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International Trade and Sustainability: Bibliometric and Cluster Analysis

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Abstract: This article studies the scientific research literature that focuses on the terms related to international trade and sustainability. For this, a bibliometric analysis using the Web of Science database and a cluster analysis on the results obtained carried out. With regard to the results, it can be pointed out that, despite being closely linked, the terms have opposing characteristics and are included in a wide variety of research trends such as those related to agriculture, industry or carbon footprint. This article is of special importance for researchers who want to have a holistic view of international trade and sustainability by identifying its main indicators in the scientific literature.

Keywords: international trade; foreign trade; sustainability; environment; bibliometrics

1. Introduction

International trade is a relevant subject of study, since it provides the basis for developing the economic growth of many countries and, if carried out efficiently (better use of resources, lower production costs or increased income.), can lead to the development of the market itself, both internally and externally: internally, as it will improve productivity and externally, as the reinvestment of capital will eventually lead to economic growth [1].

Due to the importance and complexity of the subject, there have been several diverse schools of thought in economics that have taken it as a central variable in their economic or growth theories. One of the first theories was developed in the mercantilist school, which was the dominant theory in Western Europe from around the 1500s until 1800. This theory pointed to the importance of surplus in the trade balance [2], that is, when exports exceed imports.

In the late eighteenth century, Adam Smith, one of the greatest exponents of classical economics, in his book, The Wealth of Nations, proposed a theory based on how all nations would benefit from free and unfettered trade. It was based on the concept of absolute advantage, which is defined as the difference between costs of production of the same good in different countries [3]. Thus, as can be seen, there are many different and often, opposing theories.

In contrast, the term sustainability is more recent. It first appeared in the 1980s in part due to the Brundtland Report [4], which was based on data collected over three years from all over the world. The report noted that it was vitally important to change our habits and lifestyles, as failure to do so could lead to a social crisis and unrecoverable devastation of the environment. In addition, this report also gives the definition of the term sustainable development, a term that has been in frequent use in recent years; that is, sustainable development is development that meets the needs of the present generation but without compromising the needs of future generations [5].

The increased interest in recent decades for the environment and sustainability has led to supranational agreements such as the Kyoto Protocol, the Paris Climate Summit, the Madrid Climate Summit or the Goals for Sustainable Development (SDGs). The latter is also known as the 2030 Agenda,

since it establishes 17 goals (see Table 1) that address social, economic and environmental aspects, and 169 goals due to be completed by 2030.

Table 1. Sustainable Development Goals Compilation.

Goal	Definition
1	End poverty in all its forms everywhere.
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3	Ensure healthy lives and promote well-being for all at all ages.
4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5	Achieve gender equality and empower all women and girls.
6	Ensure availability and sustainable management of water and sanitation for all.
7	Ensure access to affordable, reliable, sustainable and modern energy for all.
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
10	Reduce inequality within and among countries.
11	Make cities and human settlements inclusive, safe, resilient and sustainable.
12	Ensure sustainable consumption and production patterns.
13	Take urgent action to combat climate change and its impacts.
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development.

In the very definition of the great majority of the objectives, namely Goals 11 to 17, the term "sustainable" is mentioned, which points to the fact that countries and numerous international institutions are very much aware of the overexploitation of the planet.

In Sustainable Development Goal 12, a clear example in Latin American countries may be found, who signed up to meet the SDGs and link their environmental problems with international trade. These countries have focused their trade on the export of material goods such as minerals, agricultural products or oil [6]. These materials are extracted from the natural environment and for this, new jobs are needed, giving rise to a moral and ethical debate: employment or the environment. Chuvieco et al. [7] describe how 90% of the population of Venezuela live in the north of the country; in the same area, losses of around 60% of forests have been recorded. Likewise, other authors point to the oil industry having a "pull effect" on other sectors or business in the economy by providing jobs, directly or indirectly to meet the demand for new services and with relatively high wages [8].

The problem faced by Latin American countries is that this is not a temporary trend that ends at a certain moment, but rather one that is feared will persist for some time. In the 1990s, an increase of 8.4% was observed in export goods and an 8.9% increase in total value of exports. An analysis of the data showed that of the 23 most exported products, 13 had decreased in prices, meaning that the quantity of goods exported had increased significantly in order to maintain the growth in exports despite the reduction in prices. This increase in the quantity of exported products implies a greater environmental impact due to greater exploitation. Furthermore, Latin American countries have focused too much on the extraction and export of raw materials, which has caused them to decrease the price of these goods, either due to an oversupply of products or competitiveness between countries. This has resulted in the quantity exported having to be increased further to maintain their income constant. This becomes an

ecological trap as the whole process occurs so quickly that it does not lead to investments being made to replace the decrease in natural capital [6].

In general terms, one of the indirect factors that is promoted by the exploitation of any environmental activity is the concept called ecological rucksack. Friedrich Schmidt-Bleek [9] defines it as the amount of resources that intervene in the life cycle of a product and that can later remain as waste. For example, a kilo of lignite coal has an ecological rucksack of 10 kilos of waste while a kilo of gold or platinum has a rucksack of 350 tons. The cost of this ecological rucksack is not included in the price of the products exported by Latin American countries, because, as Gudynas [6] points out, if this were so, the cost of products would be much higher than their current market value.

The environment, however, is not the only factor to play a relevant role in the attainment of the SDGs, trade is also important, hence, the creation of the concept of fair trade. This concept was born as a response to commercial exchanges with little or no impact on sustainable development, in aspects such as poverty, inequalities and, of course, the environment [10]. Therefore, it is important to frame fair trade in the SDGs, for example:

- End poverty by guaranteeing international trade with fairer conditions between consumers and small producers (SDG 1).
- Promote sustainable agriculture by transferring knowledge between countries and organizations in order to increase productivity (SDG 2).
- Achieve gender equality with a greater inclusion of women in commercial and production activities (SDG 5).
- Promote decent working conditions, eliminating child and forced labor (SDG 8).
- Seek inclusive, fair and sustainable development by promoting alternative and solidarity production and consumption patterns (SDG 12).
- The initiative to create this kind of trade itself refers to a Global Alliance to achieve the Sustainable Development Goals (SDG 17).

Andrade [11] changes the focus somewhat and defines it as a commercial relationship based on transparency and respect, which will lead to greater fairness in transactions. This term covers both social and economic aspects and is established as an alternative to traditional trade in order to support excluded or disadvantaged producers.

Other authors [12,13] point out that the supply side, producers and workers, are located mainly in the southern hemisphere, while fair trade organizations, also called "Northern Organizations" are located mainly in Europe, the United States, Canada and, to a lesser extent, Japan. However, in order to carry out their activities through the fair trade organizations, both bidders and applicants must comply with certain standards: the businesses must be governed by democratic laws, and the activity carried out must be environmentally and socially sustainable. In turn, Northern organizations pay a fair price that will be the market price plus an additional premium to producers, and they must also pay between 40% and 50% in advance to avoid overindebtedness of producers.

Likewise, Northern organizations advise on production and management aspects, and promote the transformation of the product in the country of origin to increase job creation. On the other hand, producers also have access to conventional markets as they are not obligated to sell their products exclusively to Northern organizations. Finally, Northern organizations provide consumer data to producers and promote a change in the international trade model that will help less developed countries [13].

