

Article

University-Industry Cooperation: A Peer-Reviewed Bibliometric Analysis

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Citation: Borges, Pedro, Mário Franco, Amélia Carvalho, Carlos Machado dos Santos, Margarida Rodrigues, Galvão Meirinhos, and Rui Silva. 2022. University-Industry Cooperation: A Peer-Reviewed Bibliometric Analysis. *Economies* 10: 255. <https://doi.org/10.3390/economies10100255>

Academic Editors: Giorgio Vittadini, Tommaso Agasisti, Roberto Ricci and Lanfranco Senn

Received: 19 July 2022

Accepted: 26 September 2022

Published: 13 October 2022

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Abstract: University-industry cooperation is associated with the transfer of knowledge and technology. This collaboration is an extremely important field of study for the world's economies, helping companies to become more competitive. The present research aims to explore and analyze the literature related to university-industry cooperation, using a bibliometric analysis as a methodology. This study intends to use an unlike approach to conduct the literature review and map the most relevant research studies, using a rigorous research protocol based on scientific documents published in the Web of Science database, using the keyword "University-Industry Cooperation". The 256 articles collected are situated in a time base between 1970 and 2020 and were submitted to content analysis in R Bibliometrix. This systematic literature review revealed that companies are increasingly focusing on cooperation with universities. The research of these publications points to a growing trend in publications of articles with the topic "University-Industry Cooperation". From the bibliometric analysis of the global research results, we highlight the most cited authors and the authors' publications over time, and we also highlight the main research topics and countries where studies were conducted. On the other hand, we also highlight the collaboration network between institutions, authors, and countries over time. The University-Industry cooperation is explored here as an added value for advancing scientific knowledge on the relationship between these two important stakeholders, opening the way for future research in this area. With this article, we hope to contribute to the evolution of scientific knowledge in this area, providing future researchers with a detailed radiography overview of the literature related to University-Industry cooperation, contributing to filling an existing gap related to the scarcity of SLR studies that focus on this scientific theme.

Keywords: university-industry cooperation; systematic literature review; bibliometric analysis

1. Introduction

Environmental context affects a wide range of economic players who look for new technical solutions, changes in society, and new types of cooperation to achieve more competitive advantages (Ramaswamy and Ozcan 2018). Here, the role of universities is based not only on knowledge transfer but also on research and co-creation with other partners. This type of cooperation can be done between universities and different companies (industry), which aims to find economic development through knowledge transfer. As a part of

globalization and the knowledge-based economy, knowledge has been recognized as an important critical resource for organizations, while university-industry cooperation has become used as a tool for knowledge sharing (Tan and Thai 2014). According to (Martinez-Noya and Narula 2018) the authors (Martinez-Noya and Narula 2018) university-industry cooperation is seen as a strategy for these types of organizations to monitor global competition. As such, in recent years, there has been a growing number of university-industry relationships (Vukasovic and Stensaker 2018).

Due to several changes, mainly at the market level, companies are constantly under pressure to change, which makes university-industry cooperation an important mechanism for competitiveness (Anderson et al. 2011). Companies, especially small and medium-sized (SMEs), lacking skilled labor for research, turn to universities to complement their skills, with the initial goal of surviving and, later, generating greater competitive advantages. Thus, university-industry cooperation can facilitate knowledge transfer and stimulate the production of new knowledge and technologies (Enkel et al. 2009; Leydesdorff and Meyer 2006). The knowledge produced by universities needs to be used by society and, therefore, applied by companies, constituting a source in the search for innovation (Youtie and Shapira 2008; Yusuf 2008).

University-industry cooperation includes collaborative research, research contracts, or scientific consulting. The results are put into practice in a process comparable to technology transfer for commercialization purposes (Perkmann et al. 2013; Leydesdorff and Meyer 2006). This interaction between universities and industry is crucial, i.e., universities and research institutes have a stronger effect on building regional development (Etzkowitz and Klofsten 2005; Jiao et al. 2016).

In this sense, university-industry cooperation is a subject of growing interest in the scientific community, especially in strategy studies. Thus, some studies have already conducted systematic literature reviews (SLR) focusing on this type of cooperation (Mascarenhas et al. 2018). However, they have focused only on the types of links between universities and/or SMEs, open innovation (Perkmann and Walsh 2007), technology transfer (Agrawal 2001; Geuna and Muscio 2009) or the flow of university research and entrepreneurship (Rothaermel et al. 2007). Although there has been a theoretical and empirical advance, the research over university-industry cooperation, as a multidisciplinary field of research, still proves to be a domain to explore given its fragmentation and the number of concepts, themes, theories, and methods involved.

It is precisely to help fill this gap that the present study sought to realize an SLR about university-industry cooperation. This SLR aims to understand which phenomena/themes are addressed by the empirical studies and what are the possible considerations for the development of studies on this topic. More precisely, from the bibliometric study, an analysis of the theme's trends was sought by answering the following main research questions (Pritchard 1969; Small 1973): (1) Is there growth in the number of publications in the period under analysis? (2) Which are the most cited references? (3) Which are the most relevant journals and authors? And (4) What is the interlocution between the authors and the main topics studied in this research area? Therefore, the contribution of this study is to present the state-of-the-art and practical application of the assumptions inherent to "University-Industry Cooperation". Another contribution lies in the fact that this study carries out exploration, synthesis, and presentation of the perspectives related to this area of knowledge, addressing the main hot topics in the international literature. In addition, this study may help future researchers in understanding of the issues addressed, being a starting point for future research focused on the topic "University-Industry Cooperation". The results also aim to expand knowledge about the studied phenomenon, evidencing new gaps that provide an advance in the field of research.

2. Literature Review

2.1. University-Industry Cooperation

University-industry cooperation is a key tool for regional economic development, driving human capital creation, knowledge, and technology transfer and reinforcing the importance of sustainability in higher education (Franco et al. 2014; Celikdemir et al. 2017; Lilles and Rõigas 2017).

Collaboration between universities and industry is currently seen as a vehicle to improve innovation across the economy through knowledge and technological transmission (Weerasinghe 2017).

Universities will have strong faculty support when they choose to engage in local and regional economic development, helping to commercialize research and increasing interaction with the industrial environment. Instruments of university-industry cooperation may involve consortia, alliances, research and development projects, staff exchanges, and one-on-one interaction between faculty and industry professionals (Lee 1996). A thorough understanding of the general motivations of university-related researchers and the underlying reasons for engaging with industry is pertinent to tailoring organizational and institutional conditions aimed at improving knowledge and technic handover between academia and business (Franco and Haase 2015).

The authors (Franco and Haase 2015) argue that reputation, publications, practical application of research, and obtaining financial resources are seen as motivations, so university researchers are predisposed to establish cooperative relationships with industry, going against what has been reported in the literature. On the other hand, university-industry cooperation has no effect on career perspectives, which contradicts the previous empirical findings. They also found that this involvement, U-I, although recognized, is not satisfactorily used as an indicator in the evaluation of individual performance and may be considered a barrier to academics' interest, leading to an undervaluation of U-I cooperation in careers.

