

## Review

# A Knowledge Map Study of an Application of a Smart Land Planning Free-Trade Zone and China's Contribution

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**Abstract:** The use of a free-trade zone (FTZ) has emerged as a smart land tool in increasing trading, attracting foreign investment, attempting financial openness and conducting other pilot economic reforms, which adds higher requirements for smart spatial planning, smart industry planning and smart management planning. However, no systematic analysis has been performed, making it difficult to provide deeper insights into FTZs. Thus, this study conducted bibliometric and visual analysis to identify the research status, new theories or practices, and potential future directions of FTZs based on 953 publications from the Web of Science Core Collection. The results show that there is a marked rise in the number of FTZ studies since 2013, which is the same year China authorized the first FTZ in Shanghai. China and the United States of America have played a leading role in FTZ research. Finally, the increasing trend in FTZ utilization will remain sizeable during its deepening development. The findings may contribute to a better understanding of FTZs and make some references to smart land-use planning experience and practices around the globe.

**Keywords:** smart land-use planning; free-trade zone; China; knowledge map; CiteSpace



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## 1. Introduction

The site selection and design of a free-trade zone (FTZ) are supported by smart land-use planning (SLUP) [1,2]. The establishment of an FTZ is also an application of SLUP, which can improve urban land-use efficiency and construction land-use quality [3,4]. To embrace the global open economy, China has used urban land to set up three types of economic zones since nationwide reform and opening-up strategy in 1978 by incorporating intensive smart actions, such as talent aggregation, policy deregulation, and R&D funding. China aims to mark out pilot zones for the market-oriented economy and the entry of foreign capitals, before extending the successful reforms to the whole country. The first type of economic zone called a special economic zone (SEZ) which was initially established in 1980 [5]. Four southern Chinese cities and one island province (in 1980, the four special economic zone were: Shenzhen, Zhuhai, Xiamen, and Shantou) were chosen as the initial special economic zones, then two northwest border-nearing cities (Korgos and Kashgar) were assigned to join these ranks. The second pilot zone is named a high-tech industrial development zone (HTIDZ), which started in 1988 [6]. This area distributes much more extensively in China, where 168 HTIDZs were located in 30 provinces or municipalities in 2020. The Anhui province alone has 18 of this type of zone. The function of HTIDZs is mainly the development of indigenous industries with the feature of being capital-intensive and knowledge-intensive, and normally supported by the local government with the preferential gain of funds and qualified personnel.

Although these two types of zones have witnessed success to a varying degree, a third mode of the zone is needed to fit the ever-changing world economy [7] and the new normal of China's economy; the latter means China's economic objective is shifting from high-speed growth to high-quality growth [8,9]. The free-trade (pilot) zone (FTZ) located in Shanghai is the kind of zone that China started to establish in 2013, with targets including increasing trade, lowering the threshold of foreign direct investment and equity investment [10], offering deregulation of the financial system [11] and business events in the zones [12], and promoting the efficiency of land use in the metropolis [13]. When these attempts have been achieved to a prominent degree, the in-zone reforms can then be generalized to vast out-zone areas [14]. With the increasingly higher land cost and development demands, running an FTZ requires smarter spatial planning, industry planning and management planning [15,16].

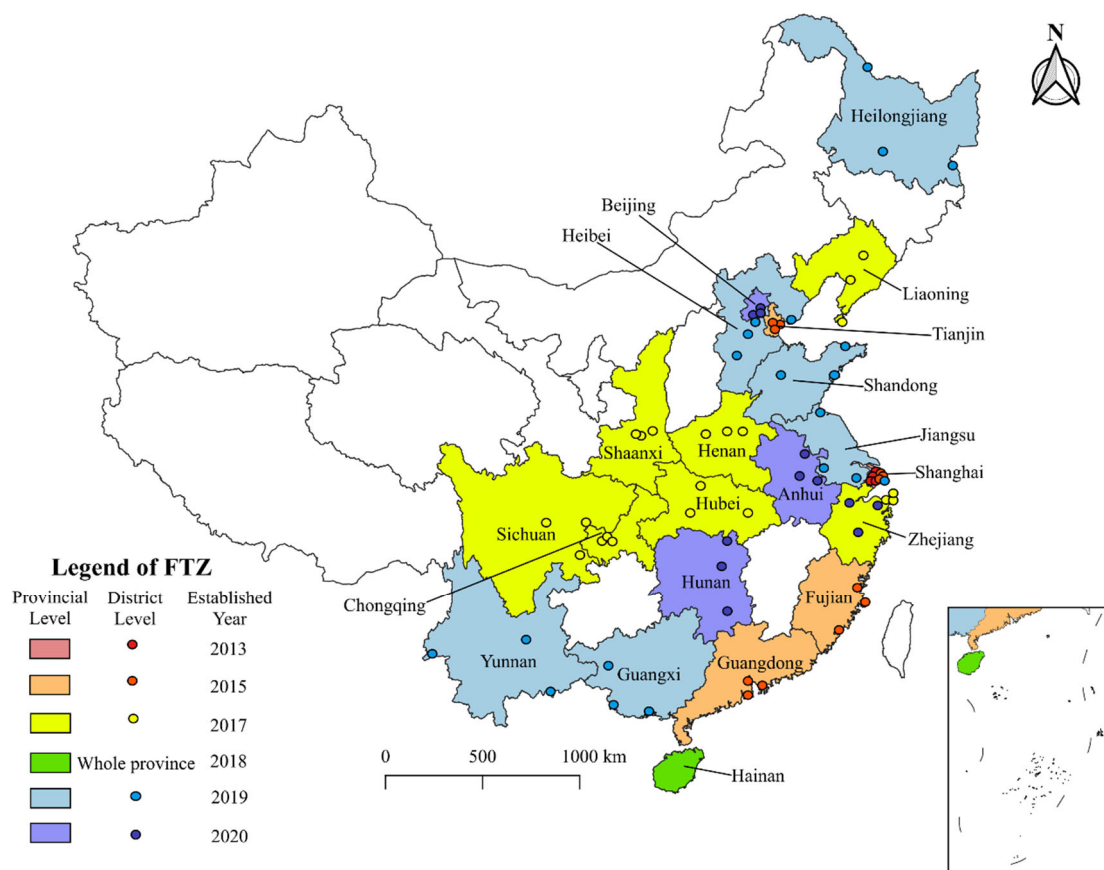
The FTZ is not a novelty world-wide, as Ireland had already founded the world's first formal FTZ in 1958, the Shannon Free Zone [17], with the initial purpose of serving passengers and crews in connecting flights with duty-free shopping and services. It then developed into an export-processing zone in the 1950s to 1960s, before it evolved into a knowledge-based industry zone over the next three decades, and finally became an FTZ with compound industries and services. In Germany, the Hamburg port (Speicherstadt) has served as a FTZ's function for 125 years, long before it received the official title. Four FTZs were formally founded in the 1980s: the free-trade (port) zone of Bremerhaven, Cuxhaven, Deggendorf, and Duisburg. The Duisburg FTZ is an inland FTZ without a coastal port but became well-developed in trading and investing due to land transportation such as China–Europe freight trains.

The US has many more FTZs and a wider geo-distribution compared to other countries; there are 293 FTZs spread across 50 states [18]. FTZs in the US are also called foreign-trade zones, with a goal of promoting the competitiveness of export industries in the US. To fulfil the economic globalization, enterprises in these FTZs enjoy low tax rates and an eased export process, and residents also benefit from the diversity of the imports [19]. Although FTZs are tightly linked to international trade, more than one-fourth of FTZs in the US are neither located along the coastlines nor settled among the rivers, which are recognized as absolute inland FTZs.

