Knowledge Map of International Technological Innovation: The Research Trend and Research Frontiers

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Abstract--**With the help of the latest visualization technology of metrology knowledge map, combined with the scientific metrology, mathematics, computer graphics and computer science, based on Co-citation analysis theory and path-finding algorithm of network, research the web of Science 6080 literatures on technological innovation from 2010 to 2014, using visualization software CiteSpace III, analysis on core journals , important authors, important documents and the research hot spot draw the knowledge maps of the technology innovation in past five years, show development trend and research hotspot in international technology innovation in past five years. Through exploration and analysis, summarizes the current international research on the technological innovation of the five major hot areas: "technological turbulence ", "carbon capture", "innovation", "market vision" and "new technology generation". At last, the paper puts up discussing and prospect to the research conclusion.**

I. INTRODUCTION

Schumpeter firstly proposed the basic concept and idea of innovation in *the Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle* published in 1912[1, 2]. Sixteen years later, he deepened the cognition of innovation in *Instability of Capitalism*: innovation is a process[3]. Moreover, he put forward the innovation theory systematically in *Business Cycles* published in the 1940s[4]. The American economist - Walt W. Rostow - raised the Theory of Economic "Take-off". He specified the concept of "innovation" as "technological innovation" and regarded "technological innovation" as the dominant issue of "innovation"[5]. With the development of technological activities and management practices, technological innovation management has developed into a mature theoretical knowledge system. It is of great practical significance for the development of technological innovation theory and practice to make clear the research focus and frontiers in this field.

Information visualization tools are designed to change the way of humans to view the world through knowledge maps [6]. Kuhn's Paradigm Theory describes the historical process of scientific development and scientific revolution as: "pre-science and paradigm formation → general science and paradigm accumulation → scientific crisis and paradigm disintegration → new normal science and new paradigm formation"[7]. This is similar to the formulation, accumulation, diffusion and conversion of citation clusters in the knowledge map. It provides rational basis for the interpretation of the knowledge map. Inspired by the viewpoint of Bernard (the scientific development model is not as distinctive as that of trees; it is as complex as networks) and based on the Science Citation Index invented by Garfield, Price took a wild guess: the complicated citation relationship between papers will form a variety of small and large networks. People conduct analysis by virtue of the graph theory, the network flow theory, applied mathematics and some other tools. ... Networks formed by the various citation relationships can cluster to form various characteristics similar to maps..."[8]. Subsequently, Price confirmed this speculation in *Networks of Scientific Papers* published in 1965[9]. Since then, an important theory formed in the scientometrics field: "the essence of scientific frontiers can be embodied by the citation of references". Therefore, this theory to explore scientific frontiers is the product of wisdom combination of Bernard, Garfield and Price. Mark Granovetter proposed the social network analysis theory. The main points were as follows: information dissemination is regular in networks. Information disseminates rapidly in nodes with strong ties in networks. The nodes almost possess the same information. Therefore, if new information or opinion appears, it can only originate from weak ties between these nodes and other network nodes[10-12]. In 1992, Ronald S. Burt put forward the theory of structural holes in *Structural Holes: The Social Structure of Competition*, namely, organizations or individuals in structural holes could enable themselves to obtain more competitive advantages and returns via some information selection principles[13]. The information Foraging Theory proposed how to obtain the maximum benefits with the minimum search costs in network environments. It provides the knowledge map with a set of techniques to search for a route of knowledge transmission. Thus, the scientific development model proceeds from the accumulation and reformation of paradigms to elaborate the formulation, accumulation and conversion of citation clusters from the macro aspect. The scientific frontier theory further exhibits the evolution of research frontiers and their knowledge base from the micro perspective. The theory of structural holes and information foraging theory provide foundations for the explanation and forecast of the knowledge map.

With the advent of technological innovation theory, both foreign and domestic scholars have conducted a lot of fruitful researches in this field, thereby significantly promoting the production practice. With the emergence of Internet+, 5G communication and some other innovative thinking and new techniques in recent years, an upsurge of research

technological innovations have been created. In order to investigate the research progress in the technological innovation field, the paper adopted the latest visualization tool - CiteSpace III to draw knowledge maps for statistical analysis. This was based on the documents related to technical innovation between 2010 and 2014 in the Web of Science database. The paper summarized the distribution of core journals, knowledge base, scientific research focus and research frontiers in the technical innovation field in the recent five years, thus grasping the research focus and trends of technical innovation. It provides references for the scientific research in the technical innovation field.

II. DATA SOURCES AND METHODS

A. Data Sources

Data to draw the technological innovation knowledge map was mainly obtained by Subject Search. Based on the consultation from experts in the scientometrics and technological innovation field, multiple retrievals as well as reference and summary of influencing documents both at home and abroad, it was eventually determined to develop Subject Search with TS = ((technological innovation*) or (technological invention*)). The retrieved time ranged from 2010 to 2014; the retrieval time was March 25, 2015. A total of 6080 search results were obtained. The bibliographic information was exported.

After standardization process of the downloaded 6080 documents, the CiteSpace3.9 R8 software was introduced for co-citation analysis. Via screening the top 30 documents in co-citation frequency raking in each time interval, Years per Slice was set as 1 year. The structure of co-citation networks of documents published between 2010 and 2014 in the technological innovation filed was counted, as shown in Table 1.

