Research On Factors Influencing the Efficiency of Agricultural Science and Technology Innovation

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Abstract. To explore the key factors affecting the efficiency of agricultural science and technology innovation, this paper selects 10 indicators to build a system of agricultural science and technology innovation influencing factors from the perspectives of government, enterprises and agriculture-related subjects, and uses a combination of intuitionistic fuzzy and DEMATEL methods for empirical analysis. It is found that three indicators: R&D funding investment (X_6), government support (X_4) and R&D personnel full-time equivalent (X_3) are the fundamental factors affecting its development. Based on this, countermeasure suggestions such as strengthening the strength of science and technology funding, increasing the proportion of R&D funding, and increasing R&D personnel are proposed as a way to improve the efficiency of agricultural science and technology innovation.

Keywords: Agriculture; Science and Technology Innovation Efficiency; Influencing Factors; Intuitionistic Fuzzy; DEMATEL Model

1 INTRODUCTION

At present, China's agricultural development has changed from quantitative growth to qualitative growth, how to enhance its own development momentum and competitiveness, improve industrial efficiency, and promote benign development between industries has become the top priority of agricultural modernization. Science and technology innovation is an important booster to promote the transformation and upgrading of agriculture, optimization of industrial institutions and enhancement of endogenous power. Efficiency is an important factor affecting agricultural science and technology innovation, which is related to the operational effect and output level of science and technology innovation. Therefore, it is of great practical significance to deeply explore the factors influencing the efficiency of agricultural science and technology innovation and clarify the logical relationship between the elements to realize agricultural modernization and high-quality agricultural development.

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Scholars of studies related to agricultural science and technology innovation efficiency carried out an in-depth analysis.Guo Jingyu et al concluded that the quality of labor force, government support, the degree of market development, and the level of independent innovation of enterprises have a significant propulsive effect on agricultural science and technology innovation efficiency[1]. Based on DEA model, Li Yonghui et al empirically concluded that the total sown area of crops is the fundamental factor affecting the efficiency of resource allocation for agricultural science and technology innovation[2]. Deng Chanhui et al concluded that the uneven allocation of agricultural science and technology resources and the unsound results assessment system are the main factors affecting its development[3]. Based on the AHP-FCE model, Zhao Lianming concluded that insufficient scientific and technical personnel and inefficient inputs and outputs are the key factors limiting their development[4].

In summary, the research related to the efficiency of agricultural science and technology innovation has been fruitful, but the following deficiencies still exist: the vast majority of mathematicians start from the evaluation index system and adopt relevant models for evaluation, and the research on the influencing factors lacks in-depth exploration. Based on this, intuitionistic fuzzy theory and DEMATEL method are used to categorize the factors influencing the efficiency of agricultural science and technology innovation and determine the key factors affecting its development according to the size of centrality.

2 CONSTRUCTION OF A SYSTEM OF FACTORS INFLUENCING THE EFFICIENCY OF AGRICULTURAL SCIENCE AND TECHNOLOGY INNOVATION

The study of factors influencing the efficiency of agricultural science and technology innovation mainly draws on the research results of Xu Weixiang[5], Guo Jingyu[1], Zhang Lixiang[6], and others to construct a system of factors influencing the efficiency of agricultural science and technology innovation by selecting 10 indicators from the perspectives of the government, enterprises, and agricultural-related subjects (shown in Table 1). Among them, the strength of government support, reflecting the strength of government support for agricultural science and technology innovation. The innovation level of agriculture-related enterprises, reflecting the importance of enterprises to agricultural science and technology innovation. The quality of rural labor force, reflecting the degree of understanding and acceptance of agricultural science and technology innovation by agricultural-related subjects. And the two indicators of patent authorization and technology market turnover characterize the output results of agricultural science and technology innovation. Among them, the number of patents granted reflects the technical output of science and technology innovation, while the technology market turnover is a direct reflection of the economic benefits of science and technology innovation. The degree of regional openness reflects the degree of regional openness to the outside world, which affects the operational efficiency of science and technology innovation to a certain extent.

