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Bibliometric Analysis of Published Documents on Entrepreneurship in Basic Sciences (Physics, Chemistry, Biology)

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ABSTRACT

In recent years, efforts to transform scientific information produced in basic sciences into technology to facilitate daily life have been increasing. In this sense, the perspective of entrepreneurship gains importance in basic sciences. This study aims analyze documents published on entrepreneurship in basic sciences (physics, chemistry, biology) using a bibliometric review. For this aim, the bibliometric analysis method based on the systematic literature review approach was used. Systematic review was carried out in the WoS database. A total of 428 documents (1994-2020) on entrepreneurship in basic sciences in the WoS were retrieved. The bibliometric analysis results were presented under two main categories as descriptive (numbers of documents according to year, author, country, organization, source, research area, WoS category area) and evaluative results (co-occurrence, co-authorship, citation analysis). Descriptive results were displayed with frequency values, and evaluative results were displayed using VOSviewer visualization software. As a result, it was determined that there is an important increase in the number of documents towards 2020. In addition, it was determined that the most productive, influential, and collaborative author is Jardım-Goncalves R, the most productive country is the USA, the most productive journal is Journal of Technology Transfer, and the most productive organization is Old Dominion University. Moreover, it has been determined that the most influential area in terms of research area is "business economics" and the most keyword co-occurrences are "entrepreneurship", "design science" and "academic entrepreneurship".

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Introduction

Science is often seen as a more theoretical and less applicable discipline, and it is not clear how science works in society (Jumini, Madnasri, Cahyono & Parmin, 2022). In recent years, the emphasis on entrepreneurship has been increasing in research conducted in basic sciences such as physics, chemistry and biology. In this sense, Deveci and Seikkula-Leino (2018) in their research, in which they examined the documents published on entrepreneurship in teacher education, draw attention to the fact that the most emphasis on entrepreneurship is made in science education. In addition, the emphasis on the concept of entrepreneurship in physics, chemistry and biology education in science education (Deveci & Seikkula-Leino, 2016; Deveci & Çepni, 2017) points to the importance of the concept of entrepreneurship in basic sciences. Thus, some studies approach entrepreneurship from a biology perspective (Nicolaou & Shane, 2014; Nicolaou, Phan & Stephan, 2021). Biology is known as the science that deals with the structure, function, heredity and evolution of living organisms. Thus,

from the perspective of biology entrepreneurship, gene therapy, cloning, stem cells, neuroscience, DNA vaccines, etc., technological developments and studies can be given as examples of entrepreneurship in the field of biology. Moreover, by providing students with knowledge and understanding about how the physical structure of the world works in physics education; it is possible for students to develop an understanding of basic concepts such as gravity, heat, light, magnetism, and electricity (Olugbenga, 2010). In this sense, from the perspective of physics entrepreneurship; thermal insulation, thermal conductivity, electrical insulation, electrical conductivity, military and security, etc., technological developments and studies can be given as examples of entrepreneurship in the field of physics. Since chemistry deals with matter and its changes, it tries to explain the chemical events of daily life (Olatunbosun, 2020). When innovations from research in chemical science are transformed into marketable products for commercial gain, chemistry entrepreneurship is embarked on (Dewi & Mashami, 2019; Olatunbosun, 2020). Thus, from the perspective of chemistry entrepreneurship, the chemical industry, textile, paper, petroleum, hygiene materials, etc., technological developments and studies can be given as examples of entrepreneurship in the field of chemistry. The concepts of "physics entrepreneurship", "chemistry entrepreneurship" and "biology entrepreneurship" will be heard more in the near future with the entrepreneurship perspective to be developed for physics, chemistry, and biology disciplines, which are among the basic sciences. Of course, one of the most important components that will enable these approaches to come to light is the institutions where basic science education is given. Therefore, it is very important to include the concept of entrepreneurship in the course contents of basic sciences such as physics, chemistry, and biology. Physics, chemistry or biology entrepreneurship could be explained the entrepreneurial mindset that enables the use of scientific concepts related to basic sciences (physics, chemistry, biology) to develop innovative solutions. Thus, individuals who graduate from basic sciences will be more likely to contribute to the commercialization of the science/knowledge produced at the university through university spin-offs or directly to the business world. In this case, concepts such as academic entrepreneurship and entrepreneurial university come to the fore.

Recognizing the strong interest in academic entrepreneurship, university spin-offs and entrepreneurial scholars are seen as potential sources of new and often groundbreaking initiatives (Skute, 2019). Scientific entrepreneurship is the sum of all the activities necessary to establish an enterprise through the combination of both scientific knowledge and business/business disciplines (Chen, Wan & Chen, 2021). In this sense, Chen et al. (2021) point out that colleges should focus on how to use scientific knowledge to develop innovative scientific initiatives such as biotechnology, medicine, or other high technologies. Along with the concept of scientific entrepreneurship, expressions such as science-based venture, technology venture, science-based business, and science-based firm are encountered in the literature.

Science-based ventures play a very important role in revealing innovations (Maine, Lubik & Garnsey, 2013). It is noted that one of the best examples of science-based ventures is biotechnology (Pisano, 2006). For example, Genentech, as the first biotechnology company, was one of the precursors of science business, which was founded in 1976 as an organization that used recombinant DNA technology for cells to produce human proteins (Pisano, 2006). In order to increase science-based entrepreneurship activities, some universities and research centers are developing special strategies to increase the entrepreneurial intention of scientists (Barron & Amorós, 2019). Technology ventures create commercial value by developing and patenting knowledge and then commercializing R&D with product sales, copyrights and/or contracts (Maine et al., 2013). On the other hand, Pisano (2006) states that science-based businesses are a relatively new phenomenon. With the phrase “science-based”, Pisano (2006) draws attention not only to benefit from existing science but also to advancing scientific knowledge and capturing the value of emerging new knowledge. Finally, science-based firms are created to take advantage of scientific knowledge commercially (Barron & Amorós, 2019). Enterprises related to advanced materials and biotechnology can be given as examples of science-based firms as businesses that aim to both contribute and profit from an emerging science base (Pisano, 2010).

Universities, which play an important role in society every day, are evolving (Almeida, 2022). In this context, with the concept of "entrepreneurial university", the relations of universities with society are undergoing a series of changes, especially at the point of spreading scientific knowledge to the economy (Etzkowitz, 1993). Thus, university spin-offs, or academic spin-offs, come to the fore (Bigliardi, Galati & Verbano, 2013; Díaz, 2020). University spin-offs are companies created from information produced in a university or R&D laboratories in order to transform the information and/or technologies developed in the institution into products (Almeida, 2022). It can be said that the concept of "spin-offs" mentioned here refers to companies established to commercialize the knowledge and skills of a university. University spin-offs are an important driver of innovation as well as economic and social development (Moog & Soost, 2022). University spin-offs also contribute to the regional entrepreneurship ecosystem by being involved in the dissemination of knowledge (Prencipe, Corsi, Rodríguez-Gulías, Fernández-López & Rodeiro-Pazos, 2020). The founding members of these spin-offs may or may not be academic scientists (Nosella & Grimaldi, 2009). Inventors can conduct research in different research fields (Chemical Engineering, Materials Engineering, Electrical and Computer Engineering, Mechanical Engineering, Chemistry, Pharmacy, Physics and Biology) and work in different faculties/departments (Daniel & Alves, 2020). In the past, creating value by developing products and services in basic sciences was seen as the domain of for-profit companies/enterprises (Pisano, 2006). In this sense, Pisano (2006) draws attention to the fact that enterprises do not deal with basic science in general and scientific institutions do not tend to do business/business world. Pisano (2006) emphasizes, for example, that the biotechnology sector combines these two fields. However, due to the fact that scientists focus on the knowledge transfer process, the need for the time required to develop an innovative idea can cause it to take much longer than traditional processes (Barron & Amorós, 2019). Thus, entrepreneurship education plays an important role in developing the skills and attitudes that help increase the number of science-based firms (Barron & Amorós, 2019).

An entrepreneurial university acts as a pathway to entrepreneurial activities that will contribute to long-term economic and social development through its multiple missions (for example, teaching, research and entrepreneurial activities) (Guerrero, Urbano & Fayolle, 2016). Thus, university entrepreneurship; while it has a strong and direct relationship with three parameters consisting of education, research and entrepreneurship activities, these three parameters have an indirect and positive relationship with economic growth (Guerrero, Urbano, Cunningham & Organ, 2014). In this sense, technology-transfer offices in non-profit universities actively seek commercial partners to license patents (Pisano, 2006). In addition, universities can form partnerships with developing companies to commercialize the basic science emerging from academic laboratories (Pisano, 2006). Much of the work on the commercialization of science focuses on institutions that have emerged to facilitate the commercialization of innovative ideas or products, such as university technology transfer offices, science parks, and business incubators (Siegel & Wessner, 2012). Thus, it can be said that universities have included or are trying to include different organizations such as science parks, business angels, venture capitalists, technology transfer offices, business incubation centers, which enable them to expand their networks, provide different services and develop foreign relations that support the creation of new ventures. In this regard, Barron and Amorós (2019) draw attention to two important questions. First, is it possible to turn scientists into entrepreneurs? Second, can scientific research get into market through entrepreneurship education programs? In this sense, Pisano (2006) draws attention to the fact that the question of whether science can be a profitable business is largely ignored. In fact, this situation can be attributed to the lack of entrepreneurship perspective, especially in the course content in basic sciences. At this point, one of the reasons for conducting the current research is to draw attention to the issue of Entrepreneurship in Basic Sciences (EBS) such as physics, chemistry and biology. In addition, the results of the current research can enable researchers to see the main trends in entrepreneurship-related studies in basic sciences. Furthermore, the current research will provide clues about the structure, social networks and current interests of the field of entrepreneurship in basic sciences. Therefore, the aim of the present research is; performs bibliometric

analysis of documents published on EBS (physics, chemistry, biology). In this context, the research questions were formed as follows.
- What are the descriptive results (year, author, country, organization, research area, source, Web of science category) of documents published on EBS ?
- What are the evaluative results (keyword co-occurrence, co-authors, citation analysis) of published documents on EBS?

