Analysis of Research Hotspots in China's Information Industry Policy: Based on Co-word Analysis and Concept Network Analysis Methods (Postprint)

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Abstract

[Purpose / Significance] This study addresses the development status of China's information industry, employing content analysis to conduct an in-depth examination of domestic research literature in the information industry domain, thereby identifying research hotspots and development trends. [Method / Process] Utilizing co-word analysis and concept network analysis methods, this study performs keyword and thematic analysis of literature related to information industry research from CNKI (China National Knowledge Infrastructure), summarizing that research hotspots in China's information industry policy domain are concentrated in six areas: development of information technology industrialization, informatization and information security, development and planning of information resources, government information services, information policy, and information industry planning within regional integration. [Results / Conclusions] Under the guidance of national information policy and strategic planning for information resources, the development of information technology progressively drives the transformation and upgrading of information industry business models. Resource disparities among different regions prompt the development of the information industry in regional integration to increasingly emphasize issues such as interest coordination and policy linkage.

Full Text

An Analysis on Chinese Information Industry Policies Research Front: Based on Co-word and Conceptual Network Analyses

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Abstract

[**Purpose/significance**] This research aims to conduct an in-depth analysis of domestic information industry literature using content analysis methods, thereby identifying research hotspots and development trends in China's information industry. [**Method/process**] Employing co-word analysis and conceptual network analysis, we examined keywords and themes from information industry research literature in CNKI (China National Knowledge Infrastructure). The study reveals that research hotspots in China's information industry policy field concentrate in six areas: information technology industrialization development, informatization and information security, information resource development and planning, government information services, information policies, and information industry planning in regional integration. [**Result/conclusion**] Guided by national information policies and information resource strategic planning, the development of information technology gradually drives the transformation and upgrading of information industry formats. Resource disparities between different regions have prompted increasing attention to interest coordination and policy linkage in regional integration of the information industry.

Keywords: information industry; information policy; information resource planning; knowledge graph

1. Research Introduction

As an emerging industrial sector, the information industry has become a crucial growth point for the national economy, significantly driving the development of related industries and the adjustment of economic structures. This study employs co-word analysis and conceptual network analysis to conduct an in-depth examination of domestic information industry literature, building upon previous research to more comprehensively and objectively reflect research hotspots in this field. Co-word analysis, a type of content analysis, operates by pairwise counting the frequency with which terms appear together in the same document. This forms the basis for cluster analysis of these keywords, revealing their relationships and thereby analyzing changes in the disciplinary and thematic structures they represent [1]. Conceptual network analysis borrows techniques from social network analysis such as K-core analysis, principal component analysis, and edge strength analysis, mapping concepts in co-word networks to individual nodes in social networks and qualitatively visualizing relationships between concepts [2]. Both methods identify the primary knowledge structure and research hotspots of a discipline or theme through statistical analysis of document keywords. The former emphasizes classification—identifying several research priorities—while the latter focuses on relationship analysis, useful for determining connections among these research priorities. By combining both methods, this study systematically and comprehensively depicts the structural characteristics and relationships among various research hotspots in the information industry, enabling analysis of key issues in China's information industry.

2. Data Preparation and Analysis Methods

This study selected journals and dissertations from CNKI as data sources. Using combined title searches with terms "information industry policy," "information resource policy," "information policy," "information industry planning," and "information resource planning" (time range: January 1994 to December 2015), and considering high-frequency keywords and their clustering in information industry research, we selected highly-cited core journal papers and dissertations as representative of research priorities at this stage. Ultimately, 1,644 records were obtained for analysis. After basic data processing, we employed co-word analysis and conceptual network analysis across three stages.

Stage 1: High-frequency term statistics and co-word matrix construction. First, we exported literature records by retrieving 1,644 records from the CNKI full-text database and exporting them in RefWorks format. Second, we performed data cleaning by importing the results into Excel, filtering for complete records with title, author, and keyword fields. Third, we conducted data organization by using Excel to count the occurrence frequency of each keyword across all records, selecting 75 keywords with frequencies above 3 as high-frequency terms representing the field's main research directions, and pairwise counting their co-occurrence in the same records to form a co-word matrix.