The functions and spatial distributions of FTZs in the US have reference value to China, as China is now planning to expand an opening-up in the economy. Similar to the national territorial area, China has also established both coastal and inland FTZs since 2017, where four provincial-level regions established 12 specific district-level FTZs in hinterland China. By October 2020, there were 6 batches of a total of 21 provincial-level FTZs (including 71 district-level zones, which the details of are found in Appendix A) that have been set up in mainland China, including the southernmost province Hainan, whose FTZ range is the entire island [20] as Figure 1 shows. All the eastern coastal provinces have possessed FTZs since 2019, whereas some of the central and west-China provinces, which have no maritime conditions, have begun to own FTZs since 2017.

However, FTZs had far less attention in academic research prior to 2013 in contrast to another similarly titled but different economic trade object, known as a free-trade agreement/area (FTA), which is signed by two or more countries and aims to remove trade barriers and economic complementarity (such as North American FTA, China-ASEAN FTA, and African continental FTA) [21–23], which is popular in both practical existence and theoretical research [24]. However, for emerging economies with comparatively low economic openness and law perfection, FTZs provide an experimental field for a higher economic openness, aimed at attracting capital and improving productivity [25]. Academic studies of FTZs have begun to grow since then, especially after 2010. For example, through a bibliographic method, de Souza Junior et al. found that the Manaus Free Trade Zone in Brazil (MFTZ) had attracted growing studies from 2010 to 2018 on research, development, and innovation within MFTZ when “Industry 4.0” was released [26]; Luna and Lizarazo summarized the regional disparity resulting from the FTZs in Colombia during 2009–2016

and provided suggestive compensation policies to mitigate these inequalities [27]. This trend may be an important factor that boosts FTZ-related research workloads. Hence, a survey of the literature on FTZ-related research can help to understand the research context, research hotspot, contributors, and high-impact publications on FTZ's theoretical study.



**Figure 1.** The FTZ distributions in mainland China (up to June 2022).

As our main method is a bibliometric analysis based on the knowledge map, our literature is chiefly focused on the research method, which is a quantitative method directed at research archives. The knowledge map refers to a method of probing the interrelations between information, objects, and characteristics through nodes, connecting lines, and clusters [28,29]. By filling out a java-based program, CiteSpace, the articles in the archives can be analyzed in multifarious graphics forms, including some key functions such as co-occurrence and co-citation analysis [30].

However, globe-based bibliometric studies on FTZs are still rare. To construct an extensive knowledge map of FTZs, this work collected the academic publications from an authoritative document database, using correlation analysis and knowledge maps to discover and summarize the traits of academic studies of FTZs, its research trends, and contributions from emerging FTZ builders such as China.

## 2. Literature Review

A knowledge map is a visual aid, often referred to as an “inventory of knowledge”, which is organized using various interconnected nodes to make it easy to find out where to look for information [31,32]. After Chen [28,29,33] first invented and utilized CiteSpace, a considerable amount of literature began to use this tool in different fields of bibliometric study. Table 1 organizes the typical literature that illustrates the basic concepts, the theoretical studies, and multiple applications of the knowledge map.

**Table 1.** Representative literature on knowledge map and FTZ research.

Classification	Study Object	Author and Literature Title
Original research of knowledge map	Basic concept and theoretical study of knowledge map	[33]
		[28]
Retrospective research using knowledge map	Renewable energy	[29]
		[32]
	Renewable energy	[34]
		[35]
	Environment and Health	[36]
		[37]
	Economics and Finance	[38]
		[39]
	Being connected with China	[40]
		[41]
	Being connected with China	[42]
		[43]

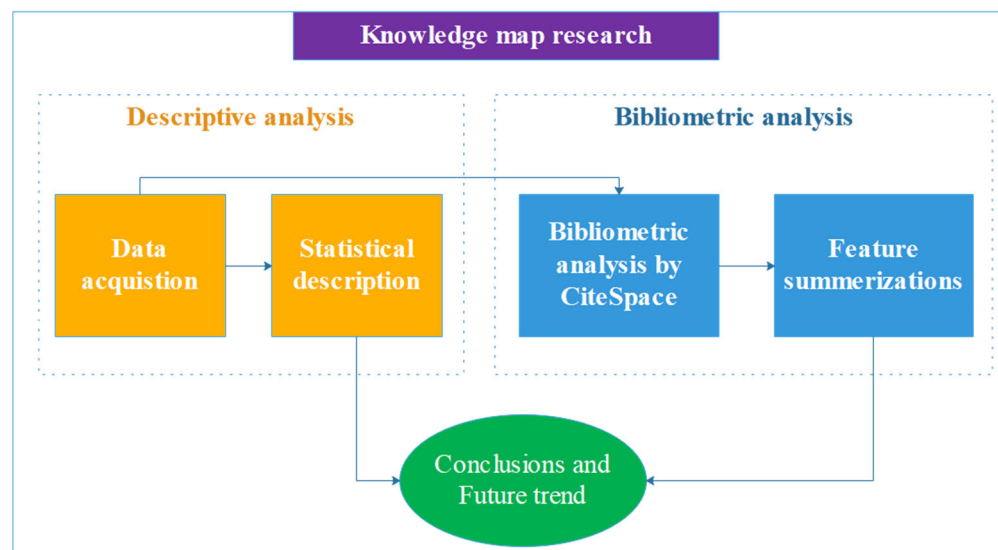
As shown in Table 1, J. Wang et al. [34] gathered and explored electrical-power system reliability when fluctuant renewable energies were connected to the grid, giving a visualized research network of hotspot keywords, country/region, and contributing institutions in the field of renewable energy; P. Ye et al. [35] chose offshore wind power as their main topic, analyzing 1562 relevant articles in terms of core keywords, dominating countries, and the co-citation network involving a subject classification. In environmental science, M. Pierpaoli and M.L. Ruello [36] conducted a bibliometric study on indoor air quality and summed up its part trend and current hotspot from 1990 to the present; C. Li et al. [44] collected 17 years of academic publications on haze, finding that the US, France, Germany, and China were the four largest contribution countries. In occupational health studies, a bibliometric study linked Parkinson's/Alzheimer's disease and occupational exposure to pesticides [38]. Zhang et al. [37] pointed out that the topics of sustainable management and green production topics within the manufacturing industry were emerging trends. In economics and business, P.K. Hota et al. [39] chose social entrepreneurship as the entry point, identifying 9 hot sub-issues from 1296 articles from 1996 to 2017; S. Kraus et al. [40] selected a prevalent focus on late-year to explore the sharing economy, finding that it involved 10 different disciplines, including environmental science and hospitality; Nath et al. [41] gave a systematic bibliometric review of shadow banking and raised seven possible questions for future research.

Several bibliometric studies embody the relationship between the main topic and China. X. Luo et al. [42] directly retrieved the coalbed methane research contributed only by China during the period of 2007 to 2016, finding that the year 2013 was the peak year for publications, before quantity decreased because of the Chinese cut-coal strategy since 2014. X. Li et al. [43] carried out a comparative study of the publications of green development between China and other countries, mapping out their different knowledge maps including co-authorships, co-published journals, and co-occurring keywords.

Through these bibliometric studies, none of them have purely studied the relationship between China's contribution to the literature and the booming total publications, nor has the free-trade zone become a topic in knowledge study. Based on this, this paper includes a bibliometric study on FTZs in three types of knowledge maps, identifying the degree of involvement from China, and summarizing possible factors that explain the rapid growth of publications since 2013.

