Identifying the research advances on COVID-19, the economy and the environment: network-bibliometric analysis and statistical validation

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Research Article

Keywords: Coronavirus, economy, environment, research production, bibliometric analysis, social network analysis, community detection

Posted Date: December 16th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1142513/v1>

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5 Abstract

6 The COVID-19 outbreak highlights the need for urgent research. The current corpus of COVID-19
7 publications is increasingly rising. In the course of scientific production, social and environmental sciences
8 tend to be overlooked or even ignored. Environmental Economics lags behind a variety of other fields on our
9 scholarship. This paper addresses the current research and development level in Coronavirus disease, the
10 economy, and the environment. To achieve these ends, a bibliometric analysis of these three interwoven areas
11 is performed. The bibliometric analysis allows the synthesis of the current literature and shows the relevant
12 patterns in research as the most relevant thematic "cores". These items can be used to interpret the existing
13 literature but also to identify relevant future developments. We created a database of all the central
14 publications within the scientific literature and listed the key terms associated with each publication. To
15 discover the structural characteristics of the co-occurrence network, we measured the density and the centre.
16 Four statistically significant groups are recognised as literature semantic cores, including environmental
17 health, economic effects and lifestyle, presenting the highest possible interconnection. It is discovered a
18 relationship between the Coronavirus and the economy and that this relationship exists in Environmental
19 Economics. The analysis of environmental aspects and environment-economy interplay within the current
20 Coronavirus pandemic claims a more punctual academic development, resulting not yet significant and
21 scarcely explored and signals the need to improve public and environmental health scholarship response.

23 **Keywords:** Coronavirus; economy; environment; research production; bibliometric analysis; social network analysis; community
24 detection.

25 **JEL codes:** C02, I15, I18, O13, Q56

26 **Introduction**

27 COVID-19 pandemic has highly influenced every aspect of life worldwide. Several research
28 activities have been undertaken to better analyse and explore the causes, the treatment, but also the
29 prevention of the new Coronavirus as the epidemic continues to develop (Acter et al. 2020). One of
30 the main research objectives is to analyse the effects of the relationships between the COVID-19,
31 the economy and the environment. In this context, urban dynamics are determinant. In fact, the
32 effects of the pandemic on global cities need to be clarified and some relevant lessons need to be
33 learned on urban planning and design for post-COVID (Sharifi and Khavarian-Garmsir, 2020).
34 Early studies on the effects of the COVID-19 on urban growth consider primarily four main themes:
35 the quality of the environment, the social and the economic impacts, the urban designs related to
36 transport, and governance and management issues (Sharifi and Khavarian-Garmsir, 2020).

37 Also, water-related impacts are evolving as effects related to the COVID-19 pandemic. These
38 effects include measures to recognise those impacts and prevent future impacts both on the water
39 ecosystem and human health (Bandala et al., 2021). The impacts of COVID-19 is also the central
40 topic pursued by Shakil et al. (2020). The authors determine some groups in the recent research
41 corpus – namely, the deterioration of the environment and COVID-19, the pandemic and air quality,
42 COVID-19 and climate/metrological variables, and temperature and COVID-19. The authors
43 suggest a research agenda on COVID-19 and climate (Shakil et al., 2020). Zambrano-Monserrate et
44 al. (2020) show a significant relationship between anti-COVID-19 policy measures and the
45 environment. The authors note an amount of negative impactful factors, and a decrease in recycling
46 and a waste production increase. Consequently, land, water, and air are exposed to danger by
47 pollution and contamination. Finally, the authors note some improvements in clean beaches, air
48 quality, and lower environmental noise.

49 The reviewed studies are of great relevance but show the need for an objective approach. Here
50 comes the relevance of bibliometrics. By using bibliometric analyses, it is possible to map a

51 research area, and in this way, to represent the connections between the various publications and the
52 authors on the field. At the same time, it is possible to determine the most relevant works within the
53 existing literature (El Mohadab et al., 2020).

