Measuring Research on County Agricultural Technological Innovation Ability Index

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Abstract Taking the mechanism of technological construction guidance theory and mode which consists of " objective-construction – evaluation-construction-objective" as a starting point, on the basis of county agricultural technological innovation ability and its index definition, this paper researches the constructing system of county agricultural technological innovation ability. Firstly, on the basis of defining county agricultural technological innovation ability and the definition of index, according to the principle of purposefulness, scientificity, systematicness, integration of dynamic state and static state, integration of quantitativeness and qualitativeness and so on, we construct the multi-level measuring system of county agricultural technological innovation ability, including 4 first-level indices, namely technological innovation environment, technological innovation basis, technological innovation ability, and technological innovation efficiency; 15 second-level indices, such as technological policy, technological system mechanism, technological institution construction, ability of innovation subject, ability of industrial expansion, scale merit, technological contribution rate. Moreover, this system has 45 third-level indices. Then, by using unascertained mathematics method and AHM method, we establish the multi-level unascertained composite measuring model of county agricultural technological innovation ability index. Finally, by using the survey data of one county in Hebei Province, and the established county agricultural technological innovation ability index model, we get the county agricultural technological innovation ability index of 0.711 by calculation, that is, the innovation ability is at the intermediate level, namely the modern agricultural substage. The empirical research proves the correctness and applicability of this model.

Key words County agriculture, Technological innovation ability, Index measuring, AHM, Unascertained mathematics, China

The county agricultural technological innovation ability is the core factor of promoting agricultural modernization construction. Taking the technological innovation as the core driving force of adjustment and optimization of county economic structure, and establishing perfect technological innovation system, have become the consensus of government at all levels and theoretical circle[1-4]. At present, the scholars and experts at home and abroad mainly focus on the macrocosmic researches on theoretical model of agricultural technological innovation, which are of significance of guidance. These researches play the role of guiding the agricultural technological construction. National Research Center for Science & Technology for Development advanced five-factor evaluation method[5]. But there is a shortage of researches with pertinency and operability on the county agricultural technological innovation ability, and it has not yet formed the systematic mechanism of technological construction guidance theory and modem which consists of " objective-construction – evaluation-construction-objective". Based on this, according to the innovation theory, coupled with the practicality of county agricultural technological innovation in Hebei Province, we construct the multi-level measuring index system of county agricultural technological innovation ability. By using unascertained mathematics method and AHM method, we calculate the county agricultural technological innovation ability index[6-7].

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1 Establishment of measuring index system of county agricultural technological innovation ability

1.1 The related definitions

1.1.1 County agricultural technological innovation ability. County agricultural technological innovation ability refers to the summation of taking elevating agricultural technological innovation ability, transforming development mode, and supporting modern agricultural construction as the main content and object; under the domination of the government, coordinating multiplex main body, such as scientific research management institutions, combination of production, teaching and research, enterprises and so on. The connotation of agricultural technological innovation ability is the general term of taking the innovation ability of innovation subject as core, innovating upon environment, innovating upon basis, and innovating upon efficiency. County agricultural technological innovation ability consists of technological innovation environment, technological innovation basis, technological innovation ability, technological innovation objective of efficiency and so on. These interrelated components mutually promote and restrict each other, forming a system.

1.1.2 County agricultural technological innovation ability index. County agricultural technological innovation ability index is the conclusion we get after we conduct holistic measuring and evaluation on all elements of county agricultural technological innovation ability by using method of weighting and mathematical modeling method. County agricultural technological innova-

tion ability index reflects the effect of construction of agricultural technological innovation ability, the stage it stays at, and the aspects which need to be strengthened, thus the county agricultural technological innovation ability index provides decision-making basis for strengthening construction of agricultural technological innovation ability. The county agricultural technological innovation ability index takes evaluation index system of technological innovation as orientation to strengthen agricultural technological construction. The agricultural technological construction is a systematic project, which should be implemented and carried out according to the components of construction of agricultural technological innovation ability and evaluation system of construction of agricultural technological innovation ability. In the mean time, we should conduct evaluation along with construction, verify the effect, adjust the focus and carry out the agricultural technological construction.

1.2 The principles of establishment

1.2.1 Purposefulness. The index system should objectively describe the essential characteristics, structure and components of county agricultural technological innovation ability, provide the service for the goal of measuring, and provide basis for the judgment of measuring results.

