Araştırma Makalesi | Research Article

Bibliometric Analysis of Articles on COVID-19 in the Transportation Industry: An Early Study

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Abstract

The COVID-19 pandemic, which emerged in Wuhan, China in November 2019 and affected the whole world, deeply affected the transportation industry as well as all sectors. The magnitude of the effects is also reflected in the number of academic publications, and the publication pool that would occur in decades has emerged in only 3 years. In this study, a quantitative bibliometric analysis, consisting of performance and collaboration analyses, was conducted to examine the vast publication pool in the context of the transportation sector. "Articles, final versions of articles and articles published in English only" filters were used to limit data. As the time limit, the years 2019-2022 were chosen. As a result of the search made in the Scopus database, a total of 951 articles were reached. R statistical program was used for data analysis and Biblioshiny was used for visualizations. Analyzes were carried out both in the context of all transport modes and separately for each transport mode. The results show that a total of 2605 authors were employed in 951 articles, 155 articles were single-authored, and 796 articles were multi-authored. Results of the analysis have revealed that the most productive countries are the USA and China, the most used keyword is "COVID-19", the most cited country is Norway, the countries with the most publication cooperation in the context of country collaborations are UK and Hong Kong, the lowest cooperation rate belongs to Türkiye and South Africa. On the other hand, it has been determined that the author with the most academic studies on COVID-19 for transport modes is HAN H. In this study, the most important result revealed within the scope of performance analyzes and cooperation analyzes is that development level of the country and the importance given to education are important variables in country productivity. As the level of development and the importance given to education increase, the number of academic studies also increases. On the other hand, another important result revealed in the study is that early COVID-19 studies receive more citations and occupy central positions in citation networks. In addition, it can be mentioned that method studies are also cited more.

Keywords: bibliometric analysis, performance analysis, collaboration analysis, COVID-19, transportation modes

Ulaştırma Sektöründe COVID-19 ile İlgili Makalelerin Bibliyometrik Analizi: Bir Erken Dönem Çalışması

Öz

Kasım 2019'da Çin'in Wuhan kentinde ortaya çıkan ve tüm dünyayı etkisi altına alan COVID-19 pandemisi tüm sektörleri olduğu gibi ulaştırma sektörünü de derinden etkilemiştir. Etkilerin büyüklüğü akademik yayın sayılarına da yansımış, onlarca yılda oluşacak yayın havuzu sadece 3 yılda ortaya çıkmıştır. Bu çalışmada, oluşan devasa yayın havuzunun ulaştırma sektörü bağlamında bibliyometrik bir analizinin yapılması amaçlanmıştır. Bu çalışmada performans analizi ve işbirliği analizinden oluşan nicel bir bibliyometrik analiz gerçekleştirilmiştir. Verileri elde etmek için Scopus veri tabanı kullanılmıştır. Verileri sınırlandırmak için yalnızca "makaleler, makalelerin son versiyonları ve yalnızca İngilizce yayınlanan makaleler" filtreleri kullanılmıştır. Zaman sınırı olarak 2019-2022 yılları seçilmiştir. Scopus veri tabanında yapılan arama sonucunda toplam 951 makaleye ulaşılmıştır. Veri analizi için R istatistik programı, görselleştirmeler için Biblioshiny kullanılmıştır. Analizler hem tüm ulaşım modları bağlamında hem de her bir ulaşım modu için ayrı ayrı gerçekleştirilmiştir. Sonuçlar, 951 makalede toplam 2605 yazarın çalıştığını, 155 makalenin tek yazarlı, 796 makalenin ise çok yazarlı olduğunu göstermektedir. Analiz sonuçları, en üretken ülkelerin ABD ve Çin olduğunu, en çok kullanılan anahtar kelimenin "COVID-19" olduğunu, en çok atıf alan ülkenin Norveç olduğunu, ülke yayın iş birlikleri bağlamında en çok işbirliği yapılan ülkelerin İngiltere ve Hong Kong olduğunu, en düşük işbirliği oranının ise Türkiye ve Güney Afrika'ya ait olduğunu ortaya koymuştur. Öte yandan, ulaştırma modlarına yönelik COVID-19 konusunda en fazla akademik çalışmaya sahip yazarın HAN H. olduğu tespit edilmiştir. Bu çalışmada performans analizleri ve işbirliği analizleri kapsamında ortaya çıkan en önemli sonuç, ülkenin gelişmişlik düzeyi ve eğitime verilen önemin ülke verimliliğinde önemli değişkenler olduğudur. Gelişmişlik düzeyi ve eğitime verilen önem arttıkça akademik çalışma sayısı da artmaktadır. Öte yandan çalışmada ortaya çıkan bir diğer önemli sonuç ise erken dönem COVID-19 çalışmalarının daha fazla atıf aldığı ve atıf ağlarında merkezi konumlarda yer aldığıdır. Ayrıca yöntem çalışmalarına da daha fazla atıf yapıldığından bahsedilebilir.

Anahtar Kelimeler: bibliyometrik analiz, COVID-19, işbirliği analizi, performans analizi, ulaştırma modları

Bibliometric Analysis of Articles on COVID-19 in the Transportation Industry: An Early Study

1. Introduction

COVID-19, which has affected the world since the first day it emerged and is one of the most pressing issues on the global agenda, is an infectious disease caused by a new type of coronavirus called SARS-CoV-2 (World Health Organization [WHO], 2021). COVID-19 was first learned on 31 December 2019, following a report of a cluster of viral pneumonia cases in Wuhan, People's Republic of China (WHO, 2021). The virus, which emerged in China, spread throughout the world in a short time and became one of the greatest dangers of the modern age. The COVID-19 pandemic has affected the politics and economies of countries and has had serious consequences in many sectors such as trade, tourism and transportation. Although there have been decreases in the number of cases from time to time as a result of measures such as travel restrictions, quarantine practices and vaccination studies brought to prevent the spread of the virus, the pandemic still could not be brought under control. On the other hand, the rapid development of new variants of the virus suggests that COVID-19 will remain on the agenda of the society for many years. As a matter of fact, the statement "The acute phase of the COVID-19 pandemic could end in 2022, but the coronavirus will not disappear," (Reuters, 2021) used by Mike Ryan, senior manager of the WHO Health Emergencies Program, supports this idea.

The reasons such as the fact that the disease is experienced as a pandemic throughout the world, its impact on the country's economies is devastating, and almost all sectors are affected, have caused an explosion in the number of academic publications on COVID-19. The number of publications on a subject that can be reached in decades under normal conditions has emerged in a time period of only two and a half years. Numerous studies have been conducted on COVID-19 in almost all industries (Abbas et al., 2021; Ashraf, 2021; Hu & Zhang, 2021; Kim, 2021; Mack et al., 2021; Maneenop & Kotcharin, 2020; Roy, 2020; Škare et al., 2021; Sun et al., 2021; Wachyuni & Kusumaningrum, 2020). This situation necessitated a comprehensive review of the literature and bibliometric analyzes of publications for different sectors were carried out.