### 3. Methodology and Data

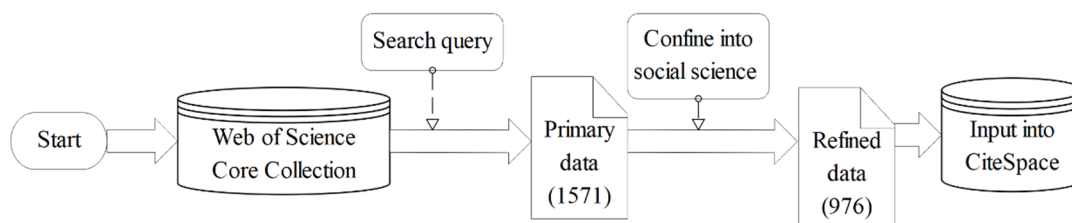
To demonstrate a bibliometric study in a reasonable and reliable mode, a series of multidimensional analyses with insightful explanations are essential. Therefore, an intact research framework is needed to instruct the research work, where the full process of data acquisition, trend summary, and visualized knowledge map analysis will be covered, as Figure 2 shows the overall research framework of the knowledge map.



**Figure 2.** Overall research framework.

As Figure 2 displays, to establish the conclusions and possible future trend in FTZs through a knowledge map, a descriptive analysis and a bibliometric analysis constitutes the research process. The descriptive analysis is the foundation step in acquiring the convictive data of the FTZ and describing its basic statistical characteristics. The subsequent bibliometric analysis can fully reveal its features in multiple dimensions. Finally, by combining the two results, conclusions and future trends in FTZ research can be summed up and speculated.

For raw data acquisition, a dedicated source of FTZ-related articles is indispensable. For this paper the Web of Science Core Collection (WOS core) of Clarivate Analytics was used as the database to extract relevant literature data for knowledge map analysis, as it is a widely-recognized documentary library base [45,46] and can offer literature from a longer period of time [47]. Based on this, we selected WOS core as the data source for retrieving the authoritative articles on FTZs, following a flow path as Figure 3 shows.



**Figure 3.** Flowchart of data acquisition before the bibliometric analysis.

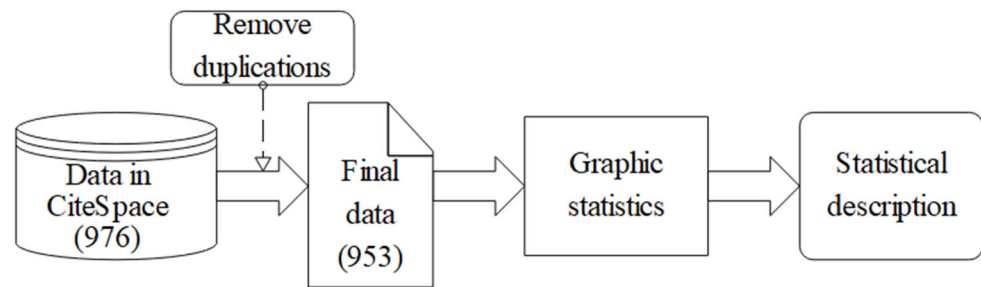
#### 3.1. Data Retrieval and Processing

As Figure 3 depicts, from the WOS core we input the search condition into the “advanced search” interface, whose search query is:

$$TS = (\text{free-trade zone}) \text{ OR } TS = (\text{free-trade pilot zone}) \text{ OR } TS = (\text{free-trade port}) \text{ OR } TS = (\text{free-economic zone}) \quad (1)$$



Moreover, we set the period as January 1960 to September 2021, considering the data integrity and the current conditions. The initial outcome of data retrieval was 1571 results, which was then refined to 976 results after setting the research field in social sciences by excluding irrelevant or weakly relevant disciplines. Finally, the refined data was translated into a compatible format and input into CiteSpace (version: 5.7.R5). However, before formally conducting the visualized bibliometric studies, a further data clean-up is a requisite which can be executed by CiteSpace. An intuitive graph presentation and a correlation analysis that may explain the statistical characteristic of the data were conducted subsequently. Figure 4 depicts this step.



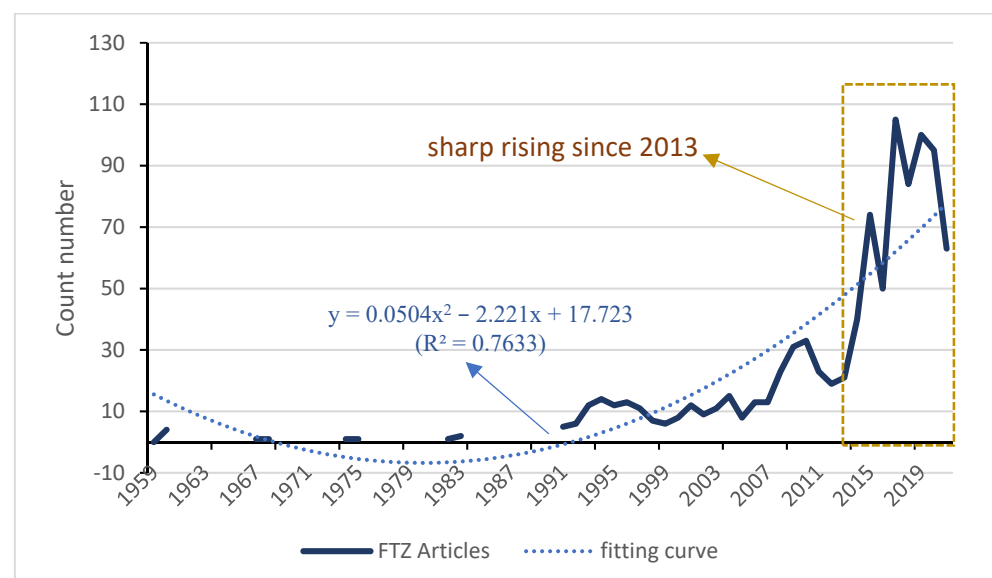
**Figure 4.** Flowchart of data processing in the bibliometric analysis.

The refined data was examined in CiteSpace and then purified by removing replicated documents. This is necessary before processing because duplicated data may interfere with the accuracy of the knowledge map [30]. The confidence level of the subsequent formal bibliometric analysis became higher with the final data after two rounds of data cleansing.

### 3.2. Data Descriptive Statistics

The final data contains 953 articles, as Figure 3 displays, but they are unevenly distributed on the timeline, where Figure 4 sketches the time distribution of the FTZ articles.

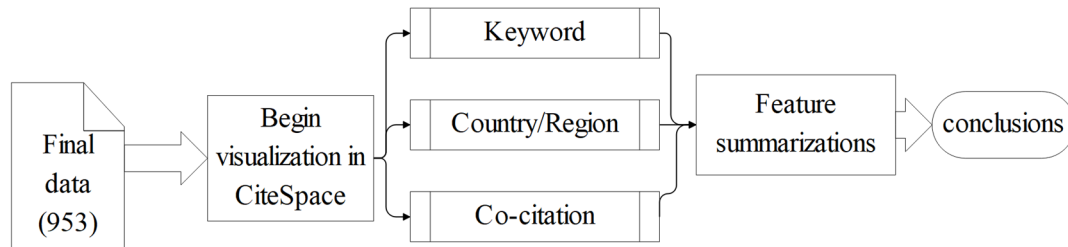
From Figure 5, we can see that the FTZ was not a hot topic in social science research for a long period because the article curve becomes continuous after 1991 but remains no more than 40 before 2013. It then went through a sharp increase after 2013, the year in which the first FTZ was established in mainland China. This uprush from 2013 to 2020 may be related to the successive establishment of Chinese FTZs, which deserves an ex-post study of the correlation between the counted articles and the number of Chinese FTZs.



