Article

Exploiting Technology to Deal with the COVID-19 Challenges in Travel & Tourism: A Bibliometric Analysis

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Abstract: This article discusses how travel and tourism organizations, the hardest-hit by the COVID-19 pandemic, have used the technology tools to deal with COVID challenges. Specifically, through a bibliometric literature review of relevant research papers on the topic of tourism and COVID-19, we provide evidence of how COVID-19 has accelerated the adoption and diffusion of various technologies by different stakeholders in the tourism value chain, and we show how these technologies have been used to deal with the challenges posed by COVID-19 pandemic. The review evidences the main research areas and allows to define future directions. Thus, we conclude this article by discussing how COVID-19 offers a unique opportunity for rethinking and renovating the tourism offer through technology.

Keywords: technology for tourism; post-COVID tourism recovery; innovation; digital transformation; bibliometric analysis

1. Introduction

COVID-19 has been causing unprecedented disruption to society, economy, and governments worldwide [1]. Various countries in the world have closed their borders, and their residents and visitors have experienced lockdown or various restrictions on their travel and general outdoor activities [1].

The COVID-19 crisis has caused unprecedented and overwhelming impacts on the economy of most countries in the world [2]. Earlier research has shown the devastating economic impact of previous pandemics on businesses, governments, and societies all over the world due to a simultaneous shock in demand and supply [3].

According to the latest research report of the world travel and tourism council [4], in 2020, the travel and tourism industry recorded a 73% decrease in international arrivals, constituting the worst year. In 2021, international tourism experienced a 4% increase in 2021; however, they remain still highly below the pre-pandemic year of 2019. The pace of recovery remains low although the traveler's confidence has increased (due to progress on vaccinations and different measures undertaken) [5].

The pandemic situation has profoundly affected all actors in the travel and tourism value chain worldwide [5]. Tourism is one of the fastest-growing economic sectors and is an important driver of employment, economic growth, and development [4,6]. However, the tourism industry is based on people's movement, aggregation, and conviviality. Thus, the COVID-19 crisis has slowed down this growth. Consequently, the closing of borders between countries, the halt to international flights, and the closure of restaurants and accommodation have caused, for the first time in history, the tourism industry to completely stop all travel and leisure-related activities.

All activities and industries of the tourism sector have been deeply affected. Bookings collapsed everywhere, and travel agencies struggle to deal with cancellations and missed bookings [1].

Data from UNWTO demonstrate as "in 2020, the Travel & Tourism sector lost more than 62 million jobs, with its contribution to global GDP falling by USD $4.5 trillion. Governments have witnessed how the loss of tourism has affected more than just jobs and livelihoods in the sector; it has also had an adverse impact on community development, the environment, and wildlife, as well as local and national economies" [5]. If we add the ancillary services and activities of the entire industry, such as restaurants and bars [7], commerce, transport and car rental, expos, conferences, cultural establishments, galleries, and museums, the impact is catastrophic.

Previous researchers demonstrated that emergence often leads to innovation and technology development [8], and in the case of the tourism sector, digital transformation and technology plays a central role in responding to the crisis [9,10].

The process of digital transformation is defined as a process that radically changes the structure of the industries due to the diffusion of digital technologies, such as the Internet of things (IoTs), additive manufacturing, big data, artificial intelligence, cloud computing, and augmented and virtual reality [11,12]. During the pandemic emergence, such technologies were widely used to address some important problems in life, and for the tourism sector, it has a major enabling factor to build resilience [5,13]. Digital technologies, especially virtual reality, enable tourists to explore new destinations easier also at home, enhancing tourist experiences [14].

Over the last years, many academics have published articles with the aim to grasp the impacts of COVID-19 on the sectors as well as the responsiveness of the sector to recover. Technological advances have played a relevant role in this process.

Based on the previous premises, this article tries to assess key findings of previous research on the topics of tourism and COVID-19 to contribute to the discussion related to how the key tourism stakeholders are using technology tools to react and redesign their processes and operations to respond to the current crisis.

Specifically, this study aims to understand the relevant technologies that allowed the tourism sector to restart after its emergence and to identify a future research agenda.

Relevant questions that come forth for the travel and tourism sector ask the following: What has been the role of technology in the recovery of the tourism sector? Which were the key technologies adopted by tourism stakeholders to recover from the crisis? Will technology shape the future of travel?

2. Methodology

In order to investigate the state of the art in the literature regarding tourism transformation and COVID-19, a systematic literature review was performed. This method allows to identify trends and future potentialities in research [15–17] and aims to study the relevant publications in the field, the most influential authors, journals, and the most frequent keyword and other bibliometric data. The reviews of the literature include the following phases [18–20]: definition of research questions; redaction of research protocol, construction of the sample to analyze; analysis and synthesis; and identification of future research trends.

The reviews started with the definition of the research question that, for this study, are defined as follows [16]:

RQ. *How do digital technologies deal with the COVID-19 challenges in travel and tourism?*

The answer to the research question allows understanding the challenges offered by technologies in tourism after COVID-19 crisis to underline how, so far, the role of technologies has been studied in the literature.

The review process continues with the definition of the research protocol to identify the information sources, period of monitoring, and tools for analysis and synthesis [21].

For this study, the scientific database used to construct the sample was *Scopus*, which is considered the most comprehensive database with extensive coverage of articles and more than 20,000 peer-reviewed journals [22]. Papers were analyzed using VOSviewer, a tool for constructing and visualizing bibliometric networks and clusters [23].

The construction of the sample phase consists in the selection of the papers to include in the literature review by using the query "tourism" AND "COVID" AND "technolog*" in the title, abstract, and author keywords, from 2019 to 2022. A set of exclusion and inclusion criteria was defined, and inclusion criteria are papers published in journals, conference papers, conference reviews, and book chapters [24]. After a reading of the abstract, to check the coherence of the paper for the aim of this study, a sample of 319 publications was considered for descriptive and cluster analysis.

Descriptive analysis and synthesis have the objective to describe the characteristics of research papers to be analyzed with the objective to highlight literature contributing to the specific topics [19] such as:

- The trend of publication: the distribution of the papers over the time;
- Geographic distribution of papers;
- Distribution of papers among journals;
- Citations analysis: number of citations of articles and citations per year;
- Relevant keywords and topics.

With VOSviewer, we performed co-occurrence analysis to evaluate authors' keywords that the paper has in common [25], and bibliographic coupling analysis [26] considers the relation among papers based on the number of references that they share [27].

The combination of these two analyses decreases errors and enhances the value of the research outcomes [28]. The review process was completed with a content analysis on each paper of the cluster defined with VOSviewer to identify emerging research areas and future directions. Each author independently carries out their analysis by reading the full text of the papers underlying the research aims and findings concerning the membership clusters and possibly repositioning the papers in other more coherent clusters. Findings of the content analysis are collected in a table and discussed with each author.

3. Research Findings

This section aims to provide the main themes and aspects investigated in the papers realized in the last 3 years with a specific focus on tourism, technology, and COVID-19. As previously in the methodological section, using a co-occurrence approach, it was possible to identify key insights discussed by scholars.

3.1. Trend of Publications

Figure 1 represents the trend of publication from 2019 to 2022, the monitored period. As it is shown, the trend is exponential with a peak in 2021 with 208 publications, which is more than triple compared to 2020, the year of the COVID crisis, with 58 publications. A similar trend is also expected for 2022, given that 52 papers were already published in the first 3 months. This demonstrates the novelty but also the importance of the research focus of the paper that requires a deep investigation in the future on the technologies' role for restart tourism.
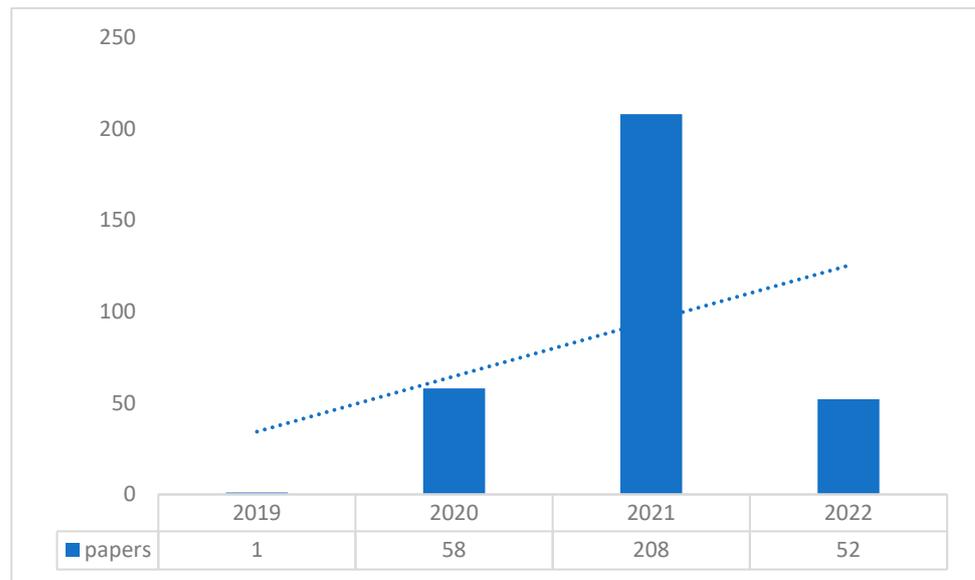
Figure 1. Trend of publications.