Although, the studies in the field of health among bibliometric studies related to COVID-19 (Ahmad et al., 2021; ElHawary et al., 2020; Khakimova et al., 2020; Oh & Kim, 2020; Yang et al., 2020; Yu et al., 2020) generally draw attention, tourism (Khan et al., 2021), finance (Rusydiana, 2021), marketing (Cruz-Cárdenas et al., 2021), social sciences (Aristovnik et al., 2020) and education (De Felice & Polimeni, 2020; Elihami, 2021) are also discussed. The continuation of the COVID-19 pandemic suggests that the number of similar studies will continue to increase in the coming years.

In this study, studies on COVID-19 in four modes of transport (airline, road, maritime and rail) are discussed. The aim of the study is to determine the performance and collaborations related to the publications dealing with COVID-19 in the transportation sector literature and to establish the basis that will be beneficial for future studies. In this context, it is aimed to understand the studies in the literature as a whole and to guide the researchers in seeing the direction and trends of the studies by systematically scanning the studies. For this purpose, it has been deemed appropriate to use bibliometric analysis as a frequently used method today.

The fact that transportation has exceeded the dimension of time and space with technological developments and sociological transformations causes the globalization of crises, as well as an increase in the rate of spread of epidemics (Meyer & Elrahman, 2019). In fact, pandemics such as COVID-19, which it caused to spread, bring restrictions to the agenda and makes road, airline, maritime and railway transportations economically difficult (Loske, 2020). The COVID-19 pandemic, which emerged in 2019 and affected all developed and undeveloped countries, negatively affected the transportation sector in general and the airline transportation in particular. While road transport was less affected by this process than other modes of transport, serious volume contractions were also observed in railway transport (International Transport Forum [ITF], 2021). Due to all these mutual interactions, the relationship between transportation and COVID-19 has been the subject of academic studies in the world.

When the literature on the transportation sector is examined, it is seen that studies dealing with the transportation-related dimensions of issues such as the environment (Du et al., 2020; Güzel & Alp, 2020; Sohail et al., 2021), sustainability (Rouhanizadeh & Kermanshachi, 2020; Tran et al., 2021), energy (Pantoleontos et al., 2021; Wei & Liu, 2020), health

(Glazener et al., 2021; Peng et al., 2021), agriculture (Bhuiyan et al., 2022; Gray, 2020), tourism (Jou & Chen, 2020; Miravet et al., 2021), economy (Tonn et al., 2021), employment (Mack et al., 2021), and the effects of COVID-19 (Sun et al., 2020) were carried out in the 2020-2021 period, which can be called the acute period of the pandemic. On the other hand, it is noteworthy that bibliometric analyzes are made in the transportation literature. Bibliometric analyzes including certain years were carried out on subjects such as air transport (Dixit & Jakhar, 2021; Falcão et al., 2021), road transport (Meyer, 2020), rail transport (Chen & Liu, 2020), accessibility (Shi et al., 2020), accidents (Zou et al., 2020), sustainable transport (Zhao et al., 2020). In addition, journals related to transportation such as Transportation Research Part B (Jiang et al., 2020), Journal of Air Transport Management (Tanrıverdi et al., 2020), Transportation Research Part D: Transport and Environment (Cao et al., 2021) were also subjected to bibliometric analysis.

When the publications related to the bibliometric analysis of the publications related to COVID-19 in the transportation sector, which is the subject of this study, are examined, two different studies were encountered in the literature. In one of the studies, Benita (2021) mapped human mobility behaviors in the context of COVID-19 through bibliometric analysis over the theme of road and air transport. In the other study, Kutela et al. (2021) investigated the geographical distribution of research themes related to COVID-19 and the transportation sector and found that the majority of the articles were from the USA, China, Japan and the UK. This study, on the other hand, differs from the studies in the literature in terms of considering all transportation modes together and making separate analyzes for each mode.

2. Methods and Materials

In this study, it was aimed to determine the bibliometric features of the articles published on COVID-19 in the transportation sector. Bibliometric studies enable scientific studies to be evaluated in terms of both quantity and quality (Al & Soydal, 2012). The term bibliometric was first used in 1969 by Pritchard (1969) to replace the term "statistical bibliography". Pritchard stated that bibliometrics can be used in almost all studies aimed at quantifying written communication processes. Scientific articles published in the field of transportation from the beginning of the COVID-19 pandemic to 28.01.2022

were analyzed in this context and tried to be quantified and visualized. Data collection and data analysis processes are detailed below.

2.1. Data Collection

The data within the scope of the study were obtained from the Scopus database, which is widely used by researchers. Scopus database was preferred for bibliometric analysis in social sciences because it contains more scientific articles than Web of Science, can present many data together, and is a comprehensive database (Falagas et al., 2008; Singh et al., 2021). The article search was carried out with the terms "COVID-19", "coronavirus" and "SARS CoV2". Various filters have been applied to limit the publications that appear as a result of the search. These filters are; "articles published in journals only", "only final versions of articles", "articles published between 2019-2022 (until 28.01.2022)" and "articles published in English only". As a result of the limitations, 139.534 articles were reached. In order to identify those belonging to the transportation sector among these articles, a transportation mode-based search was carried out. Searches "air transportation" OR "airline" OR "airway" OR "skyway" OR "railway" OR "railroad" OR "maritime" OR "cruises" OR "seaway" OR "main road" OR "highway" OR "land route" was carried out. Aviation and marine terms were not researched separately because of seaway and air transportation terms include them. As a result of the searches, 553 (58.1%) studies were carried out in the air transportation sector, 59 (6.2%) in the maritime transport, 427 (44.9%) in the road transport and 42 (4.4%) in the railway transport. A total of 1081 studies were reached. However, since more than one mode of transportation was investigated in some studies, the actual number of articles reached is 951. The screening phase was first conducted by a single author, then checked by two other authors, and any discrepancies were discussed. This method being followed in this study eliminated the possibility of including publications that are not related to the researched subject, and on the other hand, made it possible to include relevant publications in the study. The research design is summarized in Figure 1.

In 951 publications obtained through scanning; bibliometric aspects such as citation counts, average citations per study, h-indexes, most cited studies, worldwide study distributions, most productive countries, most productive journals, collaborations