Since university-industry cooperation is associated with knowledge forwarding and technology, this collaboration has proven to be fundamental for world economies, helping companies become more competitive (Mascarenhas et al. 2018). The increase in knowledge contributes to the growing level of GDP per capita and R&D expenditure. Although positive, this relationship takes time to be reflected in economic development (Lilles and Rõigas 2017). Although studies show the positivity of the University-Industry cooperation relationship, it is necessary to note that the factors that mediate this relationship are oscillating, gender, age and level of education, motivation, and disciplinary affiliation are preponderant in the tendency of researchers to cooperate with industry (Rodrigues and Franco 2019; Franco et al. 2014; Franco and Haase 2015).

There is no guiding principle of how universities should stimulate innovation and development activity in a region. It is inferred that the university's knowledge base and the prevailing mode of innovation in the regional industry should define the type of university-industry cooperation. Thus, universities play a basilar role in innovation, contributing significantly to industrial development (Isaksen and Karlsen 2010).

The university-industry connection is obstructed by unequal expectations, facing different mental structures and goals, causing a lack of mutual trust in the long run. In this sense, the need for Universities and Industries to establish strategies to achieve efficient and advantageous solutions will allow for the trust in the relationship to be reinforced (Alves et al. 2015).

2.2. Knowledge Transfer between University-Industry

Comparing the potential of different EU regions to support university-industry cooperation as an important precondition for implementing the smart specialization strategy, it was found that there is a strong East-West divide among EU regions. In order to benefit from the smart specialization strategy, more attention should be paid to the region-specific approach. Universities in central regions need to be more motivated to cooperate with

universities in lagging regions. The motivation of governance at the regional level and its capacities to support interactions between universities and industry should be developed and supported (Alves et al. 2015).

Lack of trust between institutions has proven to be a barrier to U-I cooperation. To combat this mistrust, universities should be able to present the advantages of cooperation with industry, and in the case of the existence of rights, these should be shared equally. The existence of a department in universities dedicated to supporting the creation of companies, both by students and by society in general, will allow the growth of the community in the region, making it easier to boost cooperation between universities and industry. The difference in the defined objectives is another barrier identified since industries focus on profit maximization, which is not the case for universities (Lopes and Lussuamo 2021).

Cooperation between universities and industry can facilitate knowledge transfer and even stimulate the production of new knowledge and technology. University knowledge is applied in the industry to support innovation and the creation of new technologies. University-industry cooperation fosters both new university capabilities and higher education effectiveness (Bektaş and Tayauova 2014).

The concept of technology transfer, specifically between universities, has been demonstrating its complexity by transposing from linear models of innovation to complex models, stimulating university networking and entrepreneurship. In the work (Krücken et al. 2007), the authors present three distinct models for these transfers: information and documentation, cooperation model, and boundary definition model.

Science parks (PCs) and business incubators (BIEs) have been considered worldwide as drivers of economic development. Technology transfer and the production of high-tech companies from science parks and business incubators are often associated with economic growth as well as job and wealth creation in developed and developing countries. However, there is little data regarding the role of converging economies such as Portugal. In these countries, PCs and IEs are only potential job and wealth creators if they are successful. Analyzing the population of PCs and IEs, we conclude that their contribution to economic growth in Portugal has been modest. Therefore, it is confirmed that university connections along with management adequacy are fundamental to the success of SPs and IBs (Ratinho and Henriques 2010).

2.3. University-Industry Cooperation Policies

University-industry cooperation is thought to increase both industrial productivity and educational efficiency in universities. The combination of theory and practice accelerates the learning process and facilitates the transfer of knowledge to the production field. In this context, the adoption of governmental measures to promote cooperation is a central element in part of the realization of such goals. University-industry cooperation should be carried out to optimize resource use (human resources, capital, technology, natural resources) and ensure sustainable development and improvement (Bektaş and Tayauova 2014).

The authors of the study (Alves and Cartaxo 2015) argue that governments should promote new policies that facilitate U-I cooperation, enabling universities to improve the recognition of positive savings from cooperation. In the same vein, other authors (Zhou et al. 2016) suggest the existence of government funding in R&D projects in order to promote performance during university-industry cooperation. Financial barriers are shown to be strongly related to the propensity of knowledge-intensive business services to collaborate with universities. Knowledge barriers are moderately related to the propensity of high-tech manufacturing SMEs to collaborate with universities. Although universities play important roles in the techno-economic system, their contribution to alleviating internal barriers to innovation for technology-based SMEs may be less prominent than policymakers in emerging economies expect (Franco et al. 2019).

3. Methodology

An article that uses the literature review methodology aims to promote an overview and structure related to a theme, theory, or method-specific (Paul and Criado 2020). In order to respond to the main objective of this article, i.e., to make a scientific mapping of university-industry cooperation through a bibliometric analysis, it was decided to conduct a new methodological consideration (Connor and Voos 1981; Wasserman and Faust 1994; Powell et al. 1996; Howard and Katherine 1998; Quinlan et al. 2008). According (Radu et al. 2021; Donthu et al. 2021) bibliometric research includes a set of measurements based on graphical representations and statistical tables used to present the current state and development of a subject and improve future research. The bibliometrics research follows a mixed methodology, as it provides an assessment of the qualitative and quantitative scope of each research subject which allows mapping a large volume of information contained in databases (Pritchard 1969). The bibliometrics is extremely useful for identifying the publication trends in topics/emergence terms and become dominant and influential in defining future research (Rodrigues et al. 2022).

This type of analysis provides the identification, assessment, and analysis of content in specific areas and the systematization of concepts, theories, and practices (Rowley and Slack 2004). Therefore, bibliometric literature analysis goes beyond a simple compilation of scientific documents and their contributions to a specific topic. This means that it provides critical added value since it provides a summary of the literature on the topic under study and the identification of gaps and relevant clues for future research, whose main objective is to contribute to the advancement of scientific knowledge on that topic (Mentzer and Kahn 1995). This advance is materialized through the identification of patterns of subtopics, authors, scientific journals, citations, co-citations, and keywords, among others (Prasad and Tata 2005; Treinta et al. 2014) of conceptual contents and dimensions of analysis (Pedro et al. 2018).

The bibliometric analysis research methodology followed in this work, analyzing the most cited authors and co-citations, had as the unit of analysis the scientific articles aiming at grouping the documents with the same objective and hardcore (Grácio 2016). This kind of analysis allows us to display information related to the co-author, bibliographic coupling, and co-citations in a bibliometrics map (Noyons et al. 1999; Radu et al. 2021). In addition, the methodological procedures defined by (Tranfield et al. 2003) were also followed, namely: planning, development, and presentation of results. These phases were corroborated by other authors (Dai et al. 2019). Therefore, the bibliometric analysis of a specific research area implies the adoption of a methodical and structured research strategy to select the documents to be included in the respective systematization of the literature (Diógenes et al. 2020). Thus, it is crucial to define the criteria and keywords to be used in the process of document search and specification (Bandara et al. 2011), so the delimitation of the literature search process is essential to obtain an appropriate connection between the main topic and the subtopics and, subsequently, to carry out a descriptive analysis (Treinta et al. 2014). This means that the systematic review of the literature requires that all the steps followed are clear (Briner and Denyer 2012), that the collection and systematization of data are precise (Hadengue et al. 2017) and that the results obtained are clear (Briner and Denyer 2012). The systematic review that is presented followed bibliometric analysis for the scientific mapping of the topic under discussion (Garfield 1979; White and Griffith 1981; Quinlan et al. 2008; Connor and Voos 1981; Wasserman and Faust 1994; Powell et al. 1996; Howard and Katherine 1998). Therefore, bibliometric analysis adopts a mixed methodology to provide a qualitative and quantitative assessment of a given area of interest (Geaney et al. 2015).

