



Research Status, Hotspots and Trends of University Business Incubators Based on the CiteSpace Data Calculation Method

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Abstract. [Objective] Boasting the intermediary between start-ups and external partners, university business incubators (UBIs) aid start-ups in establishing friendly partnerships with suppliers, providers of professional services, financial and funding institutions or research institutes, etc. as a means of promoting the growth, innovation agglomeration and economic development of new enterprises. By drawing the visual knowledge map of the development of UBIs, we can reveal the research frontier, trend, and development law of UBIs. [Methods] Taking 744 publications concerning UBIs in the Web of Science database source journals from 1995–2022 as the object, CiteSpace software was used to extract fields and visually display the number of publications, time, region, and authorship mapping, as well as keyword co-occurrence and clustering mutability. [Results] The study of UBIs has drawn high attention from scholars; company growth, entrepreneurial development, and innovation agglomeration constitute research hotspots in this field. In recent years, the research directions of UBIs have grown diversified, making sustainable incubator development, management model innovation, knowledge transfer, innovation ecosystem, and technology transfer crucial directions for future research.

Keywords: university business incubator (UBI) · entrepreneurship incubation · CiteSpace · knowledge map

1 Introduction

University business incubator (UBI) has become an ideal entrepreneurial platform for grassroots entrepreneurs and a paradise for incubating small science and technology enterprises because it provides the transfer of technology and scientific knowledge, the development of commodity commercialization, the cultivation of entrepreneurial enterprises, the marketing of cutting-edge research and cooperative research [1]. In China, UBI is defined as: “an institution that relies on universities with strong scientific research

Ministry of Science and Technology of the People’s Republic of China: www.most.gov.cn/index.html.

strength, combines the advantages of comprehensive intellectual resources of universities with other social superior resources, and provides a supporting platform and service for the transformation of scientific and technological achievements, the incubation of high-tech enterprises, the cultivation of innovative and entrepreneurial talents, and the combination of production, education and research" [2]. Kollmann and Stöckmann (2014) believed that the UBI played a pivotal role in accelerating the transformation of scientific and technological achievements, boosting technological innovation, cultivating small scientific and technological enterprises, and promoting regional economic development [3].

A great many scholars have actively discussed the functions and roles of UBIs. They considered that the UBI mainly consists of three functions: the first is to cultivate innovative subjects. The incubator is mainly oriented to incubate innovative subjects and scientific and technological enterprises [2]. Small and medium-sized science and technology new ventures are the main incubation objects of UBIs, and incubators are the carriers of innovative subjects such as new ventures. Cultivating innovative subjects is the most fundamental task of UBIs [4]. The second is to promote technological innovation in enterprises. With the intensification of global business competition, enterprises are bound to quickly develop new products to meet the needs of customers to adapt to the new business environment. Therefore, from the perspective of creating value through business model innovation, an increasing number of enterprises focus on intangible and high-value services (including improving technical capabilities, learning experience, knowledge, network, collaboration, etc.), and increasingly dominate the emergence of new incubation models [5]. By establishing contact with universities and research institutions, UBIs can promote enterprise growth and competitiveness through knowledge transfer if the incubating enterprises have the sufficient absorptive capacity [2]. The third is to underpin entrepreneurial activities. UBIs create an innovative and entrepreneurial atmosphere by providing space facilities, capital support, management consulting, technical consulting, and other entrepreneurial services for newly established enterprises, thus reducing the entrepreneurial cost of start-ups and helping new ventures to grow rapidly and succeed in entrepreneurship [6].

Although scholars have drawn their attention to the importance of UBIs and their positive effects on the entrepreneurial effectiveness of new ventures, there is a paucity of literature that systematically analyzes research hotspots and trends in UBIs using scientific literature analysis tools. Therefore, this paper uses CiteSpace software with the co-occurrence principle and LLR algorithm clustering principle to draw a series of knowledge maps of UBI research, and systematically reviews the current situation, hot spots, context, and trends of UBI research. Through the analysis of the knowledge map, we have mastered the research frontier of UBIs, which provides a reference for other scholars.