Stage 2: Conceptual network analysis based on the co-word matrix. First, we used UCINET software for conceptual network analysis by importing the matrix from the previous stage and using the NetDraw function to generate a conceptual network diagram. Second, we performed K-cores analysis. A K-core is a subgraph satisfying the condition that each node in the subgraph is adjacent to at least K other nodes (i.e., connected by edges), and this property would cease to exist if any other point were added to the subgraph [3]. K-cores analysis generates a series of subgraphs that progressively reveal the central architecture of the original network. Larger K-values produce subgraphs with greater node degrees that tend toward more central positions in the network structure [4]. In the NetDraw interface, selecting the K-cores function enables nodes in the conceptual network to appear in different colors based on out-degree and in-degree differences. We further used Centrality Analysis to classify nodes by degree and then expanded K-cores analysis. Here, one out-degree or in-degree indicates a co-occurrence relationship between concepts A and B. Third, we conducted principal component analysis. Using NetDraw's principal components layout arrangement, all concepts can be arranged in a fisheye pattern, with concepts dispersed from right to left according to out-degree or in-degree magnitude [5]. This arranges all nodes hierarchically based on their in-degree with the previous level, with semantic combinations of subsequent nodes forming explanations of preceding concepts. Fourth, we performed edge strength analysis. Since K-cores analysis can only indicate the existence of co-occurrence relationships but not their strength, edge strength was introduced to supplement the analysis by showing co-occurrence frequencies. Specifically, we exported the co-word matrix as .net format from NetDraw, imported it into UCINET's Pajek tool, and

obtained a new conceptual network diagram displaying edge strength through the Draw-Draw function.

Stage 3: Cluster analysis based on the co-word matrix. Using UCINET software for co-word clustering, we first imported the co-word matrix into UCINET and saved it as a dataset format. Then we selected Cluster Analysis-Hierarchical Clustering in UCINET to perform hierarchical clustering. Finally, we exported the hierarchical clustering diagram and provided further interpretation of these results based on the specific content of the literature.

3. High-frequency Keyword Statistics and Co-word Matrix Construction

Through data cleaning and organization of literature records, we obtained 1,278 keywords. Among them, 1,064 keywords appeared only once (83.2%), 139 appeared twice (10.9%), and 75 keywords appeared three times or more. Notably, "information industry" itself was the most frequent keyword. presents the statistics of high-frequency keywords (frequency $ $3) in domestic information industry research literature.

After obtaining high-frequency keywords, we used Excel to construct a co-word matrix. shows a partial view of this co-word matrix based on the 75 selected high-frequency keywords, representing the frequency of pairwise keyword co-occurrence in the same document. Due to the high frequency of "information industry" itself, its co-occurrence with other keywords in the same documents is also the most common.

4. Cluster Analysis Results

4.1 Cluster Dendrogram and Cluster Table from Hierarchical Clustering

After importing the co-word matrix into UCINET for cluster analysis, we obtained the dendrogram shown in [Figure 1: see original paper]. Based on this figure, we initially classified the 75 keywords into 14 categories. Since the dendrogram is rather complex, we used a table to represent these 14 categories of 75 keywords, which we then further simplified into 6 major categories, as shown in .

Following the initial division into 14 categories, we can further merge them from top to bottom according to the dendrogram (see): the original categories 1-5 merge into one category, namely "information technology and industrialization development," which contains the most keywords and covers electronic information industry, information technology, information markets, information consumption, industrial policies, and strategies—all belonging to the domain of information technology and industrialization. The original categories 6-8 merge into the "informatization and information security" category, which, in addition to informatization and information security, includes information systems,

infrastructure, and information resource analysis—all broadly belonging to the field of informatization and information security. The original category 9, "information resource development and planning," remains as a separate category. Based on the service attributes of geographic information and the management attributes of patent information, the original category 10 merges into category 11, "information service industry," while the original category 12 merges into category 13, "information policy and information management." Finally, the original category 14, "regional integration," also remains as a separate category.

4.2 Discussion of Clustering Results

Based on the hierarchical clustering results, we can conduct a detailed analysis of the six major themes in domestic information industry research and explore the characteristics presented in this research field.

4.2.1 Information Technology Development Driving Information Industry Format Upgrading Innovation in information technology enables advanced equipment and product manufacturing, providing a favorable external environment for information industry development [6]. The information industry comprises three aspects: information industry proper, information services, and information development. The types of information industries are closely related to information technology and highly dependent on the development of information technology hardware and software. With the development of information technology, the information industry has grown in scale and transformed from lower-level to higher-level formats [7]. Information technology possesses characteristics of permeability, driving effect, multiplier effect, networking, and systematicity, promoting the integration of the information industry [8]. Due to the high correlation among various aspects of information technology, industrial development models exhibit two patterns: on one hand, a strategy combining leading industries with supporting industries and matching upstream and downstream industries; on the other hand, a strategy of enterprise division and cooperation [9]. This cultivation and formation of the information industry chain represents the upgrading of China's information industry formats.