TABLE 1 THE STRUCTURE OF CO-CITATION NETWORKS OF DOCUMENTS IN THE RESEARCH FRONTIER OF INTERNATIONAL TECHNOLOGICAL INNOVATION (2010 - 2014)

Time partition	Standard	Total number of documents/ document	The number of nodes/ node	The number of connecting lines/ line
2010-2010	Top 30	17762	30	119/433
2011-2011	Top 30	19904	30	123/429
2012-2012	Top 30	20899	30	125/430
2013-2013	Top 30	21880	30	127/432
2014-2014	Top 30	24716	30	122/435
Total		105161	150	616/2159

B. Research Methods

The paper utilized the visualization analysis software - CiteSpace III for analysis. CiteSpace III was developed by the team of Chaomei Chen (a “Yangtze River Scholars” chair professor of Dalian University of Technology; a professor of College of Information Science and Technology, Drexel University) in September 2004. It is programmed by JAVA language. This is a specialized software used to draw knowledge maps. The software is based on the citation analysis of scientometrics. Via visualized presentation of the citation analysis results, it scientifically analyzes evolution characteristics of the various disciplines with time. Meanwhile, it vividly reveals the research frontiers of the discipline development and knowledge base of the discipline emergence. Moreover, scientific researchers can discover the key evolutionary path of disciplines more easily via interpreting the knowledge map. They can clearly find out crucial node documents playing an important role (transition or leap) in the discipline development.

III ANALYSES AND LITERATURE

A. Analysis of Core Journals

The downloaded data was sorted and aggregated into a data file. Next, it was introduced into CiteSpaceIII. The attribute of Node Types was selected as Cited Journal. The attribute of Threshold Tuning was selected as Top N per Slice; it was set as 30. The other attributes were not changed. Optimizing the knowledge map display after the program running, the co-citation knowledge map (Figure 1) of journals of international technological innovation researches could be obtained.

According to Figure 1, co-citation journals of international technological innovation researches mainly include: RES POLICY, MANAGE SCI, STRATEGIC MANAGE J, ADMIN SCI QUART, AM ECON REV, ORGAN SCI, ACAD MANAGE REV, ACAD MANAGE J, IND CORP CHANGE, TECHNOVATION, TECHNOL FORECAST SOC, HARVARD BUS REV, ECON J and QJ ECON. This result is consistent with the authorative core journals in the “innovative management” field proposed by Xu Zhenliang in his doctoral dissertation in 2010. It indicates that research in the technological innovation field maintains a stable trend in development.

It is noteworthy that the co-citation frequencies of RES POLICY, MANAGE SCI, STRATEGIC MANAGE J, ADMIN SCI QUART, AM ECON REV, ORGAN SCI, ACAD MANAGE J and some other journals are prominent. The frequencies are 2098 times, 1237 times, 1232 times, 1142 times, 1114 times, 981 times and 968 times respectively. The data indicates that these journals play a pivotal role in the field of technological innovation. They are important places to publish, collect and distribute research results. Meanwhile, they are the places where scholars of technological innovation research exchange and surge their ideas. In a certain sense, these journals support the progress of technological innovation. In other words, documents published in these journals have an important impact on the progress in the technological innovation field.

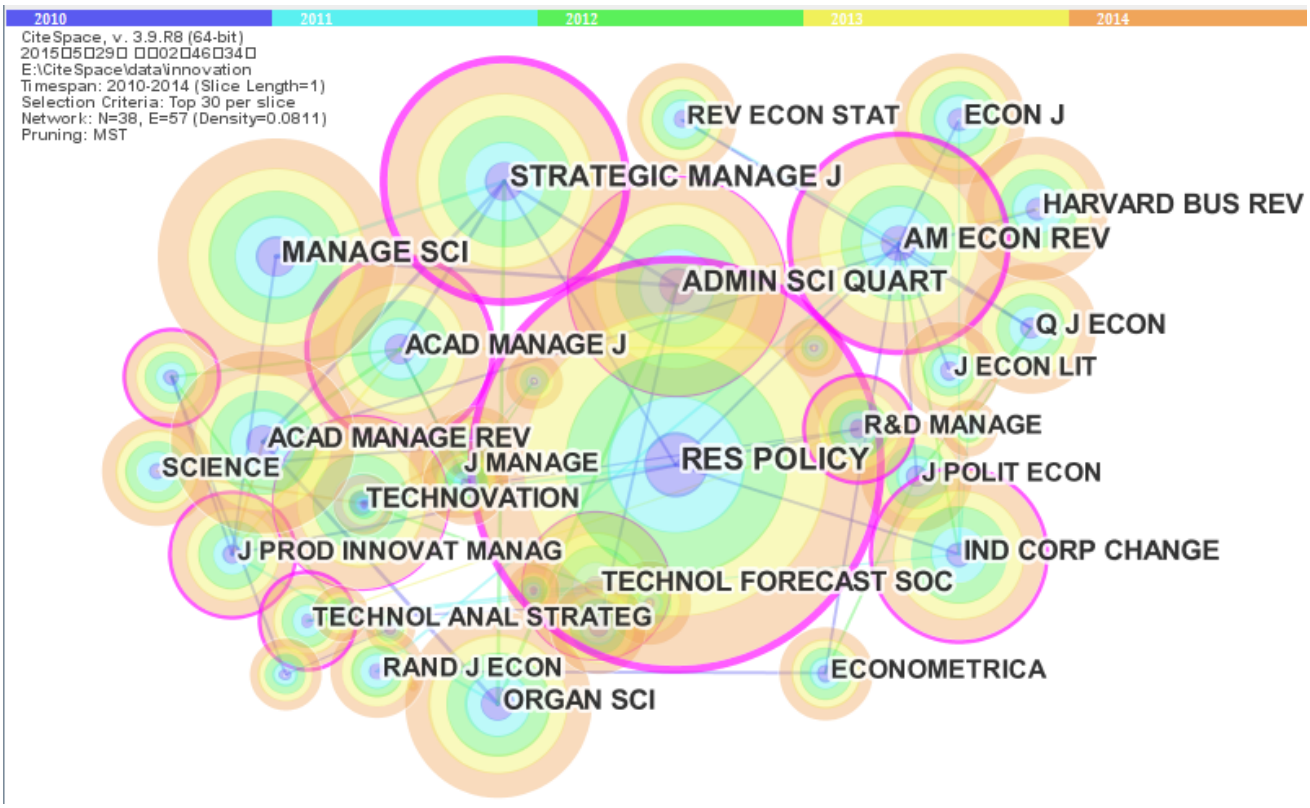

Figure 1 Co-citation of the Journals of International Technological Innovation Researches