3.2. Geographic Distribution of Papers

Figure 2 represents the network of visualization map of country co-authorship for the analyzed papers, and Figure 3 describes the number of publications (co-authorship) for each country.
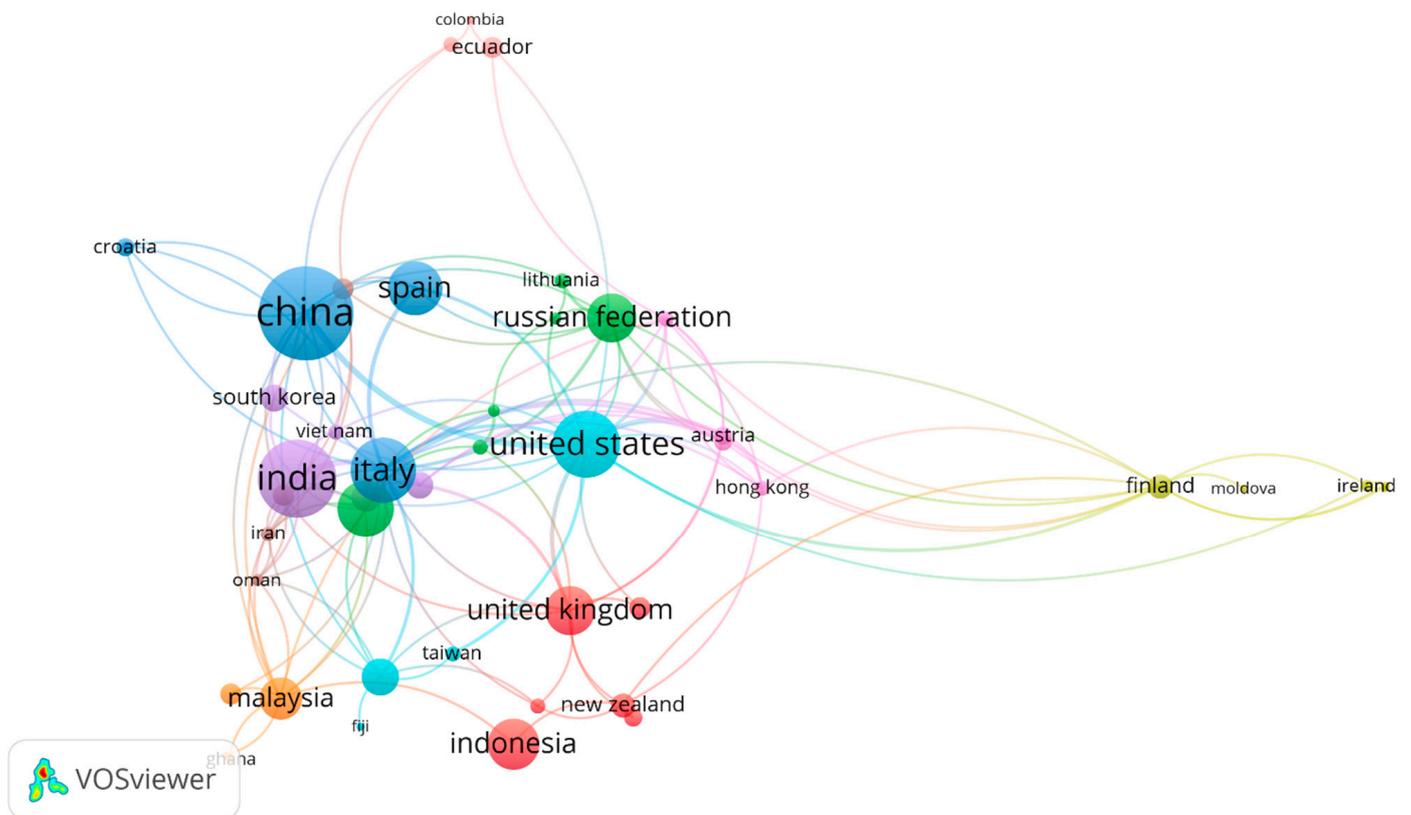
Figure 2. Geography authorship' network.
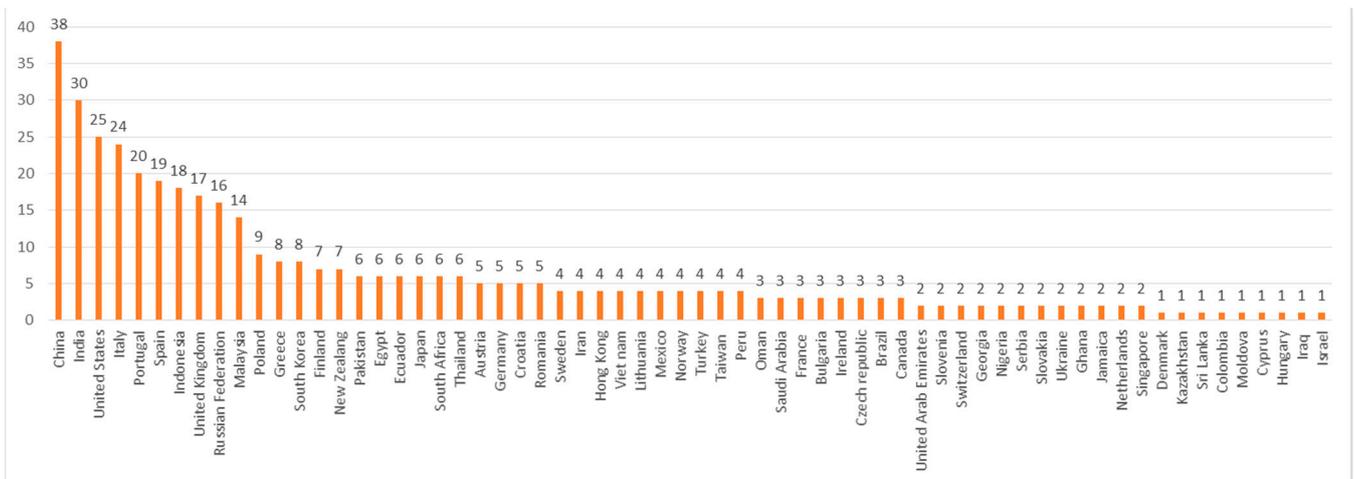
Figure 3. Geographic distribution of papers.

The analysis reveals that most of the papers are written in collaboration with different universities in different countries. Specifically, the top three countries in terms of the number of papers are China, with 38 publications; India, with 30 publications; and the United States, with 25 publications. Interestingly, the number of publications in Italy were 24 and in Portugal were 20. The results also reveal that, apart from the top 10 countries in terms of a number of papers (38,39), the others are characterized by a low level of papers ranging from 1 to 8.

3.3. Distribution of Papers among Journals

Figure 4 represents the map of the distribution of publications among scientific journals. As it can be seen, there are different sources of publications, but the top three journals are *Sustainability*, with a total of 21 publications; *Smart Innovation, Systems, and Technologies*, with 11 publications; and *Current Issues in Tourism*, with 7 publications.
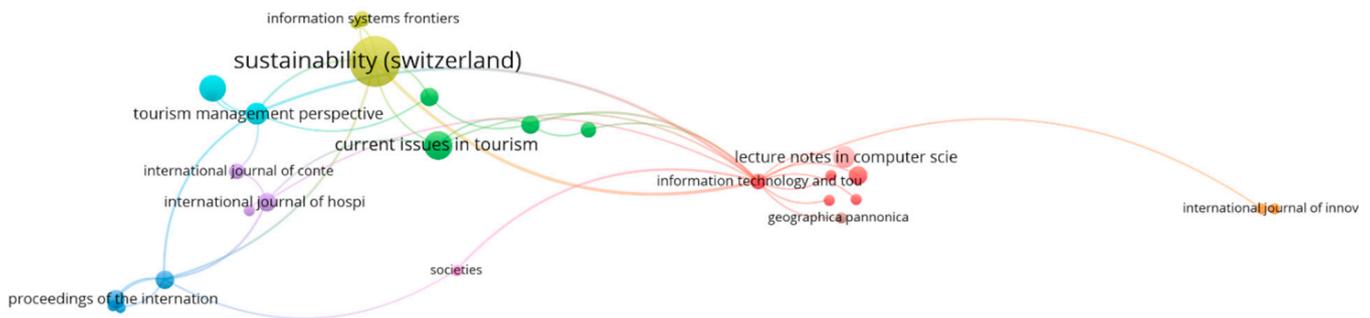

Figure 4. Journal distribution map.

