Analysis of Factors Influencing the Transformation of Strategic Emerging Industry Clusters Based on the ISM Model

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Abstract. This article applies the co-citation analysis method and Interpretive Structural Modeling (ISM) to identify the influencing factors and hierarchical structure of the transformation of strategic emerging industry clusters. The study reveals that the fundamental factors influencing the transformation of strategic emerging industry clusters in China are Financial Mechanism, R&D Capability, Technology Transformation, and Strategic leadership of central enterprises.

Keywords: strategic emerging industry, technology transformation, influencing factors, Citespace, ISM

1 Introduction

In recent years, the construction of strategic emerging industry clusters has become an important approach to promote industrial structure upgrading and create new engines for economic development. According to data from the Ministry of Industry and Information Technology, in 2022, the value-added of strategic emerging industries accounted for over 13% of the country's GDP, with 45 national-level advanced manufacturing clusters generating a cluster output value exceeding 20 trillion yuan in the same year. However, statistical data shows that only 10% to 30% of China's cutting-edge technological achievements are applied in practical production, and only 20% of the technological achievements can truly form industrial applications. With the continuous breakthroughs in China's cutting-edge technological innovation, the efficient promotion of achievement transformation will become crucial for the development of strategic emerging industry clusters. Currently, academic research in the field of strategic emerging industry clusters mainly focuses on evolutionary mechanisms [1-3], development paths [4-5], competitiveness analysis [6-7], innovation efficiency [8], while research on factors influencing achievement transformation is relatively scarce. Research in the field of achievement transformation mostly concentrates on the transformation patterns and paths in general industries [9-10], lacking sufficient consideration for the characteristics of strategic emerging industries, and often relying on subjective qualitative studies, lacking objective evaluation methods.

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Therefore, this paper focuses on the analysis of factors influencing the transformation of achievements in strategic emerging industry clusters, aiming to explore key influencing factors and their interplay mechanisms. In terms of research methodology, this study employs Citespace software to identify the main influencing factors of technology achievement transformation. Furthermore, it utilizes Interpretive Structural Modeling (ISM) [10-13] to analyze the hierarchy of various influencing factors, their interrelationships, and the paths of their effects. The objective is to provide theoretical foundations and practical references for accelerating the construction of strategic emerging industry clusters and enhancing the efficiency of technology achievement transformation.

2 ISM Model for the Factors Influencing Technology Achievement Transformation

2.1 Identification of Influencing Factors for Technology Achievement Transformation Based on Citespace

This study utilizes the co-citation analysis method in Citespace software as the basis for selecting influencing factors for technology achievement transformation in emerging industry clusters. The literature data is sourced from the China National Knowledge Infrastructure (CNKI), using "technology achievement transformation" as the search term, and the search scope is set to "subject." The keywords from 4,000 articles published between 2002 and 2023 are selected as the data source for this study. The output result is shown in Fig.1.

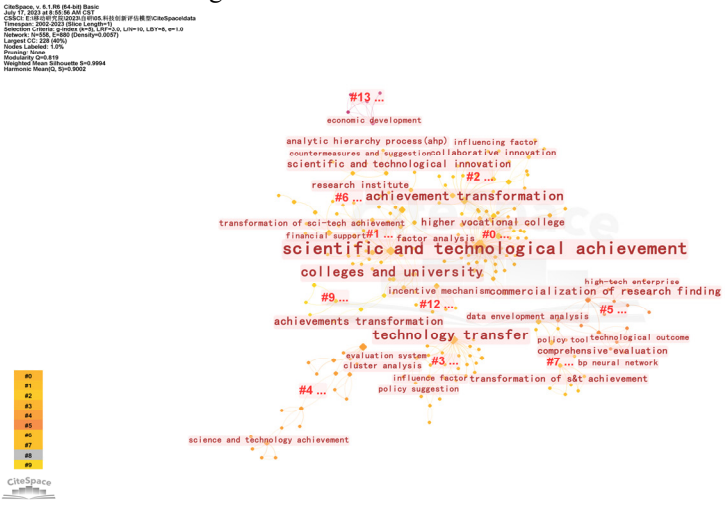

Fig. 1. Keyword Mapping for The Transformation of Technology Achievements

However, since the keywords cover various aspects such as research background, research objects, research questions, research purposes, research perspectives, and core

conclusions, and they are expressed in different forms, this paper excludes non-influencing factor keywords and consolidates similar keywords. The output results are shown in Table 1:

Table 1. Citespace Output and Consolidated Keywords

Citespace Output Results		Consolidated Keywords
Count	Keyword	
18	Incentive Mechanism	Incentive Mechanism
27	Evaluation	Evaluation Mechanism
10	Performance Evaluation	
12	Financial Support	Financial Support
2	Guide the Fund	
10	Transformation Model	Transformation Model
4	Transfoamation Platform or Proformace	
13	Intellectual Property	Knowledge Management
8	Patent	
16	Knowledge Management & Knowledge Relay	
10	Business Model	Business Model
24	Cooperation & Information Service	Cooperation Mechanism
18	Management	Scientific Research Management
8	Ability Trait & Innovative People	R&D Capability
8	Market Prediction & Economic Benefit	Technology Market
26	Contract & Commercialization of Research Finding	
37	Scientific and Technological Innovation	Technology Leadership
23	New and High Technology & Scientific Achievement	
143	Science and Technology	
161	Technology Transfer & Achievement Transformation	Technology Transformation
13	Transformation Efficiency	Achievement Conversion Cycle

Compared to other industry clusters, China's strategic emerging industry clusters emphasize the leading role of central enterprises in technological innovation. Therefore, based on Table 1, the factor "Strategic Leadership of Central Enterprises" is added to represent this influence, as explained in Table 2:

Table 2. Main Influencing Factors on the Transformation of Scientific and Technological Achievements of Strategic Emerging Industry Clusters in China

Si	Factor	Explanation
S1	Incentive Mechanism	Benefits of scientific and technological transformation and the relationship between the parties involved

S2	Evaluation Mechanism	Assessment and Evaluation Indicators for the Efficiency of Scientific and Technological Achievement Transformation
S3	Financial Support	Including investment in science and technology research and development, science and technology transformation, science and technology promotion, etc.
S4	Transformation Model	Mode of transforming scientific and technological achievements into results in industrial clusters
S5	Knowledge Management	Including intellectual property management, patent transaction rules and revenue sharing systems
S6	Business Model	Channels through which scientific and technological results can be widely disseminated
S7	Cooperation Mechanism	Mechanisms for communicating information between enterprises within a cluster
S8	Scientific Research Management	Management process of technological innovation from scientific research, technology development to technology application
S9	R&D Capability	Comprehensive quality of researchers
S10	Technology Market	Degree of matching of scientific and technological achievements with market needs
S11	Technology Leadership	Degree of scientific and technological innovation in emerging technologies
S12	Technology Transformation	Extent to which technological development can move to the next stage or be applied in other areas
S13	Achievement Conversion Cycle	Time from science and technology development to conversion to real productivity
S14	Strategic Leadership of Central Enterprises	The ability of central enterprises to dominate and lead industrial innovation and development in emerging industry clusters

2.2 Constructing the Adjacency Matrix Based on the Interrelationships between Influencing Factors

The Delphi method is used to determine whether there is a direct binary relationship between each influencing factor. The binary relationship can be represented as:

$$a_{ij} = \begin{cases} 1 & (S_i \; has \; an \; impact \; on \; S_j) \\ 0 & (S_i \; has \; no \; impact \; on \; S_j) \end{cases} \tag{1}$$