In this study, a systematic approach was used to perform the literature review, using a strict protocol and defining steps to perform the literature search and analysis based on scientific articles published on the Web of Science. The use of the Web of Science as the only source of research was a research decision motivated by the fact that the WOS has the most cited journals in this area of knowledge and also because no work of this kind was found that had only analyzed the WOS. This database source is determined by the

high level of international recognition in terms of published scientific papers quality and also because of the great level of researchers from an international academic community with a multidisciplinary character (Radu et al. 2021; Donthu et al. 2021; Noyons et al. 1999). Additionally, the use of this database is justified by its exponential recognition as a database with only peer-reviewed articles (Geissdoerfer et al. 2017), mostly used for bibliometric studies due to the presentation of more standardized and consistent data (Bandara et al. 2011; Briner and Denyer 2012). The identified articles related to “University-Industry Cooperation” were subjected to a bibliometric analysis using R Studio software. Many of these systematic reviews are based on an explicit quantitative meta-analysis of available data. However, fewer others use more qualitative analysis (Ward 2004). This study will use this bibliometric database’s quantitative and qualitative approach. Some authors have developed bibliometric studies of the associated concepts at the level of scientific papers published in a particular journal (Rodrigues et al. 2022; Bandara et al. 2011; Briner and Denyer 2012), or the analysis of research in a specific country (Weerasinghe 2017; Geissdoerfer et al. 2017).

This analysis will focus on the principal researchers who wrote the articles in our database. Through this analysis, we will ascertain which authors our database relies on to conduct its research and therefore create new knowledge in the area.

Data

Data were collected on 5 January 2021 in the Web of Science™ Core Collection database, with a chronological filter to exclude 2021 years, applying a search topic with the keyword “University-Industry Cooperation”. The search was only done using the keywords simultaneously, written together in a single line of text, without Boolean conditions “OR” and/or “AND” and/or “NOT”, running and in quotes. In fact, no filter was chosen to obtain the largest number of documents. For the categories, no filter was performed either. The inclusion criteria used were: all scientific documents written in English and that the expression “university-industry cooperation” appeared in the title and/or abstract and/or keywords were selected. However, since this is a quantitative methodology, the application of the PRISMA method was crucial to analyze the 538 articles by means of two eligibility criteria (Figure 1), which resulted in the reduction of the final base to 256 documents. Other researchers have used this method (Garfield 1979; White and Griffith 1981; Geaney et al. 2015; Geissdoerfer et al. 2017).

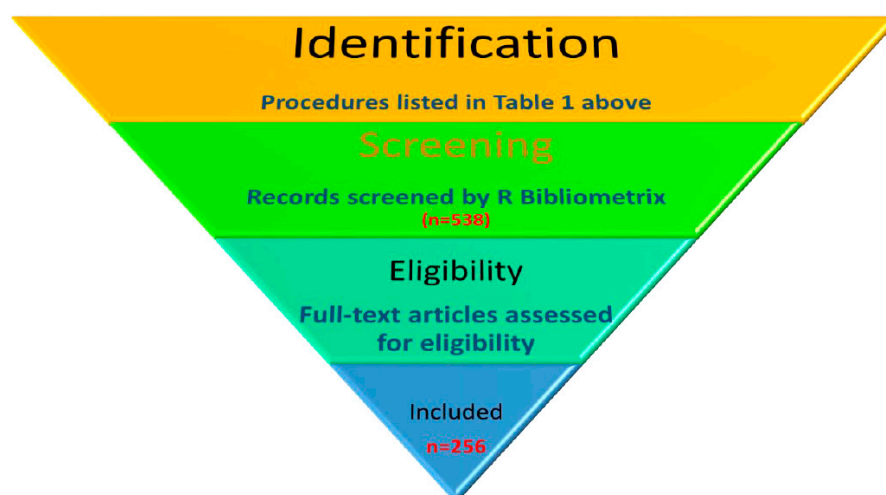


Figure 1. PRISMA diagram (Liberati et al. 2009).

Therefore, after removing the articles that did not fit the present study’s thematic, the final output of 256 documents was obtained, with no document excluded, regardless of the research topic and approach.

This decision was due to the need to know all the documents already published on university-industry cooperation in order to make this article an added value by adding something new that previously published literature reviews had not yet added. All abstracts were read to make the final decision about which articles would be included in the review. However, it was necessary to read several full papers whose abstracts did not make it clear whether or not they addressed the topic under study. The final result of 256 documents (WOS) with publication dates between 1970 and 2020 was the subject of our analysis. Using the R Studio/R Bibliometrix software, the database was analyzed from content analysis and the preparation of graphs (Aria and Cuccurullo 2017). Excel software was used for the quantitative analysis of the metrics of the articles (Ahmi 2021).

The research criteria used are presented in Table 1, which represents the research design already applied and with the results aggregated from different sources. Among other seriation criteria, common to other systematic literature review studies (Rodrigues et al. 2021; Suchek et al. 2021), it was decided to select the research areas related to the topic under analysis through the existing filters in the ISI Web of Science. On the other hand, the research equation shown in Table 1 follows the one outlined by some authors (Tranfield et al. 2003; Donthu et al. 2021; Noyons et al. 1999), as this provides the replication of this study at any point in time, to do so, it is enough to follow the research and eligibility criteria used here.

Table 1. List of items and search criteria.

Items	Criteria
Time horizon:	1970–2020
On-line database:	ISI (Web of Science)
Keywords/Search Equation:	Topic: (“university-industry cooperation”)
Query Link	https://www.webofscience.com/wos/woscc/summary/5a613b05-f20d-4d1a-96c1-0f0c18b9e3e0-3b59e9a7/relevance/1 ; accessed on 5 January 2021
Seriation by research category:	Business, Geography, Management, Planning Development, Public Administration e Urban Studies
Seriation by type of document:	All scientific documents published in WOS
Software used:	R. Studio, R Bibliometrix e Microsoft Excel
Identified documents:	538
Documents excluded:	282
Documents analyzed:	256

4. Results

Based on the data of this study, it was in 1970 that the first article on the topic “University-Industry Cooperation” was published in the area of Social Sciences, “Ministry of technologies role in sponsoring university/industry cooperation” (Dell 1970). In this article, the author addresses the Ministry of Industry and Information Technology (MIIT) universities, highlighting that they are important bases for scientific and technological research and play a critical role in the National Innovation System. In the following, we will present the trend analysis carried out on several dimensions of our research topic.

4.1. Overall Research Performance

4.1.1. Database Description

Table 2 presents information about our final database. We obtained a total of 256 articles produced by 583 authors, with an average of 2.56 co-authorship per paper.

Table 2. Final database information.

