Research on Synergistic Directions and Characteristics of Basic Research and Technological Innovation: A Case Study of the New Electronic Components Field (Postprint)

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Abstract

[Purpose/Significance] Based on the content of scientific and technological research, this study explores the collaborative directions and characteristics between basic research and technological innovation, providing reference for future collaborative development strategies between basic research and technological innovation in the field.

[Method/Process] First, the field's research development system is investigated, and an intermediate classification axis for the field is constructed to connect the content of basic research and technological innovation. Second, research directions in basic research and technological innovation are identified through literature content clustering, and quantitative evaluation methods are used to classify these directions into three development states: hotspot directions, rapid development, and slow development. Finally, based on these development states, the collaborative characteristics between basic research and technological innovation are summarized and applied to empirical analysis in the field of new electronic components.

[Results/Conclusions] The analysis of collaborative directions between basic research and technological innovation in the field of new electronic components is achieved under a research method combining content mining and quantitative evaluation. At a finer-grained research direction level, it clearly demonstrates the possible collaborative states between basic research and technological innovation, and based on their collaborative characteristics, provides specific guidance for the development of collaborative directions in this field.

Full Text

Preamble

Research on Collaborative Directions and Characteristics of Basic Research and Technological Innovation: A Case Study of New Electronic Components

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Abstract:
[Purpose/Significance] Starting from the content of science and technology research, this paper explores the collaborative directions and characteristics between basic research and technological innovation, providing references for future collaborative development strategies in the field. [Method/Process] First, we investigate the field's research and development system to construct an intermediate classification axis linking basic research and technological innovation content. Next, we mine basic research directions and technological innovation directions through literature content clustering, and use quantitative evaluation methods to classify these directions into three development states: hotspot directions, rapid development, and slow development. Finally, based on these development states, we summarize the collaborative characteristics of basic research and technological innovation, and apply them to empirical analysis in the new electronic components field. [Result/Conclusion] We achieve collaborative direction analysis of basic research and technological innovation in the new electronic components field under a combined research method of content mining and quantitative evaluation. At the finer-grained research direction level, we clearly display possible collaborative states between basic research and technological innovation, and provide specific guidance for collaborative direction development in this field based on these characteristics.

Keywords: basic research; technological innovation; science-technology collaboration; collaborative characteristics; collaborative development
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The 19th National Congress report emphasizes the need to target world science and technology frontiers, strengthen basic research, and achieve major breakthroughs in forward-looking basic research and leading original achievements. It also calls for strengthening applied basic research, expanding national major science and technology projects, and highlighting key common technologies, frontier leading technologies, modern engineering technologies, and disruptive technological innovations. Basic research and technological innovation are two important sources of scientific and technological development and social progress, forming an organic integration of interwoven and mutually reinforcing relationships [1]. Their interaction is the key to innovation and jointly determines the quality, efficiency, and direction of scientific and technological innovation [2]. Many scholars have demonstrated that basic research and technological innovation are closely related—for instance, breakthroughs in scientific principles may trigger solutions to key problems in technology development, while modern basic research and technological development are increasingly interdependent, with technological inventions providing more advanced conditions and more comprehensive research perspectives for basic research [3].

1 Related Research Progress

Scholars both domestically and internationally have primarily examined the relationship between basic research and technological innovation in three aspects. First, the most common approach uses citation analysis to measure their connection. Researchers typically use papers to represent basic research and patents to represent technological innovation [4-5], examining cross-citations between papers and patents to explore their correlation. Regarding paper-to-patent citations, W. Glänzel et al. [6] analyzed paper citation of patents and found that chemistry-related subfields tend to cite patents more than other scientific fields, indicating relatively higher technological relevance. M. Meyer et al. [7] investigated paper-to-patent citations in nanoscience and found that academic papers with patent references are more likely to be cited by other papers. Wu Feifei et al. [8] used statistical and network analysis of paper-to-patent and patent-to-paper citations to identify central science and technology domains in the network. Regarding patent-to-paper citations, S. Lo et al. [9] studied non-patent references in genetic engineering patents and found that important knowledge resources from basic research significantly influence technological development. Bai Guangzu et al. [10] examined academic paper citations in core patents of a field to identify the basic research knowledge base supporting core patent technologies. H. Y. Yeh et al. [11] attempted to set bibliographic coupling thresholds to filter irrelevant patent citations and construct patent citation networks to explore the significance of scientific paper citations in electric vehicle technology.