54

55 **Current Environmental Economics research on Coronavirus**

56 Bibliometrics has inherently addressed the issue of mapping existing publication record and pulsing
57 research question. The technique is of worth to examine hot bottom issues and, specifically,
58 ecological and global health topics as the ongoing COVID-19 pandemic (Gatto and Drago 2020a, Ho
59 and Gatto 2020, Gatto et al. 2020). Therefore, acquiring swift data and mapping on preliminary
60 research amidst the current pandemic is a priority and motivates the importance of this study.

61 To date, limited research on converging social and environmental sciences topics has been conducted
62 to investigate the 2019 Coronavirus. The topic poses delicate questions when it comes to the quality
63 of academic information, scientific cooperation and, broadly, data availability with the scope to
64 expedite and improve sound research (Homolak et al. 2020). Intuitively, the vast majority of papers
65 have been published in health science and related disciplines (Ho and Gatto 2020). Yet an array of
66 works on the economic impact of the Coronavirus on economic activity have been published (see
67 Fernandes 2020). Adding to this, the relations between Coronavirus, sustainability and development
68 emerges as an urgent matter to be examined (UN News 2020). This research field is receiving
69 increasing scientific attention (Gatto et al. 2020).

70 The current work aims at extrapolating and depicting up-to-date literature on the Coronavirus-
71 economy-environment nexus. Following Liu et al. (2018) nexus approaches allow analysing to
72 concurrently the existing interactions between different sectors. The authors highlight the issue that
73 solving one problem can possibly lead to the exacerbation of another problem. In this context, it is
74 necessary to explore the systems to discover different situations in which trade-offs exist between

75 sectors and relevant potential synergies. Nexus approaches have the expressive potential to promote
76 better governance and management practices. The aim is discovering relevant synergies and trade-
77 offs using quantitative techniques (The Lancet Digital Health, 2021; Kurian, 2017).

78 The study makes use of bibliometric analysis, network analysis and community detection with the
79 objective to extract the semantic core from the literature on COVID-19, the economy and the
80 environment. The semantic core is based on the most relevant keywords that appear strongly
81 connected within the co-occurrence network identifiable once inspecting the existing literature. The
82 semantic cores also show different concepts which can be potentially part of the nexus (the advantage
83 of bibliometric analysis is their capacity to connect multiple relevant concepts in the scholarship by
84 multiple sectors). The paper proceeds by detecting the call for explorations in Environmental
85 Economics related to COVID-19 motivated by the lack of investigations – as compared to other
86 disciplines. In this vein, the bulk of existing papers is detected, statistically analysed and discussed.

87 Following, the data and methodology used are approached. Here we present the perspective followed
88 to examine the identified literature. Furthermore, we disentangle the underlying detection exercise
89 run to detect the most relevant concepts in the literature. Hence, results are presented and assessed.
90 From the exploratory analysis of the bibliometric data, we analyse the network structure and the
91 relevant groups of keywords on these publications – i. e. the semantic cores. In that context, we
92 consider as a hypothesis the community stability as a way to validate our findings. So we use
93 computational inference in order to test the stability of our semantic cores. Where the null hypothesis
94 is reached, we can determine if we are in presence of significant structured contents in our literature.
95 Concluding remarks close the paper. The Appendix shows the different membership for the keywords
96 considered on the work, divided by community membership.

97

98 **The call for social science-environmental research on (the) pandemic(s)**

99 The emergence of Covid-19 has been globally relevant and disruptive. Rapid health, governance and
100 practice response has emerged, along with the need for preparedness and resilience action to contrast
101 emerging vulnerability (Gatto and Drago, 2020a). Cooperation in diverse areas has shown to be
102 compulsory to avoid the insurgence and spread of the outbreak. So was the need for tailored and
103 interdisciplinary research (Ho and Gatto, 2020). It arises the need to organise a response from national
104 governments and the inter-governmental organisations – above all the WHO – as for health policies
105 indications (WHO 2020). It results that environmental health is the centre of our analysis and is
106 nowadays related to the adequate design of public health policies.

107107

108 **Bibliometric analysis and Scopus database**

109 In order to analyse the literature related to COVID-19, the economy and the environment, it is made
110 use of the following query from Scopus – chosen as a prime bibliographic databases see Falagas et
111 al. (2008):

- 112 - “COVID” or “Coronavirus” or “COVID-19”;
- 113 - and “economy”;
- 114 - and “environment”.