Judging from centrality of the co-citation knowledge map of journals, the centrality of RES POLICY, STRATEGIC MANAGE J, AM ECON REV and ACAD MANAGE J is higher than that of other journals. Centrality of these four core journals reaches 0.61, 0.61, 0.52 and 0.51 respectively. According to the interpretation of the co-citation knowledge map of journals, documents published in the above journals have a larger influence. Moreover, they are of high quality. From the perspective of scientometric analysis, they are important foundations for the constitution of the technological innovation field. Meanwhile, co-citation and centrality of RES POLICY, STRATEGIC MANAGE J, AM ECON REV and ACAD MANAGE J are high. This indicates that the four journals belong to important core journals in the field of technological innovation.

B. Analysis of Important Authors

The attribute of Node Types was selected as Cited Author. The Threshold Tuning was set as 30. The other attributes were not changed. Optimizing the display after the program running, the co-citation knowledge map (Figure 2) of authors in the technological innovation field could be obtained. In the knowledge map of analysis of important authors, the author represented them with nodes; the citation frequency was reflected by the size of nodes.

It can be obtained from Figure 2: Cohen WM (653 times) was cited most frequently. Clicked on the pull-down menu "Export" and selected "Network Summary Table" to open the detailed table of node information. The top ten co-cited authors in the technological innovation field could be summarized: Cohen WM (653 times), Teece DJ (558 times), OECD (486 times), Nelson RR (463 times), Dosi G (447 times), Jaffe AB (398 times), Griliches Z (385 times), Freeman C (362 times), Eisenhardt KM (350 times) and Pavitt K (281 times). According to the centrality ranking, the top ten authors were: Cohen WM (0.60), Teece DJ (0.41), Nelson RR (0.35), Jaffe AB (0.30), Freeman C (0.29), Hall BH (0.24), OECD (0.23), Edquist C (0.22), Malerba F (0.21) and Pavitt K (0.19). Comparing the highly cited ranking and centrality ranking, we can see that there are eight authors in both ranking. This indicates that research results of these 8 authors produce a great impact. They can significantly promote the researches on technological innovation. Cohen WM, ranking first in the centrality ranking, and Levinthal made pioneering researches on the absorptive capability theory in *Absorptive Capability: A New Perspective on Learning and Innovation*. The research results played an important role in promoting the progress of the technological innovation field.

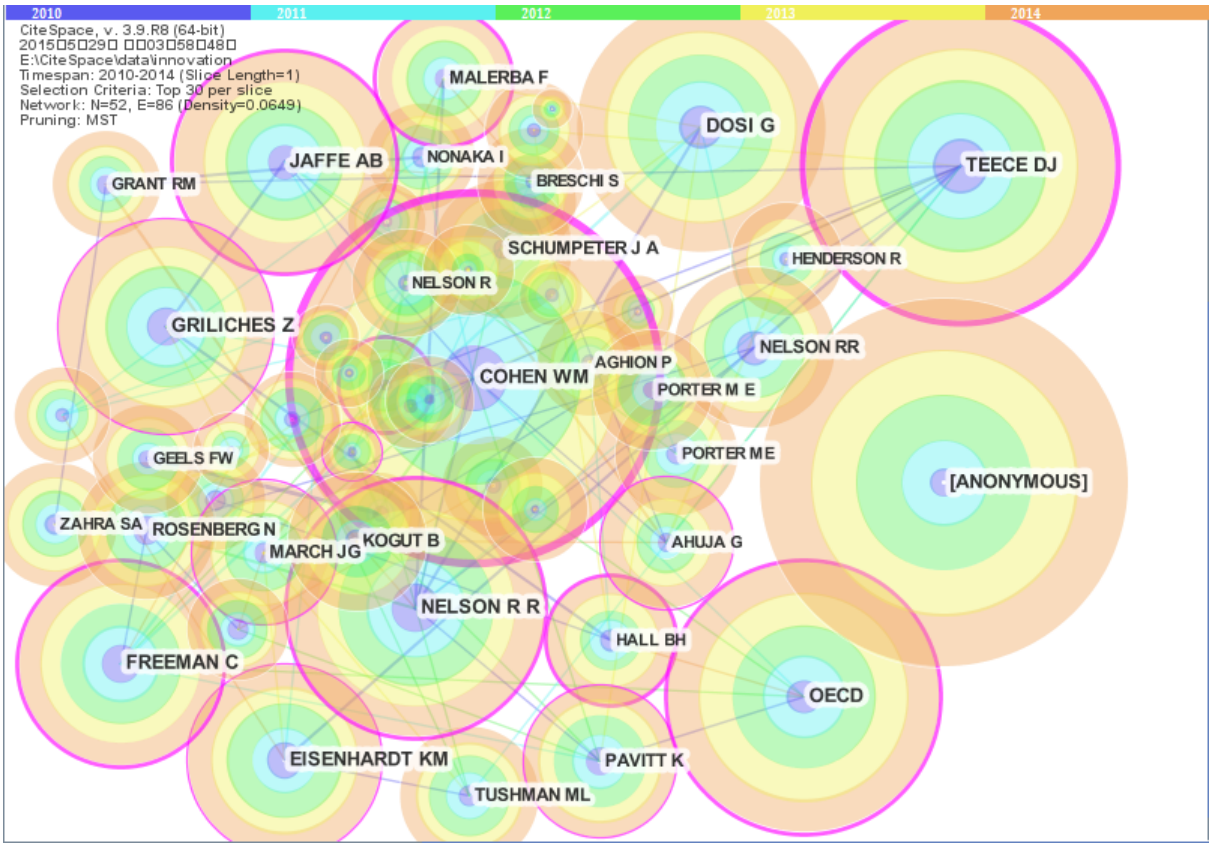

Figure 2 Co-citation of the Authors of International Technological Innovation Researches

C. Analysis of Important Documents

According to the key evolutionary path obtained from the visualized knowledge map, crucial node documents with important roles (transition or leap) in the discipline development can also be clearly found out[14].