According to [18], the number of papers on a specific research topic represents an important indicator, and in this study, 319 articles were published in the monitored period. Despite the high number of papers, the sources are characterized by fragmentation: in total, these articles are published in 199 scientific journals.

3.4. Citations per Year and Most Cited Papers

　　　Descriptive analysis also included the study of the citations of papers per year and per author. Figure 5 shows the citations received per year. Obviously, the papers published in 2020 have more citations and thus are useful to analyze the most influential papers (authors) in terms of citations.
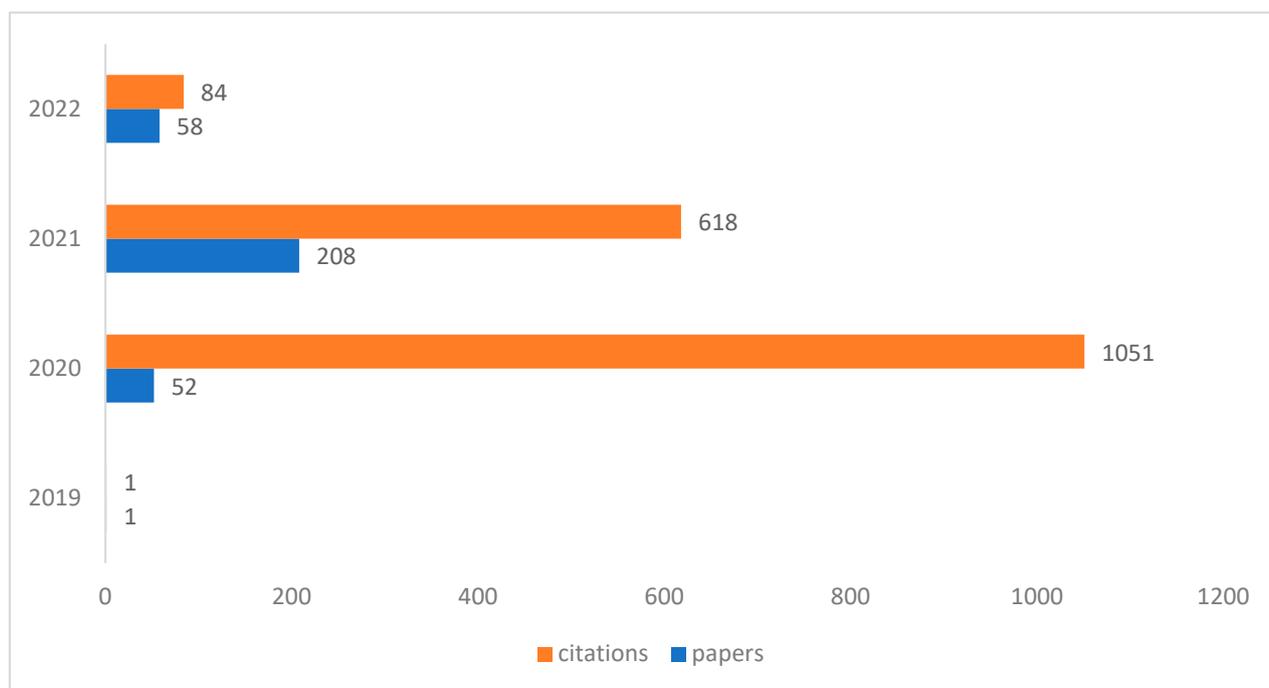
Figure 5. Journal distribution map.

　　　The analysis of the most cited papers (top 10), listed in Table 1, demonstrates that the top three papers have several citations ranging from 174 to 100. The first two were published in 2020, and the third was published in 2021.

Table 1. Top ten papers.

Authors	Title	Year	Journal	Citations	Keywords
Zeng Z., Chen P.-J., Lew A.A. [8]	From high-touch to high-tech: COVID-19 drives robotics adoption	2020	*Tourism Geographies*	174	Artificial intelligence; COVID-19 pandemic; drones; high-tech; high-touch; human-robot interaction; robotics
Gretzel U., Fuchs M., Baggio R., Hoepken W., Law R., Neidhardt J., Pesonen J., Zanker M., Xiang Z. [9]	e-Tourism beyond COVID-19: a call for transformative research	2020	*Information Technology and Tourism*	115	COVID-19; e-Tourism; growth paradigm; research paradigm; technology paradigm; transformative research
Sharma G.D., Thomas A., Paul J. [13]	Reviving tourism industry post-COVID-19: A resilience-based framework	2021	*Tourism Management Perspectives*	100	Climate action; COVID-19; global economic order; innovation; local belongingness; resilience; sustainable tourism

Table 1. *Cont.*

Authors	Title	Year	Journal	Citations	Keywords
Niewiadomski P. [29]	COVID-19: from temporary de-globalisation to a re-discovery of tourism?	2020	*Tourism Geographies*	98	Creative destruction; de-globalization; globalization; path-creation; sustainable tourism; time-space compression; tourism development
Dolnicar S., Zare S. [30]	COVID-19 and Airbnb—Disrupting the Disruptor	2020	*Annals of Tourism Research*	80	COVID-19; economic impact; hospitality industry; information and communication technology; tourism market; viral disease
Galvani A., Lew A.A., Perez M.S. [31]	COVID-19 is expanding global consciousness and the sustainability of travel and tourism	2020	*Tourism Geographies*	75	Consciousness; COVID-19; future trends; globalization; sustainability; time-space compression; travel and tourism
Ghiani E., Galici M., Mureddu M., Pilo F. [32]	Impact on electricity consumption and market pricing of energy and ancillary services during pandemic of COVID-19 in Italy	2020	*Energies*	75	Bulk power system; day-ahead market; electricity consumption; load profiles; pandemic COVID-19
Kim S.S., Kim J., Badu-Baiden F., Giroux M., Choi Y. [33]	Preference for robot service or human service in hotels? Impacts of the COVID-19 pandemic	2021	*International Journal of Hospitality Management*	74	Artificial intelligence (AI); COVID-19; robotics; robots; threat; tourism
Capolongo S., Rebecchi A., Buffoli M., Appolloni L., Signorelli C., Fara G.M., D'Alessandro D. [34]	COVID-19 and cities: From urban health strategies to the pandemic challenge. A decalogue of public health opportunities	2020	*Acta Biomedica*	72	Care services' network; city schedules; emergency mobility network; post-COVID-19 cities; post-COVID-19 communities; post-COVID-19 urban health; post-COVID-19 living spaces; public health decalogue; resilient cities; urban digitization
Seyitoğlu F., Ivanov S. [35]	Service robots as a tool for physical distancing in tourism	2021	*Current Issues in Tourism*	44	COVID-19; physical distancing; physically and socially distant service; service robots; social connectedness; social robots

As it is shown in the table, the most cited papers have a co-authorship between China, the first country in terms of papers, and the United States, the second country, in terms of papers. The second most-cited paper has co-authorship with [10], which are also the most influential authors as illustrated in Figure 6. This evidence is not peculiar considering that these authors, such as Gretztel, Baggio, or Fuchs, for several years have been engaged in research activities regarding the impact of technologies on the tourism sector.
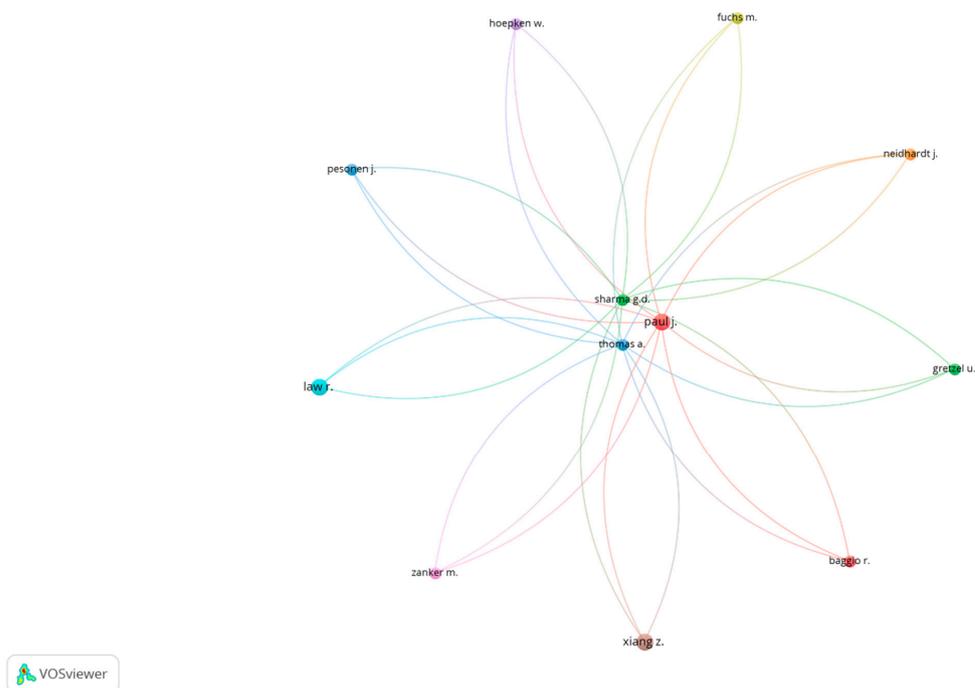
Figure 6. Most influential author.