Focusing on other aspects, in recent decades, barriers to trade have been reduced, while regulation related to environmental matters has increased [14]. Legislative differences between countries have resulted in countries with laxer regulations specializing in intensive pollution production. Furthermore, the cost to developed countries of these new environmental policies is not insignificant. For example, the US Environmental Protection Agency estimated that in the United States, the cost implementing these policies would cost USD 184 billion in 2000 for the private sector alone, equivalent to 2.6% of Gross Domestic Product.

The cost of implementing these policies have led companies to move their industries or part of the production process to other countries with more convenient environmental legislation and where labor costs are lower. China, known as the world's factory, is a clear example of this practice. The expansion of its foreign trade sector, with exports increasing from USD 0.58 trillion in 2001 to 3.34 trillion in 2010, has given rise to the development of the country, but has also triggered serious environmental problems [15]. This eagerness of developing countries to stimulate the increasing demand of other countries leads in the short term to compromise their environment, and subsequently to the overexploitation of resources [16].

Thus, as has been shown, the relationship between the concepts of international trade and sustainability are closely linked. These are issues that affect both public and private institutions; all countries, whether they are developed, developing or underdeveloped; and in social, economic and environmental spheres. In addition, it is an activity of vital importance that serves as a key piece in the development of countries.

The purpose of this research is to understand, from a bibliometric perspective, the state of the art in research related to international trade and sustainability, the evolution of the most relevant publications, countries, entities and authors, as well as the main areas of knowledge in which these studies are framed. Therefore, this work represents a contribution, by identifying the main trends in international trade and sustainability, which allows us to propose future lines of research.

2. Methodology

Assuming the transcendence and importance that the terms international trade and sustainability will have in the coming decades, it is important to observe its evolution within the scientific community. For this, a bibliometric analysis was performed.

Bibliometrics, or as it was original called, statistical bibliography was defined by Edward Wyndham Hulme as "the application of mathematical and statistical methods for books and other means of communication" [17]. Later, Alan Pritchard pointed out that this term was not entirely satisfactory, as it could be used in different fields and had, in fact, only been used four times in the previous 46 years since it could be confused with the fields of statistics or bibliography themselves [18]. For this reason, Pritchard himself suggested the creation of the concept of bibliometrics as "the application of mathematical and statistical methods for books and other media".

Other authors have offered a slightly broader and more commonly accepted definition. For example, Spinak [19] stated that "bibliometrics studies the organization of the scientific and technological sectors from bibliographic and patent sources to identify the actors, their relationships and trends". An instrument was needed to determine the priorities in the different fields of research, and even within them [20,21].

One of the advantages of bibliometrics is that there is no entity as such that can unilaterally impose a criterion or conclusion, but rather it is the scientific community itself—that is, the sum total of all their work—that will lead to quantitative results [22]. Furthermore, the publication of a document, from the point of view of the researcher or the scientific community, is not only a publication as such, but it is the result of a creativity process that is shared, judged and incorporated into existing knowledge. Thus, the knowledge cycle is completed when the new discovery is published and accepted by the scientific community in the same field [23,24].

For the preparation of this bibliometric study, different terms were selected (see Figure 1): international; trade or commerc* and sustainabil*. The symbol "*" was used in two of them in order not to exclude the rest of words belonging to the same lexical family, such as commercial, sustainable or sustainability.

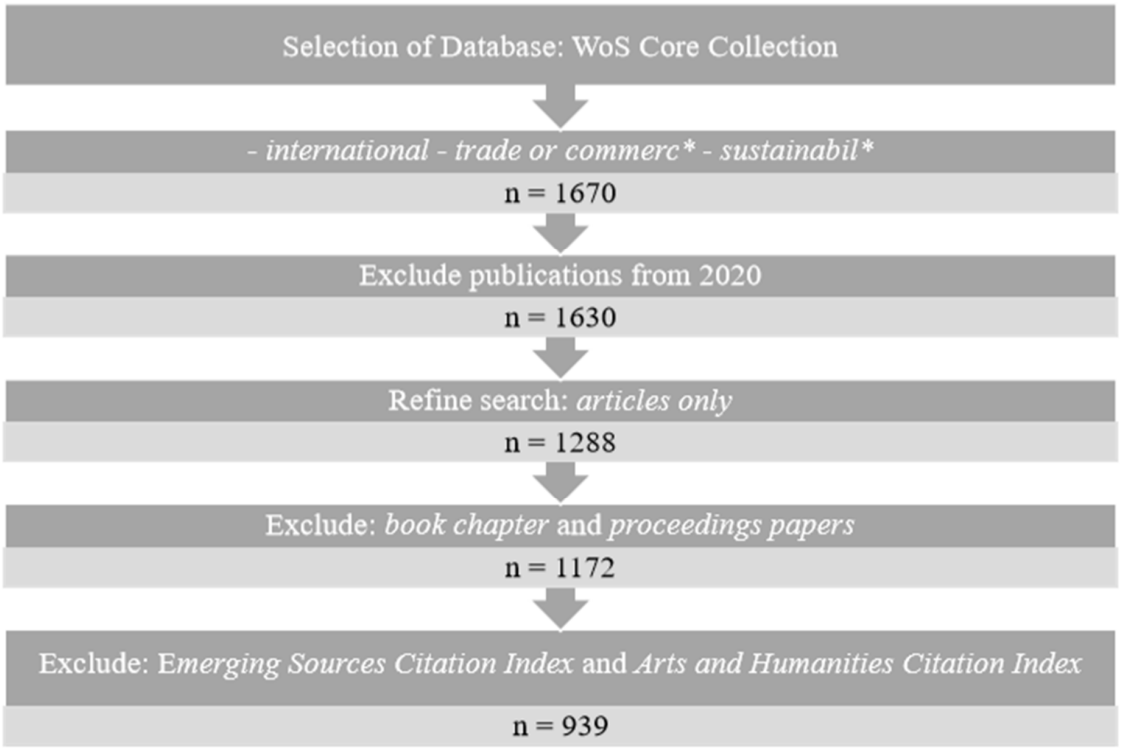

Figure 1. Flow diagram of the systematic review (Source: Own elaboration).

As the principal data source, the Web of Science (WoS) Core Collection database was selected, as it is valued as the best option in terms of age and is the most frequently used for the evaluation of scientific research [25]. In addition, a series of parameters and restrictions were established, for example, the exclusion of publications of 2020 as it is an unfinished year at the time of writing this paper. Regarding the types of documents, this study focuses only on articles, eliminating books, proceedings papers or reviews that, although due to their importance and nature may be relevant, are difficult to compare since they do not have direct impact indices. Finally, those journals that are indexed by WoS and that have an impact factor in the Journal Citation Index (JCR) were chosen. Figure 1 shows the flow diagram of the systemic review carried out.

After selecting the different terms and applying the aforementioned series of parameters, 939 articles and 18,504 citations were obtained between the years 1990 and 2019.

To measure the impact that publications have had on the scientific community, the number of citations these publications receive, their frequency, h-index and the impact factor of the journals offered by JCR were evaluated. A VOSviewer tool was used to process and create the cluster analysis.