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1970:2020
Sources (Journals, Books, etc.)	185
Documents	256
Average years from publication	11
Average citations per documents	5.716
Average citations per year per document	0.6099
References	4893
DOCUMENT TYPES	
article	79
article; proceedings paper	4
book review	4
editorial material	3
meeting abstract	2
proceedings paper	163
review	1
DOCUMENT CONTENTS	
Keywords Plus (ID)	205
Author's Keywords (DE)	746
AUTHORS	
Authors	583
Author Appearances	668
Authors of single-authored documents	58
Authors of multi-authored documents	537
AUTHORS COLLABORATION	
Single-authored documents	61
Documents per Author	0.439
Authors per Document	2.28
Co-Authors per Documents	2.56
Collaboration Index	2.68

Note: The main results are presented by the document and authors.

This summary table allows us to have an overview of the weight of articles by research items. Average and global values are presented that allow us to reflect on these aggregated values within this research.

4.1.2. Articles Published by Year and by Country

In the period between 1970 and 2020, and during these 5 decades, where the 256 documents in our database are located, the number of publications never reached more than 33 per year. Until 2012 the number of publications had little growth, and from that year on, it increased significantly. In 2020 it recorded 6 publications. It had a decrease to 14 publications compared to 2019. There seems to be a downward trend in publications about the area from 2018.

Although the average evolution of the number of publications tends to be positive, as it is possible to confirm through Figure 2, the maximum exponent happens in 2015 with the number of 33 publications.

Regarding the articles published until the year 2020 (251), these show 2177 citations, which reveals the importance of this topic for academics. Within these, the most cited article (348 citations) was published in 2015 by the researcher MAIETTA OW, who researched the drivers of research and development collaboration between companies and universities while assessing the determinants of innovation in a low-tech industry.

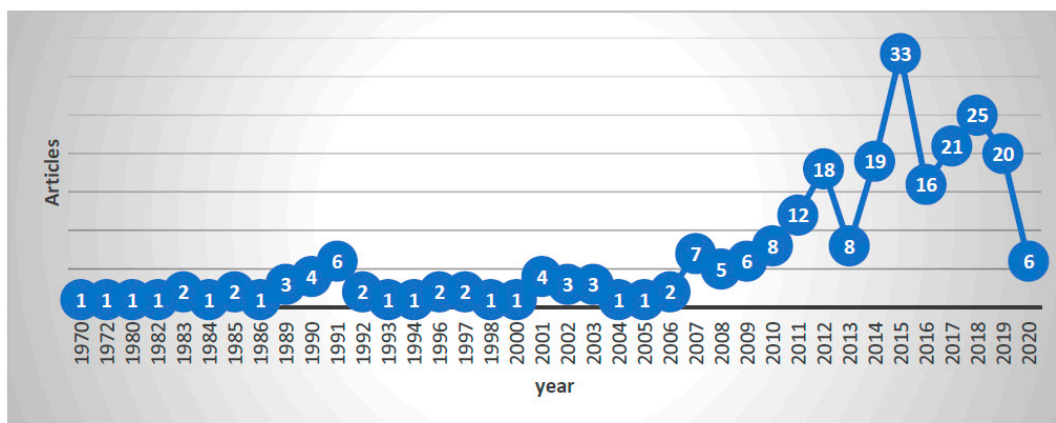


Figure 2. Number of articles published per year.

In relation to the Top 10 countries that most published in the area of university-industry cooperation, China, USA, Spain, and Germany stand out with respectively 50, 22, 20 and 18 publications which correspond to 20%, 9%, 8%, and 7%, i.e., more than 44% of the publications in the period considered were registered by these 4 countries, followed by Poland, Portugal, Brazil and Romania (Table 3). Peru’s productivity is higher than Japan’s in the ten countries that published the most in the period under study.

Table 3. Number of publications by country.

Position	Country	No. of Publications	% Publications
1	CHINA	50	19.53%
2	EUA	22	8.59%
3	SPAIN	20	7.81%
4	GERMANY	18	7.03%
5	POLAND	13	5.08%
6	PORTUGAL	12	4.69%
7	BRAZIL	8	3.13%
8	ROMANIA	8	3.13%
9	PERU	8	3.13%
10	JAPAN	7	2.73%

We have chosen to present only the first 10 countries of about 28 with publications on this subject. Portugal is in 6th position with 12 publications, followed by Brazil, Romania, and Peru. It can be said that the work and interest shown by Portuguese researchers in this area are significant.

China presents itself as the country with the most publications in this area, directing its research towards themes related to University-Industry Cooperation and sustainability to analyze the satisfactory and unsatisfactory factors of a university-industry cooperation program (Luo and Lam 2019). Moreover, the analysis of the number of university-industry cooperation programs and the relationship between student motivation, program evaluation, student attitudes and career aspirations in tourism and the university-hospitality industry cooperation program (Luo et al. 2019) and development of a multidimensional and multi-item attitude scale to assess and identify the sustainability of university-industry cooperation partnerships (Luo et al. 2018).

Additionally, it is argued that collaboration between these countries is related to the need to extend the boundaries of knowledge, crossing cultures, especially in disruptive environments such as the one generated by COVID-19, which has created a huge need for bi-dimensional cooperation, as they mentioned (Ward 2004; Liberati et al. 2009; Aria and Cuccurullo 2017).

4.1.3. Publications by Authors

In terms of authorship of the publications, through Table 4, it is possible to identify the top 10 authors. In first place we have Lukasiak E. and Skublewska-Paszowska with 6 publications each (about 5% sum of both), then 4 publications for Markuerkiaga L. However, the most cited authors are Franco M (112 citations), followed by Lukasiak E and Skublewska-Paszowska, with 34 and 32, respectively.

Table 4. Publications by authors.

Position	Authors	No. of Publications	% Publications	No. of Citations
1	LUKASIK E	6	2.344%	34
2	SKUBLEWSKA-PASZKOWSKA	6	2.344%	32
3	MARKUERKIAGA L	4	1.563%	3
4	FRANCO M	3	1.172%	112
5	HOFMANN-SOUKI S	3	1.172%	2
6	LAM CF	3	1.172%	7
7	LIU YJ	3	1.172%	0
8	LUKAC D	3	1.172%	0
9	LUO JM	3	1.172%	7
10	MATKOVIC P	3	1.172%	13

The most cited author ($n = 112$) presents 3 co-authored publications which focused on cooperation, namely:

- The analysis of the connection between the reasons that lead to cooperation between industries and a university located in Portugal through the use of the qualitative methodology. They concluded that traditional communication channels still have some weight in these cooperations (Lilles and Rõigas 2017).
- Through a quantitative study, they argued that variables such as gender, age and the influence of the university itself are factors that dictate the propensity to establish partnerships with companies and also that these alliances positively influence regional development (Rothaermel et al. 2007).
- They considered that these alliances are fundamental to offering curricular internships to students in order to increase the transfer of knowledge and innovation, as well as to facilitate the positive entry of students into the labor market (Ratinho and Henriques 2010).

The other researchers have fewer citations, which does not remove the importance of the topic studied here, as shown in Figure 3. Therefore, we can observe the production obtained by the main authors of our database over time. Each circle corresponds to a certain number of documents and the respective average number of citations. In this sense, authors with a circle at the end in their row means that they have published at least one article on the subject under consideration.