3.5. Keyword

Figure 7 are represented the clusters of keywords used by authors in the analyzed papers through VOSviewer. The tools extract keywords based on co-occurrences [36] in title, abstract, and authors keywords. This analysis allows the studying of large amounts of text focused on a specific domain [37]. The map also grouped the extracted keyword in different clusters [36].
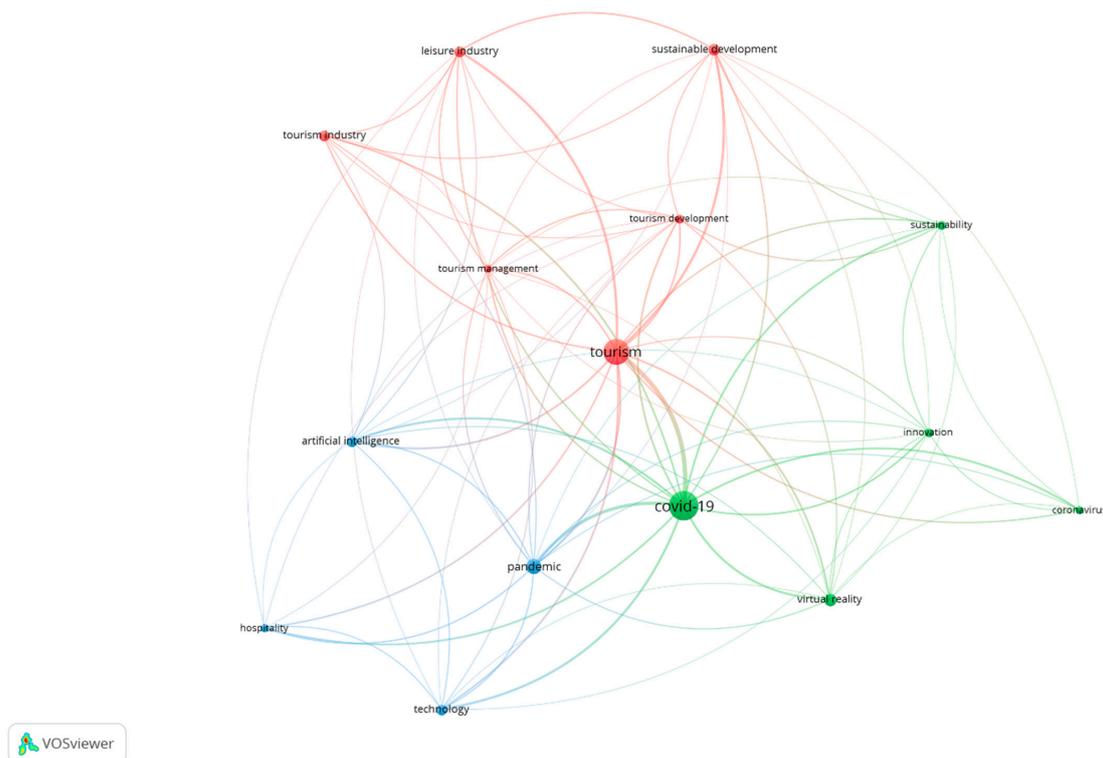
Figure 7. Keywords' cluster.

3.6. Clustering and Content Analysis

Using the bibliographic matching approach, we conducted a content analysis [26] considering the 319 papers included in the data sample. The bibliographic matching is realized by considering the articles that mainly share the same references [27]. This analysis allowed us to obtain 8 clusters and 48 papers with at least 4 common citations. The clusters obtained put together those articles that may mark a specific common topic/approach (Figure 8, Table 2).
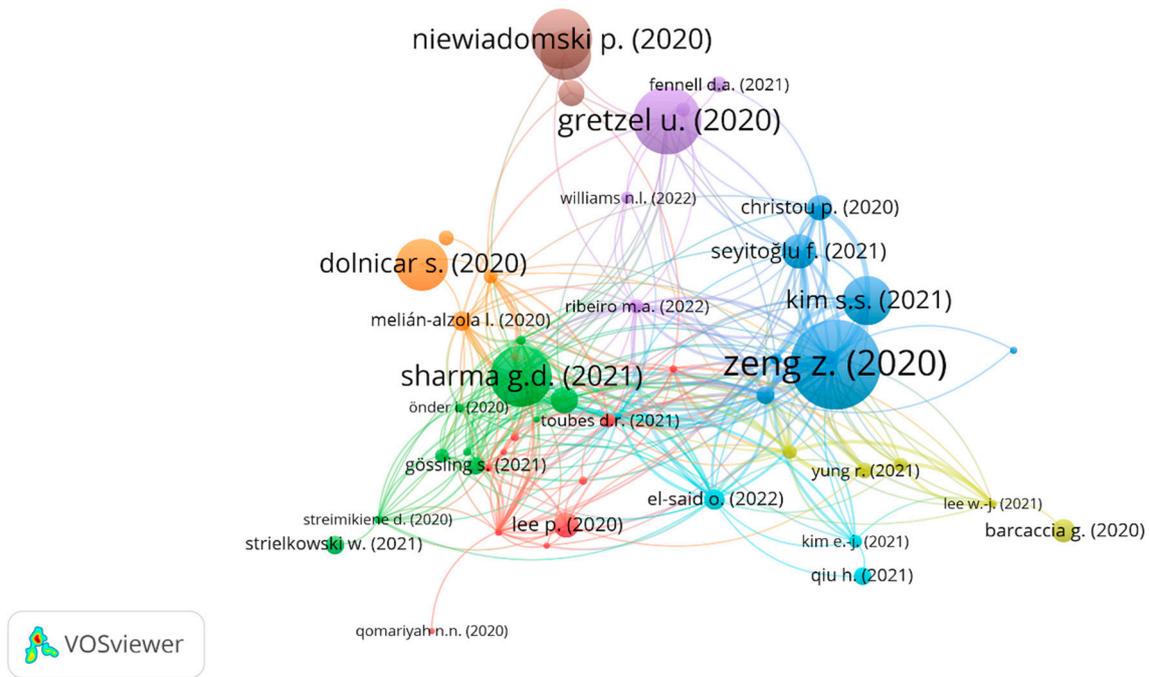
Figure 8. Bibliographic coupling.

Table 2. Papers classified in clusters.

Cluster	Authors	Title	Year	Citations	Keywords
Cluster 1: red (11 items)	Chen J., Huang J., Su W., Štreimikienė D., Baležentis T. [38]	The challenges of COVID-19 control policies for sustainable development of business: Evidence from service industries	2021	6	Business; COVID-19; enterprise; interpretive structure model; ordinal logistic regression; production and operation; service industry
	Frey B.S., Briviba A. [39]	A policy proposal to deal with excessive cultural tourism	2021	6	Copy; D62; digital technology; innovation; overtourism; P48; revived original; Z10; Z18; Z30; Z38
	Joshi V.A., Gupta I. [40]	Assessing the impact of the COVID-19 pandemic on hospitality and tourism education in India and preparing for the new normal	2021	5	COVID-19 pandemic; hospitality and tourism education; industry collaboration; internet-based learning; resilience