Table 1 System of factors influencing the efficiency of agricultural science and technology innovation

Explanatory variables	Reflected variables	Expected impact
Number of patents granted X_1	Technology introduction and absorption	+
Quality of rural labor force X_2	Average years of education of rural labor force	+
R&D personnel full time equivalent X_3	Science and technology personnel input	+
Government support X_4	Share of government funds in agricultural R&D expenditure	+
Technology Market Turnover X_5	Degree of development of technology market	+
R&D funding investment X_6	Science and technology investment status	+
Enterprise innovation level X_7	Share of R&D institutions in agricultural enterprises	+
Agricultural productivity development level X_8	Labor productivity, land productivity	+
Development level of rural economy X_9	Per capita net income in rural areas	+
Degree of regional openness X_{10}	Total foreign investment	+

3 STUDY MODEL DESCRIPTION AND CONSTRUCTION

DEMATEL, called decision making test and experimental evaluation method, mainly uses matrix calculations and graph theory concepts to describe the direct or indirect influence of each element with the rest of the elements in the constructed matrix data, and organizing the data leads to the ranking hierarchy of the elements in the system and the logical relationships between them[7].The specific steps are as follows.

Step 1: Digitize the information expressed by the indicators and construct a direct impact matrix.

Definition 2.1: Let $F = (f_1, f_2, f_3, \cdots, f_n)$ be the set of options, and the decision maker compares n options between two and constructs a judgment matrix $A = [a_{ij}]_{n\times n}$, $a_{ij} = (u_{ij}, v_{ij}, \pi_{ij}), i, j = 1,2,3, \cdots, n.$. Where, u_{ij}andv_{ij} denote the decision maker's degree of preference for options f_i and f_j, respectively. f_i and f_j when comparing them. π_{ij} denotes the degree of decision maker's hesitation for the two options, $\mu_{ij}, v_{ij} \in [0,1], \pi_{ij} = 1 - \mu_{ij} - v_{ij}$, at this time, the matrix A is called the intuitionistic fuzzy judgment matrix[8].

Definition 2.2: Assuming the existence of an intuitionistic fuzzy number $\alpha = (\mu_\alpha, v_\alpha)$ and $\pi_\alpha = 1 - \mu_\alpha - v_\alpha$ as its hesitation, the accuracy function is.

$$h^\eta(\alpha) = \frac{\mu_\alpha + v_\alpha}{1 - \eta\pi_\alpha} \quad (1)$$

It is assumed that a single expert gives a fuzzy evaluation of the study indexes according to their risk preferences, and a two-by-two comparison is made between the indexes. and then the set of score functions becomes an intuitive fuzzy preference decision that transforms the fuzzy numbers into real numbers. At this stage, in order to meet the data requirements of the initial matrix of DEMATEL, the value of the diagonal of the matrix is taken as 0, and then after normalized deformation, the direct influence matrix S based on fuzzy information is obtained as follows[8].

$$A\left[a_{ij}\right]_{n\times n}=\begin{bmatrix}(\mu_{11},v_{11},\pi_{11}) & (\mu_{12},v_{12},\pi_{12}) & \cdots & (\mu_{1n},v_{1n},\pi_{1n})\\ (\mu_{21},v_{21},\pi_{21}) & (\mu_{22},v_{22},\pi_{22}) & \cdots & (\mu_{2n},v_{2n},\pi_{2n})\\ \vdots & \vdots & \ddots & \vdots\\ (\mu_{n1},v_{n1},\pi_{n1}) & (\mu_{n2},v_{n2},\pi_{n2}) & \cdots & (\mu_{nn},v_{nn},\pi_{nn})\end{bmatrix}, \tag{2}$$

$$\xrightarrow{h^{\eta}(a_{ij})} H[h_{ij}]_{n\times n}=\begin{bmatrix}0 & h_{12} & \cdots & h_{1n}\\ h_{21} & 0 & \cdots & h_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ h_{n1} & h_{n2} & \cdots & 0\end{bmatrix}$$