Each element in the set of influencing factors is correlated with other (n-1) elements to construct the neighbor matrix of influencing factors of outcome transformation$A = (a_{ij})_{n \times n}$, as follows:

$$A_{14\times14}=\begin{bmatrix}0&0&0&1&0&0&0&0&0&0&0&0&1&0\\0&0&0&0&0&0&0&0&0&1&0&0&0&0\\0&0&0&1&0&1&0&0&1&0&1&1&1&0\\0&0&0&0&0&0&0&1&0&0&0&0&1&0\\0&0&0&1&0&0&0&1&0&0&0&0&1&0\\0&0&0&1&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&1&0&0&1&0\\0&1&0&1&0&0&0&0&0&0&0&0&1&0\\0&0&0&0&1&0&0&0&0&0&1&1&1&0\\0&0&0&0&0&1&0&0&0&0&0&0&1&0\\0&0&0&0&1&0&0&0&0&0&0&0&0&0\\1&0&1&1&1&1&0&0&0&1&0&0&1&0\\0&0&0&0&0&0&0&0&0&0&0&0&0&0\\1&1&1&1&1&0&1&1&1&0&1&0&0&0\end{bmatrix}$$

2.3 Establishing the Reachability Matrix for the Influencing Factors of Technology Achievement Transformation

The adjacency matrix represents the direct binary relationships between elements, and the ISM model defines a transitive binary relationship between factors. Through this transitivity, certain elements may establish indirect impact relationships. The reachability matrix captures the transitive binary relationships between factors, representing the relationships that can be reached between any pair of nodes through any path length. The reachability matrix (M) can be calculated using Boolean algebra operations, as shown in the following formula:

$$(A+I)\neq(A+I)^2\neq\cdots\neq(A+I)^m=(A+I)^{m+1}=M \tag{2}$$

It is calculated that$(A+I)^4=(A+I)^5$, the reachable matrix is:

$$M=(A+I)^4=\begin{bmatrix}1&1&0&1&0&1&0&1&0&1&0&0&1&0\\0&1&0&1&0&1&0&1&0&1&0&0&1&0\\1&1&1&1&1&1&1&1&1&1&1&1&1&1\\0&1&0&1&0&1&0&1&0&1&0&0&1&0\\0&1&0&1&1&1&0&1&0&1&0&0&1&0\\0&1&0&1&0&1&0&1&0&1&0&0&1&0\\0&1&0&1&0&1&1&1&0&1&0&0&1&0\\0&1&0&1&0&1&0&1&0&1&0&0&1&0\\1&1&1&1&1&1&1&1&1&1&1&1&1&1\\0&1&0&1&0&1&0&1&0&1&0&0&1&0\\0&1&0&1&1&1&0&1&0&1&1&0&1&0\\1&1&1&1&1&1&1&1&1&1&1&1&1&1\\0&0&0&0&0&0&0&0&0&0&0&0&1&0\\1&1&1&1&1&1&1&1&1&1&1&1&1&1\end{bmatrix}$$

2.4 Hierarchy of Influencing Factors

Based on the reachability matrix, the reachable set, the antecedent set$Q(S_i)$ and the intersection set of all elements are determined. Among them, the reachable set$R(S_i)$ refers to the set of other factors affected by the factorS_i , and the set of the jth column corresponding to the element of the reachable matrixS_i with the row "1". The formula is as follows:

$$R(S_i) = \{S_j | S_j \in S, m_{ij} = 1\} \quad \text{i,j=1,2,...,n} \tag{3}$$

The antecedent set$Q(S_i)$ is the set consisting of the elements of row j corresponding to the elements of column "l" ofS_i in the reachability matrix. The formula is as follows:

$$Q(S_i) = \{S_j | S_j \in S, m_{ji} = 1\} \quad \text{i,j=1,2,...,n} \tag{4}$$

The intersection set$C(S_i)$ is the intersection of the reachable set$R(S_i)$ and the antecedent set$Q(S_i)$, which reflects the mutual influence relationship among the factors. The formula is as follows:

$$C(S_i) = R(S_i) \cap Q(S_i) = \{S_j | S_j \in S, m_{ij} = 1, m_{ji} = 1\} \quad \text{i,j=1,2,...,n} \tag{5}$$