115

116 The query was lastly performed the day 11/6/2020. From the results, we are able to construct the
117 bibliometric dataset and perform the data analysis. The whole bibliometrics methodology used is
118 visualised in **figure 1**. The procedure is based on four phases:

- 119 - firstly, we analysed the bibliometric data with exploratory statistical techniques;
- 120 - then, from the original data we derived the keywords co-occurrence networks;
- 121 - hence, we perform the structural analysis of the network;

- finally, from the sorting network, we are able to decompose the network by identifying the “communities” of keywords that are maximally connected.

More particularly, an exploratory data analysis is performed to examine the structure of the existing literature on these topics at the date. From the extraction, we obtain 15 articles that are simultaneously relevant for the “COVID”, or “Coronavirus” or “Covid-19”, the “economy” and the “environment”. The outputs from the resulting bibliometric and statistical analysis (see Aria and Cuccurullo 2017) show a fragmented scenario. All the sorting articles were published in 2020, and each author shows a maximum of one publication in the reviewed literature.

The core of the literature analysis lies in network exploration. This analysis allows for exploring the sorting network (Wasserman Faust 1994). We consider the keywords being relevant piece of information to analyse the literature structure. We start from the adjacency matrix of the different co-occurrences of the keywords. Thus, in each article, we can observe the co-occurrence of the different considered keywords.

Co-occurrences networks are a key element in bibliometric analyses (Van Eck Waltman 2014). The analysis of the co-occurrences allows examining keywords occurring simultaneously in different articles. We consider publications that are characterised by the same keywords in the title or the abstract. Analysing the co-occurrence network allows discovering relevant statistical patterns related to a single topic. In fact, the most central keywords in the co-occurrence network constitute the most central topics in the literature. The high-central keywords on the co-occurrence network are recurrent themes within the literature and each connected keyword shows the presence of both the keywords in an article.

The final network is based on 94 vertices or nodes and 1674 edges or links. Where a co-occurrence of a keyword on the article exists, we can observe a single link between the two keywords. The first

146 step is to analyse the network structure. **Figure 2** shows a visualisation of the different steps of the
147 analysis: a structural analysis of the network based on the analysis of the general features of the
148 network (for instance the density) is first performed. Then, we identify the most central concepts of
149 the network. Lastly, we are able to decompose the network to find the relevant groups of keywords
150 presenting the maximal mutual interconnection.

151 For this scope, it is possible to analyse some structural indexes, showing their relevant characteristics
152 (Wasserman Faust 1994, Csardi Nepusz 2006). These features are useful to introduce the analysis of
153 the centrality of the network. This aspect is truly relevant in our work, being associable with the
154 identification of the most relevant keywords of the literature (see also Borgatti 2005 on centrality and
155 network flows). In fact, the feature of having a central position on the network means displaying a
156 particular role in the literature. For this reason, it could be important to observe these keywords since
157 these can be considered the most substantive concepts to refer to in this literature.

158 We took into account two relevant centrality indexes: the Freeman degree and the betweenness. Both
159 the indexes are cardinal and are oriented to measure different centrality patterns. In the first case, we
160 can consider a centrality index which measures the “local centrality” of a node, whereas in the second
161 case it is displayed a centrality index which measures the “global centrality” of a node (Bader et al.
162 2007). From the analysis of both the centrality indexes, we are able to identify the most relevant topics
163 in the literature.

164 Lastly, we took into consideration the different community structure of the network (Fortunato and
165 Castellano 2007, Lancichinetti and Fortunato 2009, Drago Ricciuti 2017, Drago 2017, Drago
166 Balzanella 2015) whereby we are able to identify relevant groups of different keywords which tend
167 to be linked more intensively each other with respect to the other groups. The different “communities”
168 shows relevant characteristics.

169 Communities are groups of keywords that are highly connected to each other – so they are many
170 times co-occurrent on the same papers – and weakly connected with the keywords which are part of
171 other communities (Fortunato 2010).