When the data was normalized into CiteSpace III, the attribute of Node Types was selected as Cited Reference. The attribute of Threshold Tunning was selected as Top N per Slice; it was set as 30. The other attributes used the default values. Optimizing the display after the program running, the knowledge map of co-citation document was obtained. Next, the knowledge map of foundational documents was obtained via the display in Timeline. The knowledge map was saved and displayed in Cluster to get the knowledge map of core documents.

Analysis on the knowledge base of international technological innovation researches in recent five years proceeded from two aspects: foundational documents in the early stage and core documents (documents with high citation and centrality). The two aspects constitute the theoretical basis of technological innovation researches. They are the context to research technological innovations.

(1) Analysis of foundational documents. According to Figure 3, basic documents forming the technological innovation researches in the recent five years were three documents published in the 1930s and 1940s. Wherein, two documents were written by Schumpeter J A. One was the *Theory of Economic Development* [2] published in 1934. In this book, the basic concept and idea of innovation were proposed for the first time. Later, Schumpeter put forward a complete theoretical system of innovation economics in *Capitalism, Socialism and Democracy* published in 1942. Innovation economics was based on the innovation theory. It was of important theoretical guiding significance for the development of innovation researches. The third document was the *Theory of Firm Growth* published in 1959. This was written by Penrose - a professor of Johns Hopkins University. The book extended the style of Schumpeter. It analyzed corporate behaviors from the perspective of economics and obtained the internal motivations for firm growth. From the viewpoint of innovation, the maximum value of this book was: it confirmed that innovation was an important motivation for firm growth and researched how product innovation and organization innovation promoted the firm growth. Many opinions in the book are core viewpoints in economics and management. The book created a new space for researches of the technological innovation theory.

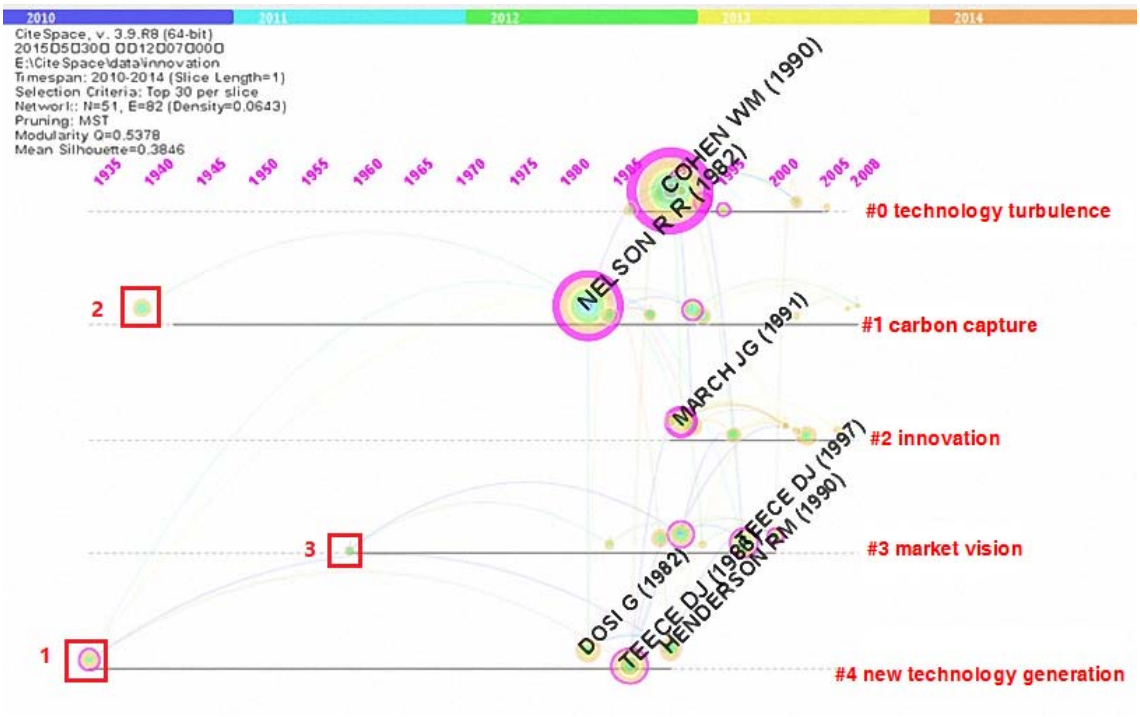

Figure 3 The Time Series and Knowledge Map of the Foundational Documents for International Technological Innovation Researches