Literature Review

Entrepreneurship; it is a broad field of study that has an intersection with fields such as education, technology, marketing or psychology (Amjada & Nasirb, 2020). In this sense, in the studies where bibliometric analyzes are carried out in the entrepreneurship literature, it is seen that the concept of entrepreneurship is worked with many sub-fields and subject headings or with different concepts. For example, in many studies where bibliometric analyzes on entrepreneurship were performed, researchers focused on social entrepreneurship (Dionisio, 2019; Granados, Hlupic, Coakes & Mohamed, 2011; Rey-Martí, Ribeiro-Soriano & Palacios-Marqués, 2016; Sassmannshausen & Volkmann, 2013). In addition to these, related to social entrepreneurship; bibliometric analyzes were conducted on economy for the common good and social entrepreneurship (Campos, Sanchis & Ejarque, 2020), social entrepreneurship in gastronomy tourism (Celebi, Pirnar & Eris, 2020), and social entrepreneurship in tourism (Sarıbaş, Kömürcü & Akbaba, 2020). There were also many bibliometric analyzes conducted on entrepreneurship in sports in the literature. For example, it could be see bibliometric analyzes on entrepreneurship and innovation in football (Escamilla-Fajardo, Núñez-Pomar, Ratten & Crespo, 2020), on sports entrepreneurship (González-Serrano, Jones & Llanos-Contrera, 2020), entrepreneurial ecosystems, knowledge diffusion and their status in sport (Calabuig-Moreno, Gonzalez-Serrano, Alonso-Dos-Santos & Gómez-Tafalla, 2021), and on sustainable sports entrepreneurship and innovation (González-Serrano, Sanz & González-García, 2020). Some of studies can be grouped under the theme of environment. Regarding the environmental theme; on forest entrepreneurship (Mourao & Martinho, 2020), on sustainable entrepreneurship (Anand, Argade, Barkemeyer & Salignac, 2021; Moya-Clemente, Ribes-Giner & Chaves-Vargas, 2021), on environmental entrepreneurship (Piwowar -Sulej, Krzywonos & Kwil, 2021), on tourism and entrepreneurship in terms of sustainability (Trip, Fagadar, Badulescu & Badulescu, 2021), on rural entrepreneurship (Pato & Teixeira, 2016), and green entrepreneurship (Kumar & Kiran, 2017) bibliometric analyzes were carried out. Some studies can be gathered under the theme of "women entrepreneurship". Regarding women's entrepreneurship; on female entrepreneurship (Deng, Liang, Li & Wang, 2021), on rural women entrepreneurship (Parmar & Gahlawat, 2020), on the phenomena of "women", "entrepreneurship" and "education" (Slavinski, Todorović, Vukmirović & Montenegro, 2020) bibliometric analyzes were carried out. Other bibliometric studies were on international entrepreneurship (Baier-Fuentes, Merigó, Amorós & Gaviria-Marín, 2019; Gupta, Pandey & Sebastian, 2021; Servantie, Cabrol, Guieu & Boissin, 2016), entrepreneurial intention (Arias, Restrepo & Restrepo, 2016; Dolhey, 2019; Ruiz-Alba, Guzman-Parra, Oblitas & Mediano, 2021), on the entrepreneurial orientation regarding the firm's performance (Andrade-Valbuena, Merigo-Lindahl & Olavarrieta, 2019; Mohammed, Talib, Kohar & Muharam, 2020) ; Pei, Shi & Shan, 2021) were performed. On the other hand, bibliometric analyzes were conducted on innovation practices in entrepreneurship education (Albort-Morant & Leal-Rodríguez, 2017) and international studies on entrepreneurial and innovative strategies (De-Sousa, Júnior, Da-Costa & Nobrega, 2020).

There were also bibliometric analyzes carried out by associating with different concepts, disciplines or sub-fields that cannot be grouped in the literature. For example; on media and entrepreneurship (Hang, 2020) on tourism and entrepreneurship (Işık et al., 2019), on ethics and entrepreneurship (Vallaster, Kraus, Lindahl & Nielsen, 2019), on religion and entrepreneurship (Block, Fisch & Rehan, 2020)), on risk and entrepreneurship (Syed, 2021), on small business management and entrepreneurship (Volery & Mazzarol, 2015), on innovation and entrepreneurship (Sharma, 2019), on

immigrant and ethnic entrepreneurship (Cruz & Queiroz-Falcão, 2016), on the link between entrepreneurship and dynamic capabilities (Cruzara, Kaniak, Junior & Teixeira, 2020), and on corruption and entrepreneurship (Uribe-Toril, Ruiz-Real, Ceresia & Valenciano, 2019) bibliometric analyzes were also carried out.

Finally, there are bibliometric analyzes conducted from an educational point of view without being associated with a different concept, discipline or sub-field in the relevant literature. At this point, on keyword analysis in entrepreneurship education from an educational point of view (Kakouris & Georgiadis, 2016), on entrepreneurship education researches in general (Aparicio, Iturralde & Maseda, 2019), on the importance of both entrepreneurship and entrepreneurship education in general (Amjada & Nasirb, 2020), on entrepreneurship in general (Ramírez, Cañizare & García, 2017), and on the past, present and future of Chinese entrepreneurship education research (Zheng, 2018) bibliometric analyzes were conducted.

In the literature, Kakouris and Georgiadis (2016) as a result of their bibliometric analyzes on entrepreneurship education from an educational point of view; points out that there is little research that refers to learning processes in the context of innovative entrepreneurship education. Moreover, Kakouris and Georgiadis (2016) point out that more research is needed to reveal a more concise picture of the educational process of "promoting entrepreneurial mindsets". In addition, entrepreneurship education creates an important area of academic interest and the research focus on entrepreneurship education has developed over the years (Aparicio et al., 2019). In this sense, it is noteworthy that many entrepreneurship programs have been designed for scientists recently in order to transform research or research results into marketable products (Barron & Amorós, 2019). In fact, there has been an increasing interest in entrepreneurship (Barron & Amorós, 2019), in the United States of America (USA) since Myles Mace gave the first entrepreneurship course at Harvard Business School in 1947 (Katz, 2003). Thus, in recent years, universities have placed more emphasis on the entrepreneurial dimension of technology commercialization and this has led to a significant increase in the number of university-based initiatives (Siegel & Wessner, 2012). Similarly, Amjada and Nasirb (2020) draw attention to the fact that entrepreneurship education is one of the important sub-fields that are emerging rapidly in entrepreneurship. As a result, entrepreneurship education for the scientific community is becoming more and more common (Barron & Amorós, 2019). Therefore, it is possible to see bibliometric analyzes in the literature both directly on the concept of entrepreneurship and in which the concept of entrepreneurship is associated with many other concepts. However, no research was found in which documents published on EBS were subjected to bibliometric analysis.

Method

Scientometrics is the science of measuring and analyzing science (Sassmannshausen & Volkmann, 2013). In this sense, bibliometrics is a method that is included in the sociometric approach (Sassmannshausen & Volkmann, 2013). Thus, bibliometrics interests the development and application of quantitative measures and indicators for science and technology based on bibliographic information (Van-Leeuwen, 2004; p. 374). As a result, the quantitative development of the relevant literature could be evaluated thanks to bibliometry (Sassmannshausen & Volkmann, 2013). In addition, the main advantage of bibliometric methods is that they bring quantitative and systematic rigor to the subjective evaluation of the literature (Paul & Criado, 2020). In the current study, the documents published on EBS (physics, chemistry, biology) in the Web of Science (WoS) database were examined by taking advantage of this advantage of bibliometrics. One of the data sources of bibliometric studies is the WoS database (Pato & Teixeira, 2016). Since the WoS database is seen as one of the main sources of scientific documents (Baier-Fuentes et al., 2019), the documents were accessed through the WoS database in the current research. Another reason for choosing the WoS database is that it scans journals with high H-index value and impact factor.

Data Source and Data Collection

While systematic literature review was carried out during the research process, the "Web of Science Core Collection" category was selected in the WoS database and the search was carried out in this way. Detailed information about the exclusion and inclusion criteria, and the processes, the keywords used during the systematic literature review process are given in Table 1.

Table 1

Inclusion and Exclusion Criteria

Database	WoS Core Collection	
Indexes	Web of Science Core Collection (Citation Indexes Science Citation Index Expanded, Social Sciences Citation Index Arts & Humanities Citation Index, Conference Proceedings Citation Index- Science, Conference Proceedings Citation Index, Social Science & Humanities, Book Citation Index– Science, Book Citation Index, Social Sciences & Humanities, Emerging Sources Citation Index)	
Date	01.03.2021	
Search option	Advanced Search	
Publication Years	Beginning - 2020	
Languages	No limit	
Document Types	No limit	
Field Tags	AK (Author Keywords)	
Keywords terms	Tags	Document count (N)
	AK= (entrepreneurship and biology)	10
	AK= (entrepreneurship and chemistry)	3
	AK= (entrepreneurship and physics)	2
	AK= (entrepreneurship and science)	206
	AK= (enterprise and biology)	2
	AK= (enterprise and chemistry)	3
	AK= (enterprise and physics)	2
	AK= (enterprise and science)	163
	AK= (entrepreneurial and biology)	1
	AK= (entrepreneurial and chemistry)	2
	AK= (entrepreneurial and physics)	0
	AK= (entrepreneurial and science)	60
Total number of documents reached		428

As noted in Table 1, all indexes in the database of “Web of Science Core Collection” were scanned during the searching process. Only the year 2021 was excluded because the catalog searching process has only been carried out in the beginning months of 2021. In addition, there was no restriction in terms of language, and documents published in all languages were included in this systematic review. The reason for including studies published in all languages in this study was that all documents in the journals searched in WoS include English titles, abstracts and keywords. In addition, there was no restriction as to the document type, and all document types were included. In the source search process carried out to found the documents, firstly, the "title" option was searched as the field tags. A very limited number of documents were reached in the resource search carried out under of tag the “title”. In the second stage, searching was carried out in the “abstracts” option as the field tags. In the “abstracts” option, the documents reached were examined in detail and many documents other than the subject intended to be examined were reached. Finally, in the third stage,

the "Author Keywords (AK)" option was searched as the field tags. As a result of the literature review carried out in the AK option, it was determined that the documents reached were on the subjects to be examined. Thus, the AK option gave the most ideal result for the documents related to the subject.

Then, the words *biology*, *chemistry*, *physics* and *science* were used in order to access documents on EBS in the AK option in the systematic search process. Therefore, the basic sciences considered in this research were limited to the words *physics*, *chemistry*, *biology* and *science*. Afterwards, it was decided to use the entrepreneurship, enterprise and entrepreneurial words related to entrepreneurship in order to reach the researches carried out in the context of entrepreneurship in basic sciences. The reason why the "*entrepreneurship*", "*enterprise*" and "*entrepreneurial*" labels were preferred for entrepreneurship was that these concepts has been used interchangeably in the literature from time to time. Finally, after the terms that should be used in terms of both basic sciences and entrepreneurship were determined, literature review was carried out by considering the dual formations of these words [for example, (*entrepreneurship* and *biology*]. As a result of these processes, a total of 428 documents were reached.