3. Results

3.1. Evolution in the Number of Publications during the Period Analyzed

The first article was found in WoS on international trade and sustainability dates from 1990. In fact, it was the only one published that year, in the Cambridge University Press journal, authored by professors Robert Goodland, Emmanuel Asibey, Jan Post and Mary Dyson entitled *Tropical Moist Forest Management: The Urgency of Transition to Sustainability*, where it is pointed out that the model of exploitation of tropical forests is unsustainable and that, although trade restrictions were being established, they had been ineffective and the damages are not very reversible [26].

The volume of articles published did not undergo great changes during the 1990s and much of the first decade of the 21st century (see Figure 2). The trend did not change until 2008 after which the number of published articles grew continuously, decreasing only with respect to the previous year

on two occasions, 2012 and 2016. Since 2008, the number of published articles has multiplied by six, reaching a maximum in 2019, with a total of 155 publications. This recent trend is evidence of the growing interest and importance of international trade and sustainability in the scientific community.

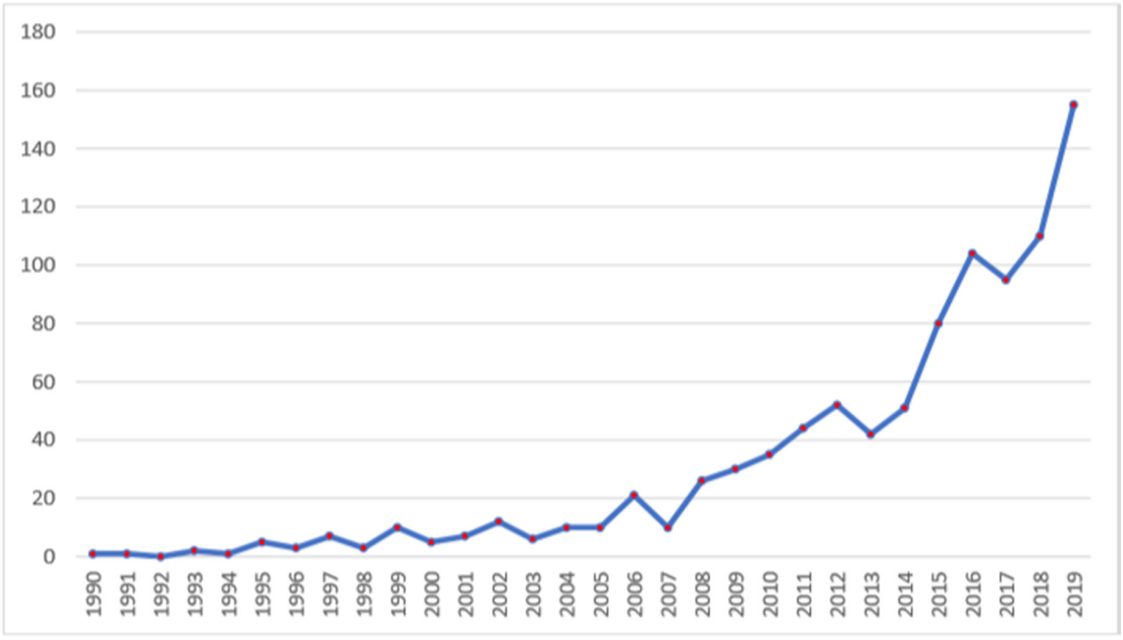

Figure 2. Annual evolution of published articles (Source: own elaboration).

In contrast, the number of citations showed a disparate trend to that of the number of publications (see Figure 3), evincing small peaks in the mid1−990s, but with a slight growth, until reaching its maximum value in 2015.

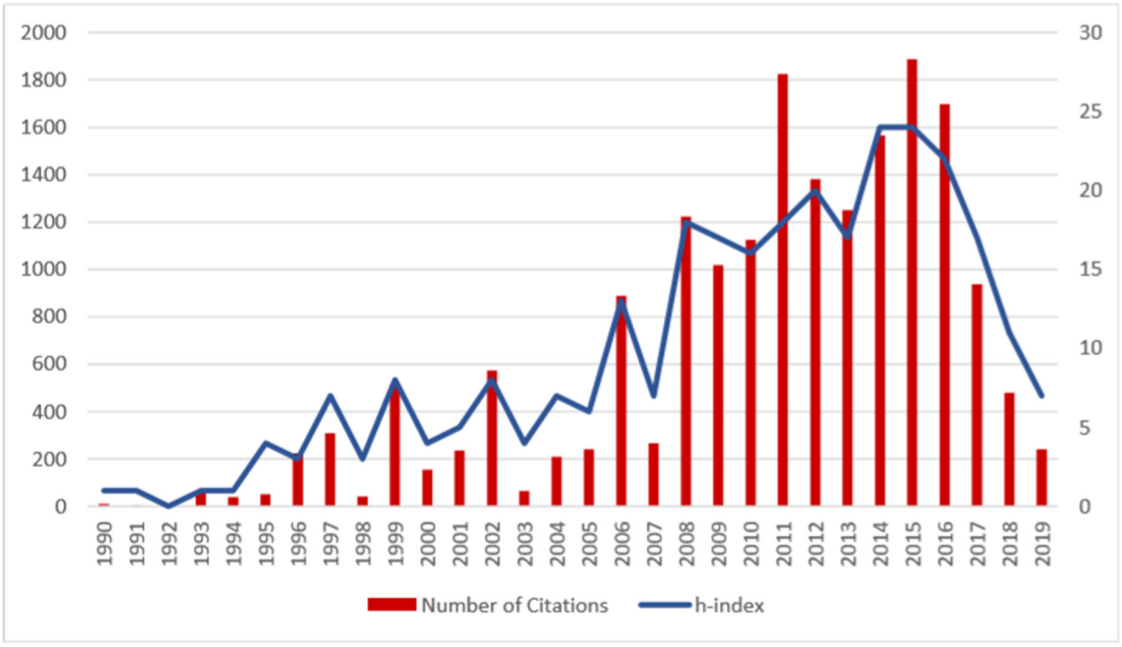

Figure 3. Evolution in annual citations and h-index (Source: own elaboration).

Furthermore, it is striking that a greater number of articles does not always imply a greater number of citations. Although from 2006 to 2014 the publication of articles more than doubled— from 21 to 51—the increase in the graph showed little more than a slight rise. Rather, this was the period in

which the citation of articles and the h-index itself evolved the most. This index followed a practically identical trend to the evolution of citations throughout the period, reaching its maximum in 2014 and 2015.

The most cited article (on 195 occasions) was Global Sustainability Accounting-Developing EXIOBASE for Multi-Regional Footprint Analysis published in 2015. This article states that in order to measure progress in sustainable development, among other items, an appropriate database would be required. The System of Environmental-Economic Accounts (SEEA) is specifically designed to measure sustainable development and the changes in environmental assets over time. This database is made up of different factors, including the national accounts of the countries, main data on trade, gas emissions, use of water, land and employment, among others. It concludes that the consumption of a country is closely linked to its environmental impact and its ability to generate wealth. In addition, inequality between countries is accentuated, because when a country becomes rich, it exploits labor in poor countries, hence the importance of the consumer learning about the indirect impact of their consumption habits [27].