Regarding mutual paper-patent citations, simultaneously examining both directions provides a more comprehensive understanding of knowledge flow between basic research and invention. For example, M. H. Huang et al. [12] analyzed cross-citations between papers and patents in fuel cell fields, revealing convergence between basic research and technological development. Zhang Xue et al. [13] explored the relationship between basic research and technological innovation in synthetic biology through cross-citation analysis of papers and patents. Gao Jiping et al. [14] used co-citation analysis of papers and patents to discover knowledge flow between science and technology.

Additionally, some scholars have explored the basic research-technological innovation relationship through "inventor-academic researcher" dual identities. For instance, G. B. Wang et al. [15] found that academic inventors achieve higher performance than pure inventors, indirectly demonstrating that close integration of basic research and technological development knowledge leads to higher innovation efficiency. Some scholars have examined relationships through institutional linkages and collaborations between academic and technology development institutions. For example, S. Bhattacharya et al. [16] mined association rules and cooperation patterns between basic research institutions and technological innovation institutions in geographical space, finding that basic research plays a crucial role in multinational corporations' technological innovation activities. Others have explored the relationship through topic or classification mapping analysis, such as Lai Yuangen [17], who studied the mapping relationship between the patent IPC classification system and the Chinese Library Classification system in academic papers to examine knowledge flow between basic scientific research and technological innovation.

Overall, current research on basic research-technological innovation linkages features more macro-level quantitative statistical analysis but less content-based collaborative direction research. Li Rui et al. [18] argue that existing science-technology linkage classification mapping is too coarse to clearly reveal the relationship landscape. Dong Kun et al. [2] suggest that more attention should be paid to revealing micro-level associations between basic research and technology from textual content, with enhanced practical application value. This study starts from knowledge content, maps connections at finer-grained research direction levels, explores collaborative characteristics and significance of basic research and technological innovation directions, and provides practical references for field-specific scientific and technological practice and future innovation development. Compared with H. Y. Xu et al. [19], who used co-word links, co-author links, and co-citation links to explore connections between scientific and technological themes, this research constructs an intermediate classification axis linking basic research discoveries and technological innovation directions, focusing on quantifying the dynamic development states of both sides within the same timeframe to quantitatively describe collaborative patterns and characteristics.

2 Research Framework and Methods

2.1 Theoretical Foundation

The discovery of the DNA double helix structure represents a major milestone in humanity's quest for truth. Collaborative innovation based on the double helix theory from biology is a widely recognized effective collaborative form and structure [20]. This theory has been broadly applied to explain the collaborative patterns formed by science and technology during innovation development. Coupling phenomena describe the intersection or association formed by two or more interacting information resources, reflecting the collaborative state between knowledge elements through common characteristic intersections. S. Yayavaram et al. [21] note that in dynamic technological environments, coupling between knowledge elements can reflect their collaborative development.

Based on the double helix theory of science and technology and knowledge coupling theory, we view basic research-technological innovation collaboration as a process of knowledge element aggregation, interaction, and integration. Knowledge elements transfer, share, recombine, and utilize between both sides, enabling them to form interactive effects through coordination and cooperation, promoting spiral knowledge value addition [22]. Specifically, this study focuses on collaborative patterns that emerge during the mutual pulling or pushing process of basic research progress and technological innovation development, presenting bidirectional driving coordination relationships and exhibiting possible collaborative states such as co-progression, driving, complementarity, and constraint. Collaborative characteristics refer to the various overall effects formed through the coupling of bilateral collaborative associations, providing guidance for future coordinated efforts, collaborative directions, and collaborative order.

2.2 Research Framework

Among numerous scientific and technological achievements, scientific papers are the richest academic research outcomes, addressing "what" and "why" questions and serving as important carriers of fundamental scientific knowledge. Patents are the richest outcomes containing technological development information, addressing "how" questions and serving as important carriers of human technological innovation. This study uses papers to represent basic research in scientific knowledge and patents to represent technological innovation in technical activities, exploring collaboration between them. The scope of basic research and technological innovation outcomes in this study has certain limitations, being preliminarily divided only by research achievement type without more precise definition.