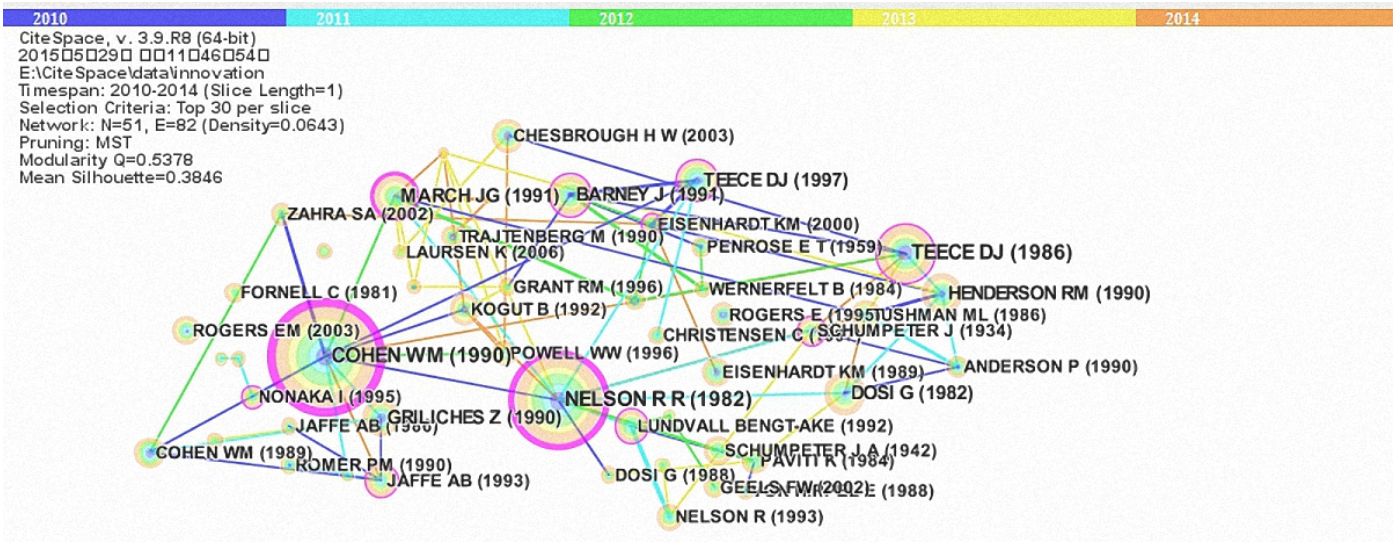

Figure 4 Knowledge Map of the Co-citation Documents of International Technological Innovation Researches

(2) Analysis of core documents. Core documents must be documents with high citation frequencies. Therefore, the analysis proceeded from this perspective. According to the knowledge map of co-citation documents - Figure 4, document with the highest citation frequency was *Absorptive Capability: A New Perspective on Learning and Innovation* written by Cohen. The paper proposed the concept of absorptive capability and broke a new ground for the future technological innovation researches. The citation frequency of *An Evolutionary Theory of Economic Change* (written by Nelson RR in 1982) ranked second. In this paper, Nelson drew a parallel between market competition and biological competition. he found a common principle between the two: the law of the jungle, namely, only the strong will survive. Therefore, to maintain competitive advantages and remain invincible, enterprises should insist on innovation and characterize Schumpeterian competition as innovation-centered competition, so as to lift innovation to a new level in

corporate functions. Document with the third highest citation frequency was *Technological Innovation Profits: Connotations of Integration, Collaboration, Permission and Public Policies* published in 1986. This paper mainly discussed a strange phenomenon in the innovation of individual enterprises: "some enterprises fail to gain profits from innovation activities. Nevertheless, simulators and customers can be benefited." Teece DJ deemed that integration and collaboration were important reasons for this phenomenon. He pointed out: innovators of new products and techniques able to provide customer values failed because of improper market positioning. In order to verify his theory, Teece DJ conducted in-depth researches on innovation in the manufacturing industry. The following conclusions were drawn: innovation was not everything. It also required certain conditions. For example, without solid industrial base, blind innovation was bound to fail. Meanwhile, he pointed out that policy environment of the domestic policy, economy, society and technology also had a significant impact on the success of innovation. These research results negatived the Omnipotence of Innovation and Nonconditional Innovation. They were of great practical significance to technological innovations. Technological Paradigms and Technological Trajectories of Dosig (1982) ranked fourth. The greatest contribution of this book was that it firstly defined "technological paradigm" and "technological trajectory". Moreover, it utilized the two definitions to explain the difference between continuous technologies and discontinuous technologies. The book indicated: "such difference is caused by the innovation process and market force. The finial products of mutual influence among technological development, economic prosperity, government policy and technology path are new paradigms." This paper provided a completely new perspective for technological innovation researches. It played an important role in promoting. It was one of the foundational documents in the technological innovation field. Document with the fifth citation frequency was *Dynamic Capability and Strategy Management* of Teece DJ (1997). In this paper, the author constructed a system to analyze the dynamic capabilities of private enterprises in the complex environment with rapidly changed technologies. This system emphasized on how private enterprises seized the source of wealth and obtained greater competitive advantages.

In terms of the centrality ranking, *Absorptive Capability: A New Perspective on Learning and Innovation* of Cohen WM published in the Administrative Science Quarterly in the late 20th century ranked first. The centrality was 0.69. The document ranking second was *An Evolutionary Therory of Economic Change* of Nelson RR (1982), with the centrality of 0.58. As for the document ranking third, it was *Exploration and Exploitation in Organizational Learning* of March JG (published in Organization Science in 1991). Its centrality was 0.29. *Technological Innovation Profits: Connotations of Integration, Collaboration, Permission and Public Policies* of Teece DJ, whose centrality was 0.20, ranked forth. The paper was published in the 1980s. The No. 5 document was *National Innovation System* written by Lundvall Bengt-Akel - a professor of the Aalborg University. The paper was published in 1992, with the centrality of 0.19

D. Analysis of the Research Focus

The downloaded data was imported to CiteSpaceIII. The attributes of Node Types and Threshold Tunning were selected as Keyword and Top N per Slice respectively. Top N per Slice was set as 30. The other attributes used fault values. As a result, the knowledge map (Figure 5) of research focus in the technological innovation field could be obtained. The ring type figure could convey more information. For example, in Figure 5, the citation of keywords was exhibited with the annual ring structure of nodes in the knowledge map. The years were represented in different colors. The years form far and near were presented by the changing colors from blue to red (from cold colors to warm colors). Contrasting them to the timeline in the knowledge map, the specific year could be identified. Size of the annual ring indicated the citation frequency of the concept. The bigger the annual ring was, the higher the citation frequency was, and vice versa. Therefore, radius (note: it's not area of the node. This is also a difference between CiteSpace and Pajek and UciNet) of a node should correspond to the total citation times of the node. Nodes marked by purple cycles had relatively great centrality (no less than 0.1).