between countries, and the most frequently used terms in titles and abstracts were investigated. The impact factors (IFs) of the journals were obtained from the Scimago Journal & Country Rank (SJR) website (https://www.scimagojr.com/journalrank.php).
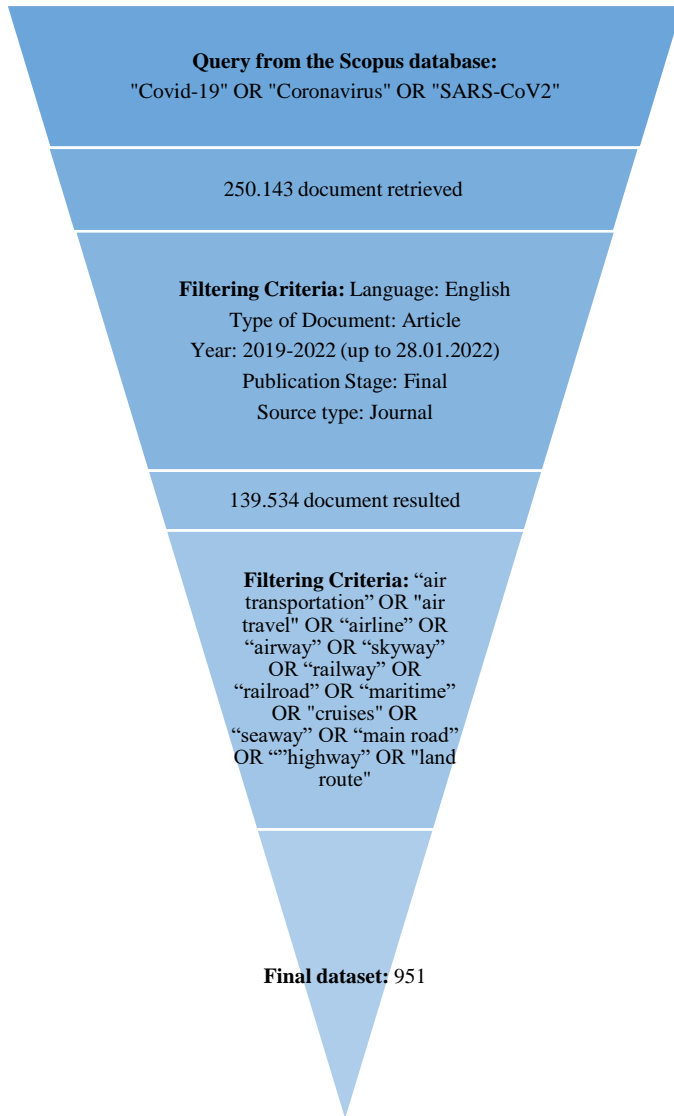
Query from the Scopus database:
"Covid-19" OR "Coronavirus" OR "SARS-CoV2"

250.143 document retrieved

Filtering Criteria: Language: English
Type of Document: Article
Year: 2019-2022 (up to 28.01.2022)
Publication Stage: Final
Source type: Journal

139.534 document resulted

Filtering Criteria: "air transportation" OR "air travel" OR "airline" OR "airway" OR "skyway" OR "railway" OR "railroad" OR "maritime" OR "cruises" OR "seaway" OR "main road" OR ""highway" OR "land route"

Final dataset: 951

Figure 1. Research design

2.2. Data Analysis

Bibliometric analysis is based on the analysis of bibliographic features of a publication, such as authors, collaborations, citations, keywords, to gain knowledge about the structure, social networks and themes of a scientific field (Zupic & Čater, 2015). To reveal the features mentioned in this study, a free open-source software R program (bibliometrix) and Biblioshiny, which acts as an interface to the R program for visualizations, were used. The data received from Scopus in bibtex format was loaded into the software, and firstly, performance analysis and then collaboration analysis were performed.

2.2.1. Performance Analysis

Performance analysis is a type of bibliometric analysis in which some quantitative data such as the number of publications in the selected sample, the number of citations, the most productive authors and countries, associated organizations, and the journals with the most publications can be obtained (Fusco et al., 2020). In this study, within the scope of performance analysis, analyzes such as the most productive authors and most productive countries, journals with the most publications and their h-indexes, the most cited countries and authors, the most used keywords, the countries of the corresponding authors, the most cited journals, the most cited publication were made.

2.2.2. Collaboration Analysis

Collaboration analysis is a method that presents countries, institutions, authors, and keywords as a node in the context of bibliometric analysis (Wang et al., 2016). In other words, collaboration analysis provides an overview of collaborative and research communities by focusing on coming together at different levels (Fusco et al., 2020). On the other hand, it is stated in the literature that studies with international collaborations are cited more (Glänzel et al., 1999; Teodorescu & Andrei, 2011). Therefore, it is necessary to investigate international cooperation in this respect. In this study, the authors and countries were taken as the unit of analysis within the scope of cooperation analysis.

3. Results

Statistics of academic studies in a particular research field are very important in terms of showing the pace and direction of development of that field of study. This situation both reveals the level of research in the relevant field and contributes to the understanding of future trends (Mao et al., 2020). In this context, studies on COVID-19 will contribute to understanding the situation in the field and predicting the future situation, although the number of years of study is relatively small. Therefore, this study focuses on academic studies on COVID-19 carried out in transport modes. In presenting the study findings, it was preferred to present the findings related to all transportation modes first, and then to present the findings of the transportation modes separately.

3.1. Findings for All Modes of Transport

3.1.1. Performance Analysis

According to the analysis, 2 (0.2%) studies were published in 2019, 260 (27.3%) in 2020, 631 (66.1%) in 2021, and 58 (6%) studies in 2022 in terms of the year the studies were published. Considering the early publications of 2022, it can be evaluated that the number of publications related to COVID-19 will be much higher in the coming days. The average number of citations per work performed is 10.82, and the annual average number of citations per document is 4.28. When the publication productivity of the countries is examined -in the context of the countries of the authors- it is seen that the USA (*n* = 282) and China (*n* = 225) take the first two places by far. Looking at the next pair, it is seen that UK (*n*= 161) and India (150) again show high productivity. Figure 2 shows the distribution of publications by country. Dark blue color indicates more publications, gray color indicates no publication. As can be seen from Figure 2, countries with high publication productivity are either economically developed countries or countries that attach great importance to scientific research.
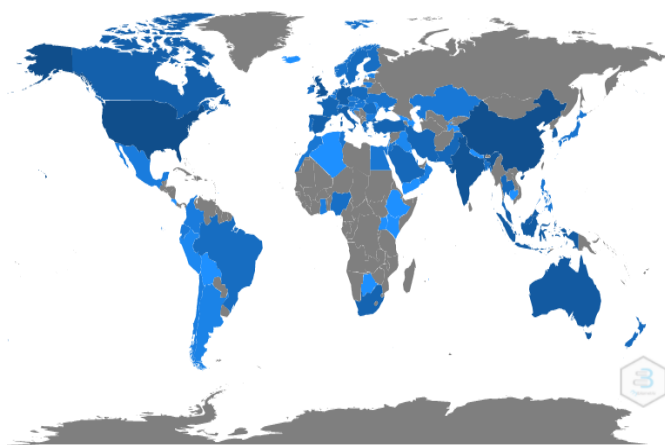

Figure 2. Productivity of countries in terms of publication numbers

In the study, a three-field plot (Sankey diagram) was created to learn relatedly which country carried out more studies on which topic and in which journals these studies were published. In the three-field plot, the 10 most used keywords were limited. In the three-field plot, countries are in the left column, keywords are in the middle column, and journals are in the right column. The three-field plot created is shown in Figure 3.
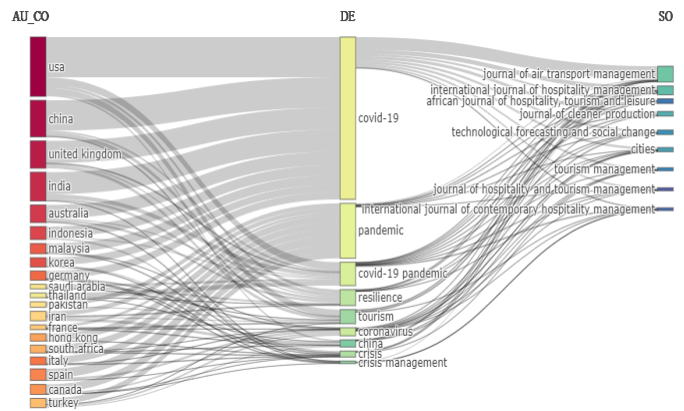
Figure 3. Productivity of countries in terms of publication numbers

As expected, the most used keyword was "COVID-19" as seen in Figure 3. When the use of this keyword by countries is examined, it is seen that countries from the USA to Italy mostly use the keyword COVID-19, while countries from Iran to Pakistan prefer the keyword "pandemic". While the publications with the keyword "COVID-19" were published mostly in the Journal of Air Transport Management, the publications with the keyword "pandemic" were mostly published in the International Journal of Hospitality Management. In this context, it would not be wrong to say that the "COVID-19" keywords are preferred more in the transportation sector and the "pandemic" keywords in the tourism sector.