Assuming that there are m experts in the expert team, denoted as $G=(g_1,g_2,g_3,\cdots,g_m)$, the evaluation of the experts needs to be synthesized, and each expert is given the corresponding weight λ_k , $\lambda=(\lambda_1,\lambda_2,\lambda_3,\cdots,\lambda_m)$ is the set of all decision experts $g_k(k=1,2,3,\cdots,m)$ weights, and the integrated intuitionistic fuzzy preference decision matrix of the decision results of the expert team is obtained as follows[9].

$$Y[y_{ij}]_{n\times n}=\sum_{k=1}^{m}\lambda_k H^{(k)}, \tag{3}$$

Where, $y_{ij}=\sum_{k=1}^{m}\lambda_k h_{ij}^{(k)}, i,j=1,2,3,\cdots,n$

Step 2: Specification of the direct impact matrix *N*.

$$N=\left(\frac{y_{ij}}{\max\limits_{1\le i\le n}\left(\sum_{j}^{n}s_{ij}\right)}\right)_{n\times n}, \tag{4}$$

Step 3: Calculate the integrated impact matrix *T*.

$$T=N(I-N)^{-1}, \tag{5}$$

where.

1) I is the unit matrix, i.e., the matrix with diagonal 1 and other values 0

2) $(I-N)^{-1}$ is the inverse matrix of $(I-N)$

3) $T=[t_{ij}]_{n\times n}$ in t_{ij} indicates the degree of direct or indirect influence of indicator j by indicator i.

Step 4: Calculate the four "degree" values of the indicators[9].

1)Influence degree

The degree of influence is the comprehensive influence matrix of the corresponding indicators of each row on the rest of the indicators of the comprehensive impact value, counted as D, then $D = (D_1, D_2, D_3, \cdots, D_n)$, where $D_i = \sum_{j=1}^{n} t_{ij}, (i = 1,2,3, \cdots, n)$.

2) Influenced degree

The influenced degree is the combined influence value of each column in the composite influence matrix on the rest of the indicators, which is calculated as C, then $C = (C_1, C_2, C_3, \cdots, C_n)$, where $C_i = \sum_{j=1}^{n} t_{ji}, (i = 1,2,3, \cdots, n)$.

3) Centrality

The centrality reflects the importance of the indicator in the overall indicator and is calculated as $M_i = D_i + C_i$.

4) Reason degree

The reason degree reflects the degree of influence of the indicator on the rest of the indicators in the overall index, and is calculated as $R_i = D_i - C_i$

Step 5: Identify the key elements affecting its development.

4 EMPIRICAL RESULTS AND ANALYSIS

The set of indicators $F = (F_1, F_2, F_3, \cdots, F_{15})$, let 5 experts compare them pair by pair. Because the language effectiveness of the experts is uncertain, the weights of the experts are equally distributed. Learning from Yang Shuaifei's method[10], the expert's language {very dissatisfied (0.05,0.95,0.00), dissatisfied (0.25,0.65,0.10), general (0.50,0.40,0.10), satisfied (0.75,0.15,0.10), very Satisfactory (0.95, 0.05, 0.00)} Perform data fuzzification processing to get the intuitive fuzzy number (Show in Table 2 and Table 3).

