Analysis of influencing factors for the realization of the ecological product value in national forest parks based on intuitionistic fuzzy DEMATEL-ISM

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Identifying the influencing factors and specific feasible paths for realizing the ecological product value of national forest parks, along with transforming the potential ecological value of ecological products into economic and social benefits, is a practical issue for achieving the transformation of "two mountains" and promoting common prosperity. In this paper, we take the Qianjiangyuan National Forest Park as the object of analysis, based on the theory of supply and demand; analyze the supply and demand mechanism for the realization of the ecological product value from three stages: supply, transformation, and demand; and summarize the influencing factors of the realization of the ecological product value in the national forest park. On this basis, we construct the intuitionistic fuzzy DEMATEL-ISM model and adopt the MICMAC method to clarify the hierarchical relationship and correlation among factors, and determine the key factors affecting the realization of the ecological product value in national forest parks. The results show that the top three factors of influence degree and centrality degree are technical support, definition of ecological resource property rights, and ecological industrialization, which have greater contribution and importance to the system. Among them, technical support is a key factor, and digital technology empowerment provides a power source for realizing the value of ecological products in national forest parks.

KEYWORDS

national forest park, ecological product, intuitionistic fuzzy DEMATEL-ISM model, influencing factors, MICMAC method

1 Introduction

Ecological products of national forest parks are a general term for providing various products and services that meet human needs through ecological regulation and human management, which are the carriers of forest resources (Xu et al., 2023; Dou et al., 2022). Excavating the ecological products of national forest parks and realizing them is of great significance to promote the coordination and unity of regional economy–society–ecology (Cheng and Li, 2023; Wang et al., 2023), which has attracted much attention from the academic community.

At present, the academic research on the realization of the ecological product value in national forest parks mainly includes the following: first, the connotation, realization path, and mode of the value of ecological products can be summarized into the industrialization mode, capitalization mode, and ecological compensation mode. For example, Xiong (2022), Hao et al. (2022), Du et al. (2023), Li et al. (2024), and other scholars started from the accounting mechanism of the value of ecological products and mainly put forward a variety of models covering the four aspects: ecological industrialization management, ecological resource trading, ecological compensation, and ecological restoration. Second, the factors affecting the realization of the value of ecological products and the identification model mainly include the supply and marketing process factors, input–output factors, property right system factors, and financial support policy factors. For example, Wang et al. (2022), Zhu et al. (2023), Li et al. (2023), Lin et al. (2023) and other scholars took the efficiency of ecological products as the objective function to explore the influencing factors on both ends of the supply and demand of ecological products, and argued that the design and improvement of the "government + market" trading system is the key to break the current dilemma of value transformation of ecological products. The above research on the connotation, realization path, and model of the realization of the ecological product value provides a key reference for the subsequent research; in particular, the analysis of the value transformation factors of ecological products from both ends of supply and demand is worthy of reference. Obviously, most of the existing studies on the factors affecting the realization of the ecological product value are based on regression models to verify the positive or negative mechanism of each factor on the transformation efficiency of the ecological product value, and few studies focus on the internal relationship between the factors, which needs further research and exploration. The DEMATEL-ISM model can achieve the purpose of clarifying important factors and their causality by mining and analyzing experts' knowledge and experience (Chen et al., 2022; Yu et al., 2023), which is a commonly used and effective method to explore the intrinsic relationship of factors. However, due to the large individual differences in experts, strong subjectivity would affect the accuracy of research results, and the process of realizing the value of ecological products is dynamic and ambiguous, and its influencing factors present uncertain characteristics (Singh and Bhanot, 2020; Wang et al., 2023). In order to overcome the defects of the traditional DEMATEL-ISM model and combine the uncertain characteristics of the factors affecting the realization of the ecological product value, an intuitionistic fuzzy method is proposed to fuzzy the expert rating results so as to improve the effectiveness and practicability of the model.

In view of this, based on the theory of supply and demand, in this paper, we analyze the supply and demand mechanism of the realization of the ecological product value from the three stages: supply, transformation, and demand; summarize the influencing factors; and then construct an intuitionistic fuzzy DEMATEL-ISM model to clarify the hierarchical relationship and correlation among factors, determining the key factors affecting the realization of the ecological product value in national forest parks. Therefore, the structure of this paper is arranged as follows: Section 2: the realization mechanism of the ecological product value in national forest parks and identification of influencing factors, including

realization mechanism analysis and index system construction; Section 3: the construction of the intuitionistic fuzzy DEMATEL-ISM model, including DEMATEL-ISM model and DEMATEL-ISM model improvement; Section 4: result analysis, including direct fuzzy evaluation, influence factor analysis based on improved DEMATEL-ISM, and verification based on MICMAC analysis; and Section 5: research conclusions and recommendations.

The possible marginal contributions of this paper are as follows: (1) based on the supply and demand logic of realizing the value of ecological products in national forest parks, the index system of influencing factors is identified and constructed, which can provide a basic reference for subsequent research; (2) we put forward the method for improving the DEMATEL-ISM model by using intuitionistic fuzzy information and applied it to the value management of ecological products in national forest parks to expand its application scope.

