thinking multi-dimensional, the analysis of one thing will be more profound, the more likely to choose genetically modified soybean; If the farmer has other occupations except agriculture, the energy input to agriculture will be greatly reduced, the attention of agricultural policy and related new technology will be reduced, so the farmers' planting intention is not strong; The more the population in the family, especially the more population with the ability to work, the more likely the farmers to choose genetically modified soybean.

b) In terms of productive characteristics, the greater the planting area of farmers, the greater the risk they face, dare to try new technologies, less likely to grow; If the farmer's agricultural income comes from soybean production more, the farmer will be very sensitive to the superiority of the transgenic technology, and enhance their planting willingness; Pesticide cost is an important factor affecting the production behavior, there may be a positive correlation between the number of pesticides applied and the willingness to plant.

c) Other factors: Farmers' good expectations of yields and benefits will increase their willingness to grow; Because most farmers think that GM soybeans have potential safety problems and farmers are both growers and consumers, farmers 'willingness to choose to grow will be reduced if farmers consider that the potential insecurity will seriously affect consumers' purchasing intention; The local agro-technical extension departments should have a good guiding role for the farmers' production behavior, agricultural extension system to build more sound, the possibility of planting genetically modified soybeans will be greater; Genetically modified soybeans are low in protein, and if farmers use soybeans for their own consumption, the planting will be compromised.

4.2. Probit Model Construction and Variable Definitions

Because there are only two kinds of values to describe planting willingness (yes or no), we firstly built a Probit model. Table 4 shows the definition of variables.

Table 4. Variable Selection, Assignment and the Expected Correlation of the Planting Intentions

Variable species	Variable name	Variable description	Mean value	Standard deviation
	Y	Virtual variable: willing to grow or not, yes = 1, no = 0		
personal characteristics	X1	Virtual variable: farmer's age, 21-30 years old = 1,31-50 = 2,51-70 = 3,>70 years old =4	2.410	0.582
	X2	Virtual variable: Education level, 0-5 =1,6-10 = 2,11-15 = 3, 16-20 = 4	2.319	0.723
	X3	Real variables: family population	3.542	1.117
	X4	Virtual variables: whether there is no second career, yes = 1, no = 0	0.375	0.484
Production characteristics	X5	Real variable: soybean planting area	94.014	224.903
	X6	Virtual variable: the proportion of soybean income in agricultural income,<10% = 1,10%-30% = 1, 30%-50% = 2, >50% = 3	2.104	0.823
	X7	Real variables: pesticide use frequency	2.042	0.934
	X11	Virtual variables: convenient management, yes = 1, no = 0	0.514	0.500
External factors	X8	Virtual variables: whether to consider the safety and health of GM soybeans before planting, yes = 1, no = 0	0.569	0.495
	X9	Virtual variables: for personal use or not, yes = 1,no = 0	0.528	0.499
	X13	Virtual variable: technical guidance = 1,no = 0	0.507	0.500
Self expectation	X10	Virtual variables: expected earnings, good = 1,poor = 0	0.528	0.499
	X12	Virtual variable: expected yield, high = 1, low = 0	0.701	0.458

The specific expression of the model is:

$$Y^* = \alpha + \beta X + \mu \tag{1}$$

$$Y = \begin{cases} 1, \text{ while } Y^* > 0, \text{ farmers expressed satisfaction} \\ 0, \text{ while } Y^* < 0, \text{ farmers expressed dissatisfaction} \end{cases} \tag{2}$$

In the equation (1), μ is the disturbance term, which obeys the standard normal distribution, so that the binary discrete selection model which affects the satisfaction of farmers can be expressed as:

$$\Pr ob(Y=1/X=x)=\Pr ob(Y^*>0/x)$$
$$\Pr ob(Y=1/X=x)=\Pr ob(Y^*>0/\mathrm{x})=\Pr ob\{[\mu>(\alpha+\beta x)]/x\}$$
$$=1-\Phi[-(\alpha+\beta x)]$$
$$=\Phi(\alpha+\beta x) \quad (3)$$

In the formula (3), Φ is the standard normal cumulative distribution function; Y is the unobservable latent variable, Y^* is the observed dependent variable, indicating whether the farmer is satisfied with the transgenic soybean; 0 is "not satisfied", 1 is "satisfactory"; X represents the influencing factor vector, x represents the actual observed , Including gender, age, educational level, employment situation, planting area, planting years, the number of drugs and other factors in the characteristics of the individual.