The second highest number of citations was 2011. The article, Changing the future of obesity: science, policy and action received 513 citations, representing 28.10% of all citations for that year (1825 citations). Its main focus is obesity, which is designated as a pandemic. Using quantitative models, the effects of behaviors, interventions and policies were calculated at different levels: from individuals to the population as a whole. The article points to the importance of establishing trade agreements that ensure healthy food for the population and how international organizations must take obesity into account when establishing trade, economic, environmental treaties and health policies [28].

As previously mentioned, because international trade and sustainability are transversal themes, the areas of knowledge that study these subjects are themselves diverse and encompass a wide range of approaches. The main research areas that focused their work on these subjects were related to the study of the importance of the environment, but also the economy itself and international relations (see Table 2). Environmental Sciences and Environmental Studies were the most prevalent in terms of articles and citations. They also possessed a high h-index value, which showed the existence of a group of publications of great influence in the scientific community.

Table 2. Number of articles, citations and h-index by research knowledge area.

Research Knowledge Area	Articles	Cites	TC/Art	h-Index
Environmental Sciences	318	7225	22.72	45
Environmental Studies	229	6423	28.05	41
Green Sustainable Science Technology	150	1657	11.05	20
Economics	142	4161	29.30	33
Ecology	116	4343	37.44	34
Engineering Environmental	85	1550	18.24	23
International Relations	51	856	16.78	14
Energy Fuel	44	930	21.14	17
Biodiversity Conservation	43	980	22.79	18
Geography	33	951	28.82	15

TC/Art: Total citations per article.

With regard to the number of citations per article, other areas of knowledge such as Economics and Ecology had the highest ratio with an average of 29.30 and 37.44 citations per article, respectively. In addition, Table 2 shows Energy Fuel, which, despite the fact that its research area was focused on a more specific subject, had more publications than Biodiversity Conservation or Geography.

3.2. Most Influential Countries

As shown in Table 3, the United States led the ranking in terms of countries publishing the greatest number of articles (256), followed by the United Kingdom (158). It is striking how between

the third ranked country—China—and Canada, ranked seventh, there was only a small difference of 14 articles. This is evidence of a high concentration of publications in a limited number of five countries, each publishing between 96 and 82 articles.

Table 3. Ranking of countries by article, citations and h-index.

Country	Articles	Cites	TC/Art	h-Index
USA	256	6427	25.11	43
United Kingdom	158	4366	27.63	35
China	96	1743	18.16	19
Australia	90	2420	26.89	25
Netherlands	88	3601	40.92	27
Germany	83	2121	25.55	24
Canada	82	2631	32.09	25
Italy	52	913	17.56	16
Spain	47	802	17.06	16
Sweden	44	885	20.11	15

TC/Art: Total citations per articles.

Among this group of five countries, there were two countries from Central Europe. Of note, The Netherlands, with 83 articles, had a similar number of publications as Germany (88), but had almost twice as many citations. Furthermore, aside from having the highest ratio of citations per article (40.92), the difference with other countries was notable; specifically, with the next ranked countries—Canada and the United Kingdom—with 32.09 and 27.63 citations per article, respectively.

Italy and Spain were the two Mediterranean countries that occupied the most relevant positions in this ranking. The first had five articles and 111 more citations than the second. In contrast, the difference in citations per article was small—0.50 in favor of Italy.

In order to delve deeper into the country analysis and the potential links between them, a co-citation cluster map between countries was created (see Figure 4). The cluster map included 38 countries that had published at least six articles out of the 106 that had published at least one article.

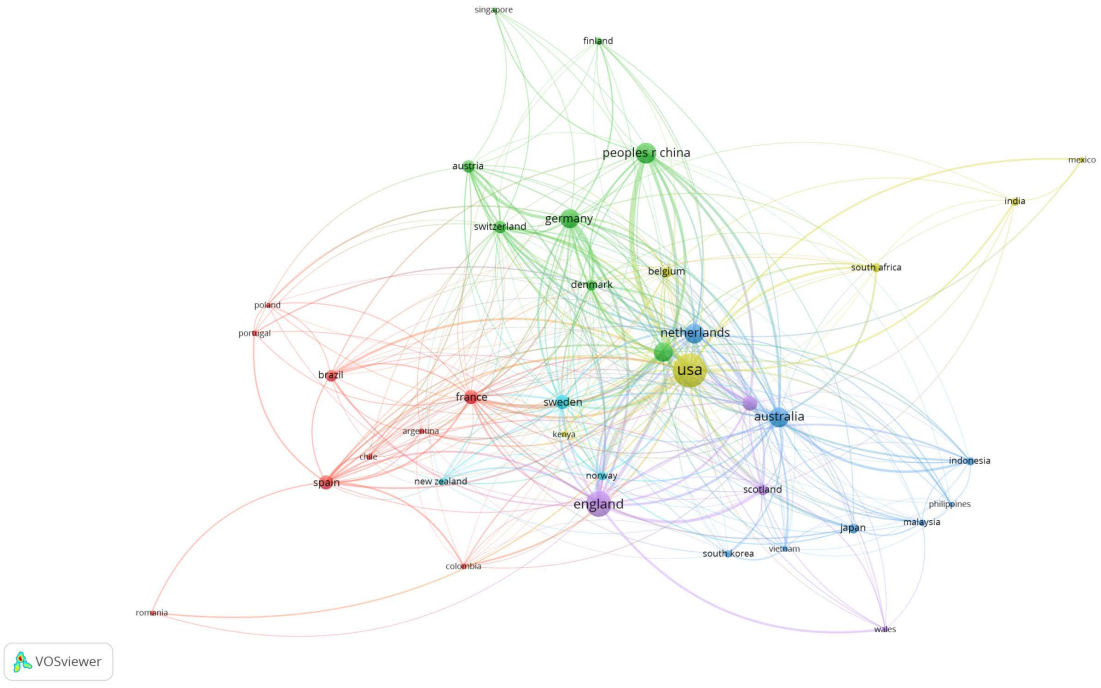

Figure 4. Cluster map of country co-citation network (Source: own elaboration).

The cluster map shows a clear co-citation link between the main nuclei mentioned in Table 3: United States, United Kingdom and China. Both the European and the Asian countries had a close link to the United States, although the links between each other were not as strong. In contrast, the strongest link on the entire map was between the United States and China, representing 17.05% for the United States. For China, its co-citation link with the USA represented 35.96% of all publications.

Regarding the number of links with the remaining countries on the map, the United States had the highest number of links in the entire cluster (35). The USA was linked to all the countries on the map, with the exception of Portugal and Singapore. Despite being ranked 13th in terms of number of publications, Switzerland boasted the second highest number of links (33), equaled by Australia. They were closely followed in the ranking by the Netherlands (32), Germany (31) and the United Kingdom (27).

There was also a strong link between Spanish-speaking countries, with Spain as the main focus, followed by Argentina, Brazil, Chile, Colombia and Mexico, all of which, in turn, also interacted with the United States.

Regarding Central European countries, the Netherlands and Germany were the most relevant, being linked to Austria, Belgium, France and Switzerland, which expanded their range of action to other more distant European countries, such as Finland or Poland. In contrast, there were small isolated foci such as Romania or Mexico, which were only related in terms of co-citation with three other countries, both having in common, once again, the United States.