1.2.2 Scientificity. The index system should be aimed at the goal of measuring and evaluation, and scientifically reflect the county agricultural technological innovation ability and its characteristics. The concept of index should be correct and the signification of index should be clear. We should ensure that there is no strong correlation among the indices, so as to avoid the conspicuous inclusion relation, that is, we should weaken and eliminate as far as possible the hidden correlation when processing.

1.2.3 Systematicness. The index system should cover the relevant indices of county agricultural technological innovation ability, and comprehensively reflect all the elements and holistic condition of county agricultural technological innovation ability.

1.2.4 Integration of dynamic state and static state. The static index is to reflect the dominant innovation ability level of county agricultural technology, on the basis of the dominant indices; the dynamic index is to reflect the development trend and untapped potential of county agricultural technological innovation ability, on the basis of the variable recessive indices after implementing promotion measures of innovation ability.

1.2.5 Integration of quantitativeness and qualitativeness. Conducting statistical analysis and calculation on indices of county agricultural technological innovation ability, is a quantitative research, but the factors that impact county agricultural technological innovation ability may not be quantified, so we need to conduct qualitative research.

1.3 Establishment of measuring system According to the principle of purposefulness, scientificity, systematicness, integration of dynamic state and static state, integration of quantitativeness and qualitativeness and so on, we construct the multi-level measuring system of county agricultural technological innovation ability, including 4 first-level indices, namely technological innovation environment, technological innovation basis, technological innovation ability, and technological innovation efficiency; 15 second-level indices, such as technological policy, technological system mechanism, technological institution construction, ability of innovation subject, ability of industrial expansion, scale merit, technological contribution rate; 45 third-level indices. The specifics of index system can be shown in Table 1.

Table 1 County agricultural technological innovation ability construction evaluation index system

Objective	First-level index	Weight W_1	Second-level index	Weight W_2	Third-level index	Weight W_3
County agricultural technological innovation ability index	Technological innovation environment	0.152	Technological policy	0.303	Preferential policy	0.257
					Incentive policy	0.451
					Policy and regulation of risk guarantee	0.292
			Technological system mechanism	0.402	Establishment of institution	0.408
					Organization of personnel	0.346
					The mechanism of government dominating the market operation	0.246
			Technological innovation culture	0.295	Innovative idea	0.152
					Publicity of typical culture	0.142
					Technological yard	0.303
					Library	0.303
	Technological innovation basis	0.298	Technological institution construction	0.215	Scientific research stations	0.500
					production, teaching & research cooperative institution	0.500
			Technological team	0.325	Number of experts	0.404
					Number of personnel with associate professorship	0.313

Continued (Table 1)

Objective	First-level index	Weight W_1	Second-level index	Weight W_2	Third-level index	Weight W_3
					Professional personnel of popularization	0.283
			Technological equipment facility	0.227	Value of equipments and instruments	0.315
					Area of the laboratory	0.320
					Technological park bases	0.365
			Technological promotion basis	0.234	Mechanization rate	0.250
					Biological rate	0.250
					Informatization rate	0.250
					Automation rate	0.250
	Technological innovation ability	0.304	Ability of innovation main body	0.174	Main body of research and development	0.314
					Main body of enterprises	0.321
					Main body of farmers	0.365
			Technological input ability	0.303	R&D capital	0.423
					Input ability of intellect	0.302
					Input ability of resources	0.275
			Promotion support ability	0.285	Public welfare promotion program	0.467
					Scientific research results	0.305
					Patent	0.228
			Industrial expansion ability	0.239	Enterprise scale	0.421
					Input ability	0.341
					Market competitiveness	0.238
	Technological innovation efficiency	0.246	Industrial benefit	0.334	Total agricultural output value	0.500
					Rural income per capita	0.500
			Efficiency of structural adjustment	0.202	Decrease rate of the primary industry	0.333
					Growth rate of the secondary industry	0.333
					Growth rate of the tertiary industry	0.333
			Efficiency of promoting developmental mode	0.231	Growth rate of mechanization	0.250
					Biological growth rate	0.250
					Growth rate of informatization	0.250
					Growth rate of automation	0.250
			Technological contribution rate	0.234	Technological contribution rate	0.623
					Growth rate	0.377

1.4 Quantification of evaluation index As the index system of county agricultural technological innovation ability not only includes quantitative indices, but also includes qualitative indices. When conducting classification on the quantitative indices, we should at first determine the evaluation classification space, then use priori knowledge to determine the ideal object, and finally compare the original data and the value of ideal object, thus we complete the classification of evaluation index of county agricultural technological innovation ability according to certain bandwidth. The evaluation classification space in this paper is as follows: $V=(V_1, V_2, V_3, V_4, V_5)=$ (High, Sub-high, Intermediate, Primary, Initial). When conducting classification on the qualitative evaluation indices, we divide the evaluation classification space into five types according to different cases, and the experts mark the five types.