Analysis of Data

In the first stage of the analysis process, descriptive results were obtained. For this, tab-delimited text files containing descriptive values (year, author, country, institution/organization, source, research area, WoS category fields) of 428 documents from the search results in the WoS interface were saved to the computer. Then, these files were arranged in the Excel electronic file and descriptive results were obtained. In the second stage, visualization approaches were used to reach evaluative results. WOSwiever software was used, which makes it possible to use some methods and techniques for visualization approaches. VOSviewer software is a free software developed by Van-Eck and Waltman (2010). Unlike most computer programs, VOSviewer, which is used for bibliometric mapping, displays graphical representation of bibliometric maps (Van-Eck & Waltman, 2010). Thus, VOSviewer has been used as a software tool for bibliometric analysis whose main function is to create bibliometric networks (Moro, Joanny & Moretti, 2020). Mapping approaches based on bibliographic data can be carried out by considering different analysis options such as co-authorship, co-occurrence, citation analysis, bibliographic coupling and co-citation. Depending on these options, there are different analysis unit options such as author, organization, country, source. Then, depending on each analysis unit, the final outputs are visualized using different levels of data mapping, such as network visualization, overlay visualization, and density visualization. The current research was conducted by considering ***co-occurrence***, ***co-authorship*** and ***citation analysis*** from bibliographic data-based mapping approaches. Thus, author keywords were taken into account as the unit of analysis in the co-occurrence analysis. In the co-authorship analysis, the author, organization and country were taken into account as the unit of analysis. Finally, in the citation analysis, the document, source, author, organization and country were taken into account as the analysis unit. In this sense, the details of the mapping approaches and criteria based on bibliographic data taken into account in the research were given in Table 2.

Table 2

Types, Units, and Limitations of Analysis Considered in Evaluative Results

Type of Analysis	Unit of Analysis	Counting method	Weights	Threshold	Visualization
Co-occurrence	Author keywords	Fractional counting	Occurrences	MNO of a keyword= 5	NV****
Co-authorship	Authors	Fractional counting	Total link strength	MND of an author=1, MNC of an author =0	NV

	Organizations	Fractional counting	Total link strength	MND of an organization =1, MNC of an organization =0	NV
	Countries	Fractional counting	Total link strength	MND of a country =1, MNC of a country =0	NV
Citation	Documents	Ignored	Citations	MNC of a document =2	NV
	Sources	Ignored	Total link strength	MND of a source =1, MNC of a source =1	NV
	Authors	Ignored	Total link strength	MND of an author=1, MNC of an author =1	NV
	Organizations	Ignored	Total link strength	MND of an organization =1, MNC of an organization =1	NV
	Countries	Ignored	Total link strength	MND of a country =1, MNC of a country =1	NV

Note. MNO* =Minimun number occurrences, MND** =Minimun number of documents, MNC***=Minimun number of citations, NV****=Network visualization

In the analysis process, firstly, keyword co-occurrence was examined. Co-occurrence presents interconnected results based on the paired presence of terms/concepts in a specified text unit (Lancho-Barrantes & Cantú-Ortiz, 2019). Thus, author keyword co-occurrences are one of the analyzes used to identify research hotspots (Ye & Li, 2020). In addition, keywords co-occurrence is important in determining the closeness of relationships between articles and the strength of the link between keywords (Li, An, Wang, Huang & Gao, 2016). Therefore, as an evaluative result in this study, firstly author keyword co-occurrences were examined.

In the second stage, co-authorship relationships were examined. Co-authorship is used for research collaboration (Ponomariov & Boardman, 2016). In addition, co-authorship is one of the most frequently used analyzes to explore collaboration models among researchers (De-Stefano, Giordano & Vitale, 2011). Network visualizations in co-authorship printouts show clusters represented in different colors. Each circle represents an author, and the size of a circle is relative to the co-occurrence weight of the authors. The distance between the two circles approximately indicates the strength of the relationship, indicating that the leading authors have formed a cohesive and well-connected research community. Network visualizations outputs presented in other analyzes are interpreted similarly.

In the third stage, citation analysis was carried out. In the citation analysis, the references given by the authors at the end of the documents form the basis of the citation analysis (Thanuskodi, 2012). In this sense, citation analysis operates on the assumption that authors cite documents they consider important for the purpose of their research (Danvila-Del-Valle, Estévez-Mendoza & Lara, 2019). Thus, it is assumed that citations are a valid and reliable indicator of scientific interaction between researchers and research institutions (Kraus, Filser, O'Dwyer & Shaw, 2014).

Two types of counting methods are generally used in mapping approaches based on bibliographic data. One of them is the full counting method and the other is the fractional counting method. In a co-authored study, each co-author has the same weight according to the full counting method (Lancho-Barrantes & Cantú-Ortiz, 2019). According to the fractional counting method, the weight of a link is fractional (Lancho-Barrantes & Cantú-Ortiz, 2019). Thus, in the fractional counting method; since a researcher is co-authors in a co-authored study, the total weight of co-authorship links in the relevant publication is equal to one (Perianes-Rodriguez, Waltman & Van-Eck, 2016). For example, when an author is considered to be in a document in collaboration with 10 authors, the weight of each of the 10 co-author links is considered as 1/10 (Lancho-Barrantes & Cantú-Ortiz, 2019). In bibliometric networks, researchers traditionally use the full counting method, but the fractional counting method should be preferred (Perianes-Rodriguez et al., 2016). In this sense, the fractional counting method is a better option than the full counting method (Waltman & Van-Eck, 2015). From this point of view, it is stated that the fractional counting method leads to more true comparisons between universities when compared to the more traditional full counting method (Waltman et al., 2012). As a result, in the current study, the fractional counting method was preferred.

Validity and Reliability

In the current research, which is designed as a bibliometric research, first of all, document titles in Excel spreadsheet records were examined one by one and it was checked whether the same document was recorded for the second time. In addition, no changes were made on the VOSviewer software network visualization outputs in the results, and the author, organization, country, source, etc. were not changed. The original forms of the names were presented. Moreover, the process of systematic literature review was reported in detail, making it will possible to compare the results in case of similar studies in the coming years. On the other hand, 428 documents obtained were reviewed by an independent researcher (saving a similar document twice, finding a document out of purpose).

Results

In this part of the research, descriptive and evaluative results were included. In this context, descriptive results firstly were presented.

Descriptive Results

Among the descriptive results of the research, first of all, the status of the number of documents by years were given in Figure 1.

Figure 1

Annual Publication Trend of 428 Documents between Period 1994–2020

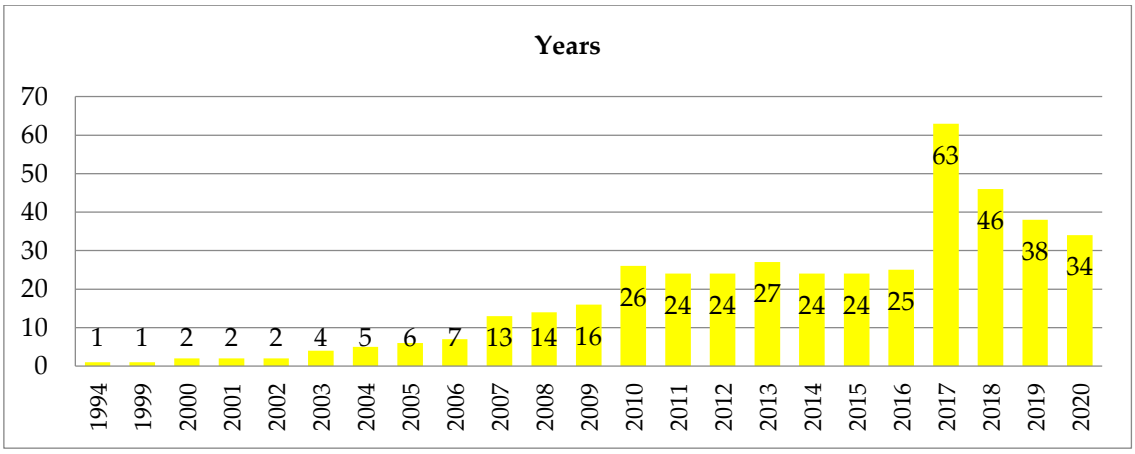
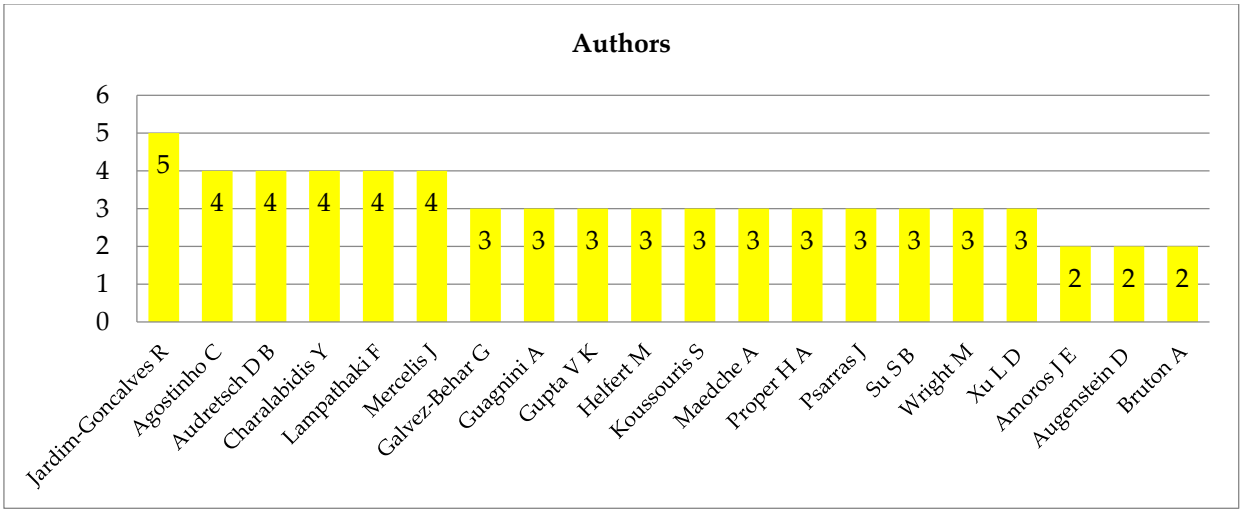


Figure 1 illustrates the progression of publications available in the WoS database on EBS (physics, chemistry, biology) in the period 1994–2020. According to the years, the first document was found in the documents in 1994. In addition, it was determined that few documents were published between 1994 and 2002, and the number of documents published from 2002 to 2010 increased as the years progressed. Moreover, it was determined that the most documents were published between 2017 and 2020. Finally, the most documents were published in 2017. The top 20 authors with the most documents among 975 authors were given in Figure 2.