Considering the 25 countries with the largest number of articles as a reference and analyzing the continents where they are located, Europe had 13 countries with a total of 664 articles and 18,200 citations, which translates into 27.41 citations for each article (see Table 4), followed by the American continent (United States, Canada and Brazil), with 368 articles and 9811 citations—26.66 citations per article. The United States represented 69.56% of articles from that continent.

Table 4. Ranking of continents according to number of countries, articles and citations.

Continent	Number of Countries	Articles	Cites	TC/Art
Europe	13	664	18,200	27.41
America	3	368	9811	26.66
Asia	6	180	2800	15.56
Oceania	2	101	2527	25.02
Africa	1	19	137	7.21

TC/Art: Total number of citations per article.

Asia was the third ranked continent with 180 articles, 2800 citations and 15.56 citations per article. Despite including six countries in the ranking, China represented 53.33% of all articles and 62.25% of all citations. Oceania had two countries—Australia and New Zealand—although the first of these represented practically 90% and 95% of the articles and citations respectively.

Finally, South Africa, the only country on the African continent, was ranked 18th with 19 articles and 137 citations—an average of 7.21 citations per article. Kenya also appeared on the co-citation cluster map by country (see Figure 4), but due to the low number of published articles, it was not included in the 25 countries with the largest number of publications.

3.3. Most Influential Journals

Articles concerning international trade and sustainability can be found in all kinds of scientific journals and in different areas of knowledge.

The journals taken into account for this analysis were those indexed in WoS and with an impact factor in the JCR (see Table 5). *Sustainability* and *Ecological Economics* can be considered the most influential journals as well as being the most prolific with the greatest number of published articles—54 and 49 articles, respectively. Both journals accounted for 10.95% of all published articles. Curiously,

the impact factor of the journal *Sustainability*, which published the most articles, was the lowest of the journals analyzed.

Table 5. Ranking of the most influential journals with a Journal Citation Index (JCR) impact factor according to articles, citations and h-index.

Journals	Impact Factor	Articles	Cites	TC/Art	h-Index
Sustainability	2.592	54	344	6.37	8
Ecological Economics	4.281	49	2629	53.65	26
Journal of Cleaner Production	6.395	47	786	16.72	17
Marine Policy	2.865	19	588	30.95	11
Environmental Research Letters	6.192	14	261	18.64	8
Global Environmental Change Human and Policy Dimensions	10.427	14	511	36.50	9
Journal of Industrial Ecology	4.826	13	249	19.51	9
PLoS ONE	2.766	12	235	19.58	8
Ecology and Society	4.136	11	489	44.45	6
Proceedings of the National Academy of Sciences of the U.S.A.	9.580	11	638	58	9

TC/Art: Total number of citations per article.

The journal *Ecological Economics* stood out for its large number of citations, the sum of these being even greater than the total sum of the first six journals. Its h-index (26) was also significant, being much higher than the remaining publications by a wide margin. It was followed by *Journal of Cleaner Production*, with 17, and *Global Environmental Change Human and Policy Dimensions* and *Journal of Industrial Ecology*, both with nine articles. Also of note is the journal *Ecology and Society* which had the second highest ratio of citations per article of the ten journals included in the ranking.

The journal with the highest impact factor was the *Global Environmental Change Human and Policy Dimensions*, with double the number of citations of other journals such as *Environmental Research Letters* or *PLoS ONE* with an equal or similar number of publications.

Of the ten most influential journals, eight of them focused mainly on the environment and sustainability, with *PLoS ONE* and *Proceedings of the National Academy of Sciences of the U.S.A*. focusing on other subjects. The first, *PLoS ONE*, focused on research in the fields of science and medicine. The second, *Proceedings of the National Academy of Sciences of the U.S.A*. covered the areas of social sciences, biology, physics and biomedics. Consequently, it can be deduced that of all the scientific journals in this ranking, none of them focused on matters related international trade or the commercial relations that may exist between different countries. This may be due to a generalized lack of interest in environmental concerns within these fields of research.

It is worth noting that the journals published by the Elsevier publishing company have an important presence in Table 5. This publisher defines itself as "a global information analysis company that assists institutions and professionals in the progress of science, advanced care in of health, as well as to improve the execution of the same for the benefit of humanity". In fact, Elsevier is responsible for publishing the following: *Ecological Economics*, *Journal of Cleaner Production*, *Marine Policy* and *Global Environmental Change Human and Policy Dimensions*. These four journals occupied the top six ranked journals with the highest number of publications—129 articles representing 13.73% of the total published articles.

3.4. Most Relevant Authors and Cited Articles

Jianguo Liu, who was awarded the "Rachel Carson Award for Sustainability" was the most prolific author with the largest number of publications (see Table 6). He is a distinguished professor at Michigan State University in wildlife and fisheries and holds the position of Director of the Center for Systems Integration and Sustainability. This research center bases its study on the integration of natural and social sciences to find sustainable solutions. Furthermore, Professor Jianguo Liu had the

second most cited article with 382 citations (see Table 7) entitled *Framing Sustainability in a Telecoupled World*. In it, he points out the growing interaction between the most remote parts of the world that have profound implications for sustainability and mentions how, although numerous sustainability studies have been carried out in particular areas, little attention has been paid to the impact of these interactions on sustainability. He cites biofuel as an example, for which demand has increased and has led to a reduction in land dedicated to food production. In 2008, this resulted in increased prices and reduced supply translated into food shortages and a discontented population in many nations [29].

Table 6. Ranking of most prolific authors.

Author	Affiliation	Art	Cites	TC/Art	h-Index
Liu, J.G.	Michigan State Univ. (USA)	8	445	55.63	4
Junginger, M.	Utrech Univ. (Netherlands)	7	320	45.71	7
Vicent, A.C.J.	Univ. of Columbia (USA)	7	177	25.29	6
Faaij, A.	Univ. of Groningen (Países Bajos)	6	308	51.33	6
Kissinger, M.	Ben Gurion Univ. (Israel)	6	159	26.50	5
Rees, W.E.	Univ. of British Columbia (Canada)	5	325	65.00	5
Kastner, T.	Senckenberg Biodiversitat and Klima-Forschungszentrum (Germany)	5	247	49.40	5
Schaffartzik, A.	Univ. de Bodenkultur Wien (Austria)	5	149	29.80	3
Kucukvar, M.	Qatar Univ. (Qatar)	5	129	25.80	4
Sumaila, U.R.	Univ. of British Columbia (Canada)	5	109	21.80	4

Art: Articles; TC/Art: Total number of citations per article.

Table 7. Most Cited Articles.