**Figure 5.** The annual count number of FTZ articles.

### 3.3. Bibliometric Analysis in the Knowledge Map

The bibliometric analysis is calculated and presented in the form of a knowledge map of the following workflow as Figure 6 shows.



**Figure 6.** Flowchart of bibliometric program analysis.

Based on the flowcharts directing the bibliometric study of FTZs, the results will be presented in terms of correlation analysis, keyword visualization, country/region visualization, and reference co-citation analysis, respectively.

By analyzing the statistical characteristics and three bibliometric features, a relatively objective understanding of the research on FTZs can be presented. The next section describes the results of these investigations with visualized outcomes.

## 4. Results

### 4.1. Country/Region Visualization and Statistics

The visualized co-occurrence map of the country/region can bring an explicit view of their weightiness and centrality. The node size shows the weightiness of a country/region [34], and the violet ring's thickness of a node denotes its centrality [35]: a concept first proposed by Freeman [48], in which the node's degree of the central position in a network is measured. The thickness and quantities of connecting lines in a knowledge map of co-occurrence represents the intensity and diversity of an individual's collaboration with others [49]. Figure 7 displays the meshed network of the country/region's contribution to FTZ research.



**Figure 7.** Co-occurrence of country/region in FTZ contribution. (Note: Figure 7 is generated by the authors using CiteSpace, which is a free software that has been authorized for academic uses (see <http://cluster.cis.drexel.edu/~cchen/citespace/>, accessed on 21 April 2022)).

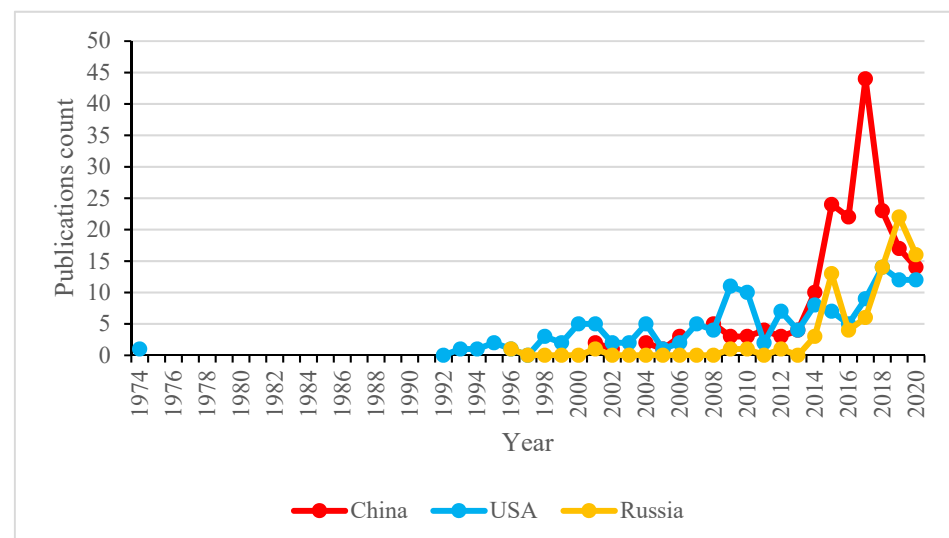
From Figure 7, it is shown that mainland China and the US have a far bigger node size than other producers, where the count number is 200 for China and 153 for the US. As for the centrality represented by the thickness of the violet outer ring, the US is the first (0.4) and China and France are tied for second place (both 0.16). Table 2 summarizes the producers which were counted no fewer than 10 times.

**Table 2.** FTZ's count numbers of the country/region.

Count	Count Rank	Centrality	Centrality Rank	Year <sup>1</sup>	Country/Region
200	1	0.16	2	2001	China mainland
153	2	0.4	1	1974	US
85	3	0.05	6	1996	Russia
47	4	0.15	5	1993	England
35	5	0.02	7	2007	South Korea
32	6	0.11	4	1989	Germany
27	7	0.1	7	1993	Canada
21	8	0.13	11	2001	Italy
21	9	0.01	10	1998	Brazil
20	10	0.16	9	1993	France
19	11	0.06	2	2005	Spain
18	12	0.08	11	2002	Netherlands
17	13	0.08	13	2003	Australia
17	14	0	13	2009	Ukraine
15	15	0	13	1999	Poland
13	16	0	5	2006	Turkey
12	17	0.03	13	1991	Mexico

<sup>1</sup> Note: The “Year” refers to the first year when an article contains the keyword in that row.

Although China leads in the number of FTZ publications, the first article that appeared in China (in 2001) was far later than that from the US (in 1974), and only until 2014, the year after the Shanghai FTZ was implemented, did China lead the annual FTZ publications. Figure 8 depicts the top three countries in cumulative publication quantities, in which China has a distinct spike in 2013–2020, and the time ranges from the establishment of the first FTZ to the twenty-first. Comparatively, the surge fluctuation in Russia is relatively low, and the US is even flatter but maintains the longest continuity. This comparison reflects the actual foundation of FTZs that can facilitate its academic research.



**Figure 8.** FTZ publications among the top 3 countries.

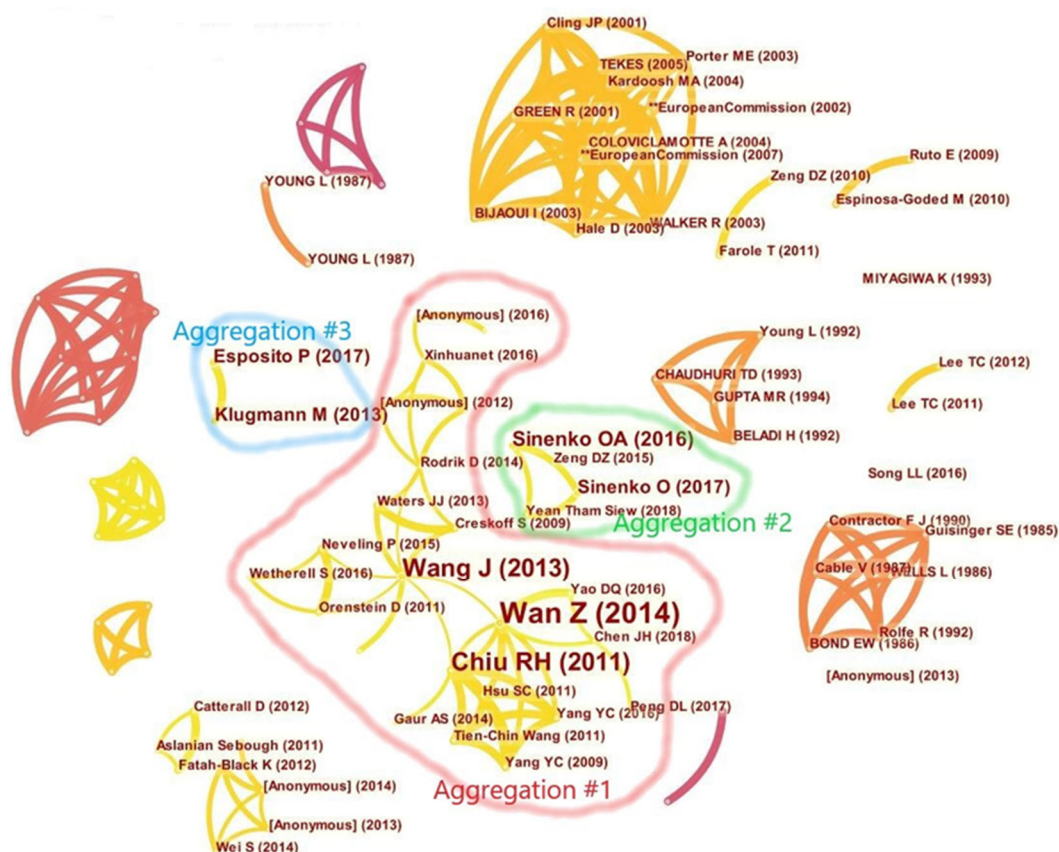
As for the most highly-cited literature in the top three countries, a policy interpretation of China's “One Belt One Road” initiative [50] is the most popular in China, with



123 citations, emphasizing that coastal harbor cities, such as Shanghai, will play an integral role in building the modern Maritime Silk Road. The second-most popular literature [51] with 51 citations interprets the seaports' development to be a consequence of a series of geo-economic policies related to FTZs, including a boom in foreign investment in the Shanghai FTZ. The US has two highly-cited articles that substantially outweigh the others (418 and 267): a case study on the Middle East's open economy [52], and a gravity model estimating the regional trade blocks' gains in the Western Hemisphere [53]. In Russia, in third place, the most-referenced work [54] with 71 citations estimates the European-Russian forest-cover change during a period of transformation in the market economy. The second paper [55] was mentioned before in the high co-occurrence keywords, but was only cited 24 times, proving that Russia's relevant research is still in the development process.