Another analysis carried out in the study was for the most cited countries. Table 1 shows the top 20 most cited countries and the average number of citations per article.

As can be seen in Table 1, Norway ranks first with 1056 citations, while China ranks second with 1046 citations. When the average citations per article are considered, Norway is in the first place and Germany is in the second place. It would not be wrong to say that the broadcasting efficiency is quite high, especially for Norway.

Another issue explored in the study is related to the journals in which the articles were published. Table 2 shows the h-index and SJR rankings of the journals in the top 20 according to the number of articles published among 1742 journals in the field of "Business, Management and Accounting".

As can be seen in Table 2, the journal with the most publications is the Journal of Air Transport Management, which focuses on the air transport

sector. However, it is seen that most of the studies are published in journals that focus mostly on the tourism sector. Considering the intense relationship between tourism and the transportation sector, this result is not surprising.

Table 1. Top 20 most cited countries, total number of citations and average citation rate per article

	Country	TC	AAC		Country	TC	AAC
1	Norway	1056	264	11	France	124	24,8
2	China	1046	10,673	12	Malaysia	122	7,176
3	Germany	940	34,815	13	South Africa	105	5,526
4	USA	744	7,75	14	Indonesia	94	4,087
5	UK	686	14,292	15	Thailand	91	10,111
6	Australia	519	19,222	16	Spain	80	4
7	India	494	8,373	17	Italy	79	5,267
8	Hong Kong	351	18,474	18	New Zealand	71	7,1
9	South Korea	241	6,514	19	South Cyprus	67	33,5
10	Sweden	132	18,857	20	Japan	61	20,333

Note. **TC:** Total Citations, **AAC:** Average Article Citations

When the journals in which 951 articles are published are examined, Tourism Management is by far the most cited journal with 768 citations. While Annals of Tourism Research (*n* = 491) is in the second place, the Journal of Business Research (*n* = 439) is in the third place. Journal of Air Transport Management, which ranks first in terms of the number of publications, ranks eighth in this list with 335 citations. In terms of contribution to the field, it is considered that the reason why tourism magazines are in the first place may be due to the higher number of researchers working in the field of tourism. However, when the contribution of the journals to the field is evaluated in the context of their h-index; Journal of Air Transport Management (h-index: 18), International Journal of Hospitality Management (h-index: 13) and Journal of Cleaner Production (h-index: 10) take the first three places.

Another issue examined in the study is related to the authors of the published articles. Table 3 shows the top 20 authors and the number of publications. When Table 3 is examined, it is seen that the author with the most publishing is Han H. (*n* = 10), while Amankwah-Amoah J (*n* = 7) takes the second place. On the other hand, it can be mentioned that the authors of Asian origin have more publications than the authors from other regions. Another issue examined regarding the authors in the study is related

to the effects of the authors on the field. In this context, h-index values were used to measure the authors' contributions to the field. As a result of the analysis, it is seen that Amankwah-Amoah J. (h-index: 5) and Khan Z. (h-index: 5) are in the first place. Gössling S. (h-index: 4), Ivanov D. (h-index: 4), Kim J. (h-index: 4) and Wang Y. (h-index: 4) take the second place.

Table 2. Journals in which studies were published, number of publications, journal h-index and SJR order

Rank	Journal	Number of Art.	Journal's h-index	Journal's SJR Rank
1	Journal of Air Transport Management	53	75	222
2	International Journal of Hospitality Management	33	122	89
3	Journal of Cleaner Production	32	200	118
4	Cities	18	90	134
5	Technological Forecasting and Social Change	17	117	96
6	Tourism Management	16	43	179
7	African Journal of Hospitality Tourism and Leisure	15	11	1046
8	International Journal of Contemporary Hospitality Management	15	86	106
9	Journal of Hospitality and Tourism Management	15	34	202
10	Transportation Research Part E: Logistics and Transportation Review	15	110	110
11	Journal of Asian Finance Economics and Business	14	14	771
12	Annals of Tourism Research	13	171	101
13	Journal of Business Research	10	195	108
14	Journal of Retailing and Consumer Services	9	89	165
15	Tourism Management Perspectives	9	43	179
16	Worldwide Hospitality and Tourism Themes	9	20	773
17	International Journal on Emerging Technologies	8	6	1735
18	Journal of Airport Management	8	2	1497
19	Tourism Review	8	32	279
20	Current Issues in Tourism	7	74	142

Various analyzes were carried out regarding the characteristics of the articles discussed in the study. For example, the most cited study out of 951 articles reviewed was Gössling et al. (2020)'s "Pandemics, Tourism and Global Change: A Rapid Assessment of COVID-19" published in the Journal of Sustainable Tourism. Ivanov (2020)'s "Predicting the impacts of epidemics on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS)", which received 56 citations and was published in Transportation Research Part E: Logistics and Transportation Review is in the second

place. Considering the journals in which these studies were published; both journals are in Q1, Transportation Research Part E: Logistics and Transportation Review ranks 110th in the SJR ranking and has an h-index of 110, while Journal of Sustainable Tourism ranks 141st and has a h-index of 103. In this context, it can be thought that publications in prestigious journals provide more citations to authors.

The five keywords that the authors used most in the studies reviewed were COVID-19 ($n = 190$), viral disease ($n = 60$), air transportation ($n = 59$), epidemic ($n = 59$) and coronavirus ($n = 48$). The word cloud created from the most used keywords is shown in Figure 4. The size of the fonts in the word cloud shows how often the relevant keyword is used.

Table 3. Top 20 authors and number of publications

Rank	Authors	Articles	Rank	Authors	Articles
1	Han H	10	11	Gössling S	4
2	Amankwah-Amoah J	7	12	Gupta S	4
3	Khan Z	6	13	Haleem A	4
4	Kumar A	6	14	Hall CM	4
5	Wang X	6	15	Ivanov D	4
6	Kim J	5	16	Kim S	4
7	Wang Y	5	17	Kim SS	4
8	Zhang X	5	18	Sharma A	4
9	Zhang Y	5	19	Wang J	4
10	Fu X	4	20	Wong IA	4

3.1.2. Collaboration Analysis

When the data is evaluated in the context of the countries of the responsible authors, China ranks first with 98 articles. Of these 98 studies, 46 were conducted only by Chinese authors, while 52 were conducted with authors from more than one country. The second country in the context of the countries of the article co-authors is the USA with 96 articles. 70 of these studies were carried out only by American authors, and 26 of them were carried out with the collaboration of authors from more than one country. Table 4 shows the top 20 articles with the most international cooperation.