172 The identified communities are groups of co-occurrent keywords that can be found in different
173 articles. These keywords show a unique relevant “semantic core” albeit being part of different articles.
174 Analysing the diverse keywords that are part of these communities, it is possible to retrieve and
175 extract some related and important concepts which allow summarising the literature. This way, it is
176 possible to conclude that communities allow interpreting the hot themes and topics in the literature
177 thanks to their logical interconnections.

178 We detect the different communities assessing the “walktrap” algorithm (Pons Latapy 2005). This
179 algorithm identifies the nodes that are part of the same group of maximally connected nodes. Short
180 random walks in the network tend to remain on the same group of nodes or in the same community
181 (Csardi Nepusz 2006). The walktrap algorithm identifies the nodes in which these random walks tend
182 to stay.

183 The community detection approach diverges from the cluster analysis because, making use of the
184 former, we are explicitly partitioning the network to identify the nodes which show mutually a higher
185 level of connectivity as a group. The cluster analysis does not necessarily involve mutually
186 interconnected nodes. That is why the membership can be interpreted as relevant groups of nodes
187 inside the network. The identified communities are also validated considering an approach based on
188 a test on the stability of the partitions against random perturbations of the initial network (Carissimo
189 et al., 2018). This procedure is useful to support the significance and the robustness of our results. In
190 order to better understand the relationships between the keywords on the communities identified, an
191 additional exploratory analysis is performed on the “aspects of life”, starting from the results of the
192 first bibliometric analysis.

193193

Figure 1: Bibliometric methodology used

209 Statistical results on preliminary research

210 From the main outputs, we get a statistical analysis of the literature considered. More detailly, we
211 start from the characteristics of the works, in which we observe 14 different sources, for all the works
212 of the literature, 94 keywords plus (ID) and 86 author's keywords (on average 6 keywords per article).
213 For the period considered (1 January 2020-11 June 2020), it is noticeable a number of citation of 0.13
214 where the figure of the authors is on 110 on all the papers. Each author has got 0.136 articles, and the

215 number of authors per document is 7.33. Only 3 authors out of 110 are single authors within the
216 articles. It is possible to conclude from this part of the analysis that the literature is fairly scattered.
217 The result is confirmed from the publishing journals evaluation. All the journals scrutinised have
218 published only one article on this literature.

219 The higher number of published works in a journal on a topic is an important signal for the researcher:
220 the higher number of publications and citations means a higher interest in the same topic and the
221 capacity to attract readers. Overall, a good research strategy using bibliometric analyses may be to
222 submit to journals in higher ranks because they are probabilistically interested in the topic and can
223 attract more readers and citations.

224 The most cited papers show an extremely shattered scenario. At the same time, the most productive
225 countries and also the most cited by publications, show a very similar situation. There are some
226 “dominant” countries, yet the values are not so high to be significant.

227 It is also interesting revealing the different mentions to relevant keywords in the articles. Intuitively,
228 the most relevant keywords are related to the COVID-19 and so we observe “Covid-19” (11 mentions)
229 “pandemic” (5 mentions) and “Coronavirus” (3 mentions), “Health” and “SARS Cov-2” (2 mentions)
230 each. It is worth to notice the results robustness: we obtain from the keyword-plus analysis a very
231 similar output. The first keyword, in this case, is “Coronavirus Disease 2019” (3 mentions)
232 “Pandemic” (3 mentions) and then a cohort of other keywords, each one mentioned 2 times.

233 The analysis of the network is represented in **figure 3**, which sketches the visualisation of the different
234 concepts obtained. From **figure 3**, we observe a very dense network and, at the same time, the most
235 central keywords of the entire network. Therefore, it is possible to analyse the network more in detail.
236 From the network statistics, we are able to understand the relevant features of the literature
237 considering the occurrences between the different keywords.

238 The number of keywords studied in the network is 94. The network can be considered dense being
239 the keywords density 0.383. Their transitivity is 0.859, the diameter is 2, the degree centralisation is
240 0.488 and the average path length is 1.506.