This research uses the internal knowledge bridge between basic research and technological innovation as a link. By constructing an intermediate classification system from a meso perspective for different intellectual property achievements (including papers and patents) in the same field, we conduct literature clustering and evaluation for basic research directions (represented by papers) and technological innovation directions (represented by patents). Based on clustering directions and their development states, we conduct linkage mapping, analyze the resulting collaborative directions and characteristics, and elaborate their guiding significance for future field development. The research framework is shown in Figure 1 [Figure 1: see original paper].

2.3 Research Methods

2.3.1 Intermediate Classification Axis Based on the selected research field, we investigate relevant national development policies, plans, industry organizational research systems, and classification standards for basic research and technological innovation. We summarize the field's first-level classification system and further investigate development conditions of both aspects under this system, conducting second-level classification discussions with field experts. The intermediate classification axis refers to a field classification system developed through comprehensive investigation and expert consultation according to field needs, linking basic research (scientific papers) and technological innovation (patent literature) at a relatively fine-grained classification level. The intermediate classification axis comprehensively examines field development directions, integrates expert opinions, and uses fine-grained classification levels to formulate search themes, linking scientific papers and patent literature through the same theme to objectively and accurately connect both sides of field basic research and technological innovation.

2.3.2 Basic Research Direction Mining and Evaluation Literature coupling clustering, co-citation clustering, and direct citation clustering can all be used for research direction analysis. As related literature [23] indicates that bibliographic coupling analysis yields the highest internal document similarity within research themes and produces the best clustering effect, this study uses literature citation coupling relationships for text clustering to obtain optimal document clusters. We summarize themes to represent basic research directions. Referring to relevant research direction evaluation studies [24-26], we establish an evaluation index system for basic research directions, primarily assessing three aspects: novelty, growth, and attention. The evaluation index system is shown in Table 1 .

First, research direction novelty is represented by index (X), measured by the average publication year of literature in that direction, as shown in Formula (1):

$$X = \Sigma(y \cdot n_y)/N$$

where y represents the year, N is the total number of publications in the research direction, and n__y is the number of publications in year y.

Second, research direction growth is represented by index (Z), measured by paper growth rate. Under observation time window Δt, the growth degree of a research direction is shown in Formula (2):

$$Z_{i,\Delta t} = \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}} \cdot 100\%$$

where P__i,t represents the number of publications of research direction i in year t, P__i,t+1 represents the number in year t+1, and N__t represents the year interval. P__i,t is smoothed to reduce time factor effects.

Third, research direction attention is represented by index (G), comprehensively considering the average number of papers in the recent three years (P), annual citation frequency (C), and number of authors publishing in the direction (A), as shown in Formula (3):

$$G = W_{1P} + W_{2C} + W_{3A}$$

The entropy weight method determines secondary index weights for attention. Information entropy and index weight calculations are shown in Formulas (4) and (5):

$$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} P_{ij} \ln P_{ij}$$

$$W_i = (1 - E_i)/(K - \sum_i E_i)$$

In Formula (4), P_{ij} = Y_{ij} / Σ_i Y_{ij}. If P_{ij} = 0, then lim_{P_{ij}$→$0} P_{ij} ln P_{ij} = 0. Based on the information entropy formula, we calculate the information entropy E_1, E_2…E_K of each index. In Formula (5), i = (1, 2, 3).

2.3.3 Technological Innovation Direction Mining and Evaluation Based on the investigated intermediate classification axis, we conduct patent map clustering analysis on invention patent data and summarize thematic content of clustered patent documents to represent technological innovation directions. Referring to relevant technology direction evaluation studies [27-28], we evaluate technological innovation directions from three aspects: novelty, growth, and attention. The specific evaluation index system is shown in Table 2 .

First, technology direction novelty is represented by (C), determined jointly by the average patent application time (T) and average remaining protection period (S) of the technology direction. A more recent average application time and longer average remaining protection period indicate higher technology novelty. The calculation formulas are:

$$T = \sum_i Y_i \cdot N_i / \sum_i N_i$$

$$S = (20 \cdot 365 - D)/365$$

$$C = W_{1T} + W_{2S}$$

In Formula (6), N_i represents the number of patent applications in year i, Y_i represents the application year, and i = 2010, 2011, … 2019. In Formula (7), D represents the number of protection days elapsed as of March 31, 2020. In Formula (8), W_1 and W_2 are index weights determined through the entropy weight method in Formulas (4) and (5).