As it can be seen in Table 4, the countries that cooperate most proportionally are UK (MCP = 0.62), Hong Kong (MCP = 0.57) and Sweden (MCP = 0.57). The countries with the least international cooperation are South Africa (MCP = 0.05) and Thailand (MCP = 0.11). Although Türkiye has 14 publications, it has no

international cooperation. On the other hand, a cooperation network has been created to show which countries the cooperation takes place. Figure 5 shows cooperation networks on the basis of countries.

Figure 4. Wordcloud generated from Keyword

Table 4. Country collaboration

Country	A	SCP	MCP	MCP %
China	98	46	52	0,5306
USA	96	70	26	0,2708
India	59	50	9	0,1525
UK	48	18	30	0,625
South Korea	37	19	18	0,4865
Australia	27	14	13	0,4815
Germany	27	16	11	0,4074
Indonesia	23	21	2	0,087
Spain	20	15	5	0,25
Hong Kong	19	8	11	0,5789
South Africa	19	18	1	0,0526
Malaysia	17	10	7	0,4118
Italy	15	10	5	0,3333
Türkiye	14	14	0	0
Canada	12	8	4	0,3333
New Zealand	10	5	5	0,5
Singapore	10	5	5	0,5
Thailand	9	8	1	0,1111
Greece	7	5	2	0,2857
Sweden	7	3	4	0,5714

Note. **A**: Article, **SCP**: Single Country Publications, **MCP**: Multiple Country Publications

In the cooperation network between countries, 6 different clusters have been formed. In these clusters, while the central and most important node of the network is UK (betweenness centrality [bc]): 242,900), while the USA (bc:235,375), China (bc: 132,554), Malaysia (bc: 26,424), Canada (bc: 28,286) and Poland (bc: 22,960) are also important nodes. This result is not surprising. As a matter of fact, although UK ($n = 161$) is in the third place in terms of number of publications, its MCP is 60%, as can be seen from Table 4. While China and the USA are in the first two places in the number of publications, their MCP values are 53% and 27%, respectively.

Another issue discussed in the context of collaborations in the study is related to co-citation analysis. Co-citation analysis was performed with a minimum of two co-citations and a limit of 50 network nodes. Figure 6 shows the resulting network structure for co-citation analysis.
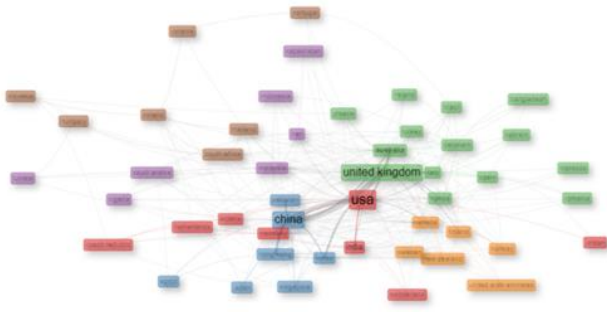

Figure 5. Country collaboration network

The results of co-citation analysis show that the most central and most important nodes "Fornell C. 1981" (bc: 231,577), "Gössling S. 2020" (bc: 285,011), "Ivanov D. 2020" (bc: 111,084) and "Sobieralski J.B. 2020" (bc: 19,840). As mentioned in the performance analysis section, Gössling et al. (2020) and Ivanov (2020)'s articles are the most cited studies in the data set. The study of Fornell and Larcker (1981) is a method study, and it is considered normal to be cited with many studies. As a matter of fact, the number of citations of this study in Google Scholar is 85246. The number of citations of the study in Web of Science is 45537 (22.03.2022). In this context, it is quite expected that this study will take place in the network center. Another important publication in the network within the scope of co-citation analysis was made by Gössling et al (2020). This is an early-term study focusing on the effects of the pandemic on tourism and travel businesses (Date of submission: 06.04.2020). Gossling et al. (2020)'s work has reached a high number of citations because it is an early-term study on the one hand, and it is aimed at a wide area such as tourism and travel on the other. While the Google Scholar citation number of the study was 2659, the Web of Science citation number was 947 (22.03.2022). It can be mentioned that the number of citations received for an article published in 2020 is quite high. After all, Gössling et al. (2020)'s work is cited together with other studies, in other words, it is one of the important nodes of the citation network.

Another important node in the network in co-citation analysis is the study of Ivanov (2020). Ivanov uses a simulation application to predict the long-term effects

of COVID-19 on the supply chain. The article aims to contribute to making decisions about the future with this application. In this context, the fact that the article is an early study for COVID-19 (published on 04.2020) on the one hand, and on the other hand, making predictions about the future, has enabled it to reach a high number of citations. While the Google Scholar citation number of the article is 1068, the Web of Science citation number is 403 (22.03.2022). In this context, it can be expected that the article will be cited together with other publications.
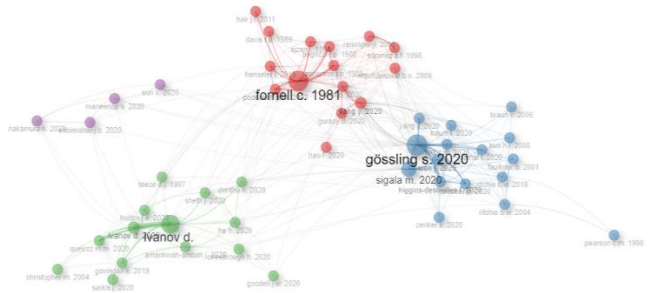

Figure 6. Co-citation network

3.2. Findings on Air Transport

3.2.1. Performance analysis

As a result of the analysis, it was determined that a total of 553 articles were published in the field of air transport and these articles received an average of 12.86 citations per document. While 68 of these articles were single-authored, 485 were multi-authored. A total of 1557 authors have worked on the published articles. In this context, studies were carried out with an average of 2.93 authors per document. It is seen that 134 articles in 2020, 380 articles in 2021 and 39 articles in 2022 were published for the air transport sector. In this context, it can be said that the most productive sector among the transport modes is the air transport sector.

Unsurprisingly, the Journal of Air Transport Management (*n* = 53) was the journal in which the studies on the air transport sector were published the most. What is surprising is that the Journal of Airport Management ranks relatively low (*n* = 13). As a matter of fact, it is to be expected that there will be more publications in this journal focused on air transport. Table 5 shows the h-indexes of the top 20 journals and related publications with the most publications on COVID-19 in the field of air transport.

As seen in Table 5, the Journal of Air Transport Management was the journal that contributed the

most to the field with 53 articles and 18 h-index values. Journal of Cleaner Production (h-index: 9), International Journal of Hospitality Management (h-index: 9) and Transportation Research Part E: Logistics and Transportation Review (h-index: 7) are other journals that contribute significantly to the field.