Figure 2

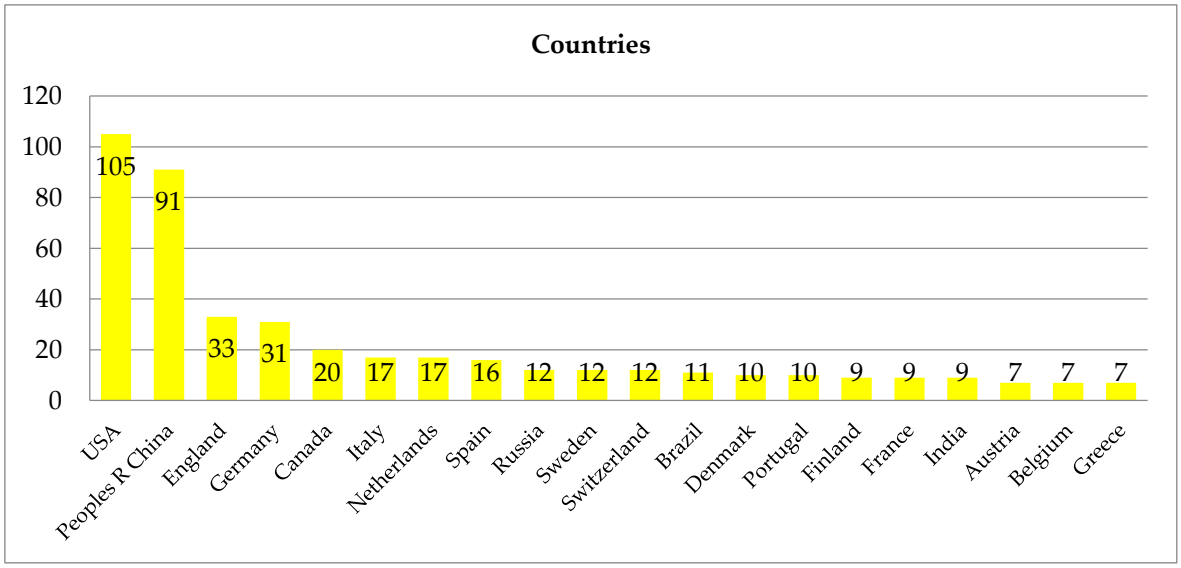
Top Authors Publishing on EBS



When the top 20 authors with the most documents were examined, it was seen that with the most documents was Jardım-Goncalves R. The authors with four documents were Agostinho C, Audretsch D B, Charalabidis Y, Lampathaki F, Mercelis J. It was also determined that 11 authors each owned three documents, the remaining 59 authors each owned two documents, and the other authors had one document each. The top 20 countries with the most documents among 67 countries were given in Figure 3.

Figure 3

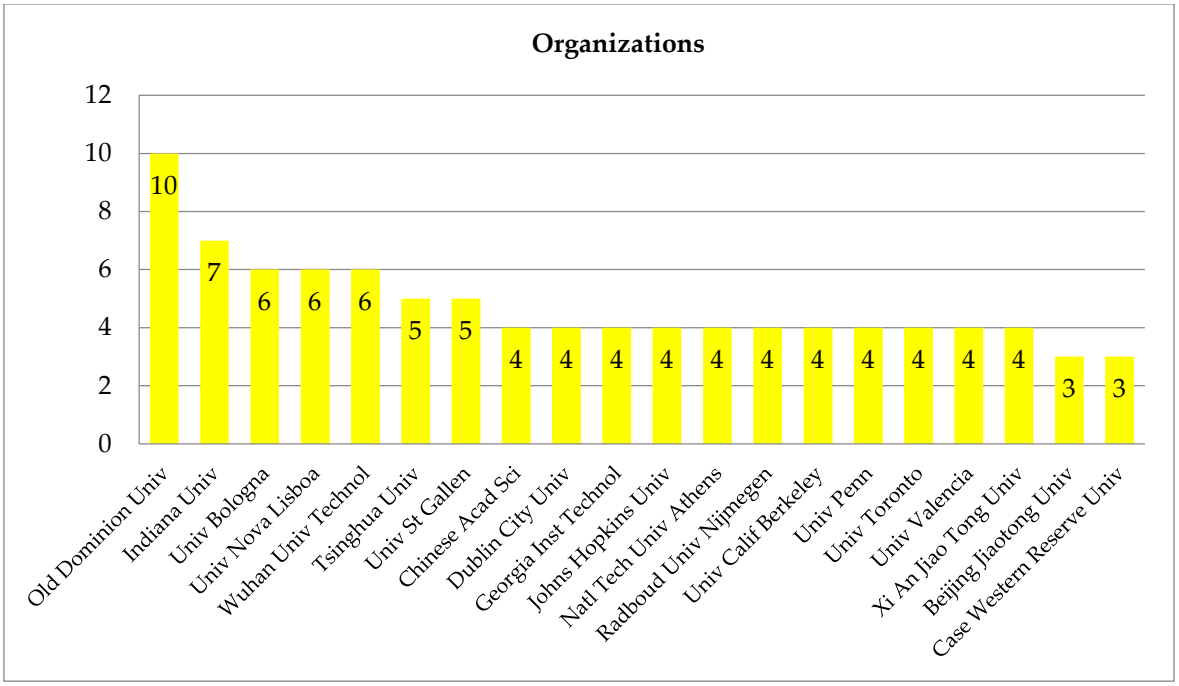
Top Countries Publishing on EBS



In the distribution of 428 documents by country, 105 documents belonging to the USA, 91 documents belonging to China and 33 documents belonging to England were determined. These countries were followed by Germany with 31 documents, Canada with 20 documents and Italy with 17 documents. The top 20 organizations with the most documents among 556 organizations were given in Figure 4.

Figure 4

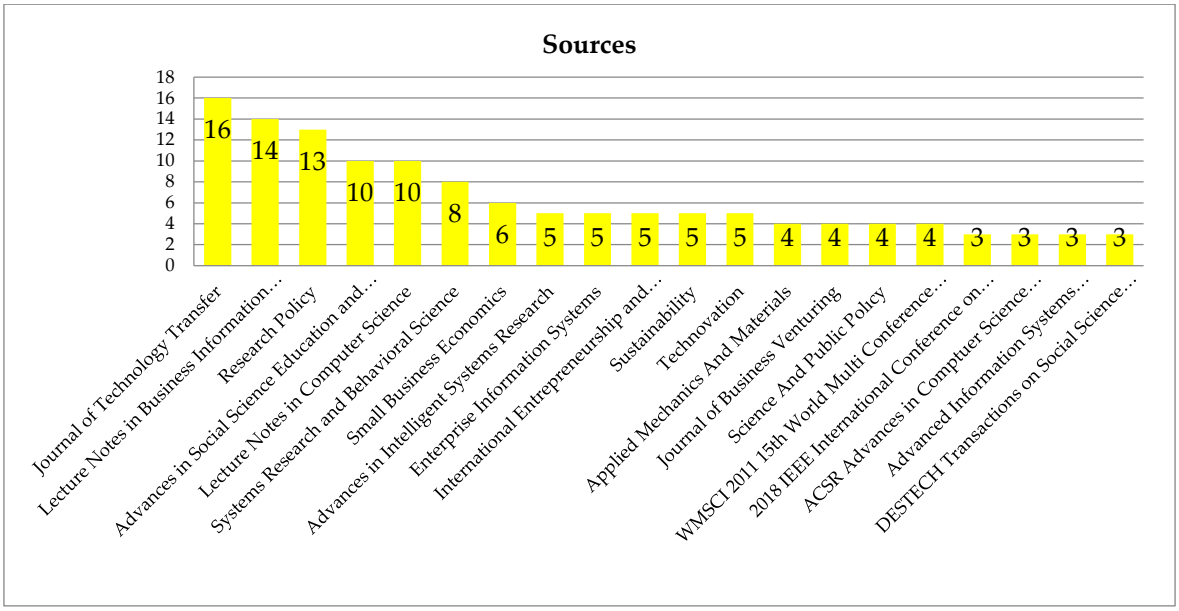
Top Organizations Publishing on EBS



In the number of documents for organizations, it was determined that 10 documents belonging to Old Dominion University and seven documents belonging to Indiana University. In addition, it was seen that there are six documents each belonging to universities named University of Bologna, NOVA University Lisbon and Wuhan University of Technology. The top 20 sources with the most documents among 353 sources (journals, conference, etc.) were given in Figure 5.

Figure 5

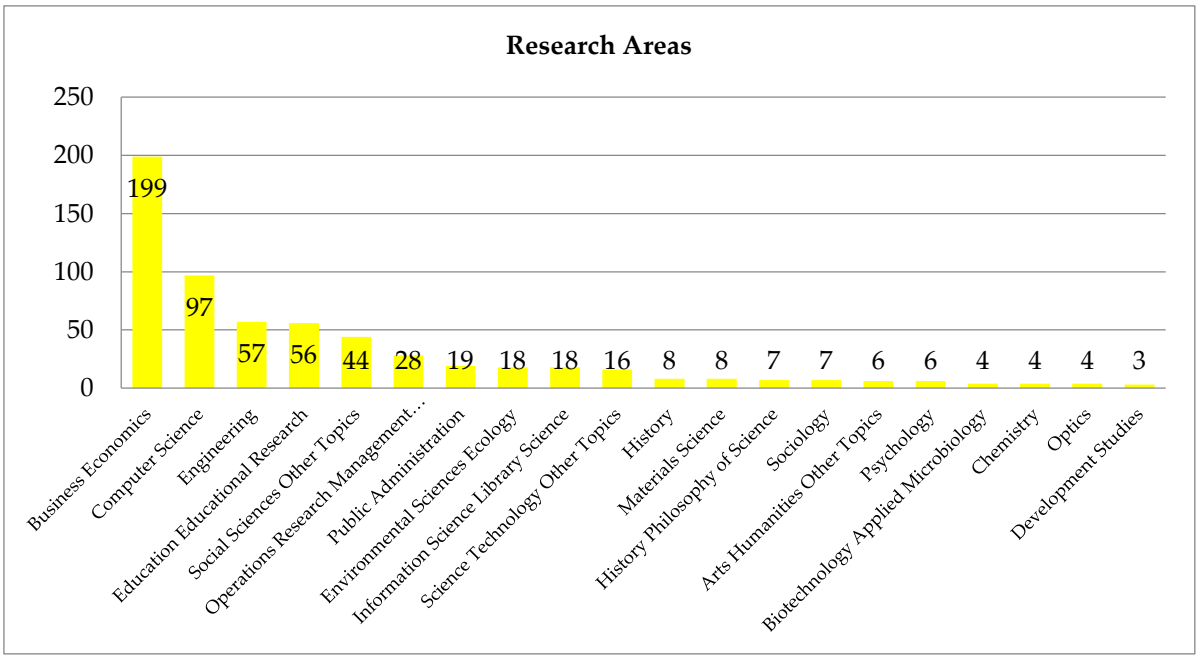
Distribution of Documents by Relevant Sources from 1994 to 2020.