Besides, we can also refine the behavior of the planting intentions by setting "no planting", "part planting", "all planting" and attempting to compare results using the ordered probit model. The concrete expansion of the Ordered probit model is:

4.3. Probit Model Results

Table 5 shows model output results calculated through Eviews6.0 software. Results show that LR (likelihood ratio) is 157.139, with corresponding probability is 0, demonstrating high overall significance of the model. In addition, by observing the concomitant probability, we can get a conclusion that, part-time farming, safety and health considerations, and expected benefits will have a significant impact on the willingness to grow GM soybeans under the 1% significant level; farmers ' age, household use, soybean income share and expected production will show a significant impact on the willingness to grow GM soybeans under the 5% significant level.

Table 5. Output Results

variable	Estimated coefficient	standard deviation	Z statistics	Adjoint probability(P)
C	3.349	3.011	1.112	0.266
X1	-1.254	0.601	-2.087	0.037
X2	-0.303	0.361	-0.839	0.401
X3	-0.380	0.296	-1.284	0.199
X4	-2.214	0.654	-3.383	0.001
X5	0.002	0.013	0.196	0.845
X6	0.965	0.446	2.162	0.031
X7	0.476	0.312	1.525	0.127
X8	-3.212	0.929	-3.459	0.001
X9	-1.445	0.565	-2.559	0.011
X10	2.344	0.763	3.073	0.002
X11	0.919	0.604	1.520	0.129
X12	1.482	0.656	2.260	0.024
X13	0.673	0.550	1.224	0.221
McFaddenR-squared	0.813			
LR statistic	157.139			
Prob(LRstatistic)	0.000			

5. Factor Analysis

5.1. Model Establishment

$$\begin{cases} x_1 = a_{11}f_1 + a_{12}f_2 + a_{13}f_3 + \cdots + a_{1k}f_k + \varepsilon_1 \\ x_2 = a_{21}f_1 + a_{22}f_2 + a_{23}f_3 + \cdots + a_{2k}f_k + \varepsilon_2 \\ x_3 = a_{31}f_1 + a_{32}f_2 + a_{33}f_3 + \cdots + a_{3k}f_k + \varepsilon_3 \\ \cdots \\ x_p = a_{p1}f_1 + a_{p2}f_2 + a_{p3}f_3 + \cdots + a_{pk}f_k + \varepsilon_p \end{cases} \quad (4)$$

Equation (4) is the mathematical model of factor analysis, can also be expressed in the form of a matrix:

$$X = AF + \varepsilon \quad (5)$$

Where F is called the factor, also known as the common factor; Ɛcalled the special factor, which represents the original variable cannot be explained by the part of the factor, the mean is 0.

5.2. Data Test

In this paper, SPSS17.0 software is used for the implementation of statistical data KMO and Bartlett test. The test results are shown in Table6.KMO test statistic is used to compare the simple correlation coefficient and partial correlation coefficient between the variables, its value is between 0 and 1.KMO value closer to 1, the greater the correlation between variables, the original variable is more suitable for factor analysis. Generally, when Bartlett test value is less than 0.05, the variables can be used as factor analysis. Table 6 shows that KMO value is0.689 and P value is 0.000, which indicates that sample data can be used as factor analysis.

Table 6. KMO and Bartlett's Test

KMO measure of Sampling	Bartlett's Test of Sphericity		
	Approx.Chi-Square	df	Sig.
0.689	229.277	78	0.000

5.3. Identify Common Factors

Based on principal component analysis (PCA), the total variances of the explanations given in Table 7, obtained by SPSS software. The results show that five common factors whose eigenvalues are greater than 1, can be obtained by rotation. The contribution rates of five common factors are:23.859%,19.342%,16.457%,14.925%,11.439%, and the cumulative contribution rate of variance is 89.021%. Five common factors are sufficient to explain the information contained in the original thirteen variables, and have significant representativenes.