Table 5. The top 20 journals with the most publications in the field of air transport and their h-indexes

Rank	Journal	Articles	h-index
1	Journal of Air Transport Management	53	18
2	Journal of Cleaner Production	22	9
3	International Journal of Hospitality Management	21	9
4	Transportation Research Part E: Logistics and Transportation Review	14	7
5	Technological Forecasting and Social Change	13	6
6	International Journal of Contemporary Hospitality Management	12	4
7	Tourism Management	12	6
8	African Journal of Hospitality Tourism and Leisure	9	4
9	Journal of Hospitality and Tourism Management	9	3
10	Tourism Management Perspectives	9	2
11	Cities	7	3
12	Current Issues in Tourism	7	4
13	Journal of Airport Management	7	1
14	Journal of Destination Marketing and Management	7	4
15	Tourism Review	7	4
16	Annals of Tourism Research	6	4
17	Journal of Business Research	6	3
18	Journal of Retailing and Consumer Services	6	2
19	Journal of Revenue and Pricing Management	6	3
20	Journal of Sustainable Tourism	6	5

The authors who publish the most in the air transport sector and the h-index values of the relevant publications are another subject investigated in the study. Table 6 shows the top 20 authors, and their h-index values.

When Table 6 is examined, it is seen that the researcher who has done the most studies is Han H. with 9 publications and the h-index value is 3. It is seen that Amankwah-Amoah J. has 7 publications, but the h-index is 5. In this context, it can be mentioned that Amankwah-Amoah J. is the author who contributed the most to the field.

In the study, it was also investigated that the studies carried out for the air transport sector are related to which institutions. In Table 7, there is a list of organizations that have a relationship with at least

five publications in the studies carried out on the air transport sector. The results of the analysis show that The Hong Kong Polytechnic University ($n = 23$) and Sejong University ($n = 12$) are in the first two places. The University of Johannesburg and the University of Surrey are ranked third and fourth, respectively.

Table 6. Top-publishing authors and their h-indexes in air transport

Rank	Authors	Articles	h-index	Rank	Authors	Articles	h-index
1	Han H	9	3	11	Fu X	3	3
2	Amankwah-Amoah J	7	5	12	Gupta S	3	1
3	Kumar A	6	3	13	Haleem A	3	3
4	Khan Z	5	4	14	Im J	3	3
5	Wang X	5	2	15	Ivanov D	3	3
6	Gössling S	4	4	16	Kim J	3	2
7	Hall CM	4	2	17	Kim S	3	1
8	Wang Y	4	3	18	Moktadir MA	3	2
9	Yang H	4	3	19	Sharma A	3	2
10	Choi TM	3	2	20	Sun X	3	3

Table 7. Organizations that have a relationship with at least 5 publications in the field of air transport

Institutions	Articles
The Hong Kong Polytechnic University	23
Sejong University	12
University of Johannesburg	9
University of Surrey	9
Kyung Hee University	8
University of Kent	8
Embry-Riddle Aeronautical University	6
University of Central Florida	6
Amity University	5
Griffith University	5
Lund University	5
Tadulako University	5
The Ohio State University	5
University of British Columbia	5
University of Canterbury	5
University of Economics	5
University of Nevada Las Vegas	5
University of Tehran	5
Zhejiang University	5

Another subject investigated in the study is related to the keywords used. Figure 7 shows the usage statistics of the keywords used in the studies conducted for the air transport sector. In the studies, the keyword COVID-19 (16%) is in the first place, air transportation (7%) is in the second place, epidemic (5%) and viral disease (5%) are in the third place.
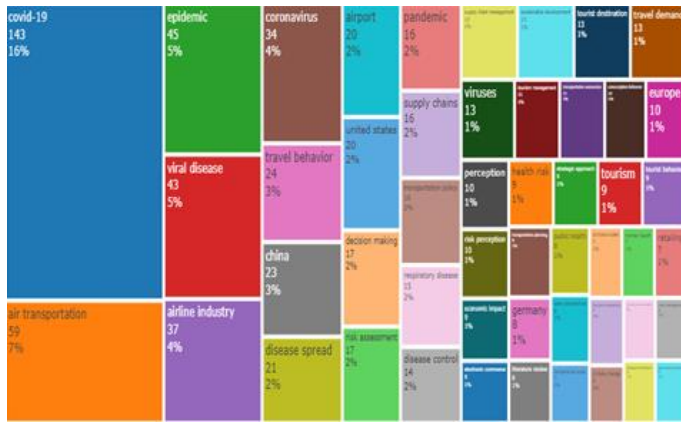
Figure 7. Keyword treemap used in air transportation studies

When the productivity of the countries in the studies conducted on the air transport sector is examined in the context of the authors' countries, as in the analysis of all transport modes, the USA (*n* = 172, 31%) ranks first, while China (*n* = 118, 21.3%), UK (*n* = 107, 19.3%) and India (*n* = 79, 14.2%) continue the list. In the citations taken by the countries, Norway (*n* = 1024) and Germany (*n* = 756) are in the first two places, as in the analysis of all transportation modes. UK (n = 549) is in the third place and the USA (*n* = 498) is in the fourth place in the list. Norway is ranked 33rd with 8 publications, while Germany is ranked 8th with 44 publications. However, considering the number of citations, it can be thought that the publications of these countries, which are in the first two rank, are either published in more visible journals or on more interesting topics.

3.2.2. Collaboration Analysis

The first issue addressed within the scope of cooperation analyzes in the study is related to the cooperation of the responsible authors of the articles published on the air transport sector on a country basis. The air transport industry is perhaps one of the most international industries.

In this context, it is quite possible that the articles were mostly conducted with international collaborations. Table 8 shows the internationality of the studies examined. As can be seen in Table 8, studies are also carried out with international collaborations in the top 20 countries with the highest number of publications, with the exception of Türkiye and Portugal. While 45 of the studies were carried out only by American authors in the USA, which ranked first, 19 were carried out together with authors from other countries, including American authors.

Table 8. Internationality of studies in the field of air transport

Country	A	SCP	MCP	MCP %	Country	A	SCP	MCP	MCP %
USA	64	45	19	0,297	Italy	10	7	3	0,3
China	48	19	29	0,604	Malaysia	10	5	5	0,5
South Korea	31	15	16	0,516	South Africa	10	9	1	0,1
UK	31	12	19	0,613	Türkiye	10	10	0	0
India	28	20	8	0,286	Canada	8	6	2	0,25
Germany	18	11	7	0,389	Singapore	7	3	4	0,571
Indonesia	17	15	2	0,118	Greece	5	3	2	0,4
Australia	15	5	10	0,667	Portugal	5	5	0	0
Spain	15	13	2	0,133	Austria	4	2	2	0,5
Hong Kong	11	3	8	0,727	Iran	4	1	3	0,75

Note. **A:** Article, **SCP:** Single Country Publications, **MCP:** Multiple Country Publications

In China, which ranks second, 19 studies were carried out only by Chinese authors, and 29 studies were carried out with authors from other countries. As can be seen in Table 8, there is no study in Türkiye and Portugal where authors from other countries collaborated.

In Figure 8, cooperation networks of countries are shown. In the network of cooperation between countries, 4 different clusters have been formed. In these clusters, the central and most important nodes of the network are China (bc: 135,110), UK (bc: 111,232), the USA (bc:100,051) and New Zealand (bc: 3,942). It can be said that this result is not surprising when the number of publications of China and the UK and the MCPs of these publications are examined (Table 8).