2 Data Sources and Research Methods

2.1 Data Sources

In this study, the core collection of Web of Science (WOS) is used as the source database, and SCI, SSCI, A&HCI, and ESCI are used as indexes. The high-level retrieval mode is adopted, and the retrieval strategy is mainly divided into three steps. In the first step, the retrieval strategy Q1 is to input the retrieval keyword TS = “university business incubator”; in the second step, Q2 is to input the retrieval keyword TS = “university incubator”; the third step is to search with Q1 OR Q2. The time span is selected from 1995 to 2022, and the retrieval time is March 1, 2023. After screening the retrieval results and cleaning the data, a total of 744 publications were obtained. The download format was in the form of a text document, and download_N.TXT (N is the natural number) was adopted to name the text. In this study, we only sifted the journal’s research process from the database to ensure that the research we used was of high quality and had been peer-reviewed. In order to ensure that all studies are applicable, we require that the full text be available.

2.2 Research Methodology

Cite Space V is a sort of visual software based on the Java platform developed by Chaomei Chen of Dreiser University in the United States. The software mainly uses the co-occurrence principle and LLR algorithm clustering principle for study, the “Pathfinder” algorithm is mainly selected for map clipping, and the clustering results are mainly marked by #, with keywords as extraction labels [7]. The clustering index is measured by two indicators, modularity value (Q for short) and silhouette value (S for short), and the clustering result is considered reasonable when $Q > 0.3$ and $S \geq 0.5$. Then we summarized the keyword frequency, centrality, and clustering results, and detected the hot frontier of research mostly based on the mutation algorithm. Figure 1 shows the CiteSpace function and parameter setting area. This interface includes the following function parameter areas: project, time slicing, text processing, network cropping, visualization, data status, running reports, and so on.

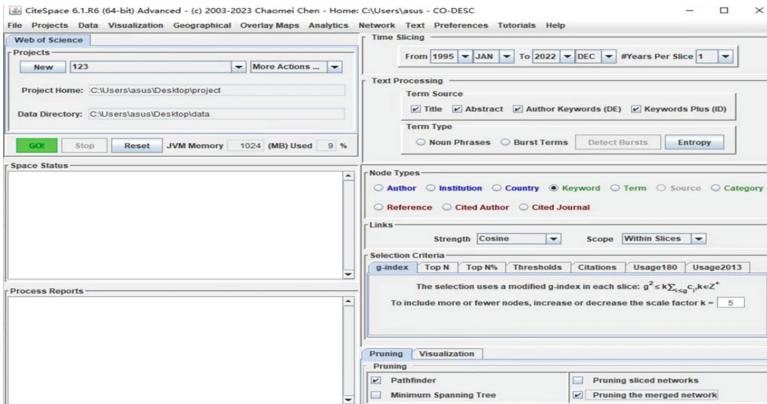


Fig. 1. CiteSpace function and parameter settings

3 Results Analysis of Literature Distribution

3.1 Distribution and Trend of Literature Publication Years

In 1951, Stanford University established the first university business incubator. After more than 50 years of evolution, Stanford University Research Park has developed into a famous Silicon Valley. Consequently, Harvard University in the United States, Cambridge University in the United Kingdom, Northeastern University in China, and other universities in many countries have successively established UBIs to help new ventures grow. Research on UBIs conducted by scholars started in 1995, and since then, more and more scholars have been engaged in the construction of UBIs. Figure 2 uses measurement methods to count the research trends of the theme of UBI: (1) The initial development stage ranges from 1995 to 2015. This stage is the beginning and development period of the research on UBIs. The overall number of publications is low, but the annual number of published articles is increasing. (2) The rapid development stage ranges from 2016 to 2019. At this stage, the amount of related literature increased significantly, reaching the largest number of published literature of 70 in 2018, and many scholars paid attention to the development of UBIs. (3) The slow development stage ranges from 2020 to 2022. In 2020, with the outbreak of the global COVID-19 pandemic, the overall development speed of UBIs was forced to slow down. It can be seen from the analysis that UBI has been the focus of academic circles in recent 10 years, and it has encountered bottlenecks in development in a certain period, so there is still much room for exploration in the research of UBIs.