Table 2. *Cont.*

Cluster	Authors	Title	Year	Citations	Keywords
	Lee P., Hunter W.C., Chung N. [41]	Smart tourism city: Developments and transformations	2020	29	COVID-19; Smart city; smart tourism; smart tourism city; sustainable development
	Lu J., Xiao X., Xu Z., Wang C., Zhang M., Zhou Y. [42]	The potential of virtual tourism in the recovery of tourism industry during the COVID-19 pandemic	2022	5	COVID-19; mixed-methods approach; sustainable tourism; theory of planned behaviour; virtual reality
	Osei B.A., Ragavan N.A., Kandappan B., Mensah H.K. [43]	"Hospitality revolution 4.0": A literature review on a unified typology of IR 4.0 technologies for the tourism and hospitality industry in the era of COVID-19	2020	5	Artificial intelligence; big data; COVID-19; hospitality revolution 4.0; industrial revolution 4.0; robotics
	Qomariyah N.N., Sari S.A., Fajar A.N. [44]	Sonia: An integrated indonesia online tourism system in new normal era	2020	4	E-tourism; integrated information system; mobile applications; personalized AI; recommender system; service-oriented architecture
	Radojević B., Lazić L., Cimbaljević M. [45]	Rescaling Smart Destinations—The Growing Importance of Smart Geospatial Services during and after COVID-19 Pandemic	2020	5	COVID-19; service optimization; smart tourism; smart tourism destination; spatial optimization
	Schimperna F., Lombardi R., Belyaeva Z. [46]	Technological transformation, culinary tourism and stakeholder engagement: emerging trends from a systematic literature review	2021	4	Culinary; food; SCS analysis; stakeholder; stakeholder engagement; technological transformation; technology; tourism
	Thomas M.J., Lal V., Baby A.K., Rabeeh VP M., James A., Raj A.K. [47]	Can technological advancements help to alleviate COVID-19 pandemic? a review	2021	4	Disinfection; healthcare; real-time monitoring; SARS-CoV-2; technology
	Toubes D.R., Vila N.A., Fraiz Brea J.A. [48]	Changes in consumption patterns and tourist promotion after the COVID-19 pandemic	2021	12	Consumption; COVID-19; digitalization; marketing; promotion; tourism
Cluster 2: green (10 items)	Aldao C., Blasco D., Poch Espallargas M., Palou Rubio S. [49]	Modelling the crisis management and impacts of 21st century disruptive events in tourism: the case of the COVID-19 pandemic	2021	7	Black swan; complexity; COVID-19 pandemic outbreak; crisis management; disruptive event; impact

Table 2. *Cont.*

Cluster	Authors	Title	Year	Citations	Keywords
	Awan M.I., Shamim A., Ahn J. [50]	Implementing 'cleanliness is half of faith' in re-designing tourists, experiences and salvaging the hotel industry in Malaysia during COVID-19 pandemic	2020	13	Cleanliness in Islam; COVID-19; Malaysian hotel industry; service design; service experience; tourists' experiences
	Gössling S., Higham J. [51]	The Low-Carbon Imperative: Destination Management under Urgent Climate Change	2021	18	Carbon management; climate change; COVID-19; destination management; resilience; value generation
	Ianioglo A., Rissanen M. [52]	Global trends and tourism development in peripheral areas	2020	6	Accommodation; competitiveness; global trends; Lapland; tourism development
	Kwok A.O.J., Koh S.G.M. [53]	COVID-19 and Extended Reality (XR)	2021	31	AR/VR; immersive technology; innovation; pandemic; schumpeter; sustainable competitive advantage
	Sharma G.D., Thomas A., Paul J. [13]	Reviving tourism industry post-COVID-19: A resilience-based framework	2021	100	Climate action; COVID-19; global economic order; innovation; local belongingness; resilience; sustainable tourism
	Sorooshian S. [54]	Implementation of an expanded decision-making technique to comment on Sweden readiness for digital tourism	2021	4	Change readiness; COVID-19; digitalization shift; expanded TOPSIS; tour and traveling
	Streimikiene D., Korneeva E. [55]	Economic impacts of innovations in tourism marketing	2020	6	Economic impacts; innovations; sustainability; tourism economics; tourism marketing
	Strielkowski W., Firsova I., Lukashenko I., Raudeliūniene J., Tvaronavičiene M. [56]	Effective management of energy consumption during the COVID-19 pandemic: The role of ICT solutions	2021	19	COVID-19; energy consumption; ICT solutions; project management; renewable energy; sustainable development
	Önder I., Gunter U. [57]	Blockchain: Is it the future for the tourism and hospitality industry?	2020	7	Blockchain; information technology; opportunities; threats
Cluster 3: blue (8 items)	Christou P., Simillidou A., Stylianou M.C. [58]	Tourists' perceptions regarding the use of anthropomorphic robots in tourism and hospitality	2020	29	Androids; anthropomorphism; humanlike robots; technology; tourist perceptions

Table 2. *Cont.*

Cluster	Authors	Title	Year	Citations	Keywords
	Ivanov S.H., Webster C., Stoilova E., Slobodskoy D. [59]	Biosecurity, crisis management, automation technologies and economic performance of travel, tourism and hospitality companies—A conceptual framework	2022	18	Artificial intelligence; biosecurity; COVID-19; crisis management; economic performance; pandemic; service automation; service robots
	Kim S.S., Kim J., Badu-Baiden F., Giroux M., Choi Y. [33]	Preference for robot service or human service in hotels? Impacts of the COVID-19 pandemic	2021	74	Artificial intelligence (AI); COVID-19; Robotics; robots; threat; tourism
	Li M., Yin D., Qiu H., Bai B. [60]	A systematic review of AI technology-based service encounters: Implications for hospitality and tourism operations	2021	12	Artificial intelligence (AI); public health emergency; service encounter; service experience; systematic review
	Mohammed I.B., Isa S.M. [61]	The Role of Internet of Things (IoT) in the Containment and Spread of the Novel COVID-19 Pandemic	2021	5	Artificial intelligence; COVID-19 pandemic; drone; Internet of things; robot
	Seyitoğlu F., Ivanov S. [35]	Service robots as a tool for physical distancing in tourism	2021	44	COVID-19; physical distancing; physically and socially distant service; service robots; social connectedness; social robots
	Van N.T.T., Vrana V., Duy N.T., Minh D.X.H., Dzung P.T., Mondal S.R., Das S. [62]	The role of human–machine interactive devices for post-COVID-19 innovative sustainable tourism in Ho Chi Minh City, Vietnam	2020	9	AI and VR devices; COVID-19; revival of tourism; robots in tourism; service 5.0; tour bubble; tourist interest; web 4.0 and 5.0
	Zeng Z., Chen P.-J., Lew A.A. [9]	From high-touch to high-tech: COVID-19 drives robotics adoption	2020	174	Artificial intelligence; COVID-19 pandemic; drones; high-tech; high-touch; human-robot interaction; robotics
Cluster 4: light green (5 items)	Akhtar N., Khan N., Mahroof Khan M., Ashraf S., Hashmi M.S., Khan M.M., Hishan S.S. [14]	Post-COVID-19 tourism: Will digital tourism replace mass tourism?	2020	13	Augmented reality; COVID-19; Digital tourism; Tourism; Virtual reality
	Barcaccia G., D'Agostino V., Zotti A., Cozzi B. [63]	Impact of the SARS-CoV-2 on the Italian agri-food sector: An analysis of the quarter of pandemic lockdown and clues for a socio-economic and territorial restart	2020	26	Agriculture; applied research; COVID-19; food industry; Italy; sustainability; technology transfer
	Lee W.-J., Kim Y.H. [64]	Does VR tourism enhance users' experience?	2021	6	COVID-19; extraversion; hedonic value; tourism; utilitarian value; visit intention; VR experience

Table 2. *Cont.*

Cluster	Authors	Title	Year	Citations	Keywords
	Schiopu A.F., Hornoiu R.I., Padurean M.A., Nica A.-M. [65]	Virus tinged? Exploring the facets of virtual reality use in tourism as a result of the COVID-19 pandemic	2021	12	Virtual reality; viruses; conceptual model; intention to use; perceived ease of use; perceived usefulness; TAM model; through the lens; virus spreading; tourism
	Yung R., Khoo-Lattimore C., Potter L.E. [66]	Virtual reality and tourism marketing: conceptualizing a framework on presence, emotion, and intention	2021	15	Destination marketing; emotion; intention; presence; virtual reality
Cluster 5: violet (5 items)	Fennell D.A. [67]	Technology and the sustainable tourist in the new age of disruption	2021	15	Alternative hedonism; COVID-19; disruption; sustainable citizen; technology
	Gretzel U., Fuchs M., Baggio R., Hoepken W., Law R., Neidhardt J., Pesonen J., Zanker M., Xiang Z. [10]	e-Tourism beyond COVID-19: a call for transformative research	2020	115	COVID-19; e-tourism; growth paradigm; research paradigm; technology paradigm; transformative research
	Ribeiro M.A., Gursoy D., Chi O.H. [68]	Customer Acceptance of Autonomous Vehicles in Travel and Tourism	2022	12	Acceptance; adoption; AIDUA model; artificial intelligence; autonomous vehicles; COVID-19; travel
	Williams N.L., Wassler P., Ferdinand N. [69]	Tourism and the COVID-(Mis)infodemic	2022	10	Conspiracy theories; COVID-19; infodemic; misinfodemic; vaccine hesitancy
	Xiang Z., Fesenmaier D.R., Werthner H. [70]	Knowledge Creation in Information Technology and Tourism: A Critical Reflection and an Outlook for the Future	2021	12	e-Tourism; future; information technology; knowledge creation; tourism
Cluster 6: light blue (4 items)	El-Said O., Aziz H. [71]	Virtual Tours a Means to an End: An Analysis of Virtual Tours' Role in Tourism Recovery Post COVID-19	2022	22	Coronavirus; crisis management; heritage management; PADM; pandemic; TAM; tourism promotion; visit intention
	García-Milon A., Olarte-Pascual C., Juaneda-Ayensa E. [72]	Assessing the moderating effect of COVID-19 on intention to use smartphones on the tourist shopping journey	2021	4	COVID-19; effort expectancy; moderating effect; performance expectancy; smartphone; social influence; technology acceptance models; tourist shopping journey
	Kim E.-J., Kim J.J., Han S.-H. [73]	Understanding student acceptance of online learning systems in higher education: Application of social psychology theories with consideration of user innovativeness	2021	11	COVID-19; higher education; online learning system; technology acceptance model (TAM); theory of planned behavior (TPB); user innovativeness