As it is seen in Figure 8, the USA mostly cooperates with Asian countries, UK mostly with European countries, China mostly with countries in its own region and Northern European countries cooperate with each other. In this context, it can be mentioned that geographical proximity is important for cooperation. On the other hand, in countries where education systems are highly developed, as in the case of the USA, it is seen that cooperation can be made with countries that are not geographically close, thanks to the citizens of other countries who come to the country for research or education.
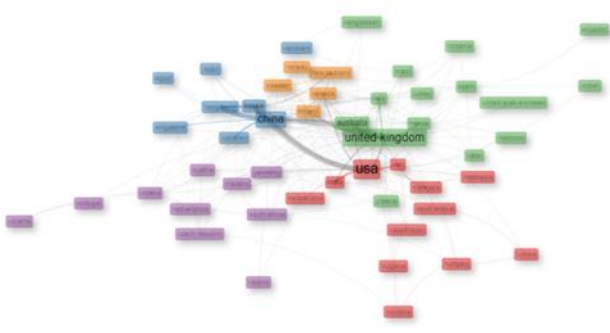
Figure 8. International cooperation network in the air transport sector

3.3. Findings on Air Transport

3.3.1. Performance Analysis

As a result of the analysis, it was determined that 427 articles were published in 235 journals in the field of road transportation and these articles received an average of 9.83 citations per document. While 85 of these articles were single-authored, the remaining 342 were multi-authored. A total of 1168 authors studied on the published articles. In this context, it can be said that studies were carried out with an average of 2.74 authors per document. It is seen that 2 articles in 2019, 129 articles in 2020, 273 articles in 2021 and 23 articles in 2022 were published for the road transportation sector. In this context, it is clear that the second productive sector among the transport modes is the road transport sector.

One of the issues addressed in the study regarding the road transportation sector is about which journals the studies are published in. Table 9 shows the journals in which the studies on road transportation are published, the number of publications and the contribution of the publications to the field (h-index).

As it can be seen in Table 9, with 16 publications the Journal of Cleaner Production is the journal with the highest number of publications in the field of road transportation. Cities and International Journal of Hospitality Management are in the second place with 13 publications each. When the contribution of the journals to the field is examined, it is seen that the International Journal of Hospitality Management (h-index: 9) and Journal of Cleaner Production (h-index: 6) gave the highest contribution.

Table 9. Journals with the most publications in the field of road transport and their h-indexes

Rank	Sources	Articles	h-index
1	Journal Of Cleaner Production	16	6
2	Cities	13	3
3	International Journal of Hospitality Management	13	9
4	Journal of Asian Finance Economics and Business	10	5
5	International Journal on Emerging Technologies	8	3
6	African Journal of Hospitality Tourism and Leisure	7	3
7	Annals of Tourism Research	6	3
8	Journal of Air Transport Management	6	5
9	Tourism Management	6	4
10	Gender Work and Organization	5	2
11	Administrative Theory and Praxis	4	2
12	Human Systems Management	4	2
13	IEEE Engineering Management Review	4	3
14	Journal of Business Research	4	1
15	Journal of Hospitality and Tourism Management	4	1
16	Journal of Risk Research	4	2
17	Knowledge-Based Systems	4	3
18	European Journal of Information Systems	3	3
19	Human Resource Management Review	3	3
20	Humanities and Social Sciences Communications	3	1

The authors who publish the most in the road transportation sector and the h-indexes of the relevant publications are another subject investigated in the study. Table 10 shows the top 20 authors, and their h-index values.

In the field of road transport, the most publications on COVID-19 were made by Khan Z. ($n = 3$), Kim J. ($n = 3$), Pillania R.K. ($n = 3$), Zhang S. ($n = 3$) and Zhang X. ($n = 3$). Kim J. (h-index: 3) is in the first place in the contribution of the authors to the field.

Another analysis carried out in the study is related to the organizations related to the studies on road transportation. In Table 11, the first 20 organizations related to the studies on road transportation are listed. As in the air transport sector, it is seen that The Hong Kong Polytechnic University is the most associated institution with 13 studies in the road transport sector. In second place is Zhejiang University ($n = 7$), which is also an Asian-based university, and in third place is Griffith University ($n = 6$), an Australian university, and Sun Yat-Sen University ($n = 6$) from China. In this context, it can be mentioned that researches on COVID-19 related to road

transportation are carried out relatively more in Asian-based organizations.

Table 10. Top 20 authors and their h-indexes in the field of road transportation

Rank	Authors	Articles	h-index	Rank	Authors	Articles	h-index
1	Khan Z	3	2	11	Jain A	2	1
2	Kim J	3	3	12	Khanthavit A	2	2
3	Pillania RK	3	1	13	Kour P	2	1
4	Zhang S	3	2	14	Krcmar H	2	2
5	Zhang X	3	1	15	Kundu T	2	1
6	Beckman E	2	1	16	Li S	2	2
7	Budhwar P	2	1	17	Liu X	2	2
8	Chayomchai A	2	2	18	Liu Z	2	1
9	Cristiano S	2	1	19	Ma H	2	1
10	Im J	2	2	20	Martin S	2	2

In the analysis of the most used keywords in studies carried out in the road transport sector, COVID-19 (16%) ranks first, while epidemic (5%), viral disease (5%) and coronavirus (5%) ranks second. The treemap created for the keywords used is shown in Figure 9.

Figure 9. Keyword treemap used in road transportation studies.

When the productivity of the countries in the studies conducted on the road transport sector is examined in the context of the authors' countries, it is seen that the USA (121, 28.3%) is in the first place, China (118, 27.6%) is in the second place, and India (74, 17%) is in the third place. In terms of the citation numbers of the countries, as in the analysis of all transportation modes, Norway (n = 1013) ranks first, China ranks second with 525 citations, and the USA ranks third

with 341 citations. Although Norway (n = 6) ranks 31st in the number of publications, the fact that it ranks first in the number of citations indicates that the productivity of the studies carried out is high.

Table 11. Top 20 organizations associated with studies on road transportation

Institutions	Articles
The Hong Kong Polytechnic University	13
Zhejiang University	7
Griffith University	6
Sun Yat-Sen University	6
Covenant University	5
National University of Singapore	5
University of Cambridge	5
University of Johannesburg	5
University of Maribor	5
Western Sydney University	5
Auckland University of Technology	4
Copenhagen Business School	4
Fudan University	4
Imam Abdulrahman Bin Faisal University	4
Royal Roads University	4
The University of Hong Kong	4
Thuongmai University	4
Tongji University	4
Universit Ca Foscari Venezia	4
Aligarh Muslim University	3

3.3.2. Collaboration Analysis

The first issue examined within the scope of cooperation analyzes in the studies carried out for the road transport sector is related to the cooperation of the responsible authors of the published articles in the context of their countries. The internationality of the published studies is shown in Table 12.