When the documents were analyzed according to the sources, it was determined that 16 documents belonging to Journal of Technology Transfer, 14 documents belonging to Lecture Notes in Business Information Processing and 13 documents belonging to Research Policy. In addition, it was determined that 10 documents belonging to the conference named Advances in Social Science Education and Humanities Research, and 10 documents belonging to the proceedings book series called Lecture Notes in Computer Science. The top 20 research areas with the most documents among 54 research areas are given in Figure 6.

Figure 6

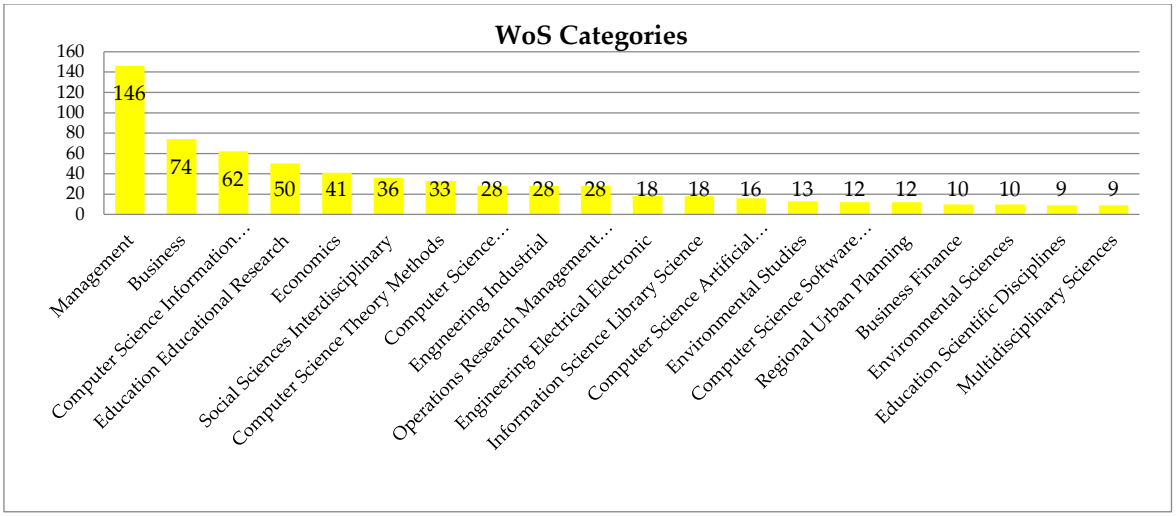
Distribution of Documents by Research Areas



According to the research areas given in Figure 6, it have been published 199 documents in business economics, 97 documents in computer science, 57 documents in engineering, 56 documents in education educational research, and 44 documents in social sciences other topics. According to the WoS category area, the top 20 category areas with the most documents among 85 category areas were given in Figure 7.

Figure 7

Distribution of Documents by Category Areas



Among the WoS category areas, it was seen that there were 146 documents in the management category, 74 documents in the business category, 62 documents in the computer science information systems category, and 50 documents in the education educational research category. In addition, there were 41 documents in the economics category, 36 documents in the interdisciplinary social sciences category, and 33 documents in the computer science theory methods category.

Evaluative Results

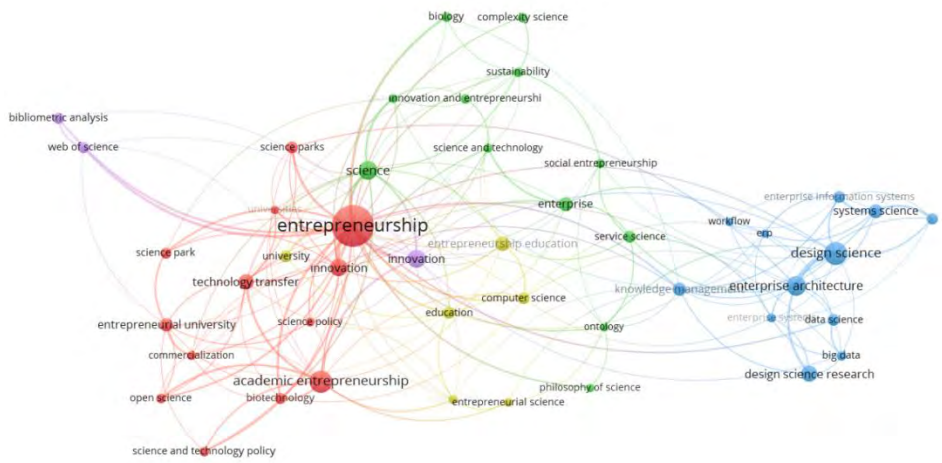
Keyword co-occurrence, co-authorship and citation analysis results were included in the evaluative results.

Co-occurrence Keyword Analysis

The network visualization results of 46 keywords that meet the criteria out of 1756 keywords by choosing at least five occurrences of a keyword related to author keywords co-occurrences were given in Figure 8.

Figure 8

The co-Occurrence Analysis of Keywords in Publications on EBS



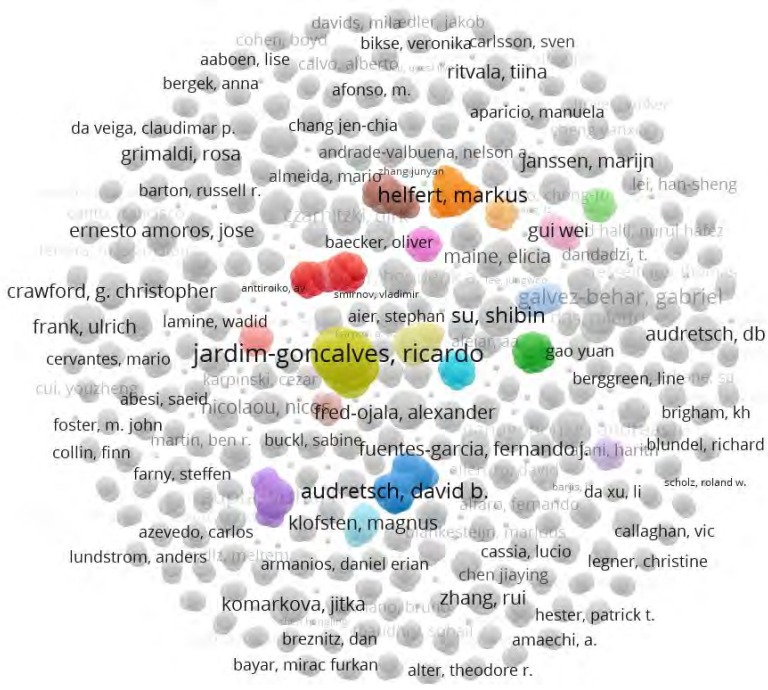
The top 10 keywords with the highest co-occurrence of the top 46 keywords were entrepreneurship (frequency of occurrence (FO)=102), design science (FO=33), academic entrepreneurship (FO=31), enterprise architecture (FO=25), science FO=22), innovation (OS=21), design science research (FO=17), technology transfer (FO=16), entrepreneurship education (FO=14). Among these keywords, the five keywords with the highest total link strength were entrepreneurship [Total Link Strength (TLS)=70], corporate architecture (TLS=23), design science (TLS=22), academic entrepreneurship (TLS=19) and innovation (TLS=19).

Co-authorship Analysis

The co-authorship analysis of authors produced 991 results. The highest total link strength of each of the 991 authors' co-authorship links was given in Figure 9.

Figure 9

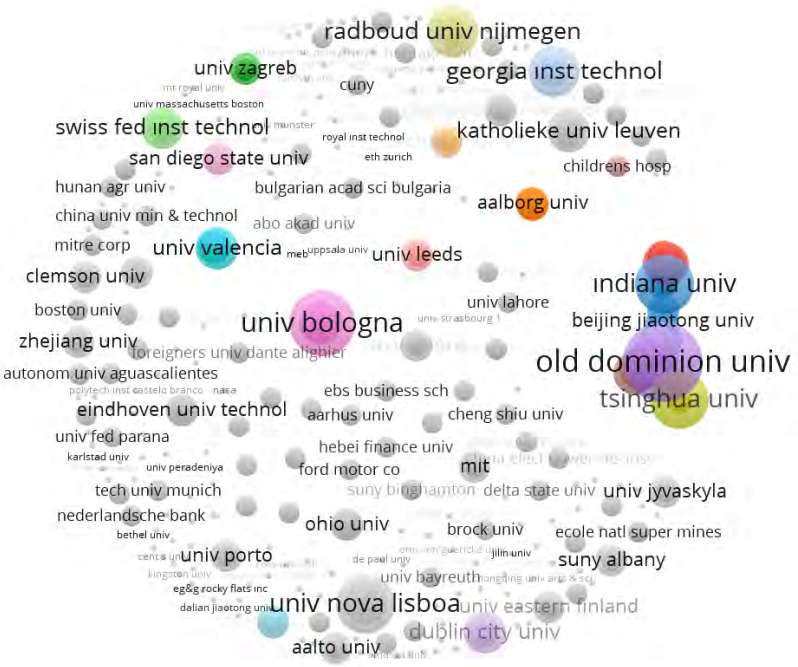
The Total Link Strength of Co-Authorship Links for Authors



The top 10 authors with the highest total link strength of co-authorship were respectively Jardim-Goncalves R (TLS=5), Agostinho C (TLS=4), Charalabidis Y (TLS=4), Lampathaki F (TLS=4), Audretsch D B (TLS=3), Galvez-Behar G (TLS=3), Guagnini A (TLS=3), Gupta V K (TLS=3), Helfert M (TLS=3) and Maedche A (TLS=3). The co-authorship analysis of organizations produced 554 results. The highest total link strength of each of the 554 organizations' co-authorship links was given in Figure 10.