Second, technology direction growth is represented by the average patent growth rate (V). Higher average growth rate indicates higher technology growth, as shown in Formula (9):

$$V = \sum_i (M_i - M_{i-1})/M_{i-1}/5$$

In Formula (9), M_i represents the number of patent applications in year i. Due to patent examination and publication time effects, i = 2013, 2014, 2015, 2016, 2017.

Third, technology direction attention is represented by the applicant growth rate (A) in that direction. Rapid increase in applicants indicates rising attention, as shown in Formula (10):

$$A = (\sum_i P_i - \sum_j P_j)/\sum_j P_j$$

In Formula (10), P_i represents the number of applicants in year i, and P_j represents the number in year j. Due to obvious short-term applicant entry/exit fluctuations and time accumulation for patent output, i = 2014, 2015, 2016, 2017; j = 2010, 2011, 2012, 2013.

2.3.4 Collaborative Characteristics of Basic Research and Technological Innovation In field topic research, most studies focus on research frontiers or emerging topic mining, only attending to the fastest-developing parts while ignoring most field content. This study examines the overall field panorama, using quartiles (Q1, Q2, Q3) of the three indicators (novelty, growth, attention) to evaluate development states of basic research and technological innovation directions linked by the intermediate classification axis, classifying them into three states: hotspot direction, rapid development, and slow development. The first quartile (Q1) equals the 25th percentile value; the second quartile (Q2) equals the 50th percentile; and the third quartile (Q3) equals the 75th percentile. Current research topic evaluation, whether single-index [29-30] or multi-index methods [31-32], generally considers content falling within a set TOP threshold range as research frontiers or emerging topics. Following existing research and considering that quartiles can better assess data distribution and concentration trends without being affected by absolute indicator values, we establish the determination conditions shown in Table 3 .

Referencing Dong Kun et al.'s [2] summary of science-technology interaction patterns, this study's basic research and technological innovation development states form nine collaborative patterns exhibiting five collaborative characteristics (see Table 4). Characteristic indicates both basic and technological innovation directions are hotspots, showing vigorous collaborative development.

Characteristic indicates basic research receives significant attention and development while technological innovation lags, showing a state where science potentially drives technology. Characteristic indicates technological innovation receives significant attention while basic research lags, showing a state where technology potentially drives science. Characteristic indicates neither side is hot, but at least one is rapidly rising, showing synchronous collaborative ascent. Characteristic indicates both sides develop slowly, showing a state where both science and technology face obstacles. Different collaborative characteristics provide different guidance for future field development.

3 Empirical Field Analysis

This study examines the new electronic components field in the electronic information industry. New electronic components constitute a knowledge- and technology-intensive industry with high R&D investment and technological risk. Located midstream in the industrial chain between complete electronic equipment and raw materials, their development speed, technical level, and production scale directly affect the entire electronic information industry's development and are significant for advancing information technology, transforming traditional industries, improving modern equipment levels, and promoting scientific progress.

3.1 Data Sources

We collected scientific paper and patent data in the new electronic components field, using papers to reflect basic research and patents to reflect technological innovation. First, through comprehensive investigation and expert consultation, we obtained the intermediate classification axis for new electronic components, including eight fine-grained categories: basic passive components, frequency selection and control components, power semiconductor devices, sensitive components and sensors, flat panel display devices, new energy storage devices, new materials and devices, and comprehensive technology research. Second, based on this axis, we retrieved paper data from the SCI database (132,016 papers from 2010-2019) and patent data from the Incopat database of IncoPat Group (513,235 patent applications over ten years). Paper retrieval primarily used keywords and WOS categories, while patent retrieval used keywords and IPC classification codes. Due to lengthy retrieval formulas, Figure 2 [Figure 2: see original paper] shows a partial screenshot. To ensure data accuracy and comprehensiveness, we conducted retrieval completeness and accuracy assessments for each of the eight branches using important applicants and domestic/foreign patent data, alternating between verification and retrieval to avoid mutual interference.

3.2 Analysis Results

3.2.1 Development Status of Basic and Technological Innovation Directions Based on paper data, we mined basic research directions in new electronic components. Due to massive data volume, we used Python to cluster 132,016 papers based on bibliographic coupling relationships. By adjusting clustering coefficients, we finally selected 256 document clusters with over 100 papers each (accounting for about 80% of total papers) for topic summarization, representing basic research directions. We then evaluated their development status by calculating novelty, growth, and attention indicators. Due to space limitations, Table 5 shows 20 research directions.