2 Realization mechanism of the ecological product value in national forest parks and identification of influencing factors

2.1 Realization mechanism analysis

Ecological products are the comprehensive products of material and spirit, function and pleasure, and culture and economy (Liu et al., 2024; Liu and Cui, 2024), and the value of production products includes multidimensional values such as economy, social and culture, and ecological services. Ecological service values and social and cultural values belong to the nonmarket value in the traditional concept, and the realization of these two types of value still lacks a perfect transformation mechanism; that is, the two ends of supply and demand cannot achieve effective matching through market transactions, and external forces are needed to promote the efficient transformation of the value. Practice and research have shown that the "government + market" trading mechanism can effectively realize the internalization of the positive externalities of the ecological product value, thus promoting the transformation of the ecological product value from the natural ecosystem to the social and economic system (Adhikari and Baral, 2018; Qin et al., 2022). The essence of realizing the value of ecological products in national forest parks is regarded as the whole process of "supply of natural ecosystem–transformation–demand of social and economic system" (Yang and Li, 2023). Therefore, the mechanism for realizing the value of ecological products in national forest parks is shown in Figure 1.

As shown in Figure 1, the supply side of ecological products in national forest parks is mainly composed of natural ecosystems, owners of ecological resources (local residents, village collectives, *etc.*), operators, and government management departments (Ma and Liu, 2023). Government departments need to ensure the sustainable and efficient supply of ecological resources. The owners of ecological resources always expect to get higher ecological benefits. Ecological operators not only expect to earn super profits but also want to be able to control costs so as to achieve high-quality operations. The demand side of ecological products in national forest parks is mainly

FIGURE 1
Realization mechanism of the ecological product value in national forest parks.
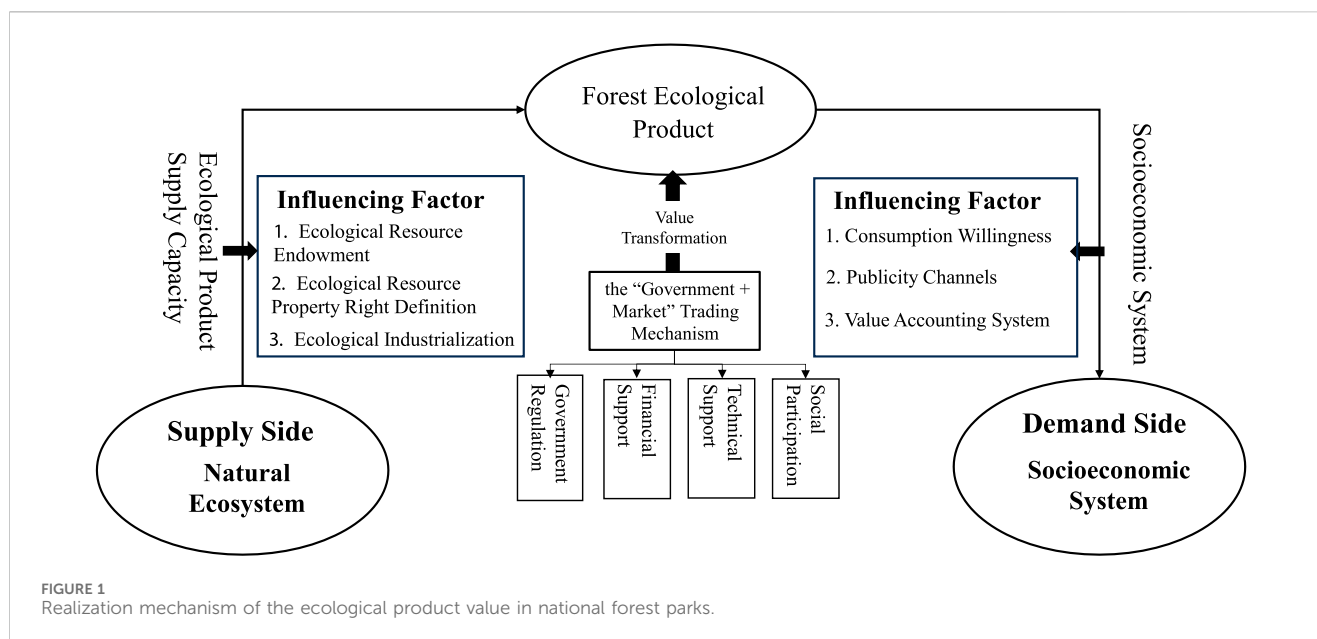
composed of natural ecosystems and social public and ecological product market developers. The natural ecosystem is not only the core supplier of ecological products but also an important demand side. Part of the cash flow generated by industrial operations often flows into ecological construction, protection, and restoration in the form of ecological feedback, making the natural ecosystem the ultimate beneficiary. Through the consumption of ecological products, the public directly or indirectly supports the ecological product industry, enhances the overall benefits of the industry, and drives more social capital to be invested in the ecological product industry, forming a virtuous circle. Ecological product market operators obtain the management and use rights of ecological assets through government–enterprise cooperation, franchise, and other means, and carry out ecological product development, ecological asset management, and ecological capital operation, especially to build ecological product brands, which can effectively realize the continuous cycle of ecological capital and value-added preservation and enhancement (Xie et al., 2017). Obviously, in the process of matching the supply and demand of ecological products, the government, enterprises, financial institutions, and the public need to participate together and actively invest in technology, capital, manpower, and other factors to jointly support the transformation of ecological resources into ecological capital.