Table 2. *Cont.*

Cluster	Authors	Title	Year	Citations	Keywords
	Qiu H., Li Q., Li C. [74]	How technology facilitates tourism education in COVID-19:case study of nankai University	2021	18	
Cluster 7: orange (4 items)	Dolnicar S., Zare S. [30]	COVID19 and Airbnb—Disrupting the Disruptor	2020	80	COVID-19; economic impact; hospitality industry; information and communication technology; tourism market; viral disease
	Herath T., Herath H.S.B. [75]	Coping with the New Normal Imposed by the COVID-19 Pandemic: Lessons for Technology Management and Governance	2020	14	Coronavirus pandemic; COVID-19; information systems management; new normal; online learning; pandemic; remote work; technology governance; technology management; telecommuting; virtual learning; virtual mode
	Melián-Alzola L., Fernández-Monroy M., Hidalgo-Peñate M. [76]	Hotels in contexts of uncertainty: Measuring organisational resilience	2020	20	Change; crisis; hotel; performance; resilience; tourism; vulnerability
	Yang Y., Zhang C.X., Rickly J.M. [77]	A review of early COVID-19 research in tourism: Launching the Annals of Tourism Research's Curated Collection on coronavirus and tourism	2021	12	COVID-19; keyword co-frequency analysis; research contribution; systematic literature review
Cluster 8: brown (3 items)	Galvani A., Lew A.A., Perez M.S. [31]	COVID-19 is expanding global consciousness and the sustainability of travel and tourism	2020	75	Consciousness; COVID-19; future trends; globalization; sustainability; time-space compression; travel and tourism
	Niewiadomski P. [29]	COVID-19: from temporary de-globalisation to a re-discovery of tourism?	2020	98	Creative destruction; de-globalization; globalization; path-creation; sustainable tourism; time-space compression; tourism development
	Streimikiene D., Svagzdiene B., Jasinskas E., Simanavicius A. [78]	Sustainable tourism development and competitiveness: The systematic literature review	2021	30	Aging society; competitiveness; consumer needs; sustainable development; tourism; tourism destinations

The bibliographic coupling analysis was integrated with deep content analysis to understand more in-depth the main research areas, and a new classification of the papers in the different clusters was performed, as in Table 3. This process required the involvement

of each researcher and author of this study, each of which proceeded independently with reading each paper and reclassifying it in new clusters (Table 3).

Table 3. Mapping Papers with Clusters.

Cluster 1	Frey B.S., Briviba A. (2021); Joshi V.A., Gupta I. (2021); Lee P., Hunter W.C., Chung N. (2020); Lu J., Xiao X., Xu Z., Wang C., Zhang M., Zhou Y. (2022); Osei B.A., Ragavan N.A., Kandappan B., Mensah H.K. (2020); Qomariyah N.N., Sari S.A., Fajar A.N. (2020); Radojević B., Lazić L., Cimbaljević M. (2020) Schimperna F., Lombardi R., Belyaeva Z. (2021)
Cluster 2	Aldao C., Blasco D., Poch Espallargas M., Palou Rubio S. (2021), Awan M.I., Shamim A., Ahn J. (2020); Gössling S., Higham J. (2021); Ianioglo A., Rissanen M. (2020); Kwok A.O.J., Koh S.G.M. (2021); Sharma G.D., Thomas A., Paul J. (2021); Sorooshian S. (2021); Streimikiene D., Korneeva E. (2020); Önder I., Gunter U. (2020);
Cluster 3	Christou P., Simillidou A., Stylianou M.C. (2020); Ivanov S.H., Webster C., Stoilova E., Slobodskoy D. (2022); Kim S.S., Kim J., Badu-Baiden F., Giroux M., Choi Y. (2021); Li M., Yin D., Qiu H., Bai B. (2021); Mohammed I.B., Isa S.M. (2021); Seyitoğlu F., Ivanov S. (2021); Van N.T.T., Vrana V., Duy N.T., Minh D.X.H., Dzung P.T., Mondal S.R., Das S. (2021); Zeng Z., Chen P.-J., Lew A.A. (2020); El-Said O., Aziz H. (2022)
Cluster 4	Akhtar N., Khan N., Mahroof Khan M., Ashraf S., Hashmi M.S., Khan M.M., Hishan S.S. (2020); Barcaccia G., D'Agostino V., Zotti A., Cozzi B. (2020); Lee W.-J., Kim Y.H. (2021); Schiopu A.F., Hornoiu R.I., Padurean M.A., Nica A.-M. (2021); Yung R., Khoo-Lattimore C., Potter L.E. (2021)
Cluster 5	Fennell D.A. (2021); Gretzel U., Fuchs M., Baggio R., Hoepken W., Law R., Neidhardt J., Pesonen J., Zanker M., Xiang Z. (2020); Ribeiro M.A., Gursoy D., Chi O.H. (2022); Williams N.L., Wassler P., Ferdinand N. (2022); Xiang Z., Fesenmaier D.R., Werthner H. (2021);
Cluster 6	Kim E.-J., Kim J.J., Han S.-H (2021); Qiu H., Li Q., Li C. (2021)
Cluster 7	Dolnicar S., Zare S. (2020); Melián-Alzola L., Fernández-Monroy M., Hidalgo-Peñate M. (2020); Yang Y., Zhang C.X., Rickly J.M. (2021)
Cluster 8	Galvani A., Lew A.A., Perez M.S. (2020); Niewiadomski P. (2020); Streimikiene D., Svagzdiene B., Jasinskas E., Simanavicius A. (2020)

Cluster 1: "**Impact of technological transformation on tourism sector**" The studies classified in this cluster considered the newly designed online platforms, smart tourism, and other virtual tools that were used during the COVID-19 or proposed for the ongoing pandemic times. Among the studies presenting a specific case study or highlighting the emergency of the technological transformation are the following: [41–44,46]. Particularly, in [46], the qualitative data suggested that virtual tourism is a promotor of sustainable tourism by enhancing the virtual accessibility for the disabled or elderly people and by reducing greenhouse gas emissions. Ref. [42], in their paper, proposed an integrated tourism system named SONIA (Service-Oriented Architecture (SOA) linked with Artificial Intelligence (AI) model), which is used to build a personalized recommender system and is supposed to be beneficial in socio-economic aspects of the tourism sector. Furthermore, the study [46] investigated the role of technological transformation in culinary tourism. They used a considerable number of other studies indexed in the *Scopus* database and concluded that there was an emergency to use digital space in culinary tourism, which helps extend the existing framework on stakeholder causal scope. Another interesting work related to technology advancement is the case of the smart geospatial services and the role in pointing to the main downturn of the current smart destination issue and in building upon the relations of the geospatial layer of data with the tourism-specific layer [45].

Cluster 2: "**Innovation tools for management**". Among the studies in this group, we found that the study of [52] and that of [13] talk about the direct impact of technol-

ogy on tourism, which, for instance, shows a great impact on sustainable development, including economic, environmental, and social aspects. Moreover, [53], in their study, highlighted the importance of technology in the sustainable competitiveness of the tourism sector. The work of [49] is a theoretical analysis of the most significant disruptive events that occurred during 2020, COVID-19, that affected the tourism sector, further affecting people's psychological well-being and the health-care system and social, economic, cultural, technological, environmental and political dimensions. As a solution, the authors proposed the adoption of a resilience model as a crisis management tool that can address disruptive events affecting tourism. This is in line with the study of [50], which suggested a "new service design" for the hotel industry, and the study of [51] that highlighted the foremost role that destination managers could play in building prosperous and resilient low-carbon tourism destination systems, supporting as such the sustainable development. To vitalize the tourism sector, [54] proposed to broaden its digital tours, and as a solution to vitalization, [57] proposed blockchain and cryptocurrencies.