If$C(S_i)$=$R(S_i)$, then this element is a high-level element, and the elements that meet this condition are at the same level. By extension, different hierarchical levels are obtained, resulting in a table showing the decomposition of factors and their relationships into five levels, as shown in Table 3:

Table 3. Breakdown of The Five Tier Factors and Their Relationships

Level	Hierarchical Factors
1	13
2	2,4,6,8,10
3	1,5,7
4	11
5	3,9,12,14

2.5 Plotting the Analytic Recursive Structure

Based on the results of the hierarchical analysis mentioned above, the 14 factors influencing the transformation of technological achievements in strategic emerging industries are distributed across 5 levels. By drawing a multi-level hierarchical structure diagram, the interpretive structural model diagram for the factors influencing the transformation of technological achievements in strategic emerging industry clusters can be obtained, as shown in Fig.2:

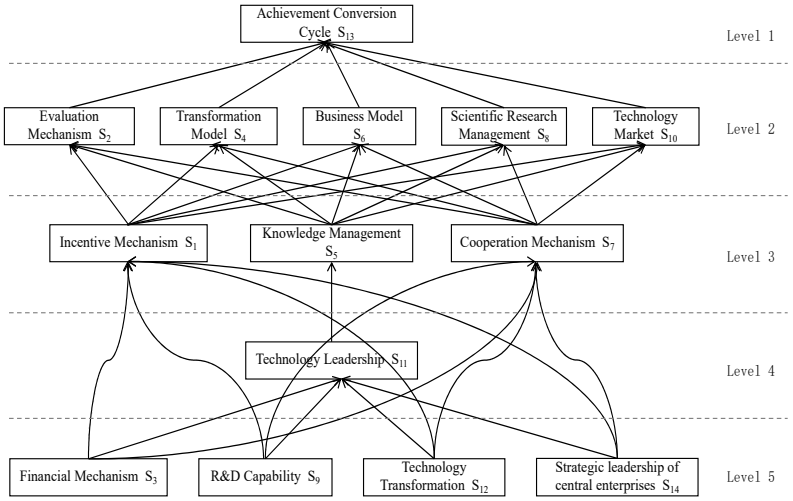

Fig. 2. Influencing Factors of Transformation of Scientific and Technological Achievements of Strategic Emerging Industry Clusters in The Hierarchical Structure Model Diagram

Based on the different levels of impact, the factors affecting the achievement transformation of strategic emerging industry clusters in science and technology are classified into 4 categories: surface-level factors, shallow-level factors, middle-level factors, and fundamental factors. The surface-level factors include Evaluation Mechanism, Transformation Model, Business Model, Scientific Research Management, and Technology Market. The shallow-level factors include Incentive Mechanism, Knowledge Management, and Cooperation Mechanism. The middle-level factor is Technology Leadership. The fundamental factors include Financial Mechanism, R&D Capability, Technology Transformation, and Strategic Leadership of central enterprises. Therefore, in promoting the achievement transformation of strategic emerging industry clusters in science and technology, it is crucial to prioritize optimization and adjustments of the fundamental factors. These factors should serve as the starting point for decision-making, gradually considering the influences of middle-level, shallow-level, and surface-level factors. By doing so, the technology achievement transformation rate of China's strategic emerging industry clusters can be fundamentally improved.

3 Conclusion

In this study, the Citespace tool was utilized to extract 14 major factors influencing the achievement transformation of strategic emerging industry clusters in science and technology. System engineering methods and the Delphi method were employed to analyze the relationships between various factors. By constructing an ISM model, a clear hierarchical structure diagram of the influencing factors was obtained, visually presenting the relative importance and relationships among the factors affecting achievement transformation. This provides a new reference for formulating strategies and recommendations to improve the rate of achievement transformation. However, it is important

to note that the ISM model is based on qualitative analysis and expert experience in analyzing the relationships between influencing factors. Further steps should involve incorporating quantitative analysis methods to provide more accurate analysis and evaluation of the effectiveness of achievement transformation.

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