2.2 Identification of influencing factors

2.2.1 Identification of supply factors

In the process of internalization of the positive externalities of the ecological product value in national forest parks, the supply side is characterized by the fact that the cost paid by producers is adequately compensated so as to continuously provide ecological products to the consumer market and finally achieve the Pareto optimal state (Adhikari and Baral, 2018; Xu et al., 2022). Therefore, the factors that can be identified on the supply side are as follows:

①The sustainability of the ecosystem is the source of the supply of ecological products. The difference in ecological resource endowment conditions of national forest parks determines their potential economic value. ②Clear property rights are the premise for the supply of ecological products. If the property rights of some ecological resources are not clear or the property right transaction is not standardized, it would directly affect the ecological assets to participate in the property right transfer and other business activities, resulting in the inability to monetize ecological products. ③Through the rational input of other production factors, followed by scale production, distribution, exchange, and other links, forest ecological industrialization can be developed, thereby improving the transformation efficiency of the ecological product value in national forest parks (Yang et al., 2021). Therefore, the main influencing factors that can be identified on the supply side of the natural ecosystem of national forest parks are the ecological resource endowment of national forest parks, the definition of forest natural resource property rights, and the forest ecological industrialization operation.

2.2.2 Identification of demand factors

On the demand side, it is characterized by the fact that the needs of society or consumption are continuously satisfied in the ecological management market of national forest parks, and the value-added space of ecological management is continuously increased (Qin et al., 2022; Liu et al., 2024). ①Consumers' willingness to pay can improve the marketization efficiency of ecological products in national forest parks. Only when the consumer's willingness to pay is greater than the price of the product, the consumer would make a purchase decision. ②Scientific and unified accounting of the ecological product value is the driving force for product commercialization and provides an effective price signal to the market, so the government needs to develop a scientific and reasonable accounting mechanism for the ecological product value. ③The promotion of ecological products is the key to brand formation and market competitiveness. Broadening

publicity channels can cover a wider range of consumer groups and improve the availability of ecological products in national forest parks (Huang et al., 2022). Therefore, the main influencing factors that can be identified on the demand side of the social and economic system of national forest parks are consumers' willingness, accounting of the ecological product value of national forest parks, and brand building and publicity.

2.2.3 Identification of transformation factors

In the process of transformation, the realization of the ecological product value in national forest parks is characterized by government regulation, financial leverage, technical support, and social participation to gather all resources and jointly promote the transformation of ecological resources into ecological capital (Song and Du, 2024; Zeng et al., 2023). ①From the perspective of the government regulation path, ecological products of national forest parks belong to public goods and have the characteristics of non-applicability and non-exclusivity. In order to reduce the "free rider" behavior, the government's macro-control and guidance can solve the externality problem to a certain extent. On the one hand, the government establishes and improves the ecological protection compensation mechanism, which can continuously improve the value transformation ability of ecological products so that the value realization is transformed from passive "blood transfusion" to "blood creation." On the other hand, the government adopts incentives and regulatory guarantee mechanisms; improves the property right system through tax preference, subsidies, and other means; balances the interests of all parties; and ensures the sustained supply of ecological products in national forest parks (Yang et al., 2021). ②From the perspective of the financial support path, the realization process of ecological products in national forest parks involves multiple links, such as resource protection, resource development, and market operation, and requires a lot of financial support to promote the flow, preservation, and appreciation of ecological resource assets. Financial institutions securitize ecological assets through innovative financing tools and other ways to expand the supply of funds for realizing the value of ecological products (Ali et al., 2025).③From the perspective of the technical support path, the rapid development of digital technology promotes data sharing and information flow among multiple departments and regions, and promotes the digitalization of ecological product monitoring, accounting, and transaction (Wu G, 2022). ④ From the perspective of the social participation path, the difference and complementarity in the needs of social stakeholders in terms of resource endowment and other aspects can directly affect the costs and shared benefits borne by all parties in the realization of ecological products (Gao et al., 2022). Therefore, the realization of the ecological product value of national forest parks is affected by four factors: government regulation, financial support, technical support, and social participation.

2.3 Index system construction

Combining the existing literature and qualitative analysis of the mechanism and influencing factors for realizing the value of ecological products in national forest parks, in this paper, we conclude that the realization of the ecological product value mainly includes three aspects: the ecosystem supply capacity, the social demand level, and the means of value transformation, and

summarize 10 influencing factors based on the whole process of "supply-transformation-demand," which finally form the influencing factors and indicator system of the realization of the ecological product value in national forest parks.