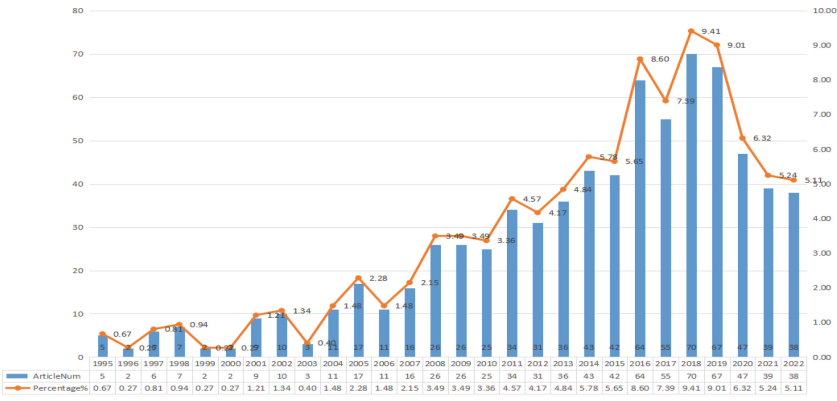


Fig. 2. The statistical trend chart of the number of published articles in years

3.2 Visual Analysis of the National Distribution of Publications

In order to understand the distribution of attention to the research on UBIs in various countries, this paper takes the node type as “country” and the time slice as one year. After visual analysis, the national co-occurrence map is shown in Fig. 3. The research on UBIs is mainly concentrated in the United States, China, Spain, Britain, Australia, and other countries. When the parameter is Timespan: 1995–2022 (slice length = 1), there are 80 nodes, 82 wires, and Density = 0. 0259 in the co-occurrence network. Largest CC is 62 (77%), suggesting that the largest group of national cooperative relations in the theme research of UBIs is 62, accounting for 77% of the total, and there are more international cooperative studies and strong cooperative relations.

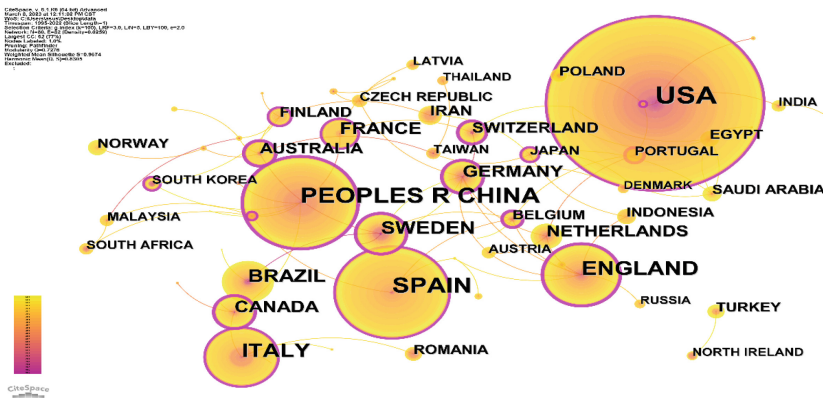


Fig. 3. Knowledge map of national distribution on corporate social capital research