With regard to the analysis on research focus in the technological innovation field, it was mainly carried out on the basis of occurrence frequency of keywords. This method was based on the following facts: keywords are the core of a paper. They are the highly summarized and condensed research objects and methods of a paper[15].

TABLE 2 CITED KEYWORDS RANKING THE TOP TWENTY IN LAST FIVE YEARS

Citation frequency	Centrality	Keywords	Citation frequency	Centrality	Keywords
1542	0.31	innovation	257	0	technological innovation
545	0.23	performance	241	0	systems
534	0.16	research-and-development	238	0	perspective
395	0	technology	222	0	policy
354	0.01	knowledge	221	0.05	absorptive-capacity
350	0.11	industry	196	0	technological-change
288	0	model	195	0	diffusion
287	0	management	187	0.01	technological-innovation
275	0	firms	163		determinants
258	0.07	growth	163		capabilities

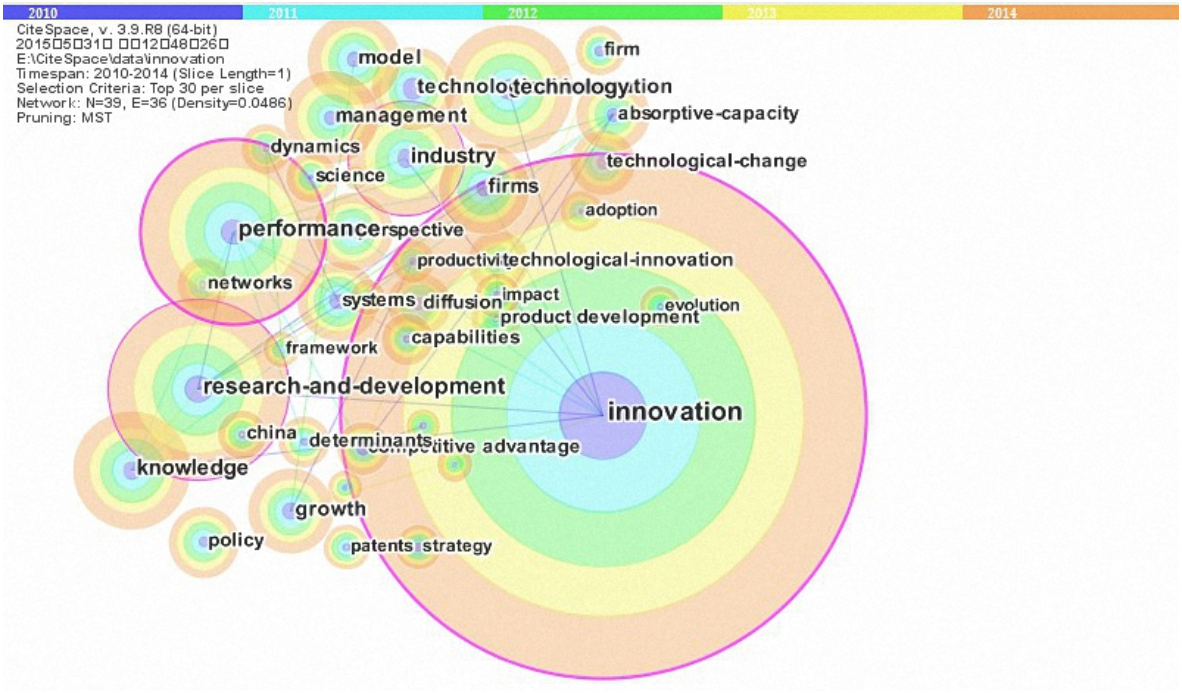

Figure 5 Knowledge Map of the Research Focus of International Technological Innovations

According to the statistic analysis on the keywords of documents in the technological innovation field in the last five years, keyword with the highest frequency was innovation. It reached 1542 times. Cited keywords ranking the top twenty were shown in Table 2. These keywords indicated: research focus of the international technological innovation field mainly focused on innovation, performance, research and development, technology, knowledge, model, industry, enterprise, growth, absorptive capability and some other aspects. Moreover, it demonstrated the diversification and empirical-focused characteristics of technological innovation researches.

Performing clustering analysis on high-frequency keywords (Figure 6), five categories of the technological innovation field could be obtained: technological turbulence, carbon capture, innovation, market vision and new technology generation. The five categories separately represented the specific research focuses in the technological innovation field in the recent five years.