4.2.2 Information Security Technology Issues Becoming Key Concerns in Informatization Information security is the second most important research area in the current information industry after information technology and industrialization development, but literature analysis also reveals many existing problems. The severe situation currently facing China's information security lies in insufficient independent research and development of information security technologies [10], lack of effective information security standards, and inadequate attention to privacy and security issues in information disclosure [11]. Based on investigations into the scale of the information security industry, market demand and regulation, and the status of products and services, scholars argue that China's information security problems concentrate on core

software's dependence on imported technology, which severely restricts information industry development [12]. The key to solving these problems lies in policy guidance for investment in the information security field, strengthening the cultivation of information security technology talents [13], and constructing a suitable information security prevention system for China.

4.2.3 Information Resource Development and Planning Focus on Standardization, Framework, and Process Uniformity As a research direction in the information industry field, information resource planning exhibits certain independence and close connection with government macro-planning. From a planning perspective, government information resource planning should include three aspects: data-level integration planning, information resource development technology-level integration planning, and business process-level planning for information resource management [14], while also considering the protection of information rights [15]. From an operational perspective, the element framework for government information resource planning includes seven aspects: concepts and values, environment, objectives, time, methodology, tools, and implementation process [16]. Under the complex scientific management system thinking mode, information resource planning should be implemented and applied from the perspectives of business architecture, application architecture, information (data) architecture, and technology architecture [17]. From the perspective of evaluation indicator systems, information resource development and planning include three aspects: objective indicator systems, operational indicator systems, and regulatory indicator systems [18].

4.2.4 Government Information Services Having Strong Applicability in Information Industry Development Government information services represent a highly applicable field in information industry development, with the most obvious public orientation. The improvement of European and American information policy systems has played a positive role in the industrialization development and market cultivation of government information services [19]. Currently, the main problems exposed in China's information service field include unclear scope of usable information resources, inadequate technical protection measures, and weak awareness of intellectual property protection [20]. For the enhancement of government information services, the government mainly undertakes functions of market and environment cultivation, management and maintenance, policy tool support, and supervision [21]. The systematic design of public information service policy content should follow principles of whole-process design, front-end focused design, people-oriented design, and dynamic design based on evaluation.

4.2.5 Information Policy Formulation Should Address Policy Coordination Issues As an important approach for the government to guide information industry development, information policies have a clear directional effect

on China's information industry development. Therefore, research in this field focuses on policy frameworks and systems, addressing issues of systematic design and policy stability, specifically concentrating on e-government, information disclosure, e-commerce, and enterprise informatization [22-24]. Current problems in China's information policies manifest in two aspects: first, weak systematicity, meaning existing relevant information policies lack unified consideration at national, local, and departmental levels; second, insufficient continuity and stability, as policy introduction mainly addresses immediate problems with strong temporariness. The fundamental reason for this problem lies in inadequate attention to policy coordination during China's information and information industry policy formulation process. During policy formulation, comprehensive consideration of five aspects—information policy subjects, objectives, problems, content, and forms—is needed [25] to construct an effective policy coordination system.

4.2.6 Policy Linkage and Interest Coordination as Key Focuses in Regional Integration Information Industry Planning Research in this field exhibits the strongest independence and marginality, with close connections among literature. This research direction is indirectly related to the information industry, with core literature being a series of articles on the Yangtze River Delta information law and policy linkage mechanism research. With the formal approval of the Yangtze River Delta regional plan, the integrated development of information laws and policies in the Yangtze River Delta region has risen to a national strategy [26]. In the process of regional integration, information resources exhibit characteristics of strategic importance, scarcity, dispersion, and multidirectionality, requiring information industry planning to fully consider issues such as rational regional differentiated development and interest compensation mechanisms [27]. Regional collaborative development is inseparable from information resource sharing mechanisms, as only effective information transmission and sharing can ensure orderly administrative coordination, commercial mutual benefit, and industrial coordination.

5. Conceptual Network Analysis

To explore connections among various keywords in domestic information industry research, we imported the co-word matrix into NetDraw to obtain a conceptual network from the co-occurrence of these 75 keywords (see [Figure 2: see original paper]). In this network, edges represent co-occurrence relationships between concepts (keywords), and edge strength expresses the intensity of these relationships (i.e., the frequency of co-occurrence). Since co-occurrence relationships are non-directional, nodes have equal out-degree and in-degree, reflecting the centrality and influence of concepts themselves [2].