Figure 10

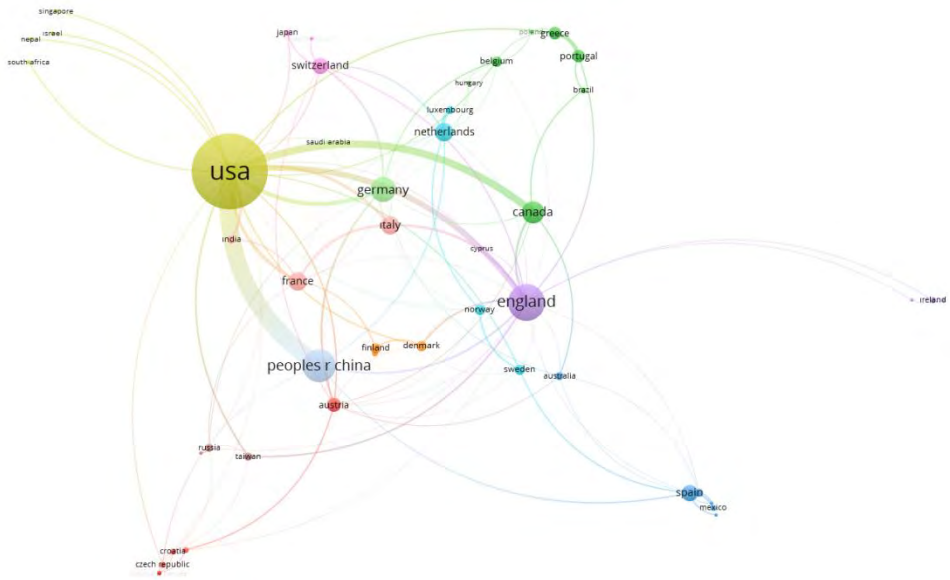
The Total Link Strength of Co-Authorship Links for Organizations



The top 10 organizations with the highest total link strength of co-authorship were respectively Old Dominion University (TLS=8), University of Bologna (TLS=6), Tsinghua University (TLS=5), NOVA University Lisbon (TLS=5), Indiana University (TLS=5), Chinese Academy of Sciences (TLS=4) , Georgia Institute of Technology (TLS=4), Radboud University Nijmegen (TLS=4), Case Western Reserve University (TLS =3), Dublin City University (TLS=3). The co-authorship analysis of countries produced 67 results. The highest total link strength of each of the 67 countries' co-authorship links was given in Figure 11.

Figure 11

The Total Link Strength of Co-Authorship Links for Countries



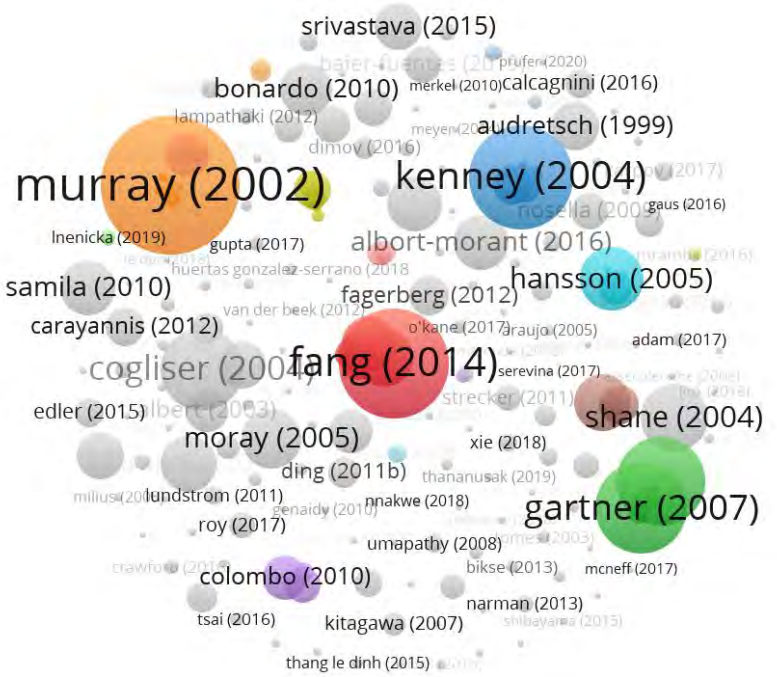
The top 10 countries with the highest total link strength of co-authorship were respectively USA (TLS=47), England (TLS=19), China/Peoples R China (TLS=17), Germany (TLS=12), Canada (TLS=10), France (TLS=8), Italy (TLS=8), Netherlands (TLS=8), Switzerland (TLS=7), Spain (TLS=7). In addition, the USA, the country with the highest total link strength, has the strongest link with China and Canada.

Citation Analysis

The network visualization of the citation links calculated for each of the 212 documents that meet the threshold value out of 428 documents in the citation analysis results in terms of documents was given in Figure 12.

Figure 12

Citation Analysis According to Documents



The top 10 documents with the highest citation were respectively; Murray [2002; Number of Citations (NC)=288], Fang (2014; NC=208), Kenney (2004; NC=191), Gartner (2007; NC=160), Lichtenstein (2007; NC=153), Cogliser (2004; NC=140), Shane (2004; NC=104), Hansson (2005; NC=96), Moray (2005; NC=87) and Xu (2006; NC=84). Detailed information about these documents with the most citation was given in Table 3. In addition, the top 10 documents with the highest citation link were respectively Murray (2002), Kenney and Goe (2004), Xu et al. (2006), Xu et al. (2009), Hansson et al. (2005), Warfield (2007), Czarnitzki et al. (2009), Wang et al. (2009), Staley and Warfield (2007), Nicolaou and Shane (2014). Moreover, these documents with the most citation were given in the reference list.

Table 3

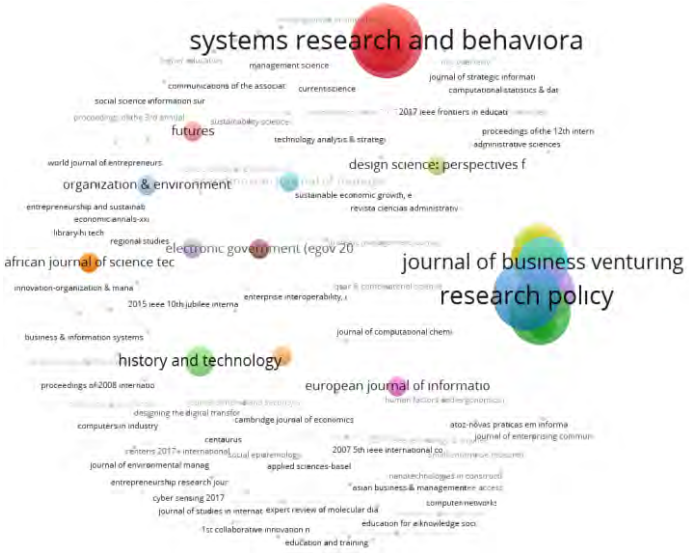
Details of Top 10 Documents in WOS by Number of Citations

No	Authors	Title	Source	Year	Number of citations
1	Murray, F.	Innovation as co-evolution of scientific and technological networks: exploring tissue engineering	Research Policy	2002	288
2	Fang, S., Da Xu, L., Zhu, Y., Ahati, J., Pei, H., Yan, J., & Liu, Z.	An integrated system for regional environmental monitoring and management based on internet of things	IEEE Transactions on Industrial Informatics	2014	208
3	Kenney, M., & Goe, W. R.	The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science at UC Berkeley and Stanford	Research policy	2004	191
4	Gartner, W. B.	Entrepreneurial narrative and a science of the imagination	Journal of Business Venturing	2007	160
5	Lichtenstein, B. B., Carter, N. M., Dooley, K. J., & Gartner, W. B.	Complexity dynamics of nascent entrepreneurship	Journal of business venturing	2007	153
6	Cogliser, C. C., & Brigham, K. H.	The intersection of leadership and entrepreneurship: Mutual lessons to be learned	The Leadership Quarterly	2004	140
7	Shane, S. A., & Ulrich, K. T.	50th anniversary article: Technological innovation, product development, and entrepreneurship in management science	Management Science	2004	104
8	Hansson, F., Husted, K., & Vestergaard, J.	Second generation science parks: from structural holes jockeys to social capital catalysts of the knowledge society	Technovation	2005	96
9	Moray, N., & Clarysse, B.	Institutional change and resource endowments to science-based entrepreneurial firms	Research Policy	2005	87
10	Xu, L., Wang, C., Luo, X., & Shi, Z.	Integrating knowledge management and ERP in enterprise information systems	Systems Research and Behavioral ScienceSyst. Res	2006	84

A total of 304 sources (journal, congress, etc.) were reached according to the sources. The total link strength of citation links of 161 sources meeting the criteria from 304 sources was given in Figure 13.

Figure 13

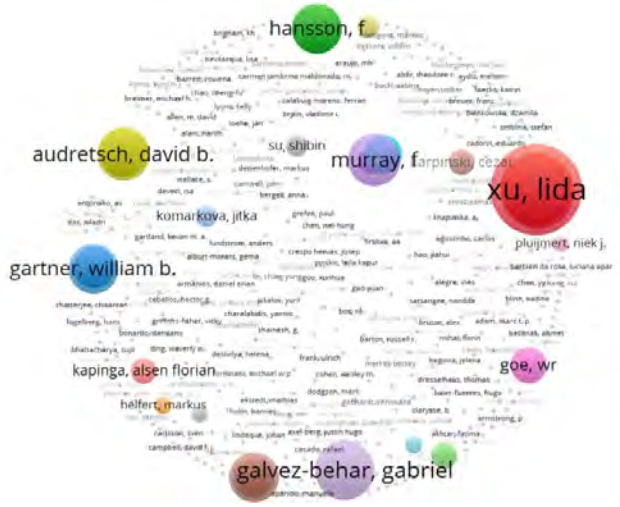
Total Link Strength According to Sources



The top five sources with the highest citation were respectively Research Policy (NC=931), Journal of Technology Transfer (NC=379), Journal of Business Venturing (NC=360), Systems Research and Behavioral Science (NC=215), and Technovation (NC=215). In addition, the top five sources with the highest total link strength of citation links were respectively Systems Research and Behavioral Science, Research Policy, Journal of Technology Transfer, Enterprise Information Systems and Technovation. According to the authors, as a result of the citation analysis, a total of 991 authors were reached. The total link strength of citation links of 611 authors out of 991 who met the criteria was given in Figure 14.