Table 7. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loading		
	Total	%of Varian-ce	Cumul-ative %	Total	%of Varian-ce	Cumul-ative %	Total	%of Varian-ce	Cumul-ative %
1	6.644	51.111	51.111	6.644	51.111	51.111	3.102	23.859	23.859
2	1.466	11.276	62.387	1.466	11.276	62.387	2.514	19.342	43.201
3	1.334	10.259	72.646	1.334	10.259	72.646	2.139	16.457	59.658
4	1.115	8.578	81.224	1.115	8.578	81.224	1.940	14.925	74.583
5	1.014	7.796	89.021	1.014	7.796	89.021	1.487	11.439	89.021
6	0.905	4.962	95.983						
7	0.325	2.503	96.486						
8	0.134	1.033	97.519						
9	0.124	0.966	98.485						
10	0.083	0.649	99.534						
11	0.025	0.199	99.733						
12	0.195	0.150	99.883						
13	0.015	0.117	100.000						

The variance-maximization method is used to perform the orthogonal rotation on the factor loading matrix, so that the factor has a named explanatory property. From the rotated component matrix (Table 8), we can see that the first factor mainly explains three variables X10, X8, X12, named self-expectation factor; the second factor explained X6, X7, X5, named production characteristics factor; The third factor explains three explanatory variables, X3, X4, and X1, which are named individual feature factors; The fourth factor explains the explanatory variables of X13, X9 and X11,named as external factors; the fifth factor explained mainly X2, an explanatory variables, named as cultural factors.

Table 8. Rotated Component Matrix

Impact factor	Common factor				
	F_1,self-expectation factor	F_2,production characteristics factor	F_3,individu-al feature factors	F_4,external factors;	F_5,cultural factors.
expected earnings X10	**0.750**	0.028	-0.078	0.038	0.034
safety and health X8	**-0.713**	-0.244	-0.089	0.157	-0.048
expected yield X12	**0.500**	0.013	-0.470	0.000	0.147
soybean income share X6	0.189	**0.832**	0.008	-0.015	-0.056
pesticide use frequency X7	-0.196	**0.698**	-0.281	-0.173	0.166
soybean planting area X5	0.335	**0.542**	-0.029	0.030	0.000
family population X3	0.063	-0.100	**0.818**	-0.100	-0.135
the second career X4	-0.411	-0.067	**0.525**	0.190	0.285
farmer's age X1	-0.004	-0.308	**0.404**	0.339	-0.375
technical guidance X13	0.132	0.131	0.130	**0.737**	0.134
for personal use or not X9	-0.296	-0.237	-0.083	**0.600**	0.093
convenient management X11	0.108	0.129	0.140	**-0.523**	0.446
education level X2	0.071	-0.026	-0.151	0.162	**0.840**

5.4. Calculate the Composite Score of the Factor

Table9 shows that the variance contribution rates of the five main factors are: 23.859%,19.342%,16.457%,14.925%,11.439%,the total variance contribution rate89.021%.

$$\frac{W_1}{W_1+W_2+W_3+W_4+W_5}F_{1X}+\frac{W_2}{W_1+W_2+W_3+W_4+W_5}F_{2X}+\frac{W_3}{W_1+W_2+W_3+W_4+W_5}F_{3X}+\frac{W_4}{W_1+W_2+W_3+W_4+W_5}F_{4X}+\frac{W_5}{W_1+W_2+W_3+W_4+W_5}F_{5X} \quad (6)$$

Composite score of each factor can be obtained through the formula (7). The final calculation results are shown in Table

$$F=0.268F_{1X}+0.217F_{2X}+0.185F_{3X}+0.168F_{4X}+0.128F_{5X} \quad (7)$$

Table 9. Comprehensive Score Table of Factors

Factor name	F	Ranking	Factor name	F	Ranking
technical guidance	0.229	1	convenient managemen t	0.052	8
soybean income share	0.223	2	the second career	0.041	9
soybean planting area	0.207	3	pesticide use frequency	0.039	10
expected earnings	0.203	4	farmer's age	0.016	11
education level	0.120	5	for personal use or no	-0.033	12
family population	0.112	6	safety and health	-0.240	13
expected yield	0.069	7			

6. Discussion and Related Countermeasures

Through the establishment of two models, we found that the factors that significantly influenced farmers' planting willingness are：soybean income share, expected earnings, expected yield, the second career, farmer’s age, for personal use or not. The larger the proportion of soybean income in agricultural income, the higher the degree of acceptance of the farmers to plant GM soybeans. Farmers who own high soybean income share will be more sensitive to relevant media information and policies related to GM soybeans. When GM soybeans have an advantage in yield and earnings, farmers will be more willing to plant them. There is a significant positive correlation between farmers' expectation of earnings, yield and planting willingness. In the reasons provided to plant GM soybeans, 70% of farmers chose “high yield” or “good income”. Part-time farming is negatively correlated with the willingness to grow, perhaps because a second career lowers income risk and may also lower the level of attention paid to GM soybeans. Older farmers are less likely to plant GM soybeans in the future, which is consistent with the statistical results of the survey. Older farmers have a cautious attitude to GM soybeans. Older farmers may have less access to information and lower initiative to accept new technologies such as GMO. The factor “for personal use or not” has a negative significant effect on willingness to grow, farmers may worry too much about the safety of GM soybeans.