5.1 K-cores Analysis

Through NetDraw's K-cores analysis function, nodes can be displayed in different colors (red, blue, black, pink, dark green, and gray) based on out-degree or in-degree magnitude. Using the Centrality Analysis function to classify nodes by degree, nodes with larger out-degree or in-degree also appear larger in size. We then interpreted the diagram using relevant social network analysis theories.

5.1.1 Information Industry Research Focuses on Electronic Information, Information Technology, Information Security, and Information Policy By observing the highest-degree bright red nodes and larger blue nodes, we can see that around the core concept of "information industry," related concepts such as "electronic information," "information security," "information technology," and "information policy" dominate in absolute in-degree numbers. This indicates that scholars have formed high consensus on these research directions in information industry studies, and these concepts occupy central positions in the network, reflecting their high viscosity, diffusivity, and vitality.

5.1.2 High Attention to Industrial Structure and Regional Economy, with Obvious Interdisciplinary Research Trends A cluster exists at the bottom of [Figure 2: see original paper] where concepts such as "linkage," "national strategy," "integrated development," and "legal policy" all interconnect and possess high K-values, appearing as red nodes. In this cluster, internal members have closer average connections with each other than with members outside the cluster, indicating that this cluster plays a special role in the conceptual network, representing a relatively independent research direction in this field.

5.1.3 Many Emerging Growth Points in Information Industry, but Still in Early Stages Notably, at the top of the conceptual network, "information resource planning" serves as a center with close connections to "information resource development," "information network," "national informatization," and "information systems." Although not forming a separate cluster, these occupy a relatively peripheral position in the network. Additionally, the K-cores analysis diagram shows edge connections among 2-3 concepts in marginal areas such as "geographic information industry" and "geographic information service," "end user" and "patent information," and "archives information" and "public information." This indicates that some scholars have conducted research on geographic information, patent information, and archives information from a broad information industry perspective, but with insufficient depth. Finally, by observing smaller nodes and dark green nodes, concepts such as "information consumption," "industrial policy," "market economy system," and "national economic informatization" become marginal terms due to their low in-degree, suggesting that current research on the market and consumption sides of the information industry is relatively weak and warrants further investigation.

5.2 Principal Component Analysis

Using NetDraw's principal components layout arrangement to disperse concepts from right to left according to out-degree or in-degree magnitude, we obtained [Figure 3: see original paper].

5.2.1 Security and Technology Are Mainstream Concerns in Recent Chinese Information Industry Policy Research Principal component analysis reveals that "information security," "information technology," and "electronic information" represent the mainstream directions of current domestic information industry research. With comparable in-degrees, and considering the evolution of information industry research and practice, we can conclude that "electronic information" occupies a central position in domestic information industry research. Advances in storage, transmission, and analysis technologies drive information product applications. As social security and personal privacy protection awareness increase, society demands higher information security standards, making "information technology" and "information security" highly concerned areas in the information industry. However, these two research directions also maintain certain independence, both positioned directly above the conceptual network with some distance from the core concept "information industry" at the lower right, each having one in-degree. On one hand, information industry development relies on information technology and information security as support; on the other hand, as the foundation of informatization, information technology development is guided by information industrialization strategies, while high information security requirements make new technology commercialization more cautious.

5.2.2 Insufficient Research Reference to Information Technology in National Strategic Planning of Information Industry Combined with the above K-cores analysis, we can confirm that the conceptual network contains a cluster and a more independent research direction. Specifically, seven concepts—"linkage," "national strategy," "legal policy," "integrated development," "regional integration," "regional planning," and "information economic evolution"—form a closely interconnected cluster that some scholars have explored in information industry research. This cluster has weak connections with information technology, security, and service fields, indicating that the reference relationship between this cluster and core research areas of the information industry is relatively weak, necessitating further deepening of collaborative research.

5.3 Edge Strength Analysis

As mentioned earlier, since K-cores analysis can only show the existence of co-occurrence relationships but not their strength, we employed edge strength analysis to demonstrate co-occurrence frequencies. Through transformation using Pajek tools, we obtained the edge strength analysis diagram shown in [Figure

4: see original paper].

Edge thickness reveals that “electronic information,” “law,” “information technology,” and “information policy” have strong edge strength with “information industry,” indicating these are the most mature areas in information industry research. Meanwhile, in the information security research direction, “critical infrastructure” and “network security” have strong edge strength with “information security”; in the information resource planning research direction, “information resource development,” “e-government,” “catalog system,” and “top-level design” have strong edge strength with “information resource planning.” These findings demonstrate that research in these two fields is also quite mature.