The larger the circle, the greater the number of publications the authors have in that year. The greater the distance between circles on the straight line means that the author has not published any article, for some time, in the field of knowledge under study. As an example, we can see in 1st place in the ranking Lukasiak E. with 6 publications from 2015 to 2020. In 2nd place, we see Skublewska-Paszowska M. with 6 publications from 2015 to 2020; in 3rd place, we have Markuerkiaga L. with 4 publications from 2015 to 2018.

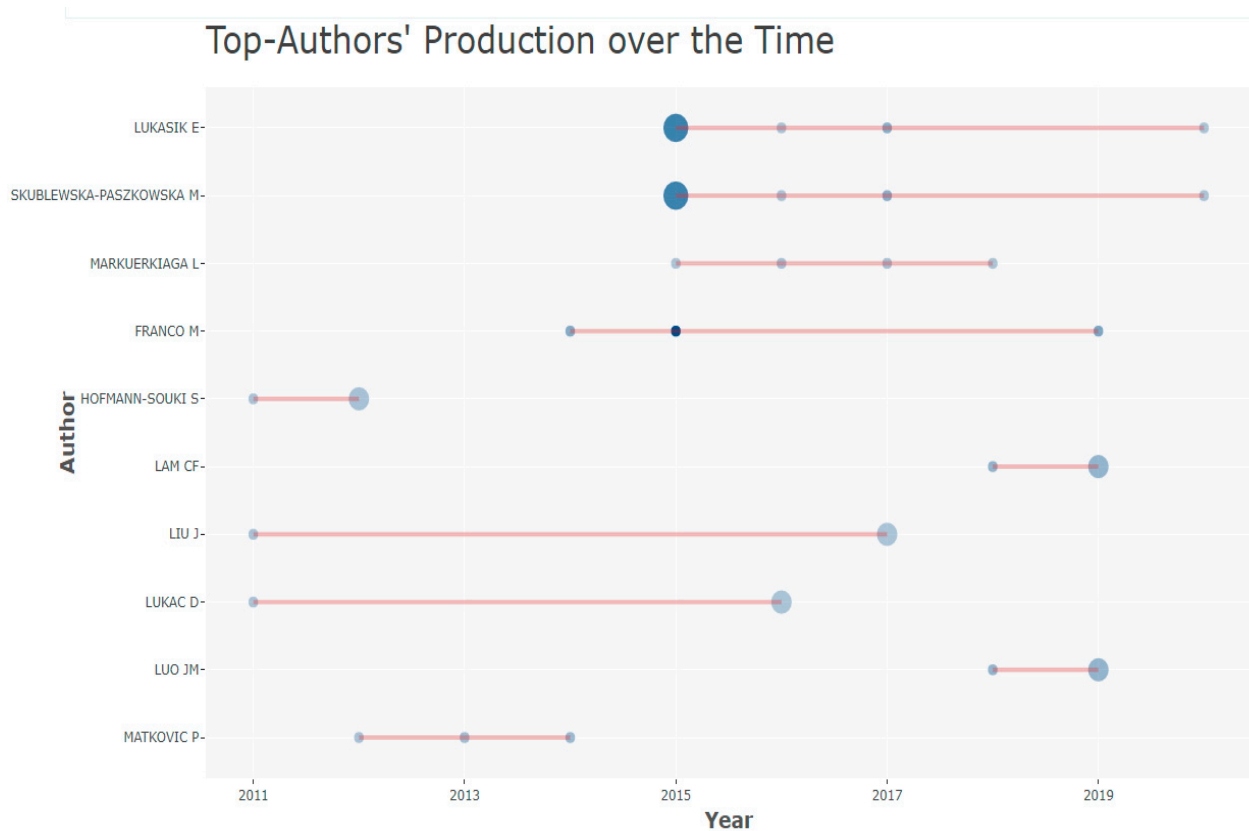


Figure 3. Author production over time.

4.1.4. TreeMap

After the search carried out in WOS, without temporal filters, the keywords “University-Industry Cooperation”, we used the software R Bibliometrix (version 1.2.5042, Boston, MA, USA) which allowed us to discover the main theoretical and conceptual lines within the academic research on university-industry cooperation. The Figure 4, presented below, details the most used concepts in this set of articles. From left to right, the most used, which in this order are:

- Innovation, Knowledge, Performance.
- Science, Firm.
- Collaboration, Entrepreneurship.

The themes highlighted in Figure 4 show the interest of academia in continuing studies that relate to alliances and cooperation with universities in order to stimulate the dissemination of knowledge in the business fabric to promote innovation and scientific knowledge. In this way, these cooperations provide students with an early insertion in the labor market, which may lead them to entrepreneurship. In other words, establishing this type of cooperation is becoming increasingly important when higher education institutions are required to think outside the box and generate critical added value in environments with disruptive trends.



Figure 4. TreeMap.

4.1.5. Themes Investigated over Time

Regarding the evolution of research themes, it was found for this research topic (Figure 5) that over time, the most relevant themes between 2017 and 2020 were Science, Economic-Development, Impact and Innovation. As of 2018, the research is more focused on Innovation and Knowledge. Notably, the themes related to Science and Innovation continue to receive much attention from researchers in this area of knowledge, with research occurring throughout the time interval under consideration.

Figure 5 highlights the importance of science between 2018–2020 (purple color), which suggests that academia and business are increasingly coming together to share and transfer knowledge supported by innovative ideas, where collaborations play a crucial role in enabling the allocation of human capital with critical mass. Figure 5 also shows the themes initially investigated and their importance for knowledge. On the left-hand side, we have the initial years, their respective themes, and the most researched current themes on the right-hand side. Looking at the oldest themes, we can see, in order of importance (in the figure, the larger the rectangle, the more important the theme is), the themes “science”, “impact”, “economic development”, and “innovation” were the most studied themes between 1970 and 2017 inclusive. After this period, “knowledge”, “innovation”, “academic entrepreneurship”, “commercialization”, and “education” stood out as the most researched themes between 2018 and 2020.

“cooperation”, and “knowledge transfer” are the words whose themes are more “cooperation” and “knowledge transfer” are the words whose themes are more related and have more relational significance with the central topic. The highlighting of these words corroborates the line of thought explained in Figure 5, given that these are the words with the highest frequency strength in the database under consideration.

4.1.7. Collaboration Networks among the Various Institutions

Figure 7 shows the collaborative networks between the various institutions to which most of the relevant authors belong. We check the Top 3, but in this case, we are able to visualize the most direct collaborative networks of this Top 3 through the nodes and edges that the schema indicates to us. An edge (or link) of a network (or graph) is one of the connections between the nodes (or vertices) of the network. In this network, we can easily see that other universities are connected in collaboration. However, we must point out that the thicker the edges are, the more intense the collaboration. For example, Xiamen University networks with Calif Davis University and Fujian Med University with different intensities of collaboration when we compare with others like Fuzhou University. The same happened with the University of Minjiang, and its network. There are no other networks between the remaining institutions in this database.