#### 4.2. Co-Citation Visualization and Features

The citation count is a direct and important indicator that weighs a publication's influence, which can also be summarized and displayed by CiteSpace [33]. In a visualized reference co-citation network, each link between two documents indicates that they are both cited by at least one article in the range of the input literature data. Every node represents an article that has been cited, but they differ in status in the network. Figure 9 produces the distribution map of the FTZ co-citation network.



**Figure 9.** Co-citation network of FTZ. (Note: Figure 9 is generated by the authors using CiteSpace, which is a free software that has been authorized for academic uses (see <http://cluster.cis.drexel.edu/~cchen/citespace/>, accessed on 21 April 2022)).

From Figure 9, we can see the co-citation network map of FTZs, where citation counts of no less than two are marked with the author (1st) and the publication year. Unlike the knowledge map of the keyword and country/region, the co-citation map manifests less linkage, as it consists of one big aggregation (#1), a medium-sized one (above the aggrega-

tion #1), and masses of small ones (including aggregation #2 and #3). This indicates that FTZs are not a tightly interrelated research theme because of the low citation count in the retrieved FTZ publications, the relatively isolated layout of the co-citation network, and only one publication [14] with the citation burst, which denotes it has experienced an increase in citations in a certain period. Table 3 provides a list of the most cited FTZ publications.

**Table 3.** FTZ articles that have been cited no less than 3 times.

Citation Count	Count Rank	Publication	Aggregation Number	Citation Burst
10	1	Wan Z, 2014, J TRANSP GEOGR, V34, P1 [14]	#1	Yes (2016–2021)
6	2	Chiu RH, 2011, ASIAN J SHIPPING LOG, V27, P423 [56]	#1	No
6	2	Wang J, 2013, J DEV ECON, V101, P133 [57]	#1	No
4	4	Sinenko OA, 2016, J TAX REFORM, V2, P168 [58]	#2	No
3	5	Sinenko O, 2017, 11th International Days Of Statistics And Economics, V0, P1421 [59]	#2	No
3	5	Esposito P, 2017, 10 ANN C EUR AC BUS, V0, P550 [60]	#3	No
3	5	Klugmann M, 2013, LEAP ZONES FASTER GR, V0, P0 [61]	#3	No
10	1	Wan Z, 2014, J TRANSP GEOGR, V34, P1 [14]	#1	Yes (2016–2021)

These seven articles are included in three isolated aggregations which are unlinked with each other, suggesting that they have different focuses on FTZs or related zones. The number one publication [14] possesses the hotspot keyword “China” which has been mentioned before. The second-most cited work [56] conducted an empirical assessment of business performance in five free-trade port zones (FTPZs) in Taiwan, and concluded that five factors, mainly on administration and tax preference, drive the FTPZ to success. Another China-related FTZ study [57] concentrating on the special economic zones’ (SEZs) economic contribution to the administrative region found that SEZs could bring about more FDI and total factor productivity growth with small side effects, such as low levels of rising costs.

The fourth and fifth articles were simply inter-linked inside an isolated aggregation #2, both centered on SEZs. The leading one with four citations explored the possible optimal tax incentives to drive SEZs [58], while the latter summarized China’s experiences in developing SEZs and their compartments on other main economies [59].

There exist two more works that were also cited three times. Two more similar concepts to promote growth are proposed: one is the LEAP zones in the US [60], and another is the urban-free zones in Europe [61]. Regardless of name, those zones share similar traits with FTZs and can be used for reference across the country/region.

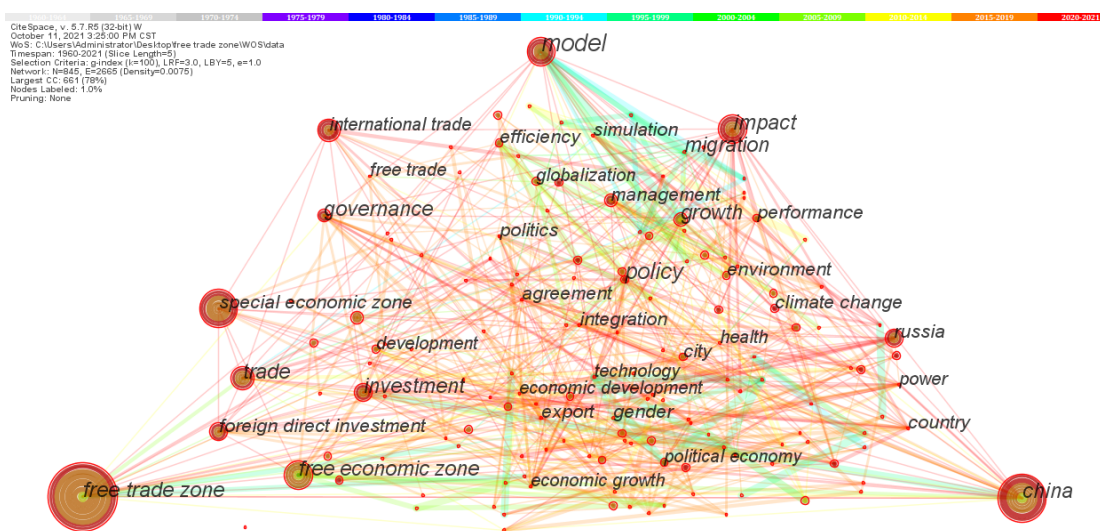
#### 4.3. Keyword Visualization

##### 4.3.1. Basic Visualization of Keywords

The keyword is a straightforward embodiment of an article’s research topic, and its co-occurrence map reflects the frequency/count and link map of the keywords [62]. The frequency of a keyword can signify its hotspot degree, enabling us to summarize past research topics and forecast future research trends [63]. For the research on FTZs, the visualized keyword knowledge map is shown in Figure 10, where each keyword is represented by a node, and a link connecting any two nodes means the corresponding two keywords co-occur in one article.

From the keyword co-occurrence knowledge map above, the core index word “free trade zone” comes out at the biggest font size or node size, showing that it has the highest occurrence frequency (67 times). Among those articles that adopted this keyword, a comparative study of the long-term operating policies between two Latin America free-trade zones [64] are cited the most (26 times). The results indicate that, when facing giant developing-economy competition (such as China) on exporting, Costa Rica’s FTZ succeeded in transferring its FTZ mode into the high-tech and service industries based on comparative advantages, whereas the Dominican Republic was faced difficulties when

keeping the traditional apparel sector running. Following the aforementioned article [14] which is in second place here, the third paper (cited 24 times) is a phenomenon study also on the Dominican Republic's FTZ. Focusing on a specific issue, especially the new labor forces constituted by educated young females that drive enterprises in the FTZ [65], illuminates that FTZs are not only a zone for innovation in techniques and management but also in human resources. To quantify the frequently reoccurring keywords, Table 4 lists those whose count number is no less than 10 among the 953 documents.