241 At this point, we can figure out the specific centrality structure of the network by analysing the
242 centrality. The two different centrality indexes show different characteristics since they confirm the
243 same results. These indexes tend to have the same results. The correlation of the two sorting measures
244 is 0.64, showing a higher level of association between the two measures. This could be interpreted
245 with the fact the network structure propends to be central and the different nodes that have a higher
246 degree. For this reason, their trend is more locally-centred on the network and tend to the centre once
247 examining the entire network structure. These nodes can be assessed as the most central and
248 prominent ones of the entire network.

249 The nodes which show the highest centrality are the following keywords: “Coronavirus disease
250 2019”, “pandemic”, “public health”, “article”, “economic aspect” and finally “human”. These nodes
251 are those which show higher prominence on the network, so they shall be the most pertinent topics to
252 be considered for future research because these topics seem to be the most interesting ones for the
253 authors involved in this literature. These nodes also indicate the importance of LCA analyses
254 associated with these relevant themes in the literature. Following Kumar et al. (2020), LCA is deemed
255 to be a relevant tool, used with the aim to identify the environmental effects and materials used in the
256 product's life cycle. The considered phases start from the acquisition of raw materials and arrive at
257 the waste management. In this respect, LCA allows the measurement of the aggregate and the
258 substantial environmental impacts of products considering all the product life cycle phases.

259 Kumar et al. (2020) say that in the context of the pandemic, the PPE (Personal Protective Equipment)
260 kits have increased in clinics and other healthcare facilities intending to minimize viral infections. In
261 this context, the PPE kits that may be extremely hazardous must be treated and disposed of
262 appropriately to prevent public health, land, and marine environments from being polluted (in our

263 analysis “environmental factor” and “public health”). The authors conclude that decentralised
264 incineration has been recognised as an environmentally sustainable management choice in contrast
265 with the centralised incinerator. The effect of transportation is also essential and often ignored. So
266 considering this context, the author reputes relevant to explore and promote decentralised disposal
267 strategies, namely a source of successful waste management, recognising various crucial elements
268 as handling, storage, or risks connected to transportation (Kumar et al. 2020).

269 These nodes also indicate the centrality of concepts connecting with COVID-19, Environment and
270 Economy. This paves the way for the investigation of the social dimension of the crisis. Importantly,
271 the UN (2021) repute that COVID-19 is concurrently a health crisis, a public health tragedy, and an
272 economic crisis (but also a humanitarian disaster, a crisis of human rights and stability). The economic
273 crisis has heavily impacted the economic systems determining a worsened recession. This crisis has
274 also determined increased poverty and inequality rates. Following the UN (2021), the analysis of the
275 social dimension is particularly relevant in Latin America and in the Caribbean. Deforestation and
276 changes in land-use have been growing in this region (yet there are lower emissions). In addition,
277 this area has shown to be extremely vulnerable to extreme weather events and natural hazards and
278 major events caused or exacerbated by climate change – leading to worsened climate justice (Cisco
279 and Gatto, 2021).

280 The final analysis is conducted to extrapolate the community structure of the network. The final
281 analysis is conducted to extrapolate the community structure of the network and evaluating its
282 stability and significance. In this respect, it is necessary to evaluate if the community structure
283 detected by the algorithms used is just a consequence of chance or is statistically significant
284 (Carissimo et al., 2018). From the “walktrap” algorithm we are able to detect 4 communities
285 observing the whole network structure. The different communities are presented on their keywords
286 members in **Appendix**. The different communities show different patterns of centrality. Community
287 1 is the most central amongst the other three and represents all the relevant themes in this literature.

Community 2 shows the relevant biological and medical concepts which can be impacted by the virus and successively community 3, are connected with the role of international institutions and their key position in disease prevention. Finally, community 4 can be interpreted as an interesting category: it mixes aspects that are intertwined with the environment, health care and health insurance. This aspect can be of interest because represents a marginal topic as a group of keywords in the network which can have some great potentialities to increase.

All the findings are sketched in **table 1** and **table 2**.