Figure 14

Total Link Strength to Authors

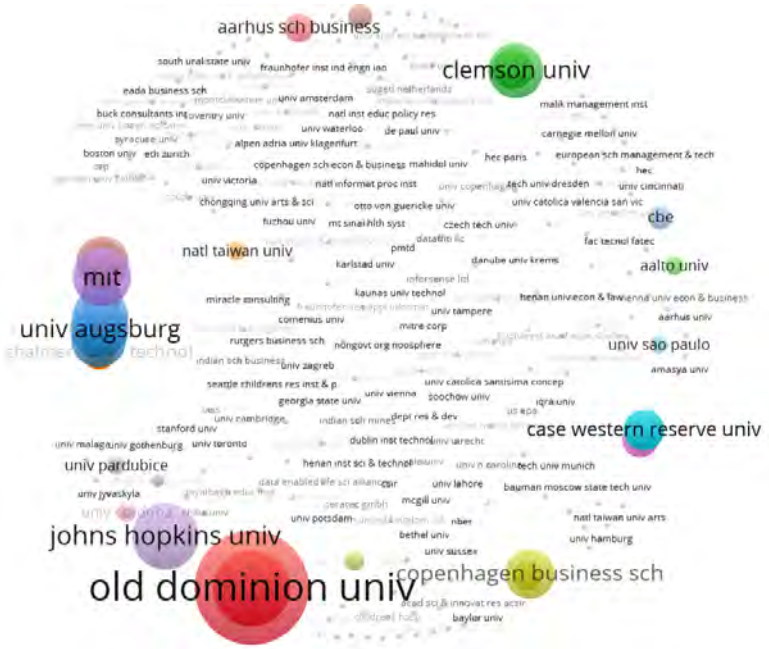


The top 10 authors with the highest citation were respectively Gartner W B (NC=313), Murray F (NC=288), Ahati J (NC=208), Fang S (NC=208), Liu Z (NC=208), Pei H (NC=208), Xu L (NC=208), Yan J (NC=208), and Zhu Y (NC=208). Moreover, the top 10 authors with the highest total link strength of citation links were respectively Xu L, Warfield J N, Luo X, Shi Z, Wang C, Wang K, Wang S, Mercelis J, Galvez-Behar G and Guagnini A. A total of 554 organizations were identified in the citation analysis

by organization. The total link strength of citation links of 387 organizations meeting the criteria from 554 organizations were given in Figure 15.

Figure 15

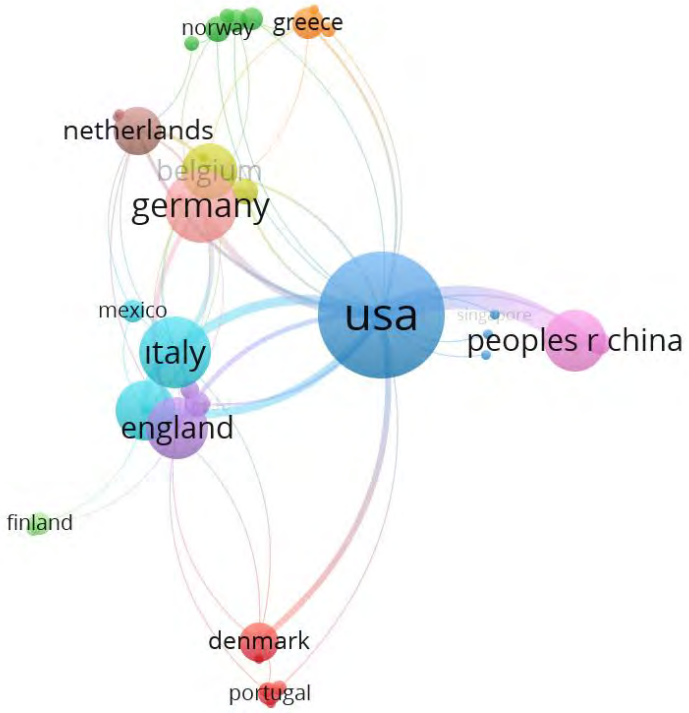
Total Link Strength to Organizations



The top 10 organizations with the highest citation were respectively Old Dominion University (NC=461), Chinese Academy of Sciences (NC=325), Clemson University (NC=313), Massachusetts Institute of Technology (MIT) (NC=309), Shanghai Jiao Tong University (NC=208), University of Science and Technology of China (NC=208), Xinjiang Institute of Ecology and Geography (NC=208), Xinjiang University (NC=208), Yanshan University (NC=208), Indiana University (NC =193). In addition, the top 10 organizations with the highest total link strength of citation links were Old Dominion University, Chinese Academy of Sciences, Northeastern University, George Mason University, Johns Hopkins University, University of Bologna, University of Lille, Massachusetts Institute of Technology, University of Augsburg and Clemson University. A total of 67 countries were identified in the citation analysis by country. The total link strength of citation links of 58 countries meeting the criteria from 67 countries were given in Figure 16.

Figure 16

Total Link Strength to Countries



The top 10 countries with the highest citation were respectively USA (NC=2702), China (NC=649), England (NC=557), Canada (NC=420), Germany (NC=366), Italy (NC=293), Denmark (NC=274), Netherlands (NC=216), Belgium (NC=207), Spain (NC=205). In addition, the top 10 countries with the highest total link strength of citation links were USA, Germany, Italy, China, England, France, Belgium, Netherlands and Greece.

Discussion

In this research, bibliometric analysis of documents published on EBS (physics, chemistry, biology) was carried out. Thus, in this section, discussions on descriptive results (year, author, country, organization, source, research area, WoS category area) and evaluative results (keyword co-creation, co-authorship, citation analysis) were carried out.

In the research on entrepreneurship in basic sciences; it was determined that a small number of documents were published each year between 1994 and 2002. From 2003 to 2010, the number of articles increased every year. In 2011 and 2016, between 24 and 27 documents were published in a balanced way every year. On the other hand, compared to other years, the most documents were published between 2017 and 2020, and the most documents were published in 2017 among these years. These results showed that the documents published on EBS were mostly published in recent years. In addition, the results show that entrepreneurship-oriented research in the fields of physics, chemistry and biology, which are among the basic sciences, gained importance after the 2000s. It can be said that there has been a significant increase in the number of documents that include the concept of entrepreneurship in basic sciences, especially after 2016. On the other hand, in the bibliometric research conducted on entrepreneurship in the literature, the number of documents varies according to years. Skute (2019) determined in his bibliometric analysis study on academic entrepreneurship that the most documents were after 2014. Skute (2019) examined published documents on academic entrepreneurship in general ("academic entrepreneurship" OR "academi* spin*" OR "universit* spin*" etc.) rather than basic sciences. As a result, in many bibliometric studies in which the concept of

entrepreneurship is conducted from different perspectives in the literature (Baier-Fuentes et al.,, 2019; Ruiz-Alba et al., 2021), it is noted that the documents have been published more in recent years. The current research results are also similar to the increase in the documents in bibliometric analysis literature on entrepreneurship in recent years. This situation can be attributed to the increase in the number of documents since the 2000s, directly related to the concept of entrepreneurship or when the concept of entrepreneurship is handled by associating it with different concepts.

The top three authors with the most documents on EBS were Jardım-Goncalves R, Agostinho C, Audretsch D B. In addition, the top three with the highest total link strength of co-authorship were Jardim-Goncalves R, Agostinho C, Charalabidis Y. Moreover, the top three most cited authors were Gartner W B, Xu L, and Lichtenstein B B, and the top three authors with the highest total strength of citation links were Mercelis J, Galvez-Behar G, Guagnini A. Considering the most cited authors in the WoS, Gartner W B was the most cited author. According to these results, the most productive, influential and collaborative author on EBS was Jardım-Goncalves R who works at the Faculty of Science and Technology in the NOVA University Lisbon. In fact, in bibliometric research, keywords (tags) and the sections in which these keywords are taken into account (title, abstract, keywords, etc.) provide important clues, limited to the researcher's initiative. In this sense, from the perspective of entrepreneurship, it is possible to get an idea about the most productive authors in the field, or in other words, depending on the dimension of the concept of entrepreneurship. The most productive or effective authors may also differ, depending on the dimension of the entrepreneurship concept in the entrepreneurship literature. For example, in bibliometric analyzes conducted for different purposes, Rey-Martí et al. (2016) found that Anderson A R is the most productive author on social entrepreneurship, Baier-Fuentes et al. (2019) found that McDougall P P is the most productive author on international entrepreneurship, and Skute (2019) found that Wright M is the most productive author on academic entrepreneurship. Therefore, productive author may vary depending on the subject area or sub-fields on which systematic literature review is performed.

In terms of research areas, the documents reached in the current research were mostly published in “business economics”, “computer science”, “engineering”, and “education educational research”. In addition, according to the WoS category areas, most of the documents reached in the current research were published in the “management”, “business” and “computer science information systems” categories. Clearly the most important areas among these research areas were “business economics”, “management” and “computer science”, and “business”. Among these areas, especially “business economics” draws attention. The fact that the most important area among these research areas is business economics can be attributed to the fact that the units or departments where the concept of entrepreneurship is discussed as a research subject are predominantly business and economics. Supporting these results, Rey-Martí et al. (2016) determined that the research area with the most published document on social entrepreneurship is business economics. In addition, Pato and Teixeira (2016) pointed out that 51% of all the articles on rural entrepreneurship were published in research areas such as economy, business and management etc. Skute (2019) determined that the first three categories in the distribution of documents on academic entrepreneurship according to WoS categories are management, business and industrial engineering. Thus, it can be said that research areas or subject areas such as “business”, “management” and “economy” come to the fore in bibliometric research on entrepreneurship, as in the current research results in the literature. The current research results show that the documents published on EBS are mostly published in these research areas. This may be evidence that these research areas are used as a basis for transforming innovative ideas developed in basic sciences into products or designs.