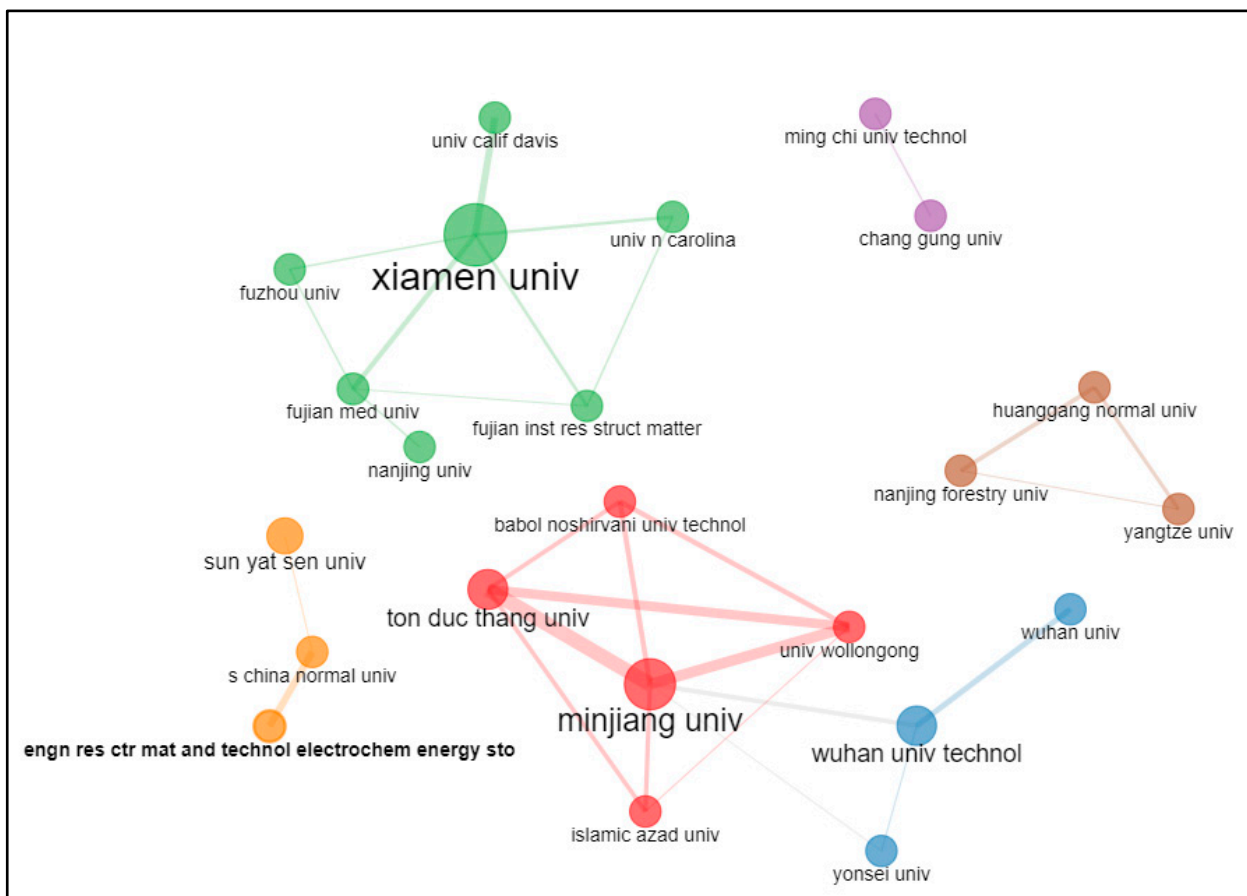


Figure 7. Collaboration networks among institutions.

Additionally, Figure 7 allows us to argue the importance of common projects and research at different universities with different cultures and geographic contexts, which reflects the continuous focus on their inter-internationalization, in which Erasmus+ programs, for example, can be an excellent channel for establishing international cooperation.

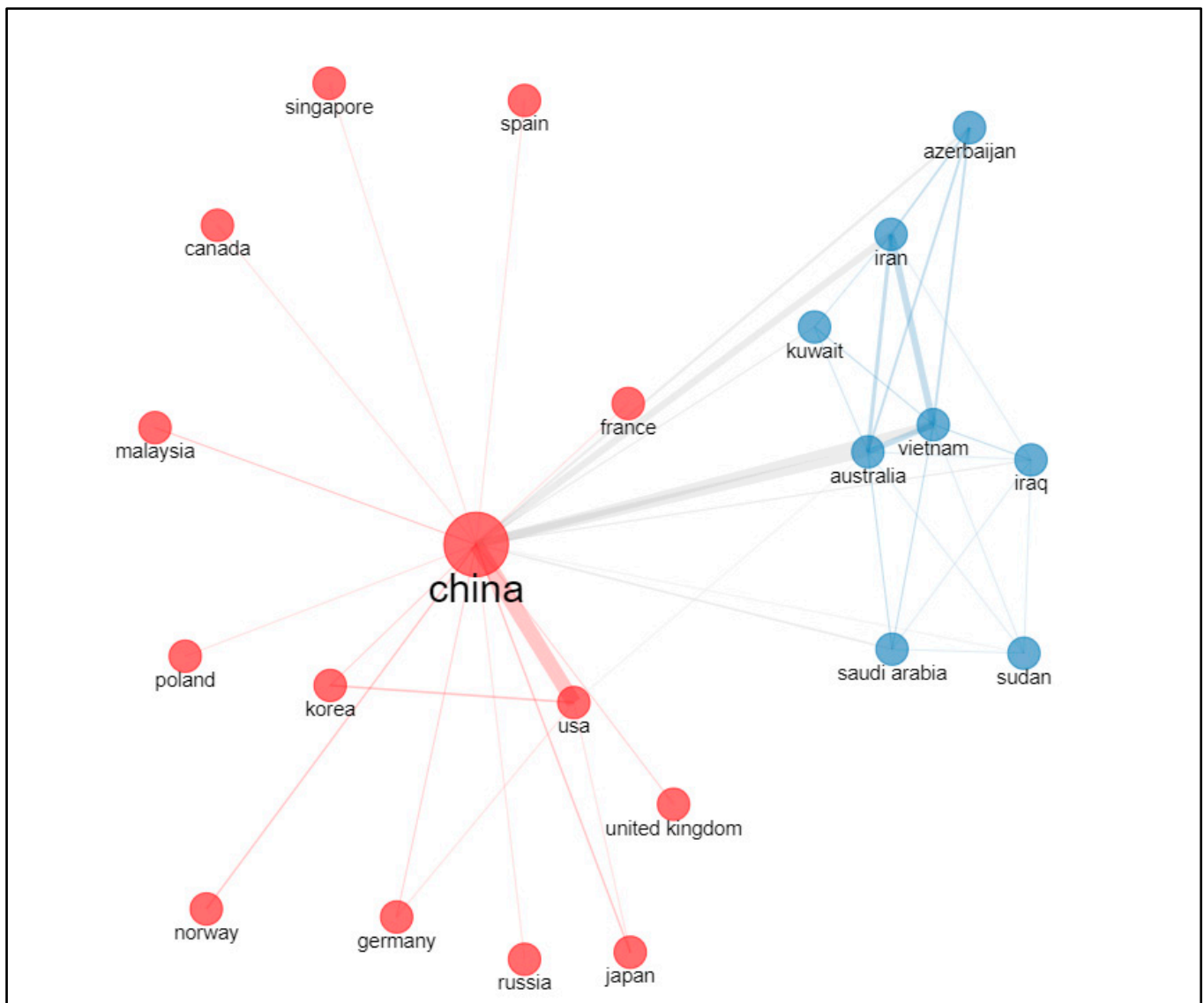


Figure 9. Country Networks.