Observing the peripheral areas of the conceptual network, we can see that “information resource planning” and “catalog system” with “e-government,” “geographic information industry” and “geographic information service” with “development planning,” and “patent information” and “end user” with “State Patent Office” respectively form three concept triangles with considerable edge strength. Additionally, concept chains with moderate edge strength formed by “information management,” “information resource management,” “national information policy,” and “Internet of Things,” “information consumption” exist near the central area of the conceptual network. This suggests these concepts have important structural impacts in corresponding marginal research areas of the information industry and possess the potential to become new research hotspots.

6. Conclusion

The information industry represents a country’s industrial and technological development direction, and the application of its technological achievements can greatly enhance work efficiency across various industries and departments. Research hotspots in the information industry are closely integrated with national policies and social development trends. Based on the above analysis, the development of China’s information industry over the past 20 years exhibits the following characteristics:

6.1 China’s Information Industry Development Transitioning from Product and Technology Replication to Encouraging Independent R&D

The main characteristic of China’s early information industry was transplantation and replication of foreign information technologies and products, introducing relatively advanced products and technologies to domestic markets. For example, imitating mature information management systems promoted informatization development in domestic government agencies and enterprises to achieve market cultivation effects. With the upgrading of information industry structure and adjustment of industrial chains, the focus has transitioned from traditional technology replication to independent R&D, emphasizing the development of

domestic brands and technologies in management information systems, information security, and databases. This also reflects the results of national policy guidance and adjustment.

6.2 National Planning and Policy Framework Design as Development Trends in China's Information Industry

Over the past two decades, China's information industry development has evolved from single-line industry planning to national planning. In the 1990s, China's information industry development planning and overall framework mainly included the Information Technology Development Policy (1992), National Industrial Policy Outline for the 1990s (1994), Report on Accelerating China's Integrated Circuit Industry Development During the Ninth Five-Year Plan (1995), Guidelines for Current Priority Development in High-tech Industrialization Key Areas (1999), and Several Policies for Encouraging Software and Integrated Circuit Industry Development (2000). After 2000, China gradually strengthened overall and long-term planning for the information industry, focusing on the design of national and comprehensive information industry development frameworks. Planning documents during this period included the information industry plan in the Tenth Five-Year Plan Outline (2001), the strategic guideline of "prioritizing information industry development" established at the 16th Party Congress (2002), the Action Outline for Revitalizing the Software Industry (2002), and the Eleventh Five-Year Plan for the Information Industry (2006). With the application and popularization of mobile internet technology, China's information industry development has gradually shifted toward cloud computing, smart cities, big data, and Internet Plus. For instance, in 2015, the State Council issued the "Outline for Promoting Big Data Development," accelerating government data opening and sharing and promoting resource integration to achieve overall advancement of the information industry and social development.

6.3 Government and Enterprise Informatization Having Direct Driving Effects on Information Industry Development

Information industry development is influenced by market demand and orientation. Government and enterprise informatization work has a clear driving effect on information industry market development and also significantly impacts information industry structural adjustment and format upgrading. China emphasizes building transparent and sunshine governments, continuously improving government information service levels, which represents direct application of information industry R&D technologies. Especially in recent years, with the influence of emerging technologies such as the Internet, smart cities, and big data, the trend of government and public sector service transformation has become increasingly evident, with higher technical requirements for data opening and data analysis. This drives the information industry to transition toward a R&D direction centered on content and data. Additionally, enterprises

are the primary venues for the transformation and application of information industry-related technological achievements in China, and providing corresponding communication technologies for enterprise cross-regional management also represents a direction for China's information industry development.

6.4 Security and Open Technologies with Independent Intellectual Property Rights Becoming Key Focuses in Information Industry Development

As a foundational area for information industry R&D, information security technology level has become crucial for information industry development. Independent R&D of information security technologies determines China's position in the information industry chain. New hotspots such as big data, open data, and Internet Plus continuously emerge, requiring China to develop information security and open technologies with independent intellectual property rights. These emerging market growth points demand adequate environments and space for data opening to provide sufficient momentum and vitality for socio-economic development. How the government can safely and effectively open the massive public data it controls has become an urgent challenge in the big data environment. Therefore, China's information industry increasingly emphasizes R&D work related to information security and data opening technologies, as only with security guarantees can effective data opening and utilization be provided.

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Note: Figure translations are in progress. See original paper for figures.