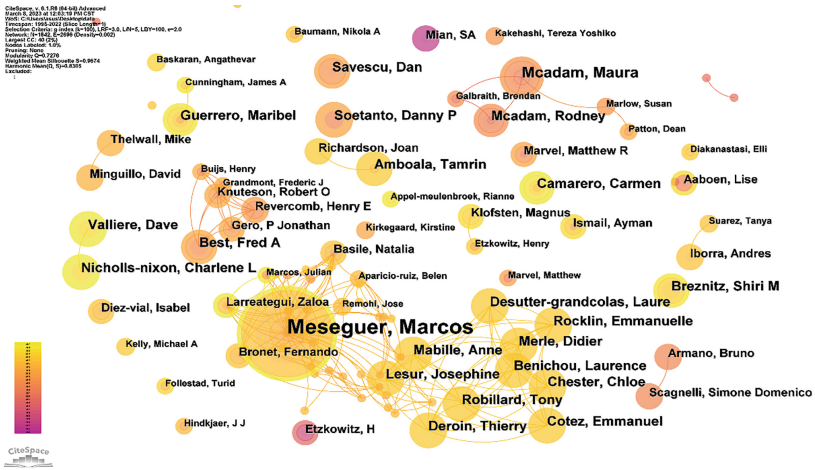


Fig. 4. Knowledge graph of author collaboration

3.3 Visual Analysis of Authors of Publications

The visual analysis of the authors of publications shows the research status of the core authors in this field. From the cooperation map of research authors (Fig. 4), the authors with the highest number of articles on UBI research include Meseguer & Marcos, Mcadam & Maura, Desutter & Laure, and so on. When the parameter is Timespan: 1995–2022 (slice length = 1), there are 1642 nodes and 2696 connections in the co-occurrence network, and the network Density Density = 0.002. Lagest CC is 40 (2%), indicating that the largest group of authors in the theme research of UBI is 40, accounting for 2% of the total. From the above analysis, we can see that UBI has more attention, the research content is relatively scattered, the author’s cooperative research base is not large, and the cooperative relationship is weak.

4 Analysis of Research Hotspots and Trends

4.1 Hotspot Analysis

Keywords are the condensation of the main viewpoints and contents of the paper, the analysis of which can reflect the hotspots and development trends in a certain research field. The larger the node “ring” area in the keyword co-occurrence graph, the more frequently keywords appear. Lines represent a co-occurrence relationship, and the more lines, the closer the collinear relationship. Substituting the node type with “keyword”, the keyword co-occurrence map is derived after CiteSpace analysis (Fig. 5). The keywords with a high frequency of key nodes in the map are: “entrepreneur”, “innovation”, “business incubators”, “incubator”, “technology transfer”, “academic entrepreneur”, “entrepreneur education”, “university”, “entrepreneur university”, etc. They all appear more than 10 times, serving as the focus of scholars in the field of UBI research. Based on the above visual analysis, it can be noted that scholars mainly explore the aspects

Table 1. High-frequency keywords

No.	Keywords	Frequency	Centrality	No.	Keywords	Frequency	Centrality
1	Entrepreneurship	75	0.09	16	Entrepreneurial ecosystems	7	0.01
2	Innovation	67	0.23	17	Accelerator	6	0.02
3	Business incubators	42	0.12	18	University incubator	6	0.03
4	Incubator	42	0.15	19	Accelerators	6	0.01
5	Technology transfer	28	0.07	20	China	6	0.04
6	Incubators	26	0.05	21	Higher education	6	0.01
7	Academic entrepreneurship	16	0.1	22	Blastocyst	5	0
8	Entrepreneurship education	14	0.01	23	Growth	5	0.03
9	University	14	0.07	24	Sustainability	5	0
10	Entrepreneurial university	11	0	25	Start-ups	5	0
11	Incubation	11	0.03	26	Knowledge	5	0.08
12	Universities	11	0.02	27	Technology	5	0.03
13	Science parks	8	0.02	28	Technical entrepreneurship	5	0.01
14	Academic spin-offs	8	0.05	29	Start-up	5	0.02
15	Time-lapse	7	0	30	Clusters	4	0.06

Combined with keyword frequency and clustering results, the key topics in the research field of UBIs can be summarized into the following six main clusters:

- (1) **Cluster # 0: Entrepreneur.** The largest Cluster (# 0) has 43 members and a silhouette value of 0.994. It is labeled as a business incubator by LLR, an entrepreneurial ecosystem by LSI, and an education institution (2.5) by MI. The major citing article of the cluster is written by Ledgerwood, G (1999.0), which is “Creating technology-based enterprise televillages - post-modern regional development theory“. The most cited members of keywords in this cluster are entrepreneurship (75), business incubators (42), and entrepreneurial university (11).
- (2) **Cluster # 1: Innovation.** The second largest cluster (# 1) has 36 members and a silhouette value of 0.961. It is labeled as a college student by both LLR and LSI and as a new business idea development methodology (1.53) by MI. The major citing article of the cluster is: Iborra, A (2017.0), “Beyond traditional innovation education