**Figure 10.** FTZ's co-occurrence knowledge map on keyword. (Note: Figure 10 is generated by the authors using CiteSpace, which is a free software that has been authorized for academic uses (see <http://cluster.cis.drexel.edu/~cchen/citespace/>, accessed on 21 April 2022)).

**Table 4.** Keywords in high occurrence frequency.

Rank	Count	Year <sup>1</sup>	Keyword
1	67	1996	Free-trade zone
2	43	1994	China
3	35	1991	trade
4	34	1992	model
5	29	2015	special economic zone
6	27	1996	Free economic zone
7	22	2015	impact
8	20	1999	investment
9	19	1994	policy
10	18	2015	international trade
11	17	1998	growth
12	14	2015	Russia
13	13	2012	management
14	13	2012	governance
15	12	2005	efficiency
16	12	2010	innovation
17	11	2018	foreign direct investment
18	11	1996	gender
19	11	2013	city
20	11	2015	export
21	11	2010	strategy

Note: <sup>1</sup> The “Year” refers to the first year when an article contains the keyword in that row.

The second-ranked keyword, which occurred 38 times, is not any index word we had input into the search statement but is a country, as Table 4 displays: “China.” This is further evidence that FTZs and China have a deep interplay aside from statistical correlation.

The most-cited document focuses on a comparison of greenhouse emissions in FTZ states and other regions [66], indicating that there are some factors in FTZs that can propel the eco-efficiency; “China” is mentioned as an example to strengthen research methods in the assessment of eco-efficiency. Subsequently, four articles have no less than 24 citations, whose research themes range from spatial heterogeneity between different free trade ports [67], to a political economy embodied in a pilot economy zone in Northeast Asia [68], to a case study on land borderline trade [55], and to the policy implications of the first Chinese FTZ establishment in Shanghai [14].

The “special economic zone” is also not an the index word but is in fifth place, indicating that SEZs have a strong relationship with FTZs, especially in China, as the 20-times cited analysis [69] points out that the preference of SEZs in eastern coastal China exacerbates the regional imbalance; henceforth, extending them into central and western China is essential. Similarly, an imbalanced distribution of FTZs may also bring about this disparity, which is why China has set up inland FTZs in the middle and western territories since 2017.

“Policy” is another non-negligible keyword, which reflects that FTZs are tightly linked with government strategies and administrations. Mohebi and Mirshojaee [70] carried out policy testing in appraising the promotion of Imam’s free-trade port exports by using the Difference-in-Differences (DID) method, where another non-FTZ port named Rajaei was regarded as the control group. Surprisingly, when compared with the non-FTZ port, the former port performed a trade deficit after the implementation of the FTZ policy, which opposed one of the original purposes of the FTZ, which was to increase exports.

#### 4.3.2. Clusterization of Keywords

Except for the direct co-occurrence map of the keywords, a cluster view can classify the nodes by the tightness of connection [30]. In the knowledge map of FTZs, there are a total of 17 clusters that cover most of the nodes. Table 5 lists their size, mean years, and cluster names. Cluster #0, namely the special economic zone (SEZ), with a size of 79, becomes the biggest element, which has been emphasized above. The year 2010 is the mean year of this cluster, indicating its hotspot status was before 2013, the year of China’s first settled FTZ. For example, Tang and Wang [71] reviewed the effort of carrying out an anti-monopoly exemption in the Shanghai FTZ, which was evolved from the Shanghai Pudong SEZ, suggesting that the FTZ can be a long-term pilot site to lower the regulations and to ease the misgivings of foreign investors. So far, however, there has been little discussion about the evaluation of land-intensive use regarding FTZs. Zhou et al. [13] conducted an empirical evaluation of the intensive land-use level in Shanghai’s FTZ. Further investigations are needed to assess the causes and shortcomings of smart land planning in FTZ site selection and spatial optimization.

**Table 5.** Clusters that generalized the keywords.

Cluster ID	Size	Mean Year	Cluster Name	Cluster ID	Size	Mean Year	Cluster Name
#0	79	2010	special economic zone	#9	43	2010	free-trade agreement
#1	62	2012	former global factory worker	#10	38	2008	alternative media
#2	58	2008	free economic zone	#11	34	2010	special sustainable development goal
#3	52	2013	methane extraction	#12	24	2009	recent gold discoveries
#4	50	2013	la paz agreement	#13	20	2009	open border
#5	48	2015	foreign trade zone	#14	13	1996	trading bloc
#6	46	2000	technology transfer	#19	6	2002	ambiguous result
#7	45	2008	paleogeographic map	#30	4	2018	diplomatic crisis
#0	79	2010	special economic zone	#9	43	2010	free-trade agreement
#8	43	2012	trading water pollution				

Note: (1) The “Size” refers to the count of the nodes; (2) The “Mean Year” is the year averaged from every keyword’s appeared year in that cluster; (3) For the implicit knowledge map of the timeline view of FTZ that contains all the clusters and hotspots variation, please see Appendix B.

Apart from cluster #0, the other clusters deserve attention as well because they keep the keyword map intact. Cluster #1, named the “former global factory worker” is the second-largest cluster, reflecting that workers’ rights and career developments are of great concern to labor-intensive FTZs. Hewamanne (2018) chose an urban FTZ in Sri Lanka, concentrating on former women-workers’ physical, social, and psychological burdens [72], and possible assistance for them to fit into social change after resignation [73]. Moreover, the social impact, including social hierarchies and gender norms, brought by their continuous efforts also emerged in Sri Lanka’s FTZs.

Cluster #2 and #5 have similar meaning to FTZs, but one inclusive keyword is noteworthy: the “inland port”, which may be the result of a good number of inland FTZs arousing research interest. For the foreign trade zones in the US, about two-thirds of them are inland rather than coastal [19]. In comparison to coastal FTZs, promoting the inland FTZ’s performance is a greater challenge because of their disadvantaged conditions in the capital, attraction, economic factors, and transportation conditions. This draws attention to how comparative advantages can be used. In these two clusters, Zheng et al. [74] studied the running mode of four inland ports in China involved with four development modes and constructed a social welfare theoretical model in which FTZ policy and port integration strategy are incorporated as the parameters. They deduced a corollary, proving that these two factors affect social welfare to varying degrees. The running mode of a port, which can be seen as its endogenous parameter, determines this degree.

#### 4.3.3. Burst Detection of Keywords

Apart from the frequency of the keywords, a burst detection can effectively reflect the variation tendency of the keywords, especially their possible sharp increase in citations over a certain period [75]. As for the keywords of FTZ, the burst detection began only after 1989, despite the existing time range starting from 1960. Table 6 displays the top-25 FTZ-related keywords with citation burst; the ranking of these keywords is a combination of their burst strength and burst duration.