Authors	Titles	Journals	Cites
Gortmaker, S.L., et al.	Obesity 4 Changing the future of obesity: science, policy, and action. 378 (9793), 838–847 2011.	Lancet	513
Liu, J., et al.	Framing Sustainability in a Telecoupled World. 18 (2), 26 2013.	Ecology and Society	382
Van den Berg, J. and Herbruggen, H.	Spatial sustainability, trade and indicators: an evaluation of the 'ecological footprint'. 29 (1), 61–72 1999.	Ecological Economics	296
Berkes, F. and Jolly, D.	Adapting to climate change: Social-ecological resilience in a Canadian Western Arctic community. 5 (2), 18 2012.	Conservation Ecology	267
Weber, C. and Matthews, S.	Quantifying the global and distributional aspects of American household carbon footprint. 66 (2–3), 379–391 2008.	Ecological Economics	255

Martin Junginger, professor at the University of Utrecht, and Andre Faaij, professor at the University of Groningen and director of the Netherlands Energy Research Center, part of the Netherlands Organisation for Applied Scientific Research (TNO) energy transition organization, were ranked second and fourth, with 320 and 308 citations, respectively. It is worth mentioning that all 141 of their citations are linked to a single article in the *Biomass and Bioenergy* journal entitled *Overview of Recent Developments in Sustainable Biomass Certification*. The article describes the opportunities and restrictions in the development of biomass certification. It also points out the costs of such certification, the limitations in international trade, the lack of an adequate methodology and the requirements of the stakeholders. The authors point to how international coordination is necessary to improve the efficiency of biomass certification systems [30]. They have also received many citations and thus possess higher h-indexes.

The article Footprints on the Prairies: Degradation and sustainability of Canadian agricultural land in a globalizing world by Professor Meidad Kissinger (159 citations in total) published in the journal Ecological Economics was cited 43 times. This work focused on how Canadian prairies, which are an important source of agricultural products ranging from grains or legumes to grass or grain fed livestock, are changing. Their future presence in international markets is being jeopardized

by the expansion of Canadian agriculture in the last century. This has changed its structure and, together with climate change, the ability of this region to be a focus in the offer of such products is at risk [31]. In addition, Canadian professor William Rees of British Columbia University had the highest average number of citations per article (65).

The third most cited article was by Jeroen van Den Bergh, research professor at the Institute of Environmental Science and Technology at the Autonomous University of Barcelona, where postgraduate studies such as the Master in Political Ecology: Decrease and Environmental Justice are offered. Harmen Verbruggen, Professor Emeritus at Vrije Universiteit Amsterdam University, with 46 publications and awarded in 2014 with the Royal Decoration of said university, is also co-author of this article. In this publication—*Spatial Sustainability*, *Trade and Indicators: an Evaluation of the Ecological Footprint*—both authors reflect how, despite the fact that in many analyses, researchers take into account several variables, few consider the impact that international trade has on the environment. These authors conclude that the flow of goods would help international trade by distributing the environmental burden in those natural areas that are less sensitive. For this measure to be effective, it must be carried out with the appropriate incentives, correct regulation and coordination between international environmental policies. Furthermore, they point to the ideas of neoclassical economics, socio-political sciences and ecology as a relevant source of knowledge in this field of study [32].

The article *Quantifying the Global and Distributional Aspects of American Household Carbon Footprint* published in 2008 by Scott Matthews, professor in the department of civil and environmental engineering at Carnegie Mellon University, and Christopher Weber, current lead climate and energy scientist for the World Wildlife Fund organization, points out the importance of environmental impact studies. As world trade increases, all efficiency techniques carried out during production should be considered, as this could lead to large national disparities in environmental analyzes. The authors point out how, for example, in 2004, and due to the increase in international trade, 30% of the impact of CO_2 emissions from households occurred outside the United States. For their investigation, they carried out a multiregional input–output analysis that took into account the interaction between the United States and its seven largest trading partners. To conclude, the article points out that for policies designed to change consumption patterns to be effective, international trade must be taken into account [33].

Likewise, there was a correlation between Table 5 (ranking of the most influential journals) and Table 7 (most cited titles). In both, more specifically, in the second, it was the publisher Elsevier that had the greatest representation in terms of the number of journals, with three articles published in *Lancet* and *Ecological Economics*.

3.5. Most Influential Universities

The role of universities in the scientific community plays a notable and crucial role, making it worthy of being analyzed. As expected, after analyzing the ranking of the most prolific authors, the universities to which they belonged also appeared prominently in the ranking of universities publishing on issues of sustainability and international trade (see Table 8). The *University of British Columbia* stood out with 27 articles and 911 citations, of which 10 publications and 434 citations belonged to the aforementioned professors Rashid Sumaila and William Rees.

The role of Dutch universities was also striking. *Wageningen University Research* and *Utrech University* published 4.57% of the 939 articles. Martin Junginger of the University of Utrecht published seven of the 16 articles attributed to his university. Lastly, the eight articles by Professor Jianguo Liu represented 57% of all *Michigan State University* articles (14).

Table 8. Most Influential Institutions.

Institution	Articles	Cites	TC/Art	h-Index
University of British Columbia	27	911	33.74	17
Wageningen University Research	27	700	25.93	17
University of London	26	676	26.00	13
Utrech University	16	749	46.81	13
University of California System	16	529	33.06	7
Centre National de la Recherche Scientifique	16	295	18.44	9
University of Sydney	15	577	38.47	9
University College London	15	448	29.87	8
Michigan State University	14	503	35.93	7
Stockholm University	14	344	24.57	7

TC/Art: Total number of citations per article.

Although they did not appear in this ranking, because their number of published articles was fewer, there were universities that stood out with regard to the number of citations received (see Table 9) such as *Vrije Universiteit Amsterdam* or the *University of Maryland*, which had only nine articles, but they had more citations than 90% of the universities mentioned in Table 8. In the case of Vrije Universiteit Amsterdam, 296 citations corresponded to the aforementioned article—*Spatial Sustainability, Trade and Indicators: an Evaluation of the 'Ecological Footprint'*.

Table 9. Institutions with the highest number of citations.

Institution	Articles	Cites	TC/Art
Vrije Universiteit Amsterdam	9	822	91.33
University of Maryland	9	820	91.11
Harvard University	10	798	79.80
Columbia University	6	538	89.66
Stanford University	9	480	53.33
China Agricultural University	5	455	91
Chinese Academy of Sciences	8	439	54.87
Copenhagen University	7	434	62
University of São Paulo	5	410	82
University of Oxford	9	403	44.77

TC/Art: Total number of citations per article.

The fact that a university may have only published a small number of articles, does not necessarily mean that they are of lesser quality or less relevant to the scientific community. China Agricultural University and the University of São Paulo, for example, only published five articles each, but received a large number of citations, since their articles received an average of 91 and 82 citations per article, respectively.

Asian institutions stood out in this field of research, since China Agricultural University and Chinese Academy of Sciences represented 7.22% of the total publications and 31.92% of the total of citations from the Asian continent, evincing a similar trend to the one previously described—in that a smaller number of publications does not necessarily imply a low impact on the number of citations.

3.6. Keyword Analysis

For the analysis of keywords, a word concurrency cluster map was prepared using a fractional method (see Figure 5). For this, the minimum agreement of a keyword was established at eight among the 4696 keywords found. Thus, 153 terms were obtained and divided into seven distinct clusters.