3 Construction of the intuitionistic fuzzy DEMATEL-ISM model

3.1 DEMATEL-ISM model

DEMATEL is widely used to reveal multifactor causal relationships due to its simple operation and convenient calculation. Due to its limited ability to explain the hierarchical relationships, it is often used in combination with the ISM model, which can determine the hierarchical structure and the degree of influence between the factors, and can help decision-makers understand the internal structure of the complex system more clearly and find out the critical factors and critical paths so as to better formulate the decision-making and management strategies. In addition, in order to verify the reliability of the model, the MICMAC analysis is usually adopted to carry out the model verification. The key steps of the DEMATEL-ISM model and its verification are as follows:

Step 1: construct the direct impact matrix A for the factors affecting the realization of the ecological product value in national forest parks and normalize the matrix A to get the standardized direct impact matrix D. The calculation formula is shown in Equation 1:

$$D = A \Big/ \max \sum\nolimits_{j=1}^{10} a_{ij}, i, j = 1, 2, \cdots, 10, \qquad (1)$$

where a_{ij} is the direct impact degree of the influencing factor i on the influencing factor j in the factors affecting the realization of the ecological product value in national forest parks.

Step 2: construct the comprehensive impact matrix T for the influencing factors of the realization of the ecological product value in national forest parks. The calculation formula is shown in Equation 2:

$$T = \left(t_{ij}\right)_{10\times10} = D\left(I - D\right)^{-1}. \qquad (2)$$

In Equation (2), I is the identity matrix.

Step 3: calculate the influence degree R, influenced degree C, centrality degree M, and causality degree N of the factors affecting the realization of the ecological product value in national forest parks.

$$\begin{cases} R = (r_i)_{10\times1} = \left(\sum_{j=1}^{10} t_{ij}\right)_{10\times1} \\ C = (r_j)_{1\times10} = \left(\sum_{i=1}^{10} t_{ij}\right)_{1\times10.} \\ M = R + C \\ N = R - C \end{cases} \qquad (3)$$

In Equation (3), when N is a positive number, it indicates that the corresponding indicator is a causal factor for the realization of the ecological product value in national forest parks, and *vice versa*, and it is a resultant factor.

Step 4: according to the calculation results of Step 3, further calculate the accessibility matrix of the factors affecting the realization of the value of ecological products in national forest parks. First, construct the overall impact matrix Q, and then, refer to the method in the literature (Wu, 2022) to calculate the accessibility matrix K.

$$\begin{cases} Q = T + I \\ \alpha = \mu + \sigma \end{cases}.\tag{4}$$

In Equation (4), α is the threshold (set to 0.4) with small impact that excludes Q, μ and σ are the mean and variance of T, respectively. When $q_{ij} > \alpha$ in Q, $k_{ij} = 1$; otherwise, $k_{ij} = 0$, thus forming the accessibility matrix K.

Step 5: decompose the accessibility matrix to obtain the reachable set, the antecedent set, and the common set, and then, analyze the structural relationship and the transmission path between levels of the factors affecting the realization of the ecological product value in national forest parks. The specific analysis process of influencing factors can refer to the steps shown in the literature (Gao et al., 2022).

Step 6: adopt MICMAC analysis to verify the results of the DEMATEL-ISM model.

3.2 DEMATEL-ISM model improvement

DEMATEL decision-making has the drawback of relying too much on expert experience. Therefore, combined with the fuzziness and uncertainty characteristics of the factors influencing the value of ecological products in national forest parks, the intuitive fuzzy DEMATEL decision-making method is proposed to make full use of the concepts of membership degree, non-membership degree, and hesitation degree to depict uncertain information (Deng et al., 2015). The details are as follows:

Suppose there is an intuitionistic fuzzy number $\alpha = (u_\alpha, v_\alpha)$, $u_{ij}, v_{ij} \in (0, 1)$, u_α is the membership degree of element x belonging to A in the domain X, v_α is the non-membership degree of element x belonging to A in the domain X, the hesitation degree is $\pi_{ij} = 1 - u_{ij} - v_{ij}$.

According to the calculation requirements of the DEMATEL initial matrix, the diagonal value of the matrix is first set to 0, and after standardized deformation as shown in Equation (5), the direct impact matrix H based on intuitionistic fuzzy information can be obtained.

$$H = (h_{ij})_{n \times n} = \begin{bmatrix} 0 & h_{12} & \cdots & h_{1n} \\ h_{21} & 0 & \cdots & h_{2n} \\ \vdots & \vdots & & \vdots \\ h_{n1} & h_{n2} & \cdots & 0 \end{bmatrix}.\tag{5}$$

In Equation (5), h_{ij} represents the degree of influence of factor S_i on factor S_j in realizing the value of ecological products in national forest parks.