Based on patent data, we mined technological innovation directions. Using the intermediate classification axis, we conducted patent map clustering analysis for each category, summarizing 39 main technological innovation categories representing 39 technological innovation directions. Table 6 shows indicators for 20 directions.

3.2.2 Linkage and Collaboration Between Directions We calculated quartile values for novelty, growth, and attention indicators of 256 basic research directions and 39 technological innovation directions (see Table 7). Based on these quartiles, we determined development states, classifying both basic research and technological innovation directions into hotspot, rapid development, and slow development categories. The new electronic components field has 55 hotspot, 114 rapid development, and 87 slow development directions in basic research; and 10 hotspot, 13 rapid development, and 14 slow development directions in technological innovation. Field experts validated these classifications, confirming the results.

Based on the intermediate classification axis, we mapped basic research and technological innovation linkages. Due to space limitations, Table 8 shows partial mapping results.

3.3 Results Discussion

Based on the intermediate classification axis, we mapped collaborative relationships between basic research and technological innovation directions. The power semiconductor devices, basic passive components, frequency selection and control components, new energy storage devices, flat panel display devices, and new materials and devices fields all include hotspot, rapid development, and slow development directions in both basic research and technological innovation, exhibiting all five collaborative characteristics. The sensitive components and sensors field lacks slow development directions in technological innovation, thus showing four characteristics (, , ,). The comprehensive technology research field only contains rapid development directions (currently mainly terahertz research), thus showing two characteristics (,). Due to space limitations, we discuss partial directions under each characteristic.

Characteristic indicates vigorous science and technology innovation development, clearly revealing hotspots on both sides. Based on this feature, we should both accelerate exploration of basic science knowledge hotspots to achieve important scientific progress and emphasize invention and creation in technological directions for major technological breakthroughs. Additionally, we should focus on hotspot conversion between basic research and technological innovation to ensure comprehensive intellectual property layout and protection, securing competitive advantages. For example, in power semiconductor devices, both transistor basic research and technological innovation are hotspots. We should accelerate basic research on "MoS2 field-effect transistors" and "two-dimensional material transistors" while emphasizing invention creation and early patent protection. Simultaneously, we should accelerate technological innovation in "power bipolar transistors," especially the currently hot insulated-gate bipolar transistor technology, and explore basic principles during innovation to advance transistor basic research.

Characteristic indicates basic research develops faster than technological innovation, showing science's potential to drive technology. Based on this feature, we should strengthen guidance and application of cutting-edge theories and methods from basic research in technological development to drive new breakthroughs. For example, in basic passive components, "memristors" receive active attention in basic science, requiring active exploration of how to apply memristor research results to drive technological improvement and innovation in resistors. Similarly, "sodium-ion capacitors/lithium-ion capacitors" in basic passive components receive significant attention, so we should emphasize applying these basic research results in technological invention to enhance related patent development.

Characteristic indicates technological innovation develops faster than basic research, showing technology's potential to drive science. Based on this feature, we should explore important basic theoretical problems needing solution in hotspot technological innovations and propose new theoretical methods to accelerate basic research. For example, in new energy storage devices, "manganese oxide supercapacitors" are rapidly developing in basic science while supercapacitor technology innovation attracts high attention. We can stimulate rapid basic research development by boldly proposing fundamental principles to solve problems during technological innovation. In flat panel display devices, basic research on "organic light-emitting diode host materials" and "active-matrix organic light-emitting diodes" develops slowly, so we should actively monitor problem breakthroughs in LED display technology innovation and explore how technological breakthroughs can inspire basic research directions.

Characteristic indicates both basic research and technological innovation are in a rising period, showing synchronous collaborative ascent. Under this feature, we should emphasize collaborative efficiency and strength in knowledge elements, actively monitoring potential hotspot directions and their mutual promotion. For example, in sensitive components and sensors (gas sensors), frequency selection and control components (filters), and basic passive components (resistors), both sides lack hotspot directions but are in collaborative development. We should monitor development on both sides, using faster-developing basic research to drive technological innovation or vice versa, ensuring parallel development while exploring potential hotspot directions.