Cluster 3: "**Application of Artificial intelligence AI, VR and robots in the tourism and hospitality sectors**". Ref. [58] proposed an analysis of the use of anthropomorphic robots in tourism. They found that these technologies contribute to the enhancement of tourism experiences. Ref. [9] described the different applications of robots in tourism, namely hospitals, airports, transportation, recreation, attraction and scenic areas, hotels, and restaurants, describing the challenges offered by these technologies. This is also confirmed in the paper of [73], which realized four experiments and found that tourists prefer robot-staffed hotels during COVID-19. In the same direction, [59] investigated the role of automated technologies to produce products and deliver services instead of human employees to reduce biosecurity risks and discussed how automated technologies represent an opportunity in the pandemic periods. Ref. [61] highlighted the contribution of IoT technologies in breaking the virus transmission allowing social distancing. This evidence is in line with the results of [35], which suggest the new services system creation based on robots and automation technologies to deliver tourist services. Increasing tourist satisfaction and loyalty through the application of AI and VR are investigated in the paper of [62], offering some insights into the development of a smart and sustainable destination. The impact of virtual tours to define tourists' profiles, perceptions, and beliefs are analyzed in the paper [71].

Finally, a systematic review on the AI in services encounters is presented in the paper of [60], which identified four models of AI technology-based services as a response to COVID-19 and proposed a conceptual framework of the influence mechanism of AI technology-based service encounter.

Cluster 4: "**Augmented and virtual reality for tourism**". In this cluster, there are some relevant studies focusing on the growing importance of augmented and virtual reality, which play important role in the enhancement of the tourism sector. Like our study, [14] used a systematic literature review of past research on the development of digital tourism from 2016 to 2020, comprising a total of 60 articles indexed in *Scopus* and *Web of Science*. They found that digital tourism was linked with virtual reality tourism, virtual tourism, and augmented reality. Ref. [65] collected their data through a within-subjects experiment, affirming that the frequent use of VR was evident during COVID-19. The same finding was present also in the study of [66]. Moreover, the empirical study of [64], from the 207 datasets collected, provided key understandings to enable the adoption of VR technology in tourism. Meanwhile, the study of [63] was found to be an outlier within the other group of works included in this cluster.

Cluster 5: "**Technology Acceleration In The Tourism Value Chain**". This cluster aggregates articles that point out how COVID-19 has accelerated the adoption and diffusion of various technologies by different stakeholders in the tourism value chain and discusses how these technologies could help different tourism stakeholders to deal with the challenges posed by COVID-19 pandemic. The articles provide evidence of relevant challenges for all tourism stakeholders to convert this crisis disruption into transformative innovation [10]

as crucial for their performance and survival. The papers highlight the role of technologies in initiating a purposive change for redesigning and rethinking marketing, sales, booking, communication, interaction, visitor flows management, mobility tracking, understanding customer behavior and preferences, planning, and decision-making processes [10,68,70]. A new and innovative future research agenda related to technology adoption in the tourism sector emerges to be necessary for innovation, sustainability, and resilience of the sector in response also to the challenges caused by the COVID-19 pandemic [70].

Cluster 6: "**Digital technologies for education**". This cluster includes papers that investigate the applications of digital technologies for tourism education. The paper [71] analyses the behavioral intention to use online and e-learning platform in higher education by presenting the results of an online survey with 216 university students enrolled in hospitality and tourism studies. Moreover, the paper [74] presents teaching approaches, methodologies, and tools used during the COVID-19 emergence in China, offering insights useful for the development of Education Informationization.

Cluster 7: "**COVID-19 impact on hospitality**". The papers under this cluster deal with accommodation resilience capacity and the kind of strategies, approaches, problems, and challenges faced by hospitality structures due to COVID situation. For example, [30] investigated the disruptive effect of COVID-19 of trading over digital platforms for the future by considering the case of Airbnb. Ref. [72] proposed a framework to investigate the effects of COVID-19 with six variables (performance expectancy, effort expectancy, social influence, and arousal). Meanwhile, ref. [76] focused on understanding the different measures, predictors, and domains of resilience as well as their effect on the performance of organizational resilience. Through empirical research among Spanish hotel managers, they argued that strategy and change dimensions affect in a relevant way the resilience of accommodation structures, and this in turn impacts their performance. Furthermore, a review of early COVID-19 research in tourism realized by Yang et al. [77] argued that the effects of the COVID-19 situation have been disruptive for the tourism industry along five main dimensions: psychological effects and behavior; (2) responses, strategies, and resilience; (3) sustainable futures; (4) impact monitoring, valuation, and forecasting; and (5) technology adoption.

Cluster 8: "**Tourism and sustainability**". The articles under this theme analyze the impact of the COVID-19 situation and all challenges faced by industry during the pandemic situation to shift the attention toward the development of sustainable tourism as well as to increase the awareness and consciousness of all tourism stakeholders toward sustainable goals. Indeed, [31], in their study, argued the role that travel and tourism could play to create the global cognizant as essential for addressing the social and environmental challenges of the 21st century as well as for new value creation and transformation in the products and experiences. Meanwhile, [29] discussed how COVID-19 offers re-discovery opportunities for tourism firms in line with principles of sustainability with the aim to avoid all "dark sides" of tourism's growth, such as environmental degradation, economic exploitation, or overcrowding. Streimikiene and Korneeva [55], through a structured literature review, sought to discover the variables that could work toward strengthening the economic, social, and environmental competitiveness of the sector. They point out that technologies have a crucial role to play for sustainable development as well as for changing tourist behaviors and awareness.

4. Discussions and Implications

In this section, we discuss the main findings and provide some new insights and implications that we try to summarize.

Implication 1: Technology has been a great partner for firms to overcome COVID-19 challenges

Technology has been widely used by tourism firms (airlines, accommodations, travel agencies, DMS) to help them recover and deal with the unprecedent challenges they were

called to deal with. Acceleration of digital technology adoption in the sector has been experienced, thus intensifying the innovation and transformation challenges for tourism firms and organizations' competencies.

Technologies demonstrated to provide high opportunities to respond to a series of challenges the sector was required to afford, such as social distancing and the safety of traveler's security of passengers and staff alike. For example, airlines, check-in, as well as baggage self-check-in in airports will become the norm, and facial recognition may replace fingerprints, as these technologies will help. For example, a Norway airport was among the leaders in touchless travel by implementing technology solutions to allow travelers to check-in, drop their bags, pass through security, and board the aircraft without interpersonal contact through the use of bar codes, mobile phones, self-service kiosks, thus making all the processes touchless [79].

Robotics were highly used also in helping airports and hotels to increase the security of passengers and staff alike [58].

The COVID-19 lockdown situation has forced the sector to use technology massively for digital experiences for virtual gatherings as alternative means of staying connected and to virtual experiences, such as virtual dinner parties, happy hours, yoga classes, religious services, weddings, and cloud clubbing, etc. [80]. Moreover, in the last years, travelers' engagement with travel and tourism organizations and destinations on social media has increased. For instance, travel-related photo-generated content on Instagram can be particularly helpful in recreating the desire to travel and for immersion in the situation depicted in the pictures.

These experiences will become increasingly important in the future as a way to "explore digitally first" and "try before buying".

Implication 2: A New competitive perspective

The COVID-19 reality have highly affected firms' operation and activities, causing a bankruptcy risk because of the significant drop in operating income and the lack of cash flow if the crisis cannot be addressed successfully in the short term [81].

However, overcoming crisis challenges, finding survival mechanisms, and transforming the crisis into an innovation opportunity are key mechanisms to resist destruction as well as for growth and renewal [82].

The articles analyzed here have highlighted that the created situation presents a transformative moment or opportunity that will change the world [10,53,80].

Researches point out four strategic ways that business use to transform and to respond to the crisis [3]:

1. Retrenchment when firms narrow the scope of the firm's business activities and take measures to reduce their costs [83] and complexity [84];
2. Persevering aims to preserve the status quo, mitigating the adverse impacts of the crisis, and sustaining a firm's business activities [3];
3. Innovating aims at the realization of strategic renewal in response to crisis [3] to realize what used to be unthinkable or unfeasible [85];
4. Exit refers to dismissing a firm's business activities in response to crisis [86] either because it is unavoidable or because of a fatalistic judgment of managers [3]. Nevertheless, a successful business exit can free up new resources [87] and create fresh opportunities.

Considering that the majority of tourism firms are small and family-based, playing a significant role in the economy as employers, wealth creators, and innovators, they do not follow formal crisis procedures [88]; they tend to sacrifice short-term performance and shareholder value for long-term survival [89,90]; they are more accountable toward their employees as well as the environment [91]; they can mobilize easily their resources to maintain their activities more resilient [92]; and they are able to react quickly, decisively, and creatively [93], thus leading to increased strategic flexibility [94].