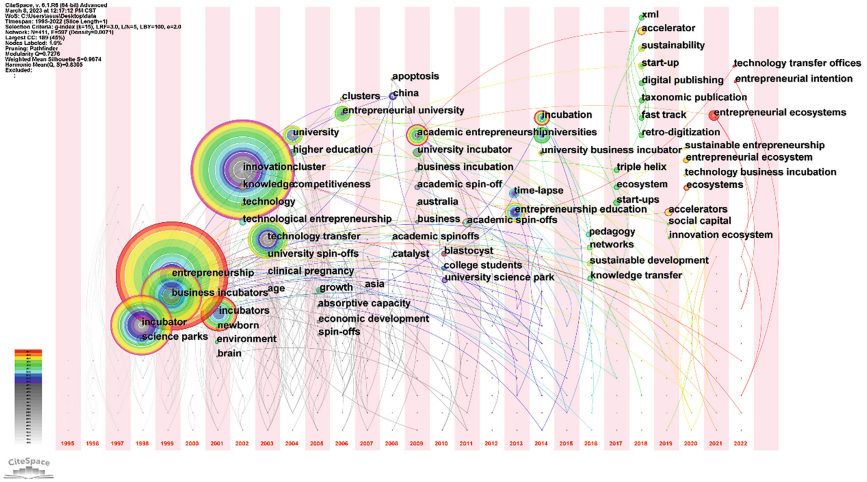


Fig. 6. Keywords co-occurrence map

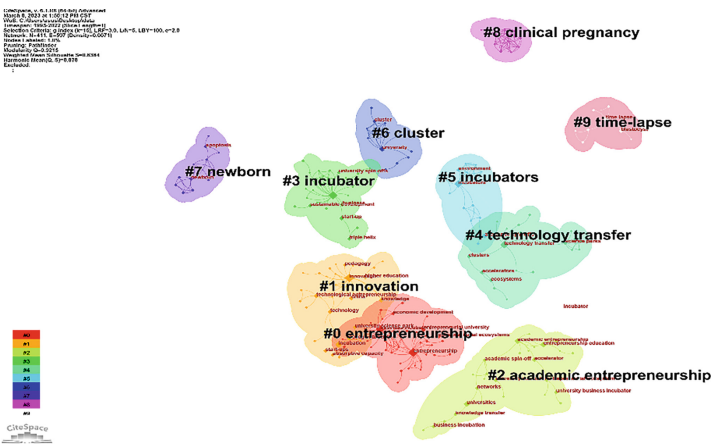


Fig. 7. Clustering diagram of keywords

in engineering promoting start-ups from universities. The most cited members in this cluster are innovation (67), innovation (11), and higher education (6).

- (3) **Cluster # 2: Academic entrepreneur.** The third largest Cluster (# 2) has 28 members and a silhouette value of 0.97. It is labeled as an inductive study by both LLR and LSI and as a knowledge link (0.39) by MI. The major citing article of the cluster is: Shankar, RK (2020.0), Scale quick or fail fast: an inductive study of acceleration. The most cited members in this cluster are academic entrepreneurs (16), entrepreneur education (14), and universities (11).
- (4) **Cluster # 3: Incubator.** The 4th largest cluster (# 3) has 26 members and a silhouette value of 0.99. It is labeled as a hi-tech industrial development zone by LLR, development trend by LSI, and renewable energy (0.33) by MI. The major citing article

of the cluster is Li, LJ (2004.0) Roles, models and development trends of hi-tech industrial development zones in China. The most cited members in this cluster are incubator (42), start-up (5), and triple helix (4).