Suppose that an expert gives a fuzzy evaluation of the indicators shown in Table 1, based on personal risk preference and scores, and assigns the relevant influence strength to each factor; then, the expert integrates the score function into an intuitive fuzzy preference decision, converting fuzzy numbers into real numbers, and constructs the direct impact matrix H, $H = [h_{ij}]_{10 \times 10}$, for the factors influencing the value realization of ecological products in national forest parks, as shown in Table 2. The remaining steps are calculated according to steps 2–6, and the hierarchical structure and multilevel hierarchical structure model diagram of influencing factors of realization of the ecological product value in national forest parks can be obtained, and finally, MICMAC analysis and test can be carried out. The relationship between the precision value and intuitionistic fuzzy number is shown in Table 2.

4 Result analysis

4.1 Direct fuzzy evaluation

Based on the expert evaluation data, the direct impact matrix H, $H = [h_{ij}]_{10 \times 10}$, of the factors influencing the realization of ecological product value in national forest parks can be calculated, as shown in Table 3:

4.2 Influence factor analysis based on improved DEMATEL-ISM

According to the DEMATEL method, the influence degree, the influenced degree, the centrality degree, and the causality degree of the factors affecting the realization of the ecological product value in national forest parks are calculated, and the results are shown in Table 4.

4.2.1 Centrality degree analysis

Centrality degree can describe the importance, contribution degree, and correlation with other factors in realizing the value of ecological products in national forest parks. The centrality degree distribution diagram of the DEMATEL model is shown in Figure 2.

As shown in Figure 2, the top three influencing factors of the centrality degree rank are technical support (S_6), ecological resource property right definition (S_2), and ecological industrialization (S_3). Influence degree and influenced degree are the values for measuring the correlation between the factor and other factors. The top three factors of influence degree are technical support (S_6), ecological industrialization (S_3), and the publicity channel (S_9). Among them, the influence degree of social participation (S_7) has little difference with the influenced degree. Although technical support (S_6) ranks the first in centrality degree, it has a higher degree of influenced degree and is more susceptible to the influence and interference of other factors because digital technology is applied in all links of "production–distribution–circulation–consumption" of ecological products in national forest parks to realize data management, monitoring, and traceability of the whole process of ecological products. Compared with other factors, the influence degree of the publicity channel (S_9) is significantly greater than that of the influenced degree, and the influenced degree ranks seventh, indicating that it is more necessary for the government to strengthen the publicity and promotion of

TABLE 1 Influencing factors and indicator system for the realization of ecological product value in national forest parks.

Phase	Factor number	Influencing factor indicator	Meaning of indicator
Supply side	S_1	Ecological resource endowment	Advantages of ecological resources, whether sustainable development is possible
	S_2	Ecological resource property right definition	Whether the property rights of ecological resources are clear and whether the property right transactions are standardized
	S_3	Ecological industrialization	Fully tap other resources to improve product prices and returns
Value transformation (supply and demand transformation)	S_4	Government regulation	Whether the ecological compensation mechanism and tax subsidy incentive system are sound
	S_5	Financial support	Degree of capital investment and the efficiency of capital use
	S_6	Technical support	Building of the digital information-sharing platform
	S_7	Social participation	Level of stakeholder involvement
Demand side	S_8	Consumption willingness	Purchase intention of ecological products of national forest parks
	S_9	Publicity channels	Availability of products
	S_{10}	Value accounting system	Whether the value accounting of ecological products in national forest parks is scientific and standardized

TABLE 2 Comparison of impact levels and expert scores.

Precision value	Degree of influence between factors	Intuitive fuzzy number score
1	No direct influence	(0.05,0.95,0)
2	Low direct influence	(0.25,0.65,0.10)
3	Medium direct influence	(0.50,0.40,0.10)
4	High direct influence	(0.75,0.15,0.10)
5	Very high direct influence	(0.95,0.05,0)

TABLE 3 Direct impact matrix of factors influencing the realization of ecological product value in national forest parks.

| Indicator	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
S_1	0	0	0.15	0.40	0.15	0.40	0.40	0.40	0.15	0.15
S_2	0	0	0.40	0.40	0.40	0.65	0.40	0	0	0.05
S_3	0.15	0.40	0	0.40	0.15	0.40	0.15	0.65	0.40	0.40
S_4	0.40	0.40	0.15	0	0.15	0.40	0.05	0.05	0.40	0.05
S_5	0	0.65	0.15	0.15	0	0.40	0.15	0.40	0.40	0.65
S_6	0.40	0.15	0.65	0.40	0.40	0	0.15	0.65	0.40	0.15
S_7	0.65	0.65	0.40	0.15	0.15	0.15	0	0.05	0.05	0.05
S_8	0.65	0.65	0.15	0.05	0.40	0.05	0.15	0	0.05	0.65
S_9	0.40	0.65	0.15	0.65	0.15	0.40	0.65	0.15	0	0
S_{10}	0.40	0.05	0.40	0.05	0.40	0.40	0.15	0	0.40	0

ecological products from national forest parks through the Internet e-commerce platform and to leverage more convenient channel advantages so as to enhance consumers' brand awareness and trust.