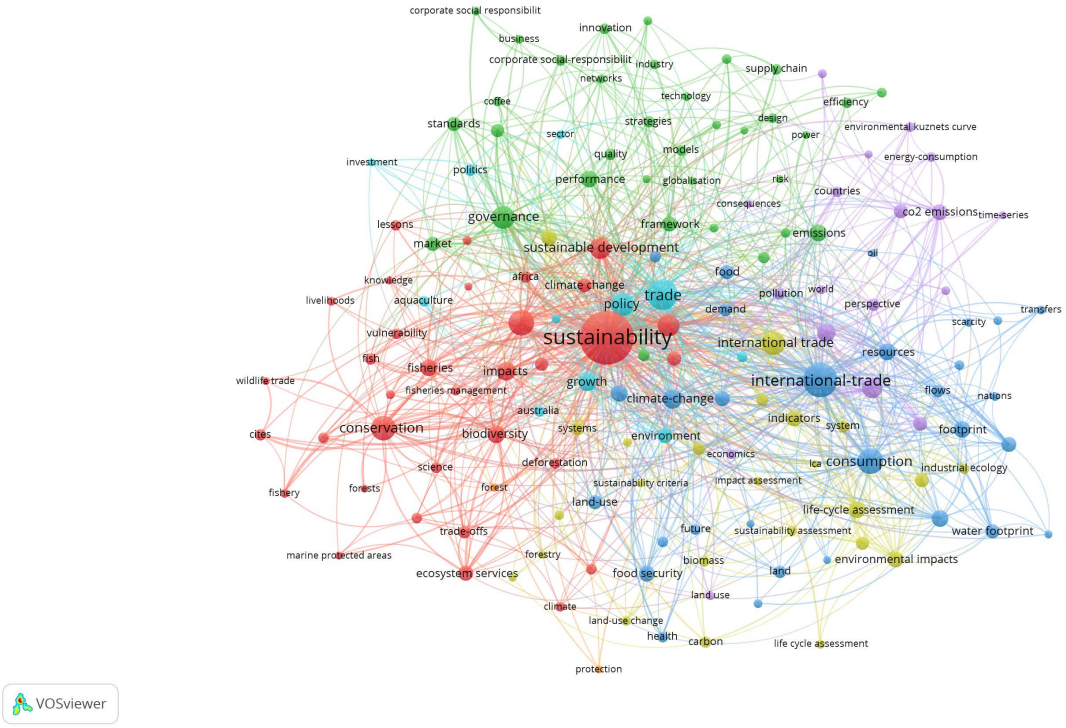

Figure 5. Cluster map of keywords (Source: own elaboration).

In the center of the map was the term sustainability, which appeared in 320 articles and had links to most of the keywords on the cluster map. This is evidence of its strong link with trade, international trade, conservation, sustainable development, management and climate change. In terms of locations, the cluster contained the terms Australia, Africa, the United States and the European Union. This cluster also stood out for the number of keywords related to marine life: fisheries, fishery, marine protected areas and fisheries management.

The second most frequently occurring term was international trade, shown on the cluster map in dark blue. This also had a close relationship with most keywords, although with fewer links than sustainability. This second cluster map had a strong link with agriculture and its use, hence keywords such as land, land use, agriculture, agricultural trade, food, food security, virtual water trade and virtual water are found. The latter defines the amount of water used in the process of making agricultural or industrial products. For this reason, countries with a shortage of this natural resource may be encouraged to export those products that demand little water in their production and import those that demand a greater quantity [34].

In the upper half of the cluster map, the terms depicted in green mainly refer to the private sector with terms such as business, industry, challenges, supply chain, efficiency, emissions, logistics and optimization. Despite this, it is interesting to note that the most frequently used term related to the private sector was governance.

Finally, the violet cluster depicts the concepts related to energy and several keywords related to the environment, for example, CO_2 emissions, pollution, ecological footprint, Kuznets environmental curve and unequal ecological exchange. The term China was also found as the second most frequent term appearing in this cluster, being mentioned 40 times.

3.7. Trend Analysis

To analyze the main trends related to international trade and sustainability, two cluster maps were produced using a fractional method: one to analyze trends in keywords used by authors (see Figure 6), and the second to examine possible trends in publishing countries (see Figure 7).

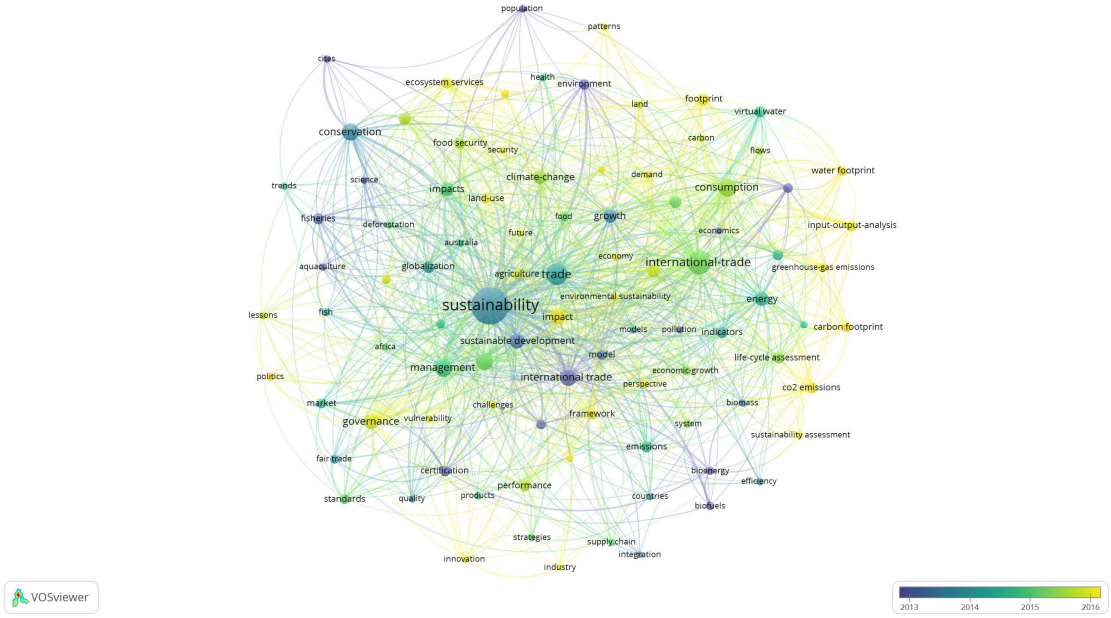

Figure 6. Cluster map of keywords by author on Web of Science (WoS) (Source: own elaboration).