- (5) **Cluster # 4: Technology transfer.** The 5th largest cluster (# 4) has 21 members and a silhouette value of 0.923. It is labeled as university technology transfer by both LLR and LSI and as dynamic perspective (0.25) by MI. The major citing article of the cluster is Dahab, SS (1998.0), Services firms in the idea science park. The most cited members in this Cluster are technology transfer (28), science parks (8), and accelerators (6).
- (6) **Cluster # 6: Cluster.** The 7th largest cluster (# 6) has 13 members and a silhouette value of 0.898. It is labeled as the Cabral-Dahab science park management paradigm by both LLR and LSI and as the communication technology sector (0.02) by MI. The major citing article of the cluster is Cabral, R (2004.0), the Cabral-Dahab science park management paradigm applied to the case of Kista, Swedish. The most cited members in this cluster are university (14), cluster (4), and support (2).

4.3 Frontier and Development Trend Analysis

Burst Detection is an algorithm proposed by Kleinberg J to measure the importance of nodes in time according to the information-foraging effect. Keyword emergence refers to keywords that appear frequently in articles published in a short time. Black horizontal lines are formed from the beginning to the end of keyword emergence, which indicates the importance and attention of keywords in this research field. The longer the emergence length, the longer the popularity of keywords lasts, and the stronger the research frontier. The more burst nodes, the more active the Active Area, which is the Emerging Trend studied. Figure 8 is obtained by using the “burstness” function of CiteSpace software, where the “Minimum duration” is set to 2 years during the detection process. In the map, Begin is the year when keywords start mutation, End is the time when it ends, the span between them is the duration of mutation keywords, and Strength is the mutation intensity.

According to Fig. 8, it can be seen that the long-term focus of scholars on the research of UBIs is “company”, and the mutation lasts from 1997 to 2011. On a global scale, UBIs are regarded as an important mechanism to incubate the development and growth of small and medium-sized enterprises [8]. The establishment of UBIs is of great significance to encourage technology companies to implement technology transfer, enterprise innovation, and performance improvement, which has been a concern by scholars for a long time. What’s more, “economic development” has become another aspect that scholars pay attention to for a long time, and the mutation lasts from 2008 to 2014. Nasir, Iqbal, Wu Xixi, and other scholars all believe that UBIs promote the occurrence of entrepreneurial behavior, while entrepreneurship contributes to the generation of new products, the increase of employment opportunities, the improvement of living standards and the reduction of poverty, and is recognized as a key momentum of innovation promotion and sustainable economic development in a country [9].

In recent years, scholars’ attention has gradually shifted to “entrepreneurial university (2018–2022)”, “startup (2020–2022)”, “impact (2020–2022)”, “model (2020–2022)” and so on. It must be affirmed that scholars still hold a positive attitude toward the

Top 29 Keywords with the Strongest Citation Bursts



Fig. 8. Top29 keywords mutation of UBIs

impact of UBIs on promoting enterprise performance and sustainable economic development. First, UBIs have established a mechanism to bridge the gap between technology discovery and commercialization. Second, in regional development, UBIs help various entrepreneurs to enter the network in coordination, promote venture capital to participate in the incubation network, and find creative projects or derivative enterprises with potential investment value. Last but not least, UBIs promote innovation and entrepreneurship by adopting open strategies and encourage entrepreneurs to discover opportunities, the operating mechanism of which incentivizes innovation and entrepreneurship of R&D organizations. For example, universities and research institutions can provide laboratories, research physical space, and R&D experience, which are difficult for new ventures to obtain complementary resources [10]. However, scholars also pay attention to the bad influence in the development of UBIs, such as blindly pursuing the increase of hatching number, the expansion of the hatching area, and the problem of low-end replication. Adding insult to injury, the unclear functional orientation of UBIs, low innovation incubation ability, and low entrepreneurial performance of incubating enterprises lead to weak market competitiveness of incubating enterprises and only bring irrational prosperity to incubating industries. Therefore, exploring and promoting the sustainable development model of UBIs has become the focus of scholars' attention at present. For

instance, the “mentor + fund + venue” mode, “vertical industry” mode, and “media support” mode are discussed and implemented currently.