4.1.10. Co-Citations Journals and Institutions

The section aims to examine the contributions of different research elements such as institutions and journals through the co-citations link. According to Small (76), the clusters of co-cited papers provide a new way to study the specialty structure of science.

The co-citation analysis allows for classifying cited references, authors, and publication sources (75) and is related to the number of times two articles are cited together and usually, these publications cited together have similar thematic (Luo et al. 2018). The benefit of this analysis is the possibility of finding the most influential publications journals in the research area and getting the institution's clusters (Hjørland 2013).

Based on the results of Figure 10, we can note that Res Policy is the journal that represents the central node and creates the most representative connections with other journals of different countries around the world.

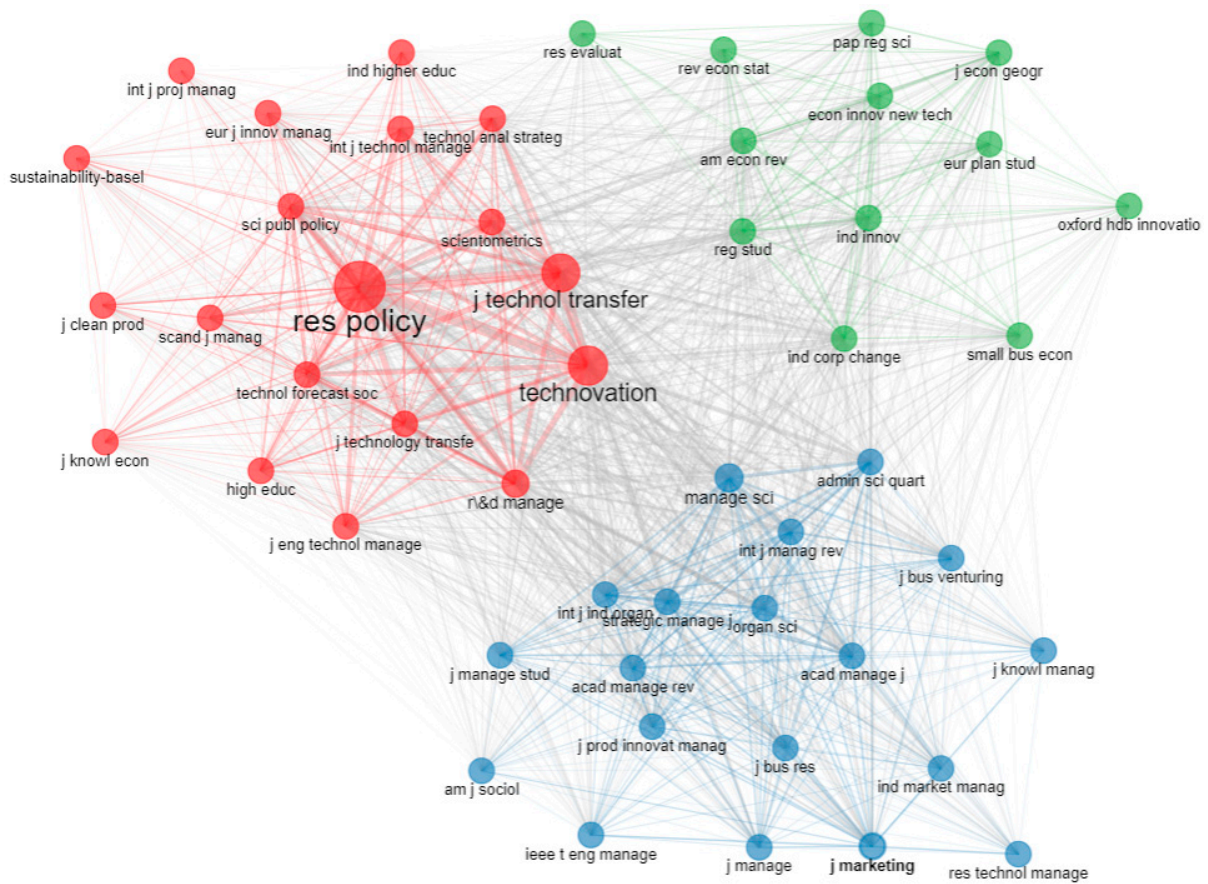


Figure 10. Co-citation Journals.

As presented in Figure 11, we can compare the author affiliations and highlight the country with the most publications in this area. The universities in China and Spain have the most significant representation in this output of institutions.

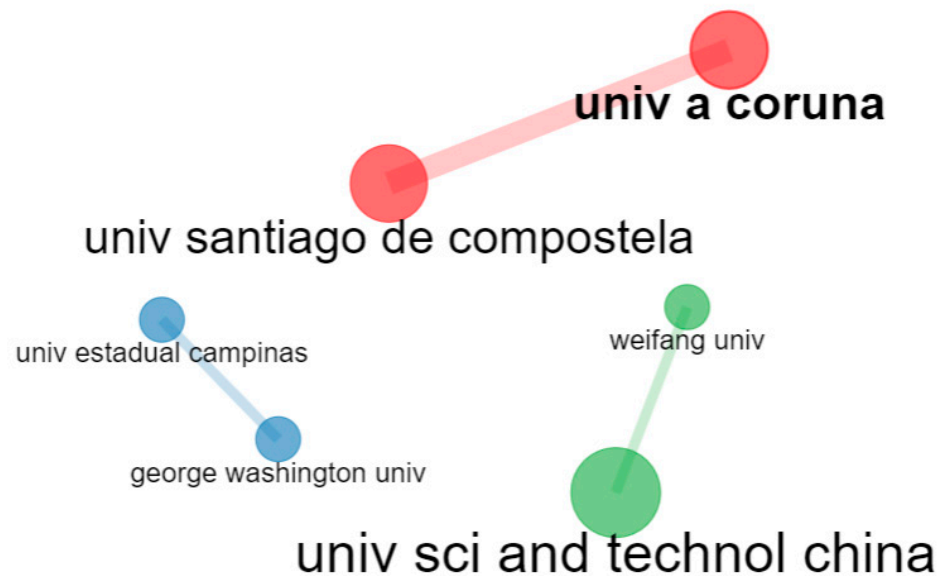


Figure 11. Co-citation Institutions.

5. Conclusions, Limitations and Future Research

This research described the published literature in terms of distribution of publications by year, most productive authors, top manuscripts by citations, total citations by country, countries of the corresponding author, network of the corresponding author, most relevant keywords and finally the most relevant keyword network. With the methodology adopted, we carry out a literature review and mapping, selecting relevant publications in the study area from Web of Science databases. The literature mapping provided an overview of what has been investigated in the application of “University-Industry Cooperation”.