The response to the crisis situation is mainly oriented toward "persevering and innovating", and both "build on the availability of slack resources, whether internally or externally, which may become scarce rather quickly in times of crisis" [3]. Therefore, a re-designing of tourism practices emerges as essential for its competitiveness and is thus being practiced [80,95].

Implication 3: Digital technologies will play a key role in Travelers' behavior

COVID-19 has had an indisputable impact on travel decisions [96] in the long term, and risk perceptions pose serious challenges to destinations that do not manage health risk appropriately [97]. Social media technologies have played a substantial role to deal with travelers' confidence and have impacted travel attitudes, intentions, and future behaviors [80].

The research demonstrates that in the future, among the digital technologies, user-generated content will continue to play a key role in reducing risks and reassuring consumers about the safety of the destination, transportation, restaurants, and accommodation. For instance, research has proven that online consumer reviews reduce uncertainty about and increase confidence and trust towards products and services [97]. Consumers increasingly produce content, share vacation memories, and leave comments about their travel experiences. Social media, in general, is essential in disaster- and health-crisis-related communication [98]. This content can be particularly useful, as it could serve to reassure about the safety and inspire other consumers about traveling.

Therefore, as the risk-related motivations are altering tourist behavior and their interaction, tourism firms need to consider the use of the different online channels to maintain customer relationships and to continue engaging with them through online activities [10]. Users' content generation and feedback sharing on tourism experiences have impacted travel attitudes, intentions, and future behaviors [80].

Academics and practitioners are predicting that the COVID-19 pandemic will result in major societal shifts with the potential ultimately to enhance consumer experiences in the long term [10,80]. Therefore, indulging the travel behavior and attitudes of tourists becomes a critical issue for the recovery of the sector.

Implication 4: Tourism Sustainability models

Sustainability has been a heated debate for a long time, attracting the attention of researchers and practitioners. The COVID-19 research has outlined the improvements registered regarding air quality, pollution, noise, etc., during the quarantine period. These effects have inspired debates concerning the carrying capacity of destinations and the definition of tourism sustainable strategies with the aim to reduce the negative social and environmental effects of tourism activities. The research points out the necessity to realize sustainable tourism trajectories to grasp positive consequences for lower emissions, place-based economic development, and tourism practices [99]. As social distancing will continue to be a relevant matter in the future, tourists will seek to avoid crowded tourist attractions. Therefore, a redesign of tourism experiences by promoting outdoor activities and nature-based tourism.

Tourism sustainable development has become a critical issue for future development trajectories [10,51,80]. The path to recovery needs to be based on a sustainable tourism model that boosts the efficient use of natural resources while producing less waste and addressing the challenges of climate change and biodiversity [100].

Technologies could play a vital role to play to accelerate and scale sustainable development [101] by enabling access to information and services; increased connectivity between individuals, organizations, and networks; as well as efficiency from improved productivity and resource efficiency [102].

5. Conclusions

The COVID-19 pandemic brought a very large volume of studies and specialized works as well as a new paradigm of how the human factor uses technology to optimize the

value chain of tourism, especially in the context in which certain problems are caused by the pandemic are avoided through technology.

In the past years, different crises have shocked the tourism sector [103], which has usually bounced back, demonstrating its remarkable resilience to mitigate sudden breakdowns in demand or supply [104–106].

However, although crises create immediate losses for tourism, research has proven that crises offer opportunities for innovation and the restructuring of productive facilities [107]. McKinsey and company [108] suggest that the pandemic is "not only a health crisis of immense proportion" but that it is "also an imminent restructuring of the global economic order' as a result of the economic impact of virus suppression, potentially including the nature of international tourism as an economic and social phenomenon".

First, we agree that tourism is one of the main actors of the economy [109]. Indeed, today, we have entered the era of the fourth industrial revolution, i.e., industry 4.0, where digital technologies are affecting all processes activities and actors in the society as well as business public and private, thus creating novel opportunities and values [11,12].

Therefore, the current crisis raises important questions about how firms can use technology to respond effectively to crises such as the COVID-19 pandemic. While technology has always been a core element in the tourism industry, its role in tourism recovery in the post-COVID era becomes more fundamental. The new demand for tourism services will be associated with a need to restructure spaces and capacities, redesign tourism experiences, adopt new standards and regulations, and institute new operational activities, especially related to safety, hygiene, sanitization, social distancing, and the like.

In this article, through a structured literature review, we showed that digital technologies and applications are essential for the tourism sector's resilience, competitiveness, and recovery.

Technology has become a major factor in building resilience in tourism [2,100]. Digital technology, such as social media, big data analytics, artificial intelligence, robotics, and virtual reality, are helping travelers as well as tourism companies to cope with the current crisis. Relevant challenges for all tourism stakeholders to convert this crisis disruption into transformative innovation [2,85,110–113] become crucial for their performance and survival.

The use of technology will change the way of working for tourism firms. Robots and automated machines can help in many operational activities at accommodation structures, airports, airlines, etc. These technologies could also be employed for performing some human-based activities, such as cleaning and sanitization but also for food delivery and other services, thus protecting employees and customers from infections. On the other hand, artificial intelligence technologies, big data solutions, and chatbox will become effective tools for redesigning and rethinking marketing, sales, booking, communication, interaction, visitors flow management, mobility tracking, understanding customer behavior and preferences, and planning and decision-making processes.

Although adopting and handling such technologies may be a challenge, especially for travel and tourism SMEs, they are essential for post-COVID competitiveness and for enabling confident travel experiences. Gartner predicts that, by 2024, automation technologies combined with process redesign will lower operational costs by 30% [114].

In addition, the need for sector reskilling and upskilling is compulsory. While some *jobs* in the sector will be displaced by the adoption of automation and technology, new job opportunities open up related to artificial intelligence, big data, and digitalization of processes and services. On the other hand, digital skills upgrades for tourism staff are necessary for dealing with digital marketing, organization of virtual experiences, handling new advanced solutions and tools for decision making, and creating and delivering digital content and information. We believe that technology will substantially change the future of work of the sector.

From a practical point of view, we have shown the general agreement that technology provides the high potential to help companies to restore operations more quickly and

in safety and help migrate to a new era for hospitality characterized by the dawn of machines and social distancing. A process redesign becomes compulsory for tourism firms to deal with the new post-COVID situation. Technology can empower process redesign with smart applications and solutions. Technology can support the automatization of some industrial processes, such as check-ins, check-outs, self-service, and personalized experiences. Different mobile apps are already being used to provide touchless services. Furthermore, solutions for touchless payments, bookings, orders, reception, and food delivery are available and could be transferred to the tourism sector as well.

From a *theoretical point of view*, this paper highlights some new research streams for guiding the transformation of the sectors. To adapt quickly to the post-COVID-19 period, tourism needs to consider the deep insights coming to the changes in consumers' psychology and behaviors and redesign and rethink and adapt their marketing strategies accordingly as well as their business models.

An essential role in the pandemic period and in the technological era is played by education in the field of tourism, and the paper [73] supports an "integrated model of acceptance of technology (TAM) and the theory of planned behavior (TPB)". Education and digital technologies in the tourism industry are a priority; [33] argued that "robots and artificial intelligence (AI) technologies are becoming increasingly important in the tourism industry". Alongside the current challenges are also green sustainable tourism, and [115] presented "a roadmap on how information technology can be used to enhance the safe experience of cultural heritage throughout the world the journey of visitors within the integrated ecological ecotourism for health".

The future of digital tourism after the COVID-19 pandemic emergence is under-researched, and it requires a more in-depth study to systematize and identify future research agenda in this field [10,63]. Therefore, some recommendations for future research agenda can be:

How will technologies help the tourism industry meet the challenges posed by COVID-19?

How will COVID-19 change the tourism business models?

How will different steps of the value chain be impacted?

Which skills, competencies, and capabilities are required for leading the post-pandemic transformation of the tourism value chain?

What is the long effect of COVID-19 on the tourist's thinking and feeling and behaviors?

What will be the role of digital transformation in the resilience of the tourism sector?

How and in what way can the tourism supply chain actors redesign the value network and proposition the sector according to the sustainable principles?

What is the role of technological advancements in the transition towards a sustainable tourism model?

What is the role of tourism technology entrepreneurship initiatives in redefining new value propositions?

Limitations: Like all studies, this research has its limitations. First of all, the timing issue of this research constitute a limitation. We reviewed the academic publication in the English language and published during the pandemic period; therefore, the literature considers a small sample of articles, and it also included commentaries and short communications. Secondly, the methodological approach has its drawbacks. Indeed, it has been argued that while bibliometric analysis techniques are an effective method for analyzing a large amount of literature, it does not obtain the reason for co-citations, or in some situations, it increases the visibility of literature review articles that are characterized by references [1,116].

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