5 Research Conclusion

Against the backdrop of the knowledge economy era, UBI is a new form produced by universities playing the third function in addition to teaching and scientific research, and it is the product of the combination of science and technology parks and universities [2]. The emergence of UBIs gives universities dual responsibilities, i.e., to produce new knowledge and promote technology transfer and knowledge spillovers [9]. The main functions of UBIs are more reflected in the innovation promotion for small and medium-sized enterprises, the transfer of technical and scientific knowledge, the cultivation of entrepreneurship and the marketing of cutting-edge research, and the development of future products. Through the visual analysis of the research literature on UBIs, the following conclusions are drawn:

- (1) The research on UBIs has been given close attention by scholars. In the 1990s, with the construction of university science parks in various countries all over the world, scholars place their premium on the research of UBIs. In the following period of time, the research on UBIs is on a steady upward trend. Until 2020, influenced by the global COVID-19 pandemic, the speed of entrepreneurship development is forced to slow down, which leads to certain restrictions on the research on UBIs. Scholars in countries with a high level of enterprise development in the world, such as the United States, Britain, and China, attach great importance to the research of UBIs and make active explorations. From the visual map of authors and institutions, the authors and institutions with an absolute advantage in the number of articles are not concentrated, showing a trend of dispersion and low cooperation, which reflects to a certain extent that scholars' continuous attention and research depth on UBIs are insufficient.
- (2) The research content of UBIs is deepening. The definition and value of major UBIs in academic circles actively discuss the role of UBIs in company growth, entrepreneurship promotion, and innovation drive. The research content of UBIs gradually converges in several directions: knowledge transfer, innovation and entrepreneurship, management mode, entrepreneurial university, and management innovation. Among them, management mode innovation, sustainable development, and innovation ecosystem are increasingly important in the research field of UBI, which are the research frontiers in the research field of UBI, and the research content and research scope are dynamically broadened.
- (3) The research direction of UBIs is gradually diversified. From the viewpoint of research trends and research hotspots, scholars in this field have moved from the initial simple exploration of the relationship between UBIs and company growth, to the later focus on knowledge transfer and innovation clustering, and then to the current emphasis on incubator sustainability, management model innovation, knowledge transfer, innovation ecosystem, technology transfer, and other directions. The research in this field tends to be detailed and diversified.

6 Conclusion and Shortcomings

744 journal articles about UBIs in the Web of Science database were selected as analysis objects. This paper uses the CiteSpace visual analysis tool to visually analyze the number of publications, regions, authors and keywords of the research on UBIs. The analysis results intuitively display the research progress and variation trend of UBIs in the past 30 years.

The results show that the emergence of UBIs endows universities with dual responsibilities: to produce new knowledge and promote technology transfer and knowledge spillovers [11]. UBIs give full play to the scientific research advantages of universities, providing services such as laboratories and equipment, management and technical support, legal consultation and network, and adding value to incubating companies [12]. In the business incubation network, the incubating enterprises in the incubator interact with investment and financing institutions, intermediary service institutions, business consulting institutions, and other new ventures through joint interaction, forming an incubation network aiming at win-win cooperation, resource sharing, and risk sharing. The incubation network provides an integrated platform for new ventures to obtain external relationship capital, and it strengthens the social capital of enterprises through cooperative relations, which makes up for the shortage of resources and capabilities of individual start-ups and is more conducive to the success of new ventures' incubation. Globally, UBIs have been regarded as an important mechanism to support the development of entrepreneurship and the growth of new enterprises.

However, it should be pointed out that on account of the requirements of CiteSpace for literature format, this study only selects journal articles (excluding series, dissertations, and conference papers), and only a database of Web of Science is selected, so it is inevitable to miss some literature. At the same time, there is no better distinction between the research status of each country or region. Future research can consider a richer database to retrieve the topic-related literature, and fully consider and analyze the literature such as dissertations and conference papers, so as to expand the research objects and further ensure the integrity of the research.

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