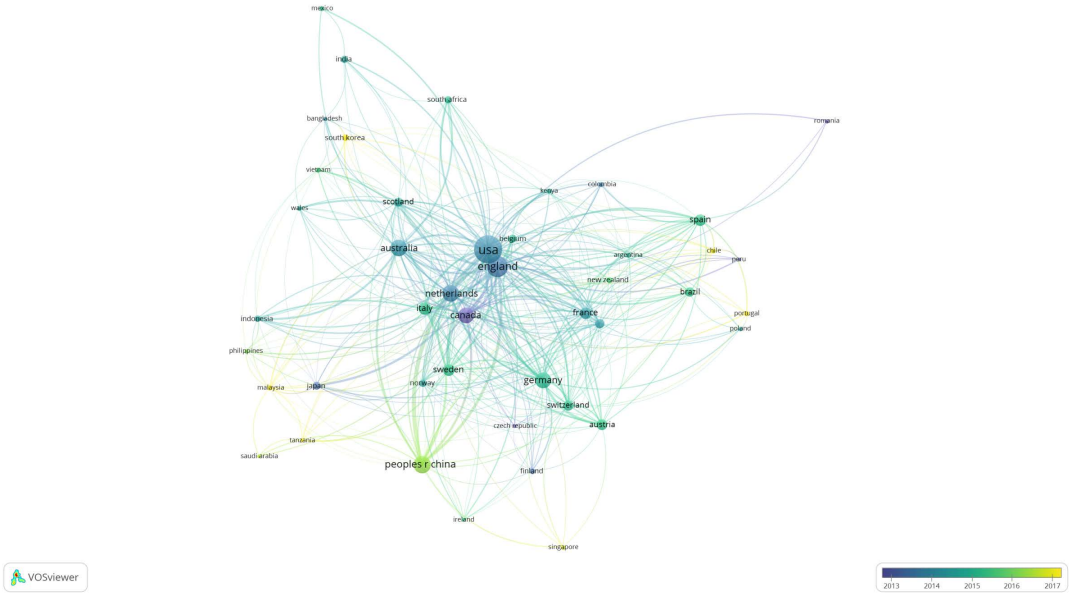

Figure 7. Cluster map of co-citations between countries on WoS (Source: own elaboration).

Regarding the first cluster map, it identified the most frequently used terms and their relevancy over time. The latest key terms are in yellow, while those in purple are the oldest concepts found in this study.

The minimum appearance of these terms was as been set at 12, which means that only 94 terms of the 4696 keywords appeared on the cluster map. Thus, it would be easy to identify if the most frequently used terms were also the most recent.

As in Figure 5 (keyword cluster map), the size of the word sustainability as depicted in the map, shows that it was the most relevant, although it was not a term that stood out as being important in articles from recent years. Something similar occurred with the words conservation and trade since their relevance was not very recent.

As of the mid2−010s, the terms that were furthest on the time horizon were population, biofuels, environment, bioenergy, pollution, cites, aquaculture, international trade, ecological footprint and economics—the latter located the furthest away.

In contrast, the most frequently used in recent years were, respectively, footprint, land-use, environmental sustainability, industry, economy, greenhouse-gas emissions, corporate social-responsibility, challenges and politics. The most recent of all the terms on the cluster map, trade-offs, reached its mean use in 2017.

However, whether the terms were older or used more recently, there was no common pattern or theme that led us to draw an exact conclusion as to why they are used (or ceased to be used). In any case, it should be noted that the most recent terms, despite not being the most used, had a strong link with many other keywords. An example of this is the link between the words impact and footprint, which had 75 and 58 links, respectively, and the mean of both was from 2016.

With regard to the co-citation cluster between countries, different criteria were established. Countries with at least five publications were included, resulting in a total of 44 countries appearing on the map. The time period considered was from 2013 to 2017.

As discussed, the United States was at the core of the map, although its dominance was not prolonged in time during the second decade of the 21st century. The mean of their publications date was from November 2013.

In recent years, other countries have become more relevant in terms of article publication. Portugal, with a mean publication year of 2018, published the most recent articles, followed by the following countries and their respective means: South Korea (October 2017), Malaysia (August 2017), Tanzania (June 2017) and Chile (October 2016). All these countries had one characteristic in common, a low volume of publications. South Korea published a total of 14 articles, Malaysia published ten, Chile and Portugal published eight and Tanzania, a mere five.

In contrast, the countries with the oldest mean of published articles were Romania (August 2009), Peru (April 2011), the Czech Republic (July 2012), Canada (October 2012) and Japan (May 2013). There was a wider variance in the number of published articles than in the previous one. Canada was the seventh country with the highest number of publications (80), Japan had 23, Romania had six and the Czech Republic and Peru published five each.

In the case of Central European countries such as the Netherlands, Germany, Austria or France, they established the mean of their publications between September 2013 and February 2015, which shows that there is no great temporal difference between them.

Spanish-speaking countries, among which Spain appeared as the maximum exponent in terms of number of publications, Chile dominated this cluster map, which stood out for its recent publications. In contrast, Peru had, on average, the oldest publications.

The main conclusion generated by this map is that the countries whose mean year of publications is the most recent, are not, with the exception of China, those producing the higher volumes of scientific publications on the subject of international trade and sustainability. In fact, they are countries that belong to the continents with the fewest publications—Africa (Tanzania) and Asia (South Korea, the Philippines, Singapore, Malaysia and Saudi Arabia). The mean year of the publications of all of them is 2016, which shows that they are the groups of countries that in recent years have been most dedicated to this field of research. Even the interaction between them is characteristic as, with the exception of South Korea that has no relationship with any country in this group, the rest of them have at least one link with this group of countries.

4. Conclusions

International trade and sustainability are matters that, by their own impact, encompass economic, environmental, social, demographic or human development issues. Despite the strong link between the two terms, they possess conflicting characteristics. While trade tends to become increasingly liberalized over time, in order to increase the well-being of society, sustainability, or better said, the environment, tends to be more restricted and controlled.

However, as previously mentioned, while international trade may be the problem, environmental sustainability could be its solution. Conversely, in certain situations, it is trade that could act as a response to environmental problems.

Despite the importance of both issues, it is notable that it was not until the end of the first decade of the 21st century that a substantial increase in publications was observed, a trend that is expected to continue.

The United States, United Kingdom and China are the three most prolific countries in terms of published articles on these issues. However, despite its high volume of scientific production on environmental issues, the environmental impact of China's industries remains unaffected. The Netherlands, despite not being a country that particularly stands out in any category, is notably present in most of them: most prolific authors, most cited articles and institutions with the largest number of publications and citations. Therefore, according to the findings, there is an interesting research line focused on an in-depth study of the international differences in order to know what causes these differences.

With regard to the journals publishing on these subjects, the most prolific focus is primarily on environmental matters, for example, *Sustainability*, *Ecological Economics* and *Journal of Cleaner Production*. Interestingly, there are no journals specialized in research on foreign trade or international relations among the top ten. In fact, it is the publisher, Elsevier that has the greatest presence in this ranking.

In terms of the keywords analyzed, the potential lack of use of the most relevant terms in this matter such as sustainability or international trade could signify that research in this field of study in the coming decades is not fully assured, since there are many alternate and varying terms that researchers are using more frequently, for example agriculture, industry, politics, impact, governance, land, demand or carbon footprint.

A similar trend occurs when analyzing countries. The absence in recent years of countries such as the United States, United Kingdom or Australia has given way to the emergence of new foci interested in the study of these disciplines. The recent interest of South Korea, Malaysia, Portugal, Saudi Arabia or Chile implies that they are expected to continue developing their scientific community in this field and continue to build on their co-citation networks.

This study has several limitations. The first limitation refers to the chosen database (WoS), leaving the possibility for future research to use Scopus, Google Scholar or similar sources.

The second limitation is related to the search terms. The words international trade or commerce * and sustainability * were selected. Although the symbol "*" was added to them in order to collect terms from the same lexical family, a search could be performed to include synonyms or even relevant terms in other languages.

Finally, in the cluster map, it was not technically possible to unify references to "international trade" and "international-trade". A similar problem occurred with the terms "impact" and "impacts".

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