2 Establishment of measuring model

In this paper, by using unascertained comprehensive evaluation method, we establish the model of county agricultural technological innovation ability index. First we integrate all the branches of model, and then we integrate the measuring and evaluation of each factor into the measuring and evaluation of principal factor. Specifically, we use the method of AHM (Attribute Hierarchy Model) to establish the multi-level measuring system of county agricultural technological innovation ability.

Then we calculate the index weight, and adopt unascertained comprehensive evaluation method to calculate the index of county agricultural technological innovation ability.

2.1 Attribute Hierarchy Model and calculation of weight

2.1.1 Establish judgment matrix. When establishing multiple comparison judgment matrix, we use the 1 –9 graduating method advanced by Satty. Multiple comparison judgment matrix $A=(a_{ij})_{n\times n}$, where a_{ij} is the ratio of importance between scheme P_i and scheme P_j under the given object; $a_{ij}\geqslant 0$; $a_{ij}=1/a_{ij}(i, j=1, 2, \cdots, n)$.

2.1.2 Transform the multiple comparison judgment matrix into the multiple comparison measuring matrix. The formula of transforming the multiple comparison judgment matrix into the multiple comparison measuring matrix is as follows:

$$u_{ij}=\begin{cases} k/(k+1) & a_{ij}=1 \\ 0.5 & a_{ij}=1 \\ 0 & a_{ij} \\ 1/(k+1) & a_{ij}=1/k \end{cases}$$

μ_{ij} that is transformed from the above formula is the comparison measuring value. We call matrix μ as the multiple comparison measuring matrix.

2.1.3 Calculate weight. From the following formula:

$f_i=\sum_{j=1}^{n}u_{ij}(i=1, 2, \cdots, n)$, $w_i=f_i/[n(n-1)/2](i=1, 2, \cdots, n)$

By calculation, we get that weight vector $W^l=(w_1^l, w_2^l, \cdots, w_n^l)$, $(l=1, 2, 3)$.

2.2 Unascertained overall evaluation Unascertained comprehensive evaluation is a comprehensive decision – making method we create for certain purpose after taking into the impact of many factors into consideration under unascertained environment. Multi-level integration method is to first integrate each branch of the model, and then integrate the second-level evaluations into the evaluation on the first-level index. The specific method is as follows.

2.2.1 Component. Factor set: $X=(X_1, X_2, \cdots, X_m)$ is a index set which consists of measuring indices; Evaluation set: $V=(V_1, V_2, \cdots, V_n)$ is a evaluation set, and the evaluation is classified as five levels, namely high, sub-high, intermediate, primary and initial; Weight set: $W^l=(w_1^l, w_2^l, \cdots, w_n^l)$ is a weight set, and w_n^l is determined by using AHM.

2.2.2 Establish the evaluation matrix of single index of sample. This paper uses expert marking method to get the single index measuring evaluation matrix μ_{1jk}.

2.2.3 By the calculation of unascertained single index measuring evaluation matrix to get the comprehensive measuring model. The comprehensive measuring model is expressed as follows:

$B=W_1\cdot W_2\cdot W_3\cdot\mu_{1jk}=(b_1, b_2, \cdots, b_n)$.

2.2.4 Calculation of county agricultural technological innovation ability index. We assume that $F=(f_1, f_2, f_3, f_4, f_5)^T=(0.90, 0.80, 0.70, 0.60, 0.30)^T$ is the mark set, and f_i is the mark of level j evaluation. By using vector product, we calculate the final measuring and evaluation result. The index of county agricultural technological innovation ability is as follows:

$Z=B\cdot F$

2.3 Classification standard of county agricultural technological innovation ability construction evaluation index system According to the support role of agricultural science and technology innovation and the internal correlation between agricultural science and technology innovation and modern agricultural construction, the theory of modern agricultural construction can be divided into five stages. The comprehensive measuring and evaluation index of county agricultural technological innovation ability can be classified as 5 grades, namely high, sub-high, intermediate, primary and initial.