Table 2 Expert team bias towards indicators (1)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	0.00	0.25	0.50	0.05	0.50	0.95	0.50	0.75	0.75	0.50
X_2	0.75	0.00	0.95	0.50	0.75	0.95	0.75	0.95	0.5	0.75
X_3	0.50	0.05	0.00	0.05	0.50	0.95	0.25	0.5	0.25	0.50
X_4	0.95	0.50	0.95	0.00	0.95	0.95	0.95	0.95	0.50	0.75
X_5	0.50	0.25	0.50	0.05	0.00	0.95	0.50	0.75	0.25	0.50
X_6	0.05	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05
X_7	0.50	0.25	0.75	0.05	0.50	0.95	0.00	0.75	0.50	0.50
X_8	0.25	0.05	0.50	0.05	0.25	0.95	0.25	0.00	0.25	0.25
X_9	0.25	0.50	0.75	0.50	0.75	0.95	0.50	0.75	0.00	0.75
X_{10}	0.50	0.25	0.50	0.25	0.50	0.95	0.50	0.75	0.25	0.00

Table 3 Expert team bias towards indicators (2)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	0.00	0.65	0.40	0.95	0.40	0.05	0.40	0.15	0.15	0.40
X_2	0.15	0.00	0.05	0.40	0.15	0.05	0.15	0.05	0.40	0.15
X_3	0.40	0.95	0.00	0.95	0.40	0.05	0.65	0.40	0.65	0.40
X_4	0.05	0.40	0.05	0.00	0.05	0.05	0.05	0.05	0.40	0.15
X_5	0.40	0.65	0.40	0.95	0.00	0.05	0.40	0.15	0.65	0.40
X_6	0.95	0.95	0.95	0.95	0.95	0.00	0.95	0.95	0.95	0.95
X_7	0.40	0.65	0.15	0.95	0.40	0.05	0.00	0.15	0.40	0.4
X_8	0.65	0.05	0.40	0.95	0.65	0.05	0.65	0.00	0.65	0.65
X_9	0.65	0.40	0.15	0.40	0.15	0.05	0.40	0.15	0.00	0.15
X_{10}	0.40	0.65	0.40	0.65	0.40	0.05	0.40	0.15	0.65	0.00

Based on the calculation method of DEMATEL to find out the importance degree of each indicator, the centrality degree reflects the importance of the indicator in the overall indicators. From Figure 1, it can be seen that R&D funding (X_6) > government support (X_4) > R&D personnel full-time equivalent (X_3), and these three indicators are the key factors affecting its development. R&D funding is a key indicator to measure the status of science and technology innovation investment, and to a certain extent determines the operational effect of agricultural science and technology innovation efficiency. Government support shows the importance of government to science and technology innovation, which has a significant positive effect on the improvement of agricultural science and technology innovation efficiency[11]. R&D personnel is an important support element of agricultural science and technology innovation, which has a key role in product design, manufacturing, research and development, transformation and promotion activities. Therefore, these three indicators are the fundamental factors affecting its development. Patent authorization (X_1), enterprise innovation level (X_7) and technology market turnover (X_5) are important factors influencing their development. The independent innovation level of agriculture-related enterprises can influence the patent authorization volume and technology market turnover to a certain extent, and also has an obvious role in promoting the operational efficiency of science and technology innovation[12]. Four indicators, namely the level of rural economic development (X_9), the degree of regional openness (X_{10}), the level of agricultural productivity development (X_8) and the quality of rural labor force (X_2), are weak key factors influencing their development. The level of rural economic development has a significant impact on agricultural science and technology innovation, per capita disposable income is an important indicator to measure the level of economic development of a region, and the use of rural residents' disposable income can reflect the level of rural economy in the region[13]. Science and technology is the first productive force, the level of agricultural productivity needs to be driven by science and technology innovation, and agricultural technology innovation plays an important role in improving the level of agricultural productivity. Conversely, the improvement of the quality of rural labor force also has an important impact on the efficiency of agricultural technology innovation, which is enhanced by the improvement of agricultural productivity in many aspects such as mechanization level, labor productivity and land productivity. Total foreign investment reflects the degree of regional openness to the outside world and has a greater impact on the flow of agricultural science and technology innovation factors.