4.2.2 Causality degree analysis

The causality degree can describe the attribution of whether the factors influencing the realization of the ecological product value in the national forest parks are cause or result factors. Among

TABLE 4 Centrality and causality degrees of factors influencing the realization of ecological product value in national forest parks.

Factor number	r_i	c_j	M_i	M_i Sort	N_i	N_i Sort	Factor attribute
S_1	3.1705	4.1709	7.3414	6	−1.004	9	Result factor
S_2	3.4539	4.8640	8.3179	2	−1.4101	10	Result factor
S_3	4.4205	3.8365	8.2569	3	0.5840	3	Cause factor
S_4	3.0417	3.9109	6.9526	8	−0.8692	8	Result factor
S_5	4.2429	3.4480	7.6909	4	0.7949	2	Cause factor
S_6	4.8178	4.6931	9.5109	1	0.1247	6	Cause factor
S_7	3.2146	3.2626	6.4772	9	−0.0481	7	Result factor
S_8	3.8155	3.5174	7.3329	7	0.2982	5	Cause factor
S_9	4.3519	3.2183	7.5701	5	1.1336	1	Cause factor
S_{10}	3.4204	3.0279	6.4483	10	0.3925	4	Cause factor

FIGURE 2
Centrality degree and causality degree distribution chart.
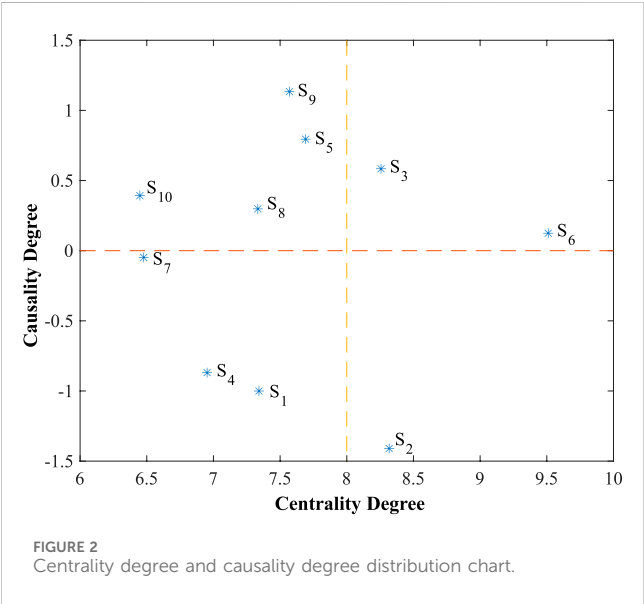
the cause factors, technical support (S_6) ranks the first in influence degree. This kind of cause index has a large indirect impact on the result indicator and has a strong promoting effect. Technical support provides new momentum for the realization of the ecological product value in national forest parks, and digital technology enables the four links of "production–distribution–circulation–consumption." First, digital productivity develops the ecological resources of national forest parks in a sustainable way and promotes the industrial management of forest ecology. Second, the digital circulation force and digital distribution force expand the traditional publicity channels, and automatically realize the accurate matching of supply and demand of ecological products in national forest parks. Third, digital consumption power promotes consumption transformation and upgrading, which is conducive to building regional public brands of ecological products in national forest parks. The ecological resource endowment (S_1) and ecological resource property right definition (S_2) are ranked lower in the causality degree of the result

indicators, and due to the larger absolute value of the causality degree of the result indicators, they are more likely to change. Relying on the advantages of the geographical location characteristics of ecological resources in national forest parks, it is possible to accurately find out the quantity and quality of ecological products in national forest parks and clarify the property rights boundary of each subject, which can improve the transformation of ecological advantages of forests into economic advantages.

4.2.3 Analysis of influencing factors based on ISM

According to Step 5, a multilevel hierarchical structure model of the factors influencing the realization of the ecological product value in national forest parks can be obtained, as shown in Figure 3.