High: the index of county agricultural technological innovation ability is that $Z\in[0.9, 1]$, at stage of post-modern agriculture (the stage of intelligent agriculture); Sub-high: the index of county agricultural technological innovation ability is that $Z\in[0.8, 0.9)$, at stage of modern agriculture; Intermediate: the index of county agricultural technological innovation ability is that $Z\in[0.7, 0.8)$, at sub-stage of modern agriculture; Primary: the index of county agricultural technological innovation ability is that $Z\in[0.6, 0.7)$, at primary stage of modern agriculture; Initial: the index of county agricultural technological innovation ability is that $Z\in(0, 0.6)$, at initial stage of modern agriculture.

3 Empirical research

This paper uses the survey data of a county in Hebei Province, so as to conduct measuring and evaluation on the county agricultural technological innovation ability, and the specific steps are as follows.

(1) Determination of index weight. By using the method of AHM (Attribute Hierarchy Model), we conduct single factor judgment and evaluation on all indices, so as to get the weight coefficient of first-level index, second-level index and third-level index. The data are listed in Table 1.

(2) Establishment of unascertained relationship matrix. This research involves 45 second-level indices. In order to illustrate the problem, we select out 4 second-level indices and 11 third-level indices under first-level index of technological innovation basis, to study the process of quantification, which can be seen in Table 2.

(3) Set of unascertained evaluation. $V=(V_1, V_2, V_3, V_4, V_5)$ (High, Sub-high, Intermediate, Primary, Initial), Mark set $F=(f_1, f_2, f_3, f_4, f_5)^T$, where f_1, f_2, f_3, f_4 select the lower limit value under correspond level; f_5 selects medium value of the corresponding level interval.

(4) Analysis of results. By conducting unascertained calculation on the weight in Table 1, we get the index of county agricultural technological innovation ability that $B=W\cdot\mu_{1jk}=(0.286, 0.257, 0.257, 0.135, 0.076)$, thus $Z=B\cdot F=0.711$. Through referring to the evaluation standard, we know that the agricultural technological innovation ability of this county is at intermediate level, namely sub-stage of modern agriculture.

4 Conclusion

Taking the mechanism of technological construction guidance theory and mode which consists of "objective-construction-

Table 2 Unascertained evaluation matrix and weight

First-level W_1	Second-level index W_2	Third-level index W_3	Unascertained relationship matrix and weight					
			High	Sub-high	Intermediate	Primary	Initial	Weight of item
Technological innovation environment 0.152	Technological policy 0.303	Preferential policy 0.257	0.1	0.3	0.2	0.3	0.1	0.356
		Incentive policy 0.451	0	0.4	0.3	0.2	0.1	0.423
		Policy and regulation of risk guarantee 0.292	0.1	0.2	0.4	0.2	0.1	0.221
	Technological system mechanism 0.402	Establishment of institution 0.408	0.2	0.4	0.2	0.2	0	0.395
		Organization of personnel 0.346	0.1	0.3	0.3	0.2	0.1	0.369
		The mechanism of government dominating the market operation 0.246	0.1	0.3	0.2	0.3	0.1	0.236
	Technological innovation culture 0.295	Innovative idea 0.152	0	0.4	0.3	0.2	0.1	0.157
		Publicity of typical culture 0.142	0.1	0.2	0.4	0.2	0.1	0.228
		Technological yard 0.303	0.2	0.4	0.2	0.2	0	0.301
		Library 0.303	0.1	0.3	0.3	0.2	0.1	0.314

evaluation-construction-objective" as a starting point, on the basis of the concept of county agricultural technological innovation ability, this paper constructs the multi-level measuring system of county agricultural technological innovation ability, including 4 first-level indices, namely technological innovation environment, technological innovation basis, technological innovation ability, and technological innovation efficiency; 15 second-level indices, such as technological policy, technological system mechanism, technological institution construction, ability of innovation subject, ability of industrial expansion, scale merit, and technological contribution rate; 45 third-level indices. This paper also constructs the measuring model of county agricultural technological innovation ability. Based on these, we calculate out the index of county agricultural technological innovation ability of one county in Hebei Province. According to the measuring and evaluation result of the county agricultural technological innovation ability index of this county, by reverse calculation, we get the contribution rate of second-level indices to first-level indices, and the contribution rate of first-level indices to the index of county agricultural technological innovation ability. By referring to the actual standard, we can find the difference and better guide the future construction work. In practical application, in general, we should conduct one measuring and evaluation every year, conduct one general evaluation three to five years, summarize results, find out the shortcomings, and frame the construction program of technological ability, in order to promote county agricultural technological innovation ability and boost county agricultural technological innovation construction.

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