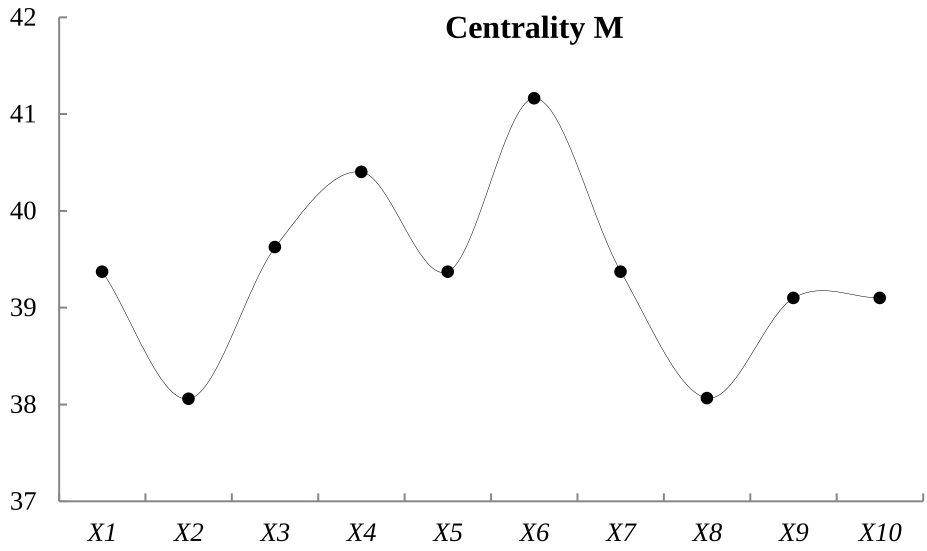

Figure 1 Efficiency centrality of agricultural science and technology innovation

5 RESEARCH FINDINGS AND SHORTCOMINGS

1.Research fingdings

This paper explores the factors influencing the efficiency of agricultural science and technology innovation based on the intuitionistic fuzzy DEMATEL model, and analyzes and ranks the degree of importance of each indicator. The conclusions obtained from this study are as follows: three indicators of R&D funding investment (X_6), government support (X_4) and R&D personnel full-time equivalent (X_3) are the fundamental factors influencing its development. The three indicators of patent and new variety application authorization (X1), the basic level of independent innovation of agriculture-related enterprises (X_7) and the turnover of technology market (X_5) are important factors influencing its development. In response to the findings of this study, the following countermeasures are proposed.

2.Suggestions for countermeasures

Strengthen the investment in science and technology resources to enhance the capacity of agricultural science and technology innovation. Strengthen the leading position of the government in agricultural science and technology innovation, and guide banks, insurance and other social entities to enter the agricultural field in the form of innovation funds and risk funds to broaden the source channels of resources and improve the resource allocation capacity. Do a good top-level design. Formulate strategic planning and R&D plans for agricultural science and technology innovation, condense major agricultural research projects, focus on supporting basic and forward-looking research with social and ecological benefits, and guarantee stable sources of funding for agricultural science and technology promotion[14].

Further increase the investment in science and technology innovation in terms of human, financial and material resources, focusing on increasing the proportion and ratio of agricultural R&D funding, scientific research personnel and science and technology funding, so that all indicators are maintained within a reasonable range, to enhance the capacity of agricultural science and technology innovation investment and thus enhance the efficiency of agricultural science and technology innovation. To guide the concentration of various innovation factors to enterprises, various agricultural research institutes and colleges and universities at all levels should increase the opening and sharing of agricultural science and technology resources, establish public platforms for technology research and development in cooperation between science enterprises and schools and enterprises, and better develop products and technologies needed by the market[15].

Promote the integration of "industry, academia, research and use", implement major projects of scientific and technological innovation, promote the transformation and application of major scientific and technological achievements, and improve the output capacity of agricultural science and technology innovation. At the same time, explore market-oriented transformation mechanisms to commercialize and market their achievements and promote the overlapping output of scientific and technological achievements. Build composite talents and promote the flow of achievements. On the one hand, introduce international and first-class scientific research teams, cultivate practical talents who are good at application and know how to manage, and build up a professional team with reasonable age stratum, perfect knowledge structure and strong R&D capability. On the other hand, we should increase the publicity of technical achievements, promote the cross-border flow of achievements, and promote the mutual sharing of achievements, thus enhancing the efficiency of agricultural output.