Characteristic indicates both basic research and technological innovation develop slowly, entering a bottleneck period. This may 预示 a new round of scientific and technological transformation brewing. Under this feature, we should actively explore key obstacles and consider adjusting or 开拓 new directions—collaborative transformation may be the beginning of disruptive innovation. For example, in frequency selection and control components, oscillator basic science and technological innovation both develop slowly, requiring bold attempts and transformations in conventional research, such as shifting from mature conventional band applications to incompletely opened bands. Such attempts require time but represent early planning and layout for breakthrough development.

This study's innovations include: (1) Examining not just hotspot collaborative directions but overall hotspot, rapid development, and slow development directions; (2) Establishing an intermediate classification axis linking basic research and technological innovation for clearer connection visualization; (3) Combining text mining with quantitative analysis to reveal collaborative patterns from internal knowledge connections. Overall, this collaborative characteristic analysis provides clearer micro-direction development status, more systematic reference information, and decision-making basis for field development, innovation strategy formulation, and research resource allocation.

Limitations include: some directions cannot be mapped, possibly due to data collection or scarcity; technological innovation directions are coarser than basic research directions; and how to more finely link the two perspectives or further refine the intermediate classification axis requires further exploration.

References

[1] RIPA. Science and technology as dancing partners[M]//Technological Development and Science in the Industrial Age. Netherlands: Springer Netherlands, 1992.
[2] Dong Kun, Xu Haiyun, Luo Rui, et al. Review on the analysis of the relationship between science and technology[J]. Journal of the China Society for Scientific and Technical Information, 2018, 37(6): 642-652.
[3] Zhang Jinzhu. Research on breakthrough innovation identification method based on citation science knowledge mutation[D]. Beijing: University of Chinese Academy of Sciences, 2013.
[4] Meyer M. Tracing knowledge flows in innovation systems[J]. Scientometrics, 2002, 54(2): 193-212.
[5] Bhattacharya S, Kretschmer H, Meyer M. Characterizing intellectual spaces between science and technology[J]. Scientometrics, 2003, 58(2): 369-390.

[6] Glänzel W, Meyer M. Patents cited in the scientific literature: An exploratory study of 'reverse' citation relations[J]. Scientometrics, 2003, 58(2): 415-428.
[7] Meyer M, Debackere K, Glänzel W. Can applied science be 'good science'? Exploring the relationship between patent citations and citation impact in nanoscience[J]. Scientometrics, 2010, 85(2): 527-539.
[8] Wu Feifei, Huang Lucheng, Shi Yuanxuan. Analysis of science-technology relationship based on mutual citation of literature and patents[J]. Science of Science and Management of S.&T., 2013, 34(10): 13-20.
[9] Lo Szu-Chia. Scientific linkage of science research and technology development: A case of genetic engineering research[J]. Scientometrics, 2010, 82(1): 109-120.
[10] Bai Guangzu, Zheng Yurong, Wu Xinnian, et al. Research on disruptive technology foresight method based on literature knowledge association[J]. Journal of Intelligence, 2017, 36(9): 38-44.
[11] Yeh H Y, Sung Y S, Yang H W, et al. The bibliographic coupling approach to filter cited and uncited patent citations: A case of electric vehicle technology[J]. Scientometrics, 2013, 94(1): 75-93.
[12] Huang M H, Yang H W, Chen D Z. Increasing science and technology linkage in fuel cells: A cross citation analysis of papers and patents[J]. Journal of Informetrics, 2015, 9(2): 237-250.
[13] Zhang Xue, Zhang Zhiqiang, Chen Xiujuan, et al. Analysis of the relationship between basic research and technological innovation in synthetic biology[J]. Journal of the China Society for Scientific and Technical Information, 2020, 39(3): 231-242.
[14] Gao Jiping, Ding Yi, Teng Li, et al. Knowledge flow analysis under patent-paper hybrid co-citation network[J]. Studies in Science of Science, 2011, 29(8): 1184-1189.
[15] Wang G B, Guan J C. Measuring science-technology interaction using patent citations and author-inventor links: An exploratory analysis from Chinese nanotechnology[J]. Journal of nanoparticle research, 2011, 13(12): 27-42.
[16] Bhattacharya S, Meyer M. Large firms and the science-technology interface: Patents, patent citations, and scientific output of multinational corporations in thin films[J]. Scientometrics, 2003, 58(2): 265-279.
[17] Lai Yuangen. Linkage between journal papers and patent literature[J]. Document, Information & Knowledge, 2011(1): 63-69.
[18] Li Rui, Rong Junfeng, Zhang Lingling. Discussion on deficiencies and improvements of "science-technology linkage" measurement models: From the perspective of discipline-field correspondence optimization[J]. Library and Information Service, 2013, 57(5): 86-93.
[19] Xu H Y, Winnink J, Yue Z H, et al. Topic-linked innovation paths in science and technology[J]. Journal of informetrics, 2020, 14(2): 1-18.
[20] Wang Yadong, Zhu Lin. Research on innovation model based on technology and knowledge double helix structure[J]. Science and Technology Management Research, 2017(9): 1-7.