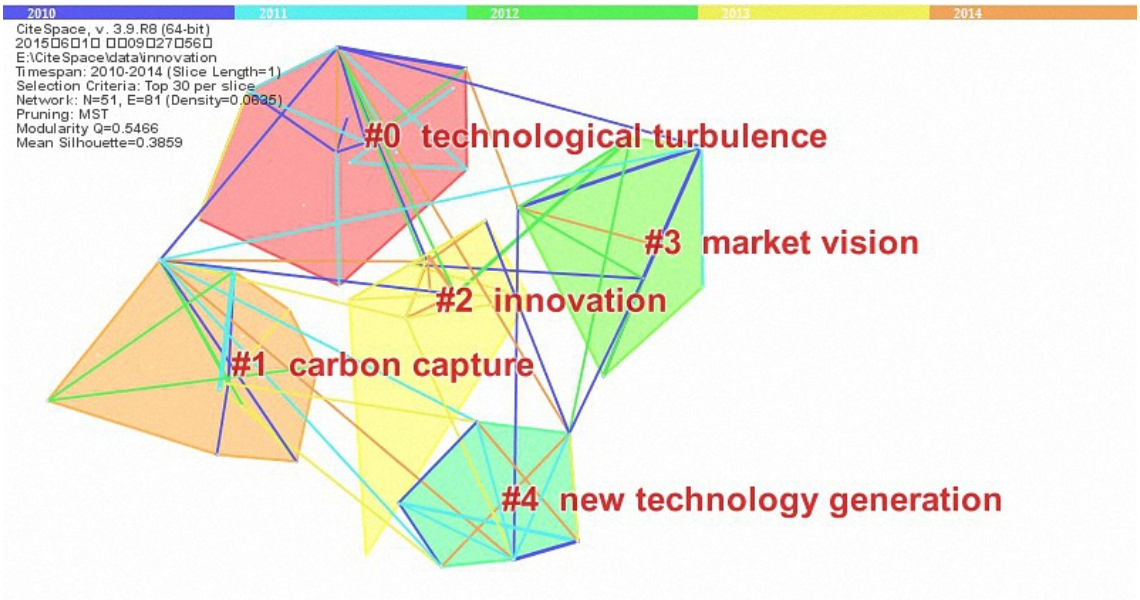

Figure 6 Clustering View of the Research Focus of International Technology Innovations

E. Analysis of Research Frontiers

From the viewpoint of scientometrics, research frontiers are temporary components of scientific documents in a certain field of science[16]. They are unstable. They may either become classical documents or disappear after a long time. We can not easily determine whether they have long-term values.

In CiteSpace III, research frontiers of a discipline were manifested as emerging source document groups. They reflected the characteristics of research frontiers from two perspectives: the main body to describe the viewpoint and references. Specifically, research frontiers were embodied by documents forming the co-citation matrix and highlighted words or highlighted word clusters used in the source documents. Based on this, research frontiers in the technological innovation field could be explored through the mutations of keywords.

The downloaded and standardized data was imported to CiteSpace III. The attributes of Node Types, Term Type and Threshold Tunning were selected as Keyword, Burst Terms and Top N per Slice respectively. Top N per Slice was set as 30. The other attributes remained unchanged. Ran CiteSpace III and displayed the knowledge map in Timezone. The knowledge map (Figure 9) of technological innovation research frontiers could be obtained after optimizing the display.

The paper explored frontier issues occupying important positions in the international technological innovation field in the recent five years. In the paper, identifying words with the maximum weight value were selected from the five clusters of the knowledge map of technological innovation researches. The larger the weight value was, the more influential the field represented by this identifying word was. In the analysis, it was important to combine with the source documents. Wherein, the cluster # 1 contained a total of 222 nodes. It was the cluster with the most nodes among all the clustering results (# 0 contained 214 nodes; # 2 contained 139 nodes; # 3 contained 175 nodes; # 4 contained 192 nodes). Analyzing the clustering identifying words obtained from TF * IDF and LLR, such cluster was mainly research subject related to technological innovation strategies, including the flexible strategy, knowledge absorptive capability, technological innovation, development cooperation and innovation output. Research subjects of # 0 were relatively concentrated. Keywords obtained from TF * IDF included product innovation, success, project complexity, information technology, system innovation and novelty. Judging from these keywords, # 0 was mainly the research related to the complexity of technological turbulence and product innovation, information technology and system innovation. Compared to # 1, # 2, # 3 and # 4 had fewer nodes. In general, however, they had relatively high outline values. This indicated that they had relatively concentrated research frontiers. With regard to # 2, the keywords obtained from TF * IDF included: technological innovation activity; quantitative approach; introduction; research partnership. Keywords obtained from LLR covered: technological innovation activity; regional innovation systems; technology. According to these keywords, the research frontier of # 2 was mainly innovation of corporate activities and regions. In terms of # 3, keywords obtained from TF * IDF were as follows: technological innovation system; automotive fuel; formative stage; innovation modeling comparison project;