**Table 6.** Top 25 keywords with the strongest citation bursts.

Keywords	Strength	Begin	End	Burst Duration in 1989–2021
duty-free zone	4.33	1990	2003	-----
unemployment	3.48	1992	2003	-----
tariff	2.6	1994	1999	-----
trade	2.37	1996	1999	-----
globalization	2.45	2002	2007	-----
conservation	2.28	2010	2013	-----
health	2.87	2012	2017	-----
free-trade zone	5.75	2014	2017	-----
special economic zone	4.81	2014	2019	-----
Shanghai	2.99	2014	2015	-----
investment	2.61	2014	2021	-----
Russia	2.39	2014	2019	-----
impact	3.73	2016	2021	-----
history	2.47	2016	2019	-----
strategy	2.32	2016	2019	-----
free zone	2.32	2016	2019	-----
negative list	2.29	2016	2017	-----
model	3.91	2018	2021	-----
management	3.64	2018	2021	-----
foreign direct investment	3.25	2018	2021	-----
development	2.58	2018	2019	-----
tax preference	2.34	2018	2019	-----
risk	2.27	2018	2019	-----
data envelopment analysis	2.23	2018	2019	-----
climate change	2.27	2020	2021	-----



In the right-most column of Table 6, the red blocks mean that a keyword is burst in the corresponding years, while the blues are not. Among these relative high burstiness keywords, “duty-free zone” becomes the number-one keyword in terms of citation burst, with a strength of 4.33 and the longest duration from 1990 to 2003, which is much higher than “free-trade zone” itself at eighth place, whose burst started late in 2014, providing evidence that duty-free is a key precondition of building a full-fledged FTZ. “Unemployment” is in second place, indicating that employment status is another significant issue in FTZs, where labor-intensive industries are located in most cases. “Shanghai” also experienced a citation burst in 2014–2015, just 1 year after Shanghai’s FTZ establishment in China. Except for the concentrations above, health and climate change, trade, investment, management, and strategy have received scholars’ attention, which may be due to an FTZ’s distinct feature of labor-intensive factories that are larger in scale and performance-orientated, in contrast with the non-FTZ area.

#### 4.4. Discussion

This study appears to be the first to conduct a bibliometric and visual analysis of FTZs. Through the bibliometric analysis based on country/region, literature co-citation, and keywords, the knowledge map of FTZs gives the following features: (1) the US has the longest research history on FTZs and the highest research centrality, indicating its cornerstone status of FTS study; (2) China started its FTZ research much later but has developed its research intensity rapidly, the increase coinciding with the establishment of China’s real FTZs; (3) the co-citation analysis shows that the heterogeneity exists in the FTZ literature, as their clusters are scattered; (4) the significance of China in FTZ research becomes evident gradually, as China appears to be first place in research quantity, included in the top three keywords, and has been frequently embodied in the highly co-cited FTZ articles.

Therefore, we can conclude that the linkage between the practical application and theoretical research of FTZs is tight, in which the FTZ’s current important position in China brings about valuable research, explaining the rapid expansion of China’s contribution. We can infer that China will show a steadily upward trend of FTZ research in the future, along with more economic experiments and pilot open policies. In fact, scholars have already examined China’s FTZ effects on regulatory innovation [76], income disparity [77], green production [25], transportation efficiency [78], and environmental effects [79]. This progress substantiates the upward trend, and we believe the breadth and depth of FTZ research will be enhanced further. Among these estimations of FTZ effects, Jiang et al. [37] used the synthetic control method to estimate the extra promotion of policy effects on the Shanghai FTZ, finding that the FTZ could bring extra promotion of green total factor productivity (GTFP) by driving technical innovations; Ma et al. [80] used the PSM-DID (Propensity Score Matching-DID) method to extend the driving effect of FTZs on GTFP in 280 Chinese cities; Zhuo et al. [25] used DID method to find that FTZs can be a “policy trap” by exacerbating the discharge of wastewater and exhaust gases in Guangdong because of low-end industries’ expansion. All the signs of progress from this research have illustrated that FTZs can bring diversified policy implications of FTZ, and that the positive effects play a leading role, but also that negative effects exist. The sufficient policy samples in China can move toward the differentiated policy effects of FTZs based on the heterogeneous city sizes and geographical locations [81].

## 5. Conclusions

### 5.1. Summary of Results

In order to fill the gap in systematic research in the field of FTZ so that the main progress and insights in this field can be identified more effectively, a novel bibliometric and visual analysis method was applied in this study to elaborate on the development, hotspots, and trend directions for further research.

By delimiting a specialized land in a city requiring smarter industrial technologies and management measures in limited space, a free-trade zone represents a special economic



and exporting zone because it gives a lower threshold to both local and foreign investment, with a variety of supporting services and tax preferences. However, as FTZs represent a long-existing matter worldwide, they have aroused little academic research concerns before 2013. The situation has changed since then, and 2013 is also the year China authorized the first FTZ in Shanghai. Since then, both the foundation of Chinese FTZs and the research into FTZs has boomed. This paper has collected FTZ-related research up until September 2021 from the Web of Science Core Collection, proving an evident correlation between the number of FTZ yearly research articles and the quantity of Chinese FTZs. Then, by inputting the FTZ document data into a knowledge map program, the outcome strengthened this relationship from aspects of the country/region co-occurrence, the co-citation networks, and the keyword co-occurrence map.

In the country/region analysis, China had the largest number of total publications and the leading annual publications since 2014 but has a relatively lower centrality in the map compared with the US. The co-citation map indicates that the interlinks of the co-cited articles are not tight, as it constitutes several isolated aggregations, indicating that the referential significance of the current FTZ literature is not sufficient. However, the biggest aggregation contains the top three most-cited publications; two of them are from mainland China and are based on research on Chinese free-trade zones (ports). Hence, we can conclude that China's FTZs draw domestic scholars to explore, and this leads to future booming FTZ research around the globe.

In the keyword knowledge map, "China" is the second most-counted keyword, just behind the "free-trade zone", which is the main index word and is also recognized as the biggest cluster calculated by CiteSpace. With the two previous analyses, this outcome is further proof of China's significance in observing the FTZ's performance. Meanwhile, the employee's rights and benefits in the FTZs are inescapable, considering the role of FTZs in economic growth.

Taken together, the study certainly makes several noteworthy contributions that have a bearing on FTZs and provides a basis for a deeper insight into this field.

### 5.2. Research Trend

In the future, the addition of FTZs in China may be slowed because the current 21 FTZs already have extensive coverage, but the research output on FTZs will not decrease. One reason for this is that FTZs are still in their infancy, which can be promoted and diversified in functions and running modes, drawing the investigations and implications embodied into theoretical research. Additionally, setting an FTZ is a typical quasi-experiment that can be observed and measured in economic data, giving the scholars a perfect object in policy reviews through continuous running; the longer the time, the ampler data that is obtained. Therefore, we consider that FTZ-related research will maintain a trend in growth, and both the numbers and methods will expand. As for the international cooperation on FTZ research, the situation may continue to be unimproved as FTZ is not a transnational term. On account of this, communications and interviewing on each other's FTZs at the firm level, government level, and academic level will be much more constructive than running each one individually. There is room for further progress in determining smart land planning in FTZ site selection and spatial optimization. This is an important issue for future research. A further study with more focus on big data, the Internet of Things, GIS, artificial intelligence, and other technologies regarding FTZs is suggested.

### 5.3. Research Deficiencies and Future Works

Although the bibliometric study in this paper sketches the research context of FTZs and gives a reference for possible future development, the level of detail is relatively low. The FTZ can exert impacts on the development of an open economy [82], change the mode of government management [83], and promote a high land-utilization rate through industrial agglomeration [13]. Hence, future works on FTZs should focus on policy effects on specified

domains where more methods, such as empirical studies and scenario simulations, can come into use.

Despite these promising results, questions remain. These data should be interpreted with caution because of their reliance on the absolute values of articles relative to countries without any information on the nature of publications. Moreover, despite the keyword analysis function, the analytical tool in this study may lack a detailed analysis based on the content extraction, which may result in incomplete information in the trend estimation. The centrality calculated by the analytical tool may also reflect quantity within the manuscript rather than the quality of it, and country/region/keywords/cited references with high centrality is probably a result of a short-term research hotspot. Therefore, deeper studies, such as meta-analysis or textual analysis in future works may be able to promote the objectivity and comprehensiveness of the FTZ's research trend with more countable and convincing findings.