The model adopted in this paper still has shortcomings; the evaluation of indicators given by experts is similar to a certain extent, which leads to the ambiguity of grading data results (centrality) and cannot effectively distinguish the strong and weak relationships among indicators, thus the targeted opinions put forward have certain limitations.

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REFERENCES

[1] Guo Jing-Yu, Fan Fan. Research on the efficiency and influencing factors of agricultural science and technology innovation in Yangtze River Economic Belt[J]. Science Management Research,2020,38(03):126-131.

[2] Li YH, Bai LP. Research on the efficiency of agricultural science and technology innovation resource allocation and influencing factors in Yunnan Province[J]. China Agricultural Resources and Zoning,2019,40(06):63-69.

[3] Deng Chanhui,Ma Qiaoyun,Wei Lili. Research on regional differences in the efficiency of agricultural science and technology innovation in China and its influencing factors[J]. China Agricultural Resources and Zoning,2020,41(05):231-237.

[4] Zhao Lianming. Research on the efficiency of agricultural science and technology innovation resource allocation and its influencing factors in Chongqing[J]. China Agricultural Resources and Zoning,2018,39(07):92-98.
[5] Xu Weixiang,Wang Rui,Liu Chengjun,Xu Yan,Liu Xiaowen. Research on the spatio-temporal evolutionary characteristics of agricultural science and technology innovation in China and its influence mechanism[J]. China Science and Technology Forum,2021(08):108-119.
[6] Zhang L.M., Yu M.L., Wang X.H.. Measurement and comparative study of agricultural science and technology innovation efficiency[J]. Agricultural Technology Economics,2016(12):84-90.
[7] Baruah S, Raj S, Ray A, et al. Analysis of influencing factors for costs on substation siting based on DEMATEL method [J]. Procedia Engineering, 2012, 38: 2564-2571.
[8] Xu Z. Compatibility analysis of intuitionistic fuzzy preference relations in group decision making[J]. Group Decision and Negotiation, 2013, 22(3): 463-482.
[9] Li Mei. Research on intuitionistic fuzzy multi-attribute decision making method based on decision maker preference perspective[M] Beijing:Beijing University of Technology Press,2017.04
[10] Yang Shuaifei. Research on the selection of cross-border e-commerce logistics service providers [D]. Hangzhou University of Electronic Science and Technology, 2020.
[11] Wang Xiaojun, Sun Lixin, Wu Jingxue, Mao Shiping. The impact of innovation factor clustering on the synergistic development of agricultural science and technology in Beijing, Tianjin and Hebei[J]. Geographical Research and Development,2021,40(03):140-144+150.
[12] Ma Yanyan,Tai Yibo,Lv Jiaying. Evaluation of the efficiency of agricultural science and technology resources allocation in Ningxia based on DEA model[J]. Jiangsu Agricultural Science,2021,49(03):224-231.
[13] Wu Fan,Gao Qiang,Liu Tao. Agricultural science and technology innovation, spatial spillover and agro-ecological efficiency[J]. Statistics and Decision Making,2020,36(16):82-85.
[14] Zhao LJ,Zhang YX,Pan FH,Wang L. Research on the impact of science and technology human resources and capital on the efficiency of agricultural science and technology innovation[J]. East China Economic Management,2016,30(01):100-105.
[15] Huang Longjunjiang,Liu Lingyu,Xiao Hui,Liu Xiaojin. Agricultural science and technology innovation, agricultural technical efficiency and agricultural economic development-an empirical analysis based on vector autoregressive (VAR) model[J]. Science and Technology Management Research,2021,41(12):107-113.