In order of priority, the countries with the most documents on EBS were the USA, China and England. In addition, the top three countries with the highest total link strength of co-authorship were the USA, England and China. Results shows that the USA was productive and a strong collaborative country on entrepreneurship in basic sciences, followed by China and England. On the other hand, the top three most cited countries were the USA, China, and England, while the top three countries with the highest citation total link strength were the USA, Germany, and Italy. Citation analysis

results show that USA was the most influential country on entrepreneurship in basic sciences. Among these countries, it is noteworthy that especially the USA and China have more documents than other countries. Among the reasons why the USA and China come to the fore; In these countries, scientific studies for basic sciences, product and innovative idea research and development activities, investments in basic sciences, opening the way for commercialization of products and faster patenting processes can be counted. In addition, the fact that the USA has a large number of documents on EBS may have brought it to the forefront as the country with more citations. In addition, the fact that advanced technologies originate in America on the one hand and that low and medium low technologies used in daily life originate in China on the other can be seen as another factor explaining these results. Finally, in some of the researches in which bibliometric reviews on entrepreneurship are carried out, the USA is at the top of the list of the most influential countries according to the types of entrepreneurship or the concepts that entrepreneurship is associated with. For example, in studies on social entrepreneurship (Rey-Martí et al., 2016), international entrepreneurship (Baier-Fuentes et al., 2019), academic entrepreneurship (Skute, 2019), it has been determined that the most influential country is the USA.

The journals with the most documents were respectively Journal of Technology Transfer, Lecture Notes in Business Information Processing, and Research Policy. Thus, the Journal of Technology Transfer was the most productive journal on entrepreneurship in basic sciences. When the Journal of Technology Transfer is examined closely, it can be seen that it is an international journal that aims to provide an understanding of technology transfer applications, sheds light on how technology transfer should be and allows exchange of ideas on these issues. Moreover, the top three journals with the highest citation were Research Policy, Journal of Technology Transfer, and Journal of Business Venturing. In addition to, the top three journals with the highest total link strength of citation links were Research Policy, Technovation, and Enterprise Information Systems. Thus, the Research Policy was the most influential journal on EBS. It has also been determined that the scientific meetings with the most publications were respectively WMSCI 2011 15th World Multi Conference on Systemics, Cybernetics and Informatics, 2018 IEEE International Conference on Engineering Technology and Innovation ICE ITMC, and Advanced Information Systems Engineering Workshops. In this sense, WMSCI 2011 15th World Multi Conference on Systemics, Cybernetics and Informatics was the most productive scientific meeting on EBS. In bibliometric research, by looking at the number of documents and citations of the sources, the results such as the most productive or most effective journal, congress and publishing can provide important clues about the these sources that should be followed first by researchers who want to do research on any subject. The fact that documents with an entrepreneurial dimension in basic sciences were published in this journal to a large extent within the scope of the current research can be attributed to the use of innovative knowledge and ideas produced in basic sciences in the development of technology and the contribution of this journal to the transfer of technology to different science and subject areas. In addition, since studies with an entrepreneurship dimension in basic sciences are related to the concept of academic entrepreneurship, similar results were found in a research conducted on academic entrepreneurship. For example, Skute (2019) in his bibliometric analysis study on academic entrepreneurship determined the top three most productive journals were Journal of Technology Transfer, Research Policy and Technovation. On the other hand, in bibliometric studies based on the concept of entrepreneurship, it can be seen that the most influential or productive sources differ according to the types of entrepreneurship or the concepts to which the concept of entrepreneurship is associated (for example, Baier-Fuentes et al., 2019; Pato and Teixeira, 2016; Rey-Martí et al., 2016; Ruiz-Alba et al., 2021).

Organizations with the most documents were Old Dominion University, Indiana University and University of Bologna. In this sense, Old Dominion University was the most productive organization on EBS. Moreover, the top three organizations with the highest citations on EBS were Old Dominion University, Chinese Academy of Sciences, and Clemson University. In addition, the top three organizations with the highest total strenght of citation links were Old Dominion University, Chinese Academy of Sciences, and Northeastern University. These results show that the Old

Dominion University was the most influential organization on entrepreneurship in basic sciences. Furthermore, the top three organizations with the highest total link strength of co-authorship on EBS were Old Dominion University, University of Bologna, and Tsinghua University. The Old Dominion University was the most strong collaborative country on entrepreneurship in basic sciences. In bibliometric research, the number of documents and citations of organizations on any subject provides important clues for productivity and efficiency of organizations. Within the scope of the current research, the Old Dominion University is the most productive, influential, and collaborative organization on entrepreneurship in basic sciences. Therefore, the Old Dominion University's research interest in EBS and collaboration with other organizations may be greater. Founded in 1930, Old Dominion University is a public research university located in Norfolk, Virginia, USA. It is noted on the official homepage of Old Dominion University that it has more than 24,000 students, contributes $2.6 billion annually to Virginia's economy, and is an entrepreneurial-minded doctoral research university. In bibliometric research on entrepreneurship, it can be seen that the most productive and the most influential organizations differ according to the types of entrepreneurship or the concepts that entrepreneurship is associated with (Amjada and Nasirb, 2020; Baier-Fuentes et al., 2019, Ruiz-Alba et al., 2021; Skute, 2019).

The top three words that show the most keywords co-occurrence were “entrepreneurship (Cluster 1: Red)”, “design science (Cluster 2: Green)” and “academic entrepreneurship (Cluster 1: Red)”. Cluster 1 had 13 words and the highest co-occurrence words was “entrepreneurship”. Thus, from these words, it is clearly can be seen that the most co-occurrences words of authors are more related to “entrepreneurship” and its relevant terms (for example, academic entrepreneurship). Moreover, three important keywords with the highest total link strengths were “entrepreneurship”, “corporate architecture” and “design science”. It can be said that the concepts of entrepreneurship and design, which are among these keywords, express the process of transforming the knowledge discovered in basic sciences and the ideas produced into entrepreneurial projects. The results from the keyword co-occurrence network of this study provide a clear picture of the current state of EBS as a research topic. Visualization of co-occurrence network can also help not only to illustrate past research hot spots, but also to reveal potential or neglected research areas (Koo, 2017). After the word of “entrepreneurship”, the word “design science” emerges as an important concept. Baskerville (2008) states that the concept of “design science research” is expressed in terms such as “design science”, “design research” and “design theory”. Additionally, Baskerville (2008) points out that, due to some disagreement about what these terms mean, the term “design science research” is a broader term to encompass various meanings of others. According to Van-Aken (2005), the task of design science is to develop knowledge that professionals of the discipline can use to produce (design) solutions to their field problems. Thus, Baskerville (2008) states that design science is about understanding and developing potential components to create a structure that aims to solve a problem. In design science, which is an exploratory research, attention is drawn to the fact that the "artificial phenomenon" should be created by the researcher (Holmström, Ketokivi & Hameri, 2009). Thus, it can be said that design science comes into play when it comes to entrepreneurship in basic sciences. Keywords in bibliometric analyzes can offer important clues to researchers who want to do research in a related field or subject in terms of forming the theoretical framework of research reports and seeing the variables discussed. Therefore, it may be considered normal for the keywords or concepts that show a common occurrence in different studies to differ. In the bibliometric analyzes carried out on entrepreneurship in the literature, it can be seen that the concept of entrepreneurship takes place in hot spots, sometimes alone and sometimes with a prefix (Amjada and Nasirb, 2020; Aparicio et al., 2019; Baier-Fuentes et al., 2019; Ruiz-Alba et al., 2021).

In the research, among the documents published on entrepreneurship in basic sciences, the top three documents with the most cited were Murray (2002), Fang et al. (2014) and Kenney and Goe (2004). In addition, the top three documents with the highest citation links were Murray (2002), Kenney and Goe (2004) and Xu et al. (2006). These results show that Murray (2002) was the most mentioned and most benefited article on entrepreneurship in basic sciences. In fact, Murray (2002)

focuses on the question of exactly how science is commercialized. Thus, "Murray (2002)" is used as a basic document for researchers doing research on entrepreneurship in basic sciences. In this sense, citation analyzes can provide researchers with the opportunity to easily identify important documents in the field they want to examine. Thus, depending on the citation analysis in bibliometric research, it is possible for researchers to identify documents that stand out according to the concept, term or subject area they want to research. For example, according to Aparicio et al. (2019), the first three of the most cited articles on entrepreneurship education were Kuratko (2005), Peterman and Kennedy (2003) and Souitaris, Zerbinati & Al-Laham (2007).

Conclusions

As a result, it has been determined that there has been a significant increase in the number of documents published on EBS near 2020, and 2017 was the most productive year. In terms of authors, Jardim Goncalves R was the most productive, influential and collaborative author on EBS. In terms of countries, the USA was the most productive, influential and collaborative country on EBS. In terms of sources, the most productive source was Journal of Technology Transfer, and Research Policy was the most influential source having the highest total link strength. In addition, Old Dominion University was the most productive, influential, and collaborative organization on EBS. Furthermore, the most influential research area was business economics, and the important keywords with the most co-occurrences were "entrepreneurship", "design science" and "academic entrepreneurship". Furthermore, the most mentioned and benefited document on EBS is Murray (2002). Of course, these results are valid within the scope of some limitations. For example, WoS was used as a database in this study. In this sense, similar studies can be conducted in databases such as Scopus and ERIC in future bibliometric studies. In addition, the keywords used in the process of accessing documents in the current research are limited to "biology", "chemistry", "physics", "entrepreneurship", "enterprise" and "entrepreneurial". Thus, this current study is limited to physics, chemistry and biology as a basic science. In future research, bibliometric research can be conducted on entrepreneurship in the fields of music, engineering, design, language education, computers, etc. It is also noteworthy that keywords such as academic entrepreneurship, science-based entrepreneurship, university spin-offs are encountered in the document searching process with these keywords. It can be said that bibliometric researches on academic entrepreneurship, science-based entrepreneurship, and university spin-offs can be carried out. In this research were used "author keyword" as the field tag. In future studies, document searches in different field tags (such as title, abstract) can be done. Another remarkable result within the scope of the current research is that approaches such as "technology transfer" and "design science" are encountered. Concepts such as "technology transfer" and "design science", which mean the transformation of ideas, information or technologies produced in basic sciences (physics, chemistry, biology) into products, evoke entrepreneurial projects [E-STEM (entrepreneurship, science, engineering, mathematics and technology)] used in science education.

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