[21] Yayavaram S, Ahuja G. Decomposability in knowledge structures and its impact on the usefulness of inventions and knowledge base malleability[J]. Administrative science quarterly, 2008, 53(2): 333-362.
[22] Wu Yue, Gu Xin, Tu Zhenzhou. Research on the formation process of industry-university-research collaborative innovation based on knowledge flow[J]. Research on Library Science, 2015(23): 87-93.
[23] Boyack K W, Klavans R. Co-citation analysis, bibliographic coupling, and direct citation: Which citation approach represents the research front most accurately?[J]. Journal of the Association for Information Science and Technology, 2014, 61(12): 2389-2404.
[24] Lu Chao, Hou Haiyan, Ding Ying, et al. Review on emerging research topic detection abroad[J]. Journal of the China Society for Scientific and Technical Information, 2019, 38(1): 97-110.
[25] An L, Lin X, Yu C, et al. Measuring and visualizing the contributions of Chinese and American LIS research institutions to emerging themes and salient themes[J]. Scientometrics, 2015, 105(3): 1605-1634.
[26] Deng Qiping, Chen Weijing, Zhang Lingling, et al. Analysis of research frontiers in artificial intelligence based on multi-dimensional feature measurement[J]. Journal of Intelligence, 2020, 39(3): 56-62.
[27] Liu Xiaoling, Tan Zongying. Research progress on emerging technology topic identification methods[J]. Library and Information Service, 2020, 64(11): 145-152.
[28] Li Xin, Wang Jingjing, Yang Zi, et al. Research on emerging technology identification based on SAO structure semantic analysis[J]. Journal of Intelligence, 2016, 35(3): 80-84.
[29] Small H, Boyack K W, Klavans R. Identifying emerging topics in science and technology[J]. Research policy, 2014, 43(8): 1450-1467.
[30] Gonzalez-Alcaide G, Llorente P, Ramos J M. Bibliometric indicators to identify emerging research fields: Publications on mass gatherings[J]. Scientometrics, 2016, 109(2): 1283-1298.
[31] Wang Q. A bibliometric model for identifying emerging research topics[J]. Journal of the Association for Information Science and Technology, 2017, 69(2): 290-304.
[32] Li Bei, Chen Xiangdong. Identification of emerging technologies in nanotechnology based on patent citation coupling clustering[J]. Journal of Intelligence, 2015(5): 35-40.

Author Contributions

Zhang Lingling: Framework and concept development, technological innovation direction research, basic research-technological innovation linkage research;
Zhang Yu'e: Research methodology guidance;
Du Li: Feasibility and significance guidance;
Ling Shiting: Data retrieval and cleaning, intermediate classification axis research;
Lin Qing: Data retrieval and cleaning, intermediate classification axis research;

Yu Mengxia: Basic research direction clustering research.

Research on the Collaborative Direction and Characteristics of Basic Research and Technological Innovation: Taking the Field of New Electronic Components as an Example

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Abstract: [Purpose/Significance] Starting from the content of science and technology research, this paper discusses the collaborative direction and characteristics between basic research and technological innovation, providing references for future collaborative development strategies. [Method/Process] First, we investigate the field's research and development system to construct an intermediate classification axis connecting basic research and technological innovation content. Then, we mine basic research and technological innovation directions through literature content clustering, and use quantitative evaluation to classify them into three development states: hotspot direction, rapid development, and slow development. Finally, based on these states, we summarize collaborative characteristics and apply them to empirical analysis in the new electronic components field. [Result/Conclusion] We realize collaborative direction analysis in the new electronic components field through combined content mining and quantitative evaluation, clearly displaying possible collaborative states at the finer-grained research direction level, and provide specific guidance for collaborative direction development based on these characteristics.

Keywords: basic research; technological innovation; science-technology collaboration; collaborative characteristics; collaborative development