As shown in Figure 3, financial support (S_5) and publicity channels (S_9) located at L3 are the deep factors. Among them, the financial input is the endogenous driving force of market operation, encouraging financial institutions to strengthen the development of green financial products, fully leveraging the role of social capital in optimizing industrial structure, extending industrial chain, and realizing the capitalization of forest resource assets. The two main functions are transferred to technical support (S_6): ecological resource property right definition (S_2) and government regulation (S_4), thus affecting the whole system. The ecological resource property right definition (S_2), ecological industrialization (S_3), technical support (S_6), and consumption willingness (S_8) located in L2 are supporting factors. It is not only affected by deep factors but also closely related to the upper index ecological resource endowment (S_1) and government regulation (S_4). Among them, technical support (S_6) is a key factor, and digital technology provides a power source for realizing the value of ecological products in national forest parks. Through the joint cooperation services for production and marketing, the information between the production and consumption ends is unimpeded, which not only expands the market supply of ecological products in national forest parks but also improves the economies of scale of ecological products in national forest parks. Ecological resource endowment (S_1), government regulation (S_4), social participation (S_7), and value accounting system (S_{10}) located in L1 are surface factors, which
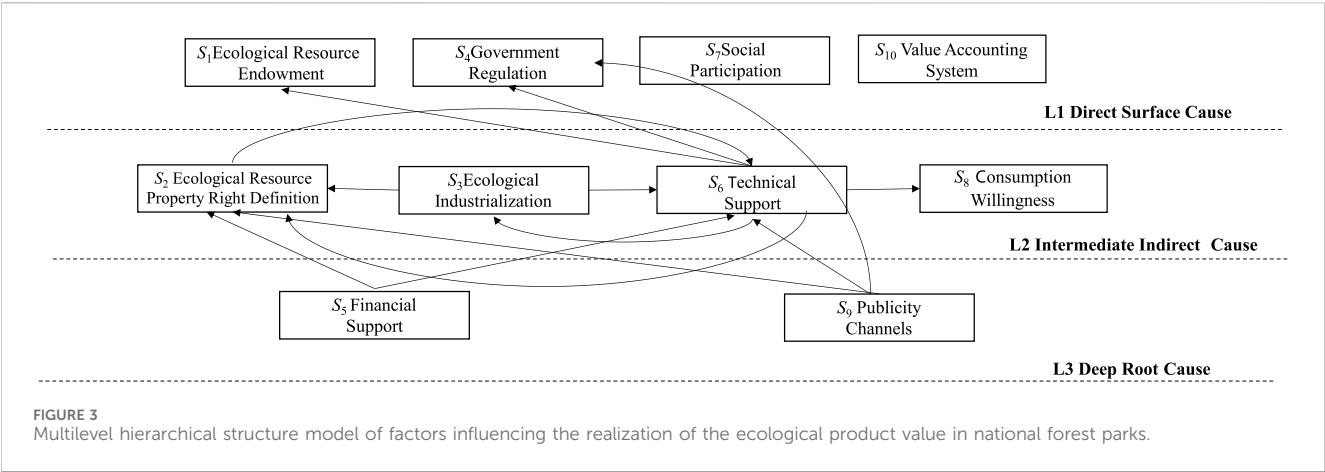
FIGURE 3
Multilevel hierarchical structure model of factors influencing the realization of the ecological product value in national forest parks.

TABLE 5 Calculation results of driving force and dependency.

Indicator	Driving force	Dependence	Indicator	Driving force	Dependence
S_1	1	7	S_6	6	6
S_2	6	6	S_7	1	1
S_3	6	6	S_8	6	6
S_4	1	7	S_9	7	1
S_5	7	1	S_{10}	1	1

directly affect the realization of the value of ecological products in national forest parks. Among them, government regulation has a cross-layer influence relationship, through policy support, tax incentives, financial subsidies, and other ways, to strengthen the institutional supply and guarantee ecological products in national forest parks, and further promote the industrial management of forest ecology.

4.3 Verification based on MICMAC analysis

By summing the rows and columns of the accessibility matrix, the cross-influence matrix multiplication method can calculate the driving force and dependence of the influencing factors, and then clarify the correlation and categorization relationship between the influencing factors, which are classified into four attributes: dependent factors, associated factors, autonomous factors, and independent factors. The calculation results of driving force and dependence are shown in Table 5 and Figure 4.

As shown in Table 5, ecological resource endowment (S_1) and government regulation (S_4) are dependent factors, which have the characteristics of high dependence and low driving force, and are easily affected by other factors, so they can be driven by the enhancement of other factors. The property right definition (S_2), ecological industrialization (S_3), technical support (S_6), and consumption willingness (S_8) are autonomous factors, which play a transitional role in the system due to their balanced dependence on driving forces. Financial support (S_5) and publicity channel (S_9) are independent factors, and the high driving characteristics are not

affected by other factors, indicating that such factors affect other factors through intermediary utility, which is the deep reason to promote the realization of the ecological product value in national forest parks. Finally, by comparing Figure 4, it is found that MICMAC analysis results are consistent with DEMATEL-ISM model results, which further demonstrates the accuracy of this model.

5 Research conclusions and recommendations

5.1 Research conclusions

Based on the supply and demand logic of realizing the value of ecological products in national forest parks, in this paper, we construct the index system of influencing factors and use the intuitionistic fuzzy DEMATEL-ISM method to establish an analysis model to elaborate the importance of each influencing factor and the causal relationship and hierarchical structure among the factors. The research conclusions are as follows:

(1) The top three factors in influence degree and centrality degree are technical support, ecological resource property right definition, and ecological industrialization, which show greater contribution and importance to the system; however, the ecological resource property right definition is a result factor. Other factors indirectly affect the realization of the value of ecological products in national forest parks by
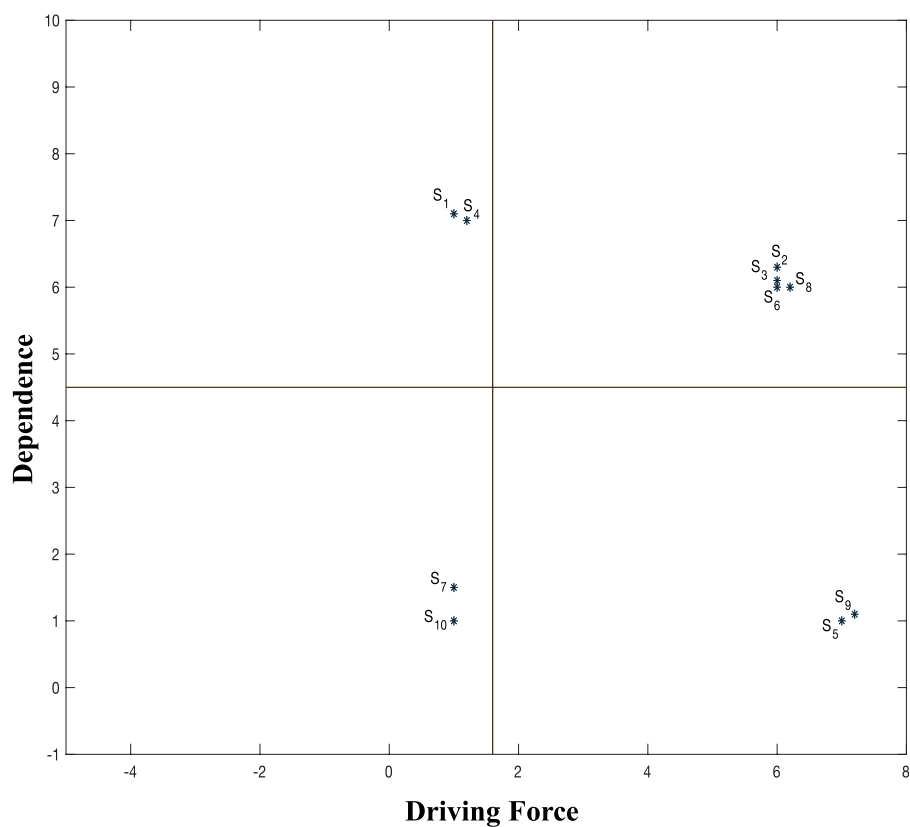
FIGURE 4
MICMAC analysis result chart.

influencing them, so they are not important factors. The comprehensive results show that the key factor of realizing the value of ecological products in national forest parks is technical support, which has a strong promoting effect.

(2) The multilevel hierarchical structure of factors affecting the realization of the ecological product value in national forest parks is three level, in which financial support and publicity channels are the root factors and should be continuously improved as the basic work. The ecological resource property right definition, ecological industrialization, technical support, and consumption intention are the supporting factors, which play the connecting role in the system. The remaining factors are surface factors that have a direct impact on value realization in the short term.

5.2 Recommendations

As the key influencing factor with the highest degree of centrality degree, technical support can be considered to promote its development through the improvement of other factor indicators because of its large influence. Based on this, in this paper, we put forward the following suggestions on how digital technology can realize the value of ecological products in national forest parks.

(1) Establish a digital system for dynamic monitoring of ecological products in national forest parks and do a good

job in digital accounting of the value of ecological products in national forest parks. Relying on advanced investigation and monitoring technology, accurately find out the quantity and quality of various types of ecological products in national forest parks, clarify the ownership, clearly define the property rights, and then realize ecological protection, restoration, and comprehensive management. At the same time, promote the standardization and scientization of the GEP accounting system. Use the GEP automatic accounting platform to improve accounting efficiency and accuracy, and to promote the inclusion of GEP accounting results in performance assessment, government policy regulation, operation, and development financing so as to ensure the supply of ecological products in national forest parks.

(2) Use digital technology to strengthen long-term loan support for the main body of ecological product management and development in national forest parks. Strengthen financial policy support and innovate financing and lending models for ecological rights and interests. Taking the accounting value of ecological asset interests and potential cash returns from ecological industry operations as the underlying assets, issue digital financial products and services such as ecological bonds and ecological damage insurance. Through digital platforms that connect the financial market and the capital market, introduce social capital, increase the enthusiasm of stakeholders such as the government, enterprises, and the public and then innovate

the multi-subject and market-oriented value realization mechanism of national forest park ecological products.

(3) Strengthen the construction of a multidirectional digital talent system. In the process of realizing the value of ecological products of national forest parks, professional talents who know how to apply and practice technology are needed. On the one hand, forest farmers at the production end should increase the publicity and promotion of ecological products in national forest parks through Internet platform channels, which is conducive to building regional public brands of ecological products in national forest parks. On the other hand, at the consumption end, the public should enhance the scientific cognition and thinking of the value of ecological products in national forest parks and promote the market trading of ecological products in national forest parks through a series of brand planning and promotion, which is conducive to enhancing the public's willingness to consume.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author.

Author contributions

XH: Supervision, Writing – original draft, and Funding acquisition. ZH: Validation and Writing – review and editing. BQ: Writing – review and editing. DY: Formal analysis and Writing – review and editing. ZQ: Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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