6.1. Use Outreach and Education to Provide Information about GMO Soybeans

People tend to fear the unknown. To improve public awareness and promote informed choices, more information about GM crops needs to be circulated, and this information must be scientifically accurate while also considering different opinions and offering opportunities for information exchange. Clear, understandable popular science about GM crops will help people understand the role of farmers’ opinions and will increase understanding among farmers themselves. Examples include media outreach, public lectures, and online opportunities for people to interact with experts. Popular science should provide transparent, realistic information about GM crops. Recognizing that different cultivation processes are subject to different guidance will help farmers can assess the safety risk of GM crops. Farmers' attitude towards GM soybeans is influenced by the quality of information available. Positive messages will increase farmer's perception of earnings; negative information will increase the risk perception of farmers, and contradictory information will increase the doubts of GM soybeans. The media is an important avenue for providing this information. Some high-profile media campaigns promoting non GMO products have potentially increased consumer concerns. Additionally, media have reported unwarranted findings about GM soybeans. Media need to provide objective and scientific messages about GM soybeans to help farmers and the public understand the issues. To avoid speculation and inflammatory media reporting, the government should promptly address any examples of dispute over GM crops, and guide the media to correctly convey the information.

6.2. To Enhance the Non GMO Soy Brand to a Strategic Height

With the convening of the fourth meeting of the twelve session of the National People's Congress, "increasing soy" was promoted as an important part of agricultural supply side reform. "Increase" refers to both volume and quality of domestic soybeans. To increase production, technical research is needed; to increase quality, a brand strategy is particularly urgent. A first step is to establish protection mechanisms for domestic Non-GM soybeans. Protection mechanisms should include ways to prevent gene pollution of high quality non GM soybeans, improved agricultural insurance system, and price subsidy policies. Establishing protected areas of Non GM soybeans in China's major soybean producing areas such as Heilongjiang Province, especially for high yield, high oil soybeans, where access is strictly controlled, can help prevent genetic pollution. Domestic agricultural insurance policies must be established, offering financial support to insurance companies to expand and/or transfer [16]. For price subsidies, local conditions should be adapted to local conditions, as soon as possible to implement the best way of subsidy. The object of subsidy should be strictly targeted at the real grower. In addition, the timing of subsidies will be announced before sowing, subsidies processes are in compliance with rules.

In addition to protection, improvements soybean processing are needed. To build a healthy and stable industry, progression from simple and primary processing to deep processing; To build a healthy and stable industry, the processed product line should be expanded to include not only soybean oil and meal but also tofu, soy milk and other high protein products; to improve the added value of products; and to invigorate the terminal brand. The government could offer credit, tax and other policy support to deep processing methods. Farmers will likely cooperate to implement precision planting and standardized production to reach the target market, supporting "one village one product"[17].

6.3. Continue Research and Development of both Transgenic and Non GM Soybeans

Increased financial investments in research and development of both GM and non GM soybeans are needed, with an emphasis on upgrading technologies for soybean breeding. In addition to continuing basic research, areas to emphasize in non GMO soybean research include: how to increase "high yield and high protein" and "high protein and high oil" varieties, working to improve yield per unit area, improve seed, with an emphasis on domestic soybeans. For example, in October 2015, the high protein soybean variety "East agriculture 42C", planted by farmers in “Red light “cooperative, MinHe village, Bin county, Heilongjiang Province and guided by Experts from the Northeast Agricultural University, reached a level of 498 kg per mu. It represented quite high yield in agricultural production, its comparative effectiveness had surpassed the corn, realizing the combination of high yield and high protein, is the current urgent need of soybean varieties. For GMO soybeans, in addition to continuing basic research, areas to emphasize include:

develop a functional gene with independent intellectual property rights, and improve methods for experimental planting. These efforts will help domestic soybeans remain competitive in an international market.

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