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## Appendix A

**Table A1.** The list view of all the free trade (pilot) zones (FTZ) in China (up to June 2022).

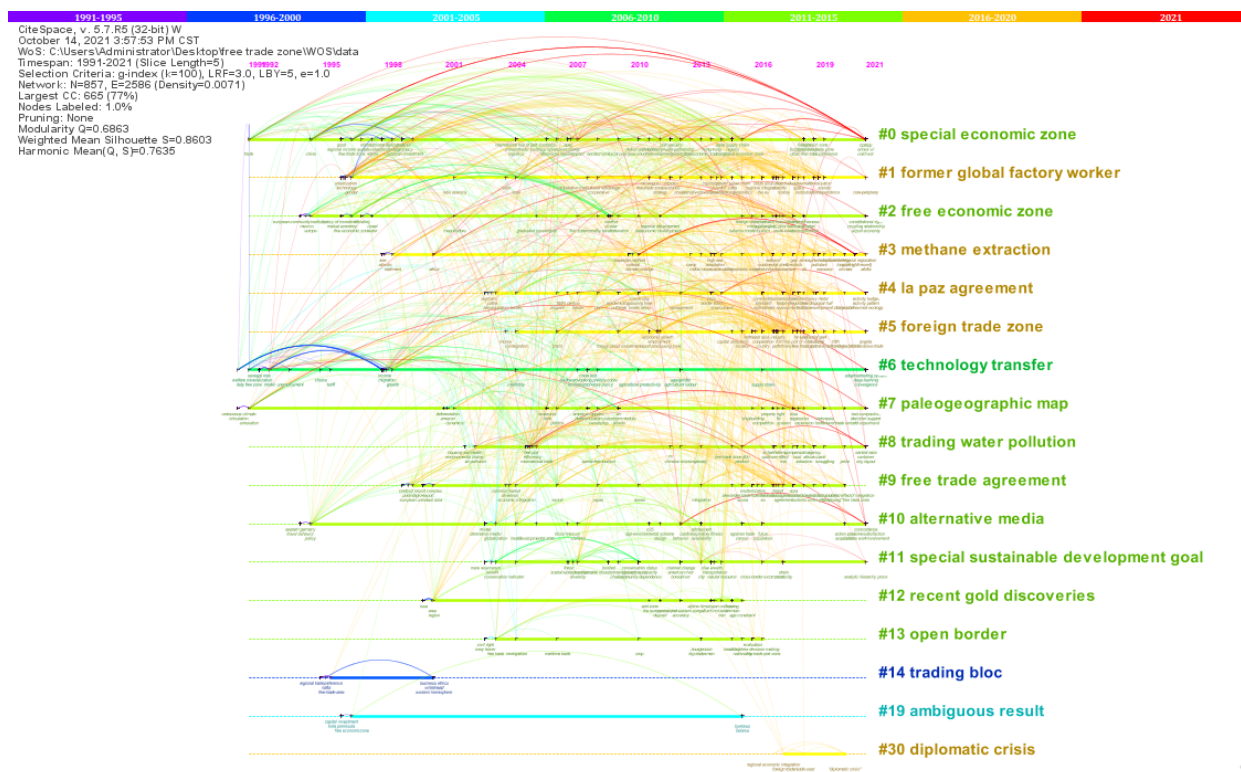
Provincial FTZ Name	Establishment Time	District-Level FTZ Name	Site	Batch
China (Shanghai) Pilot FTZ <sup>1</sup>	Sep. 2013	Waigaoqiao Free Trade (Logistics Park) Zone	Coastal	1st
		Yangshan Free Trade Port Area		
		Pudong Airport Free Trade Zone		
	Dec. 2014	Jinqiao (Economic and Technological) Development Subzone		
		Zhangjiang Hi-tech Subzone		
		Lujiazui Financial Subzone (including Expo Area)		
Aug. 2019	Lin-gang Special Area			
China (Tianjin) Pilot FTZ	Apr. 2015	Tianjin Port Dongjiang Area	Coastal	2nd
		Tianjin Airport Area		
		Binhai CBD Area		
China (Guangdong) Pilot FTZ	Apr. 2015	Nansha area of Guangzhou	Coastal	2nd
		Qianhai Area of Shenzhen		
		Hengqin Area of Zhuhai		
China (Fujian) pilot FTZ	Apr. 2015	Fuzhou Area	Coastal	2nd
		Xiamen Area		
		Pingtian Area		
China (Liaoning) Pilot FTZ	Mar. 2017	Shenyang Area	Inland	3rd
		Dalian Area	Coastal	
		Yingkou Area		

Table A1. Cont.

Provincial FTZ Name	Establishment Time	District-Level FTZ Name	Site	Batch
China (Zhejiang) Pilot FTZ <sup>2</sup>	Mar. 2017	Offshore Island Area of Zhoushan Island	Coastal	3rd
		North Area of Zhoushan Island		
		South Area of Zhoushan Island		
	Sep. 2020	Ningbo Area		6th
		Hangzhou Area		
		Jinyi Area		
China (Hubei) Pilot FTZ	Mar. 2017	Wuhan Area	Inland	3rd
		Xiangyang Area		
		Yichang Area		
China (Sichuan) Pilot FTZ	Mar. 2017	Chengdu Tianfu New Area	Inland	3rd
		Chengdu Qingbaijiang Rail Port Area		
		South Sichuan Port Area		
China (Shaanxi) Pilot FTZ	Mar. 2017	Xi'an central Area	Inland	3rd
		Yangling Demonstration Zone		
		Xi'an International Trade & Logistics Park Area		
Hainan Free Trade Port <sup>3</sup>	Apr. 2018	The entire Hainan Island	Coastal	4th
China (Shandong) Pilot FTZ	Aug. 2019	Jinan Area	Inland	5th
		Qingdao Area	Coastal	
		Yantai Area		
China (Jiangsu) Pilot FTZ	Aug. 2019	Nanjing Area	Inland	5th
		Chongzuo Area		
		Qinzhou Harbor Area		
China (Guangxi) Pilot FTZ	Aug. 2019	Nanning Area	Inland	5th
		Chongzuo Area	Coastal	
		Qinzhou Harbor Area		
China (Hebei) Pilot FTZ	Aug. 2019	Xiong'an Area	Inland	5th
		Zhengding Area		
		Daxing International Airport Area		
		Caofeidian Area	Coastal	
China (Yunnan) Pilot FTZ	Aug. 2019	Kunming Area	Inland	5th
		Honghe Area		
		Dehong Area		
China (Beijing) Pilot FTZ	Sep. 2020	Scientific and Technological Innovation Area	Inland	6th
		International Business Services Area		
		High-end Industry Area		
China (Anhui) Pilot FTZ	Sep. 2020	Hefei Area	Inland	6th
		Wuhu Area		
		Bengbu Area		
China (Hunan) Pilot FTZ	Sep. 2020	Changsha Area	Inland	6th
		Yueyang Area		
		Chenzhou Area		

Note: <sup>1</sup> Shanghai FTZ expanded twice, one was in Dec. 2014 and another was in Oct. 2019; <sup>2</sup> Zhejiang FTZ was initially founded in 2017, and expanded in Sep. 2020; <sup>3</sup> Hainan Province is an offshore island which is liable to economic experiments at larger scales, this is a reason why Hainan's FTZ range is the entire island.

## Appendix B



**Figure A1.** The timeline view of the keyword knowledge map. Note: Figure A1 is an auxiliary map to Figure 10 and Table 5 to indicate the keyword clustering through the time variation.

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