The present findings (Figures 6 and 7) are consistent with the literature review, cooperation between universities and industries can facilitate knowledge transfer and stimulate the production of new knowledge, innovative process, and technologies (de Freitas et al. 2013; Enkel et al. 2009; Leydesdorff and Meyer 2006) the collaborative research, scientific consulting, or technology transfer (Berbegal-Mirabent et al. 2015; Leydesdorff and Meyer 2006; Perkmann et al. 2013). We cannot dissociate the university from the industry, nor the industry from the university, to obtain the best synergies and the more innovative practices on both sides.

The collaboration networks among institutions and networks among authors is a field of action that has been intensifying (Figures 8 and 9), thus confirming that the collaboration between universities and industry is presently seen as a channel to improve innovation in the world economy sectors through knowledge and technology transfer, assisting companies to further competitiveness (Weerasinghe and Dedunu 2020; Mascarenhas et al. 2018). Also, combining theory and practice accelerates the learning process and facilitates the transfer of knowledge to the production field.

With this research, we have provided answers to the research questions posed. There has been a clear growth in the number of publications since 2012, reinforcing the idea that University-Industry Cooperation has increasingly proven to be a current and evolving topic, which also demonstrates the recent and prominent use of this topic (as can be seen in Figure 6).

This investigation found that in terms of the authorship of publications, Lukasik E. and by Skubluewska-Paszowska led with 6 publications on the main theme. However, the author with the highest number of references cited was Franco M. as we can confirm in Table 4

In the main theme label, the most cited journals are in this area of knowledge, and the one that deserves the most emphasis is the journal “Industry and Higher Education”. Most studies in this area have been carried out in China, followed by the USA, and Spain. Regarding the general conclusions of the literature mapping, we can state that University-Industry Cooperation is increasingly the object of scientific study and represents an area with great research potential that must evolve since there are still several gaps.

We believe that in a similar analysis of words, the cooperation between university and industry will certainly lead to the innovation processes materializing in knowledge transfer. Regarding the keyword analysis, the most frequently repeated keywords are “Innovation” and “Cooperation”. These terms are more relevant to understanding the line of research, which is more focused on the reality of industry challenges than on theoretical explanations.

This subject’s new guidelines and trends can be considered by the occurrence of the most frequent keywords used in newly published research.

The collaboration networks among institutions and networks among authors is a field of action that has been intensifying (Figures 8 and 9). Thus, confirming that the collaboration between universities and industry is presently seen as a channel to improve innovation in the world economy sectors through knowledge and technology transfer, assisting companies to further competitiveness (Mascarenhas et al. 2018). As endorsed in the literature review, university-industry cooperation is the main tool for economic development, driving knowledge and technology transfer (Franco et al. 2014; Celikdemir et al. 2017; Lilles and Rõigas 2017).

Based on the assumption of cooperation between industry and university, this research was treated transversely in several related subjects and culminated in interesting results concerning network collaboration, networked authors, and knowledge and technology transfer. The research returned a total of 256 articles, covering a period from 1970 to 2020. The articles were then subjected to a bibliometric analysis and literature mapping to present an overview of the studies on “University-Industry Cooperation” this work carried out a referred bibliometric review of scientific articles published in this area with an analysis of the publications on University-Industry Cooperation in the last decades identifying the evolution trends and future research opportunities.

The exploration of the 256 scientific articles identified in this study provides a solid theoretical basis for understanding University-Industry Cooperation in the last 50 years worldwide, from 1970 to 2020. In a general conclusion, we can state that the publication of studies on this subject has increased in the last 5 years, with the peak of publications in 2015 with 33 publications. It was also found that it was in the last decade that more publications were made. It is noteworthy that the highest percentages of research in the universe of all published articles on “University-Industry Cooperation” are published in high-quality journals in the area and tend to be highly cited. This conclusion reinforces that this topic has been gaining increasing importance and research interest. In this sense, there was a growth in the volume of publications, especially after 2012, reinforcing that the University-Industry Cooperation has increasingly proven to be a current and evolving theme. In short, over the past three decades, much research has been done on university-industry cooperation, and this research area is of high interest and still has a long way to go.

Universities act differently and are conditioned by political, legal, economic, and social issues. Therefore, their cooperation relations with industry are different, so the contribution to economic development will also be made differently. Thus, cooperation between academia and industry depends on the types and structures of knowledge exchange processes in which these entities are involved, so it can facilitate and hinder the use of university knowledge as a competitive asset that encourages economic growth. (Mascarenhas et al. 2018).

This thorough exploration allowed us to produce a bibliometric analysis of the articles, ranking them according to their respective resulting levels of academic importance. This further concludes that this topic continues to stimulate high levels of interest in researchers who have seen an increase in the number of research projects in this field in a very contributive way in recent years. This issue has been going on for a long time and remains relevant today with the growth of the institutional collaboration between industry and university (University-Industry Cooperation).

The present research provides important insights into the scientific analysis of institutional cooperations, revealing rational structures on the subject. One of the most important contributions is to systematize the literature on the topic and the relationship between distinctive related terms. This research is a true contribution to the knowledge scientific in this field of research.

Ultimately, we undertake that the university’s function is not only to qualified professionals but also to produce knowledge. The combination of theory and practice accelerates the learning process and facilitates knowledge transfer to the production field.

In conclusion, notable research has been conducted over the past 5 decades on university-industry relationships and cooperation. Despite these numerous studies on this subject, there is still a need to expand and improve the research, to better deepen the knowledge of the conditioning variables and the facilitators of this type of cooperation.

As a limitation, it should be noted that this study used only the Web of Science as a research database involving international articles on the topic of “University-Industry Cooperation”. Another limitation may be related to the keywords used that could be combined in another way, widening or restricting the search domains and the scientific areas encompassed in the filtering.

As a future research proposal, it is important to point out that this bibliometric study can be replicated by selecting other databases such as SCOPUS and ScienceDirect. This investigation of trends on the theme of University and Industry cooperation, gave us the possibility of developing in the future. Further to this investigation, a more in-depth qualitative study needs to be generated from the survey of quantitative data related to the publications, as well as from the analysis of the content of the articles selected and classified as part of the research.

Author Contributions: Conceptualization, P.B. and R.S.; methodology, R.S., M.F., and G.M.; software, R.S.; validation, C.M.d.S., M.R., G.M., and A.C.; formal analysis, R.S. and G.M., M.F.; investigation, A.C., M.F.; resources, C.M.d.S. data curation, R.S.; writing—original draft preparation, G.M.; writing—review and editing, A.C. and G.M.; visualization, P.B.; supervision, P.B.; project administration, R.S., M.F., and A.C.; funding acquisition, C.M.d.S., M.R., P.B., M.F., G.M., and R.S. All authors have read and agreed to the published version of the manuscript.

Funding: The work of author Rui Silva is supported by national funds through the FCT—Portuguese Foundation for Science and Technology under the project UIDB/04011/2020 and by NECE-UBI, Research Centre for Business Sciences, Research Centre under the project UIDB/04630/2022. The work of the author Amélia Oliveira Carvalho is supported by national funds through the FCT—Portuguese Foundation for Science and Technology under the project UIDB/04728/2020.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: The authors gratefully acknowledge the University of Trás-os-Montes and Alto Douro and CETRAD (Centre for Transdisciplinary Development Studies) and University of Beira Interior (NECE—UBI) and CIICESI.

Conflicts of Interest: The authors declare no conflict of interest.

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