When the countries of the authors are investigated, it is seen that the Chinese authors are the researchers with the highest number of publications (n = 54), 25 of these studies were carried out only by Chinese researchers, and 29 studies were carried out by Chinese authors together with researchers from other countries. Considering the researchers from the USA (n = 36), which ranks second in the number of publications, 29 studies were conducted only by American authors, while 7 studies were conducted with researchers from other countries, including American researchers. What stands out in Figure 8 is the lack of collaboration with researchers from other countries in the studies conducted by South Africa (n = 10) and Türkiye (n = 5). It is possible to add India

to this list. As a matter of fact, researchers from India studied with researchers from more than one country in only 1 of 35 studies. As mentioned in the previous sections, Türkiye has a similar situation in the air transport sector. In this context, it can be said that researchers in countries such as South Africa and Türkiye should increase their cooperation with researchers from other countries. In this way, it is foreseen that the results will be more generalizable, and on the other hand, it will be easier to make comparisons among countries.

Table 12. Internationality of studies in the field of road transport

Country	A	SCP	MCP	MCP %	Country	A	SCP	MCP	MCP %
China	54	25	29	0,537	New Zealand	6	5	1	0,1667
USA	36	29	7	0,1944	Singapore	6	4	2	0,3333
India	35	34	1	0,0286	Spain	6	4	2	0,3333
UK	20	5	15	0,75	Thailand	6	5	1	0,1667
Australia	13	7	6	0,4615	Canada	5	3	2	0,4
Hong Kong	12	5	7	0,5833	Indonesia	5	5	0	0
Germany	10	5	5	0,5	Sweden	5	2	3	0,6
South Africa	10	10	0	0	Türkiye	5	5	0	0
Italy	7	4	3	0,4286	Ireland	4	3	1	0,25
Malaysia	6	5	1	0,1667	South Korea	4	3	1	0,25

Note. **A:** Article, **SCP:** Single Country Publications, **MCP:** Multiple Country Publications

In Figure 10, cooperation networks of countries are shown in the studies carried out for the road transportation sector. As seen, the collaborations are divided into 6 clusters. In these clusters, the central and most important nodes of the network are China (bc: 280,302), the USA (bc:235,089) and UK (bc: 178,237). Considering the internationality level of the UK's publications (75%), it is expected to be one of the central and most important nodes of the network. On the other hand, it is seen that the USA and UK mostly cooperate with European countries and China mostly cooperates with countries in its own region. There is also an independent relationship between Hungary, Poland, and Slovakia (Figure 10).

4. Discussion

This study provides a comprehensive picture of the studies done on COVID-19 in the transport industry. There are a few valuable studies in the literature (Benita, 2021; Kutela et al., 2021) in which studies related to COVID-19 in the transportation sector are examined bibliometrically, but this study differs from other studies as it both deals with all transportation modes as a whole and provides analysis separately for each mode.
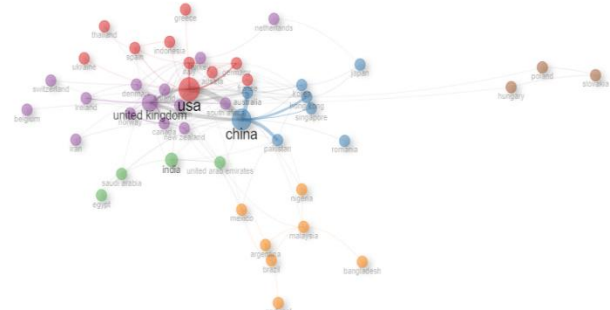

Figure 10. International cooperation network in the road transport sector

It is seen that the number of studies on COVID-19 is increasing exponentially every day for all sectors. The situation is not different for the transport sector. In the transportation sector, 951 articles were published in 345 journals between November 2019 and 28.01.2022, and a total of 2605 authors were included in the studies. While 155 of the articles were single-authored, 796 were multi-author articles. There is an average of 0.365 articles per author, and the collaboration index is 3.09. Although collaborations have been carried out in most of the studies, it is seen that these collaborations are generally limited to a single time.

As the cooperation analyzes show, the UK is the country with the highest level of internationality. Hong Kong, Sweden and China are other countries with a high level of internationalization. The countries with the lowest level of internationalization are Türkiye, South Africa and Thailand, respectively. It is stated in the literature that as the degree of internationality of publications increases, they receive more citations (Teodorescu & Andrei, 2011). On the other hand, the use of data obtained from different countries in studies with a high level of internationality also ensures that the results are more generalizable. In this context, it can be mentioned that researchers in countries with low internationality should work together with researchers from other countries in order to increase the generalizability of their studies and to get more citations, and therefore to contribute more to the field they work in.

Another result that emerged in the collaboration analysis is that the UK is the most important node

(country) in the network center in collaborations. Other important nodes in the network are China, the USA, Malaysia, and Canada, respectively. When the important nodes in the network are examined, it is seen that these countries are either developed countries or countries that attach high importance to education. As a matter of fact, in the United Nations (UN) 2020 education index, UK ranks 13th, Canada 16th, the USA 17th, Malaysia 62nd and China 85th (UN, 2020). Although Malaysia and China are behind in the education index, it is known that the number of academic publications is very high.

Another issue examined within the scope of collaboration analysis is related to co-citation analysis. As a result of the analysis, it is seen that the most central and most important node of the citation network is the study of Fornell and Larcker (1981). The study of Fornell and Larcker (1981) is related to structural equation models and is a method study that deals with unobservable variables and measurement errors. In this respect, it is quite usual that this work is located in the network center. On the other hand, it can be mentioned that the studies referring to the work of Fornell and Larcker (1981) are quantitative studies based on structural equation modeling. The study of Gössling et al (2020), which emerged as one of the important nodes in co-citation analysis, is an early period study focusing on the impact of COVID-19 on tourism and therefore modes of transport. Ivanov (2020)'s study, another important node, is on the supply chain and tries to explain the consequences of disruptions in the supply chain through a simulation. Finally, the study of Sobieralski (2020), which is one of the important nodes in the citation analysis network, focuses on the air transport sector and focuses on the employment uncertainty caused by COVID-19 in airline businesses. It can be said that the studies of Gössling et al (2020), Ivanov (2020) and Sobieralski (2020) are early researches. On the other hand, shedding light on the relevant field within the framework of the subjects examined also contributed to their citations with other publications, so they became important nodes in the network.

The bibliometric method used in this study has been very useful in terms of seeing the general picture of the studies carried out on COVID-19 in the transportation sector. However, there are several limitations in the study. The first limitation is related to the keywords used to search for transport modes. The fact that different concepts can be used in different countries regarding transportation modes may have caused some articles to be inaccessible. Another limitation is about data collection. Using only the Scopus database in data collection, to scanning only English articles, only final versions of articles to scan are limitations in terms of data collection. These determined limitations reveal the possibility of exclusion of some articles in the field. The inclusion of other databases, all publications and studies published in all languages in future studies will allow a more comprehensive result to be revealed. Another limitation is related to the publication year intervals of the articles. In this study, only the articles published between 2019-2022 (until 28.01.2022) were scanned. The fact that the scanned year interval was short prevented the analysis of the direction of the development in the field, how the development was achieved between which years, and whether the subject headings changed according to the years. In the following years, with the increase in the number of articles on COVID-19 and the maturation of the field, it is considered important to conduct a similar study in order to see the development. On the other hand, in future studies, it is another important issue that should be investigated on which subject headings in the transportation sector.

Ethics Committee Approval Statement

Due to the method used in this study, ethics committee approval is not required.

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