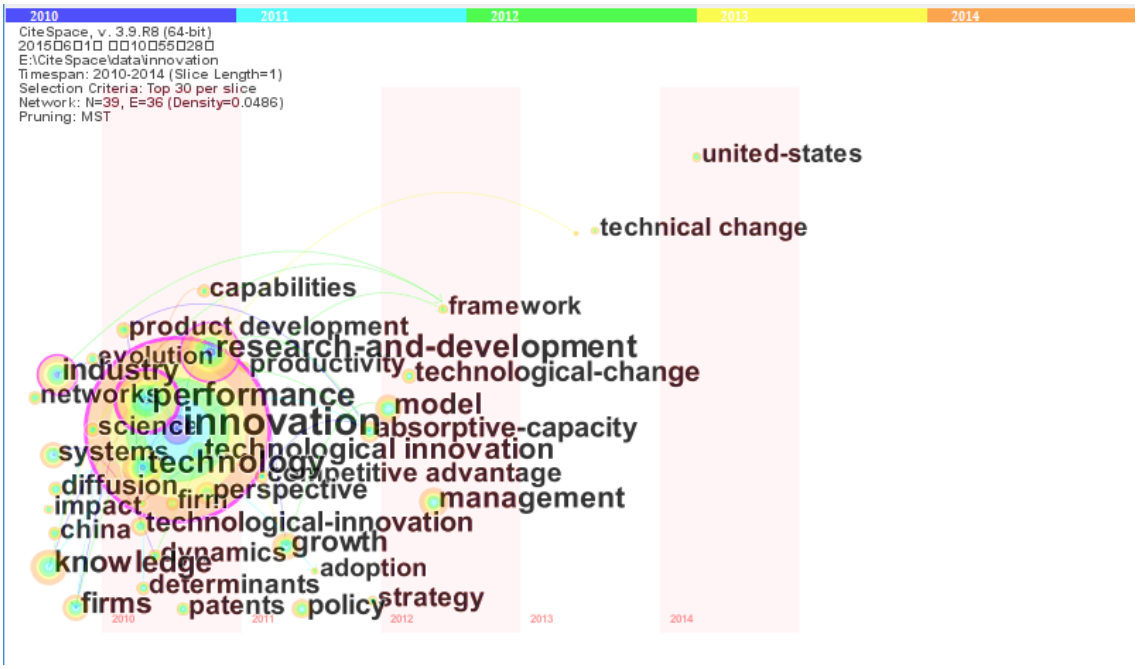

Figure 7 Knowledge Map of the Research Frontiers of International Technological Innovations

technological change; technological innovation system development. Keywords obtained from LLR were shown below: comparing systems approach; complementarily; innovation modeling comparison project; explorative study. Based on these, the research frontiers of # 3 could be summarized: changes of innovation models and technologies; technology innovation system. As for # 4, keywords obtained from TF * IDF were included: innovation diffusion theory; collaboration technology evaluation; organizational conscience; labor; collaboration. The keywords obtained from LLR were listed below: innovation diffusion theory; organization conscience; formation. Therefore, research frontiers of # 4 were mainly innovation diffusion theory and collaboration technology evaluation. From the analysis of the above clustering results, the international technological innovation has formed a complete technological innovation chain (including knowledge, research and development, product, diffusion and evaluation). The chain is based on the combination of the organization theory and the theory of economic evolution. Moreover, it takes the technological innovation system as the condition and regards enterprises and their alliances as the subjects. Researches on organization-related issues have become the knowledge base of technological innovation. For example, such issues include the influence of the interaction between organizational innovation and technological innovation, network embeddedness and network characteristics on the innovation of organizational technologies. The technological innovation system, innovation model and technological innovation are not merely the research frontiers of technological innovation. They are also important foundations for the technological innovation practice. In addition to the above contents, influence of the search of innovation knowledge and heterogeneity of corporate knowledge on innovation, innovation diffusion theory and collaborative innovation are also important frontier issues of the current technological innovation researches.

IV. CONCLUSION

Based on the Keyword Search method, this paper retrieved documents related to technological innovation researches between 2010 and 2014 in SCI, SSCI and some other databases of Web of Science. It carried out information visualization analysis on the retrieved documents with the visualization tool - CiteSpace III. According to the knowledge map of technological innovation researches, core journals, authors, knowledge base, research focus and research frontiers in this field were exhibited. Moreover, the following conclusions were drawn:

(1) Via visualization analysis on the knowledge map on journals with certain international influence included in Web of Science, the directory of authoritative journals with a significant impact in the technological innovation field was determined. Furthermore, according to the analysis from the perspective of co-citation and centrality, RES POLICY, STRATEGIC MANAGE J, AM ECON REV and ACAD MANAGE J were journals with both high citation and high centrality. This indicated that the four journals were authoritative periodicals in the field of technological innovation.

(2) On the basis of the analysis of important authors and documents, the author summarized the co-citation ranking of documents in the technological innovation field published between 2010 and 2014. This provided guidance for researchers in the technological innovation field to read documents. Moreover, the important co-citation documents in this field in the recent five years were analyzed through the analysis on foundational and core documents. The author summarized foundational documents and central documents with great influence in the technological innovation field between 2010 and 2014.

(3) Based on the interpretation of the knowledge map formed by clustering analysis on keywords of documents in the international technological innovation field in the recent five years, the author summarized the research focus and frontiers in this field. The technological innovation researches had formed technological turbulence, carbon capture, innovation, market vision and new technology generation. Via the scientometric analysis on international technological innovation researches in the recent five years, the frontier issues of international technological innovations were obtained: technological innovation strategy (flexible strategy, knowledge absorptive capability, technological innovation, development cooperation and innovation output); product innovation (mainly the complexity of technological turbulence and product innovation, information technology and system innovation); innovation of corporate technological innovation activities and regions, knowledge management (patent protection) and research subjects related to innovation strategies, including the flexible strategy, knowledge absorptive capability, technological innovation, development cooperation, innovation output, etc. Meanwhile, a certain amount of researches were developed in the aspects listed below: complexity of technological turbulence and product innovation, information technology and system innovation, innovation of corporate technological innovation activities and regions, environmental policies and sustainable development, innovation networks and technology upgrades, diffusion theory and collaboration technology evaluation, etc.

(4) Technological innovation researches were gradually integrated and mixed with the related disciplines and theories. They have shown a trend of diversified development. In the research field of international technological innovations, technological innovation has become a hot issue of business survival and economic development. It has risen to the level of enterprise development strategies and got involved in all aspects of business management. Documents about empirical researches in the field of technological innovation are increasing year by year.

This paper only conducted analysis and preliminary exploration on the documents in the international

technological innovation field in the recent five years. More issues need further researches. For example, although the international technological innovation focus has been summarized, what is the research focus of domestic technological innovations? Is it in line with that of the international technological innovations? If there is difference, what is this phenomenon caused by? We expect that the academic peers can carry out more researches to enrich the research results of technological innovations. Let's work together to discover this gold mine of scientific knowledge maps!

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