Figure 2: Structural analysis

Uncertainty analysis: Coronavirus or Covid-19 and aspects of life

309 The query was performed on the Scopus database. The results are compared with the initial
310 bibliometric results. We replicate all the analyses we have already performed with the goal to evaluate
311 the relationship between Covid-19 and lifestyle. It is interesting to note that the lifestyle is also present
312 in the communities related with the first analysis and there was associated with aspects as “chronic
313 disease” and “immune-deficiency”, “immune system” and “vulnerable population” (community 2).
314 These aspects link relevant concepts as vulnerability to the lifestyles.

315 It is possible to investigate more in detail the aspects of lifestyle which are investigated in this
316 literature. On the second community detection performed using the second bibliometric analysis, we
317 found two communities: in the first one we found concepts as “oxygen therapy”, “quarantine” and
318 “virus transmission”, whereas in the second one we found as relevant words “pandemic”,
319 “coronavirus infections” and “disease transmission” “infection control” and “practice guideline”.
320 Following Carissimo et al. (2008) also in this case, testing the significance of the identified
321 community structure we can conclude, this is not a simple outcome due to chance (figure 7).

322 The results can be summarised interpreted through the lens of the following works: Acter et al. (2020),
323 Sharfuddin (2020) and D’Adamo et al. (2020). Examining the short run, the keywords extracted show
324 that the literature pivots around potential ways of controlling the infection by Coronavirus disease. In
325 this respect, the focus is on aspects related to lifestyle. These considerations are related both to normal
326 life as rules to avoid disease transmission, but also key rules related the medical practice (for a general
327 overview see Acter et al. 2020, and Ali and Alharbi 2020). Lifestyle also includes nutrition, which is
328 strictly intertwined with environmental quality and health (Agovino et al., 2018).

329 The publications also stress the importance of preventive measures – for instance, the role of hygiene
330 and sanitation on the spread of Coronavirus disease. These are quite relevant in determining correct
331 lifestyles against Covid-19. This is the case for “washing hands” (one of the relevant extracted
332 keywords from the community) and in general careful hygienic measures (keeps hands away from
333 eyes, mouth and nose), that seem to be amongst the compelling measures to avoid the virus

334 transmission. Similarly, time, social distance and an attentive lifestyle oriented to avoid crowds
335 constitute additional measures to be contemplated.

336 The emerging scholarship also highlights the symptomatology of Covid-19 which needs to be
337 carefully checked to allow prompt medical response useful to avoid the virus transmission. Measures
338 and prophylaxes such as “quarantine” and “social isolation” (community 1 in the second bibliometric
339 analysis performed) can be considered determinant to avoid the spread of the virus.

340 Environmental factors are crucial factors also when it comes to lifestyles. A decisive research point
341 discovered concerns whether the seasons and the meteorological conditions can have an impact on
342 the disease spread. This implies that lifestyles should be addressed to minimise the risk of
343 transmission of the disease in every climatic situation. A case study can be heating: “artificial
344 ventilation” and “air conditioning system” should be carefully evaluated and a “respiratory etiquette”
345 maintained in closed spaces (see Lu et al, 2020 regarding the role of air conditioning in expediting
346 the spread of disease to populations). Respiratory etiquette is another relevant behaviour in modern
347 lifestyles – for instance, coughing or sneezing into the elbow or arm (as “preventive measures” in
348 community 1 of the first community in the additional bibliometric analysis – see also Zayas et al.
349 2020).

350 The virus outbreak has had an impact on lifestyle, affecting the daily lives of millions of people. In
351 fact, the pandemic determined, in the short run, massive job losses, whereby entire economic sectors
352 and businesses have experienced severe damages, shut down and even bankruptcy (Saadat et al.
353 2020). Conversely, this situation determined, in the short term, reduced water pollution and improved
354 air quality. Nevertheless, this evidence needs to be evaluated considering the long-run and the
355 disruptive impact of Covid-19 on the economy as we have observed on the main bibliometric analysis
356 performed. The reduced water pollution, the improved air quality and in general the lower impact on
357 the ecosystems and climate change lead to changes in behaviour not only in humans but also in other
358 beings on the planet, in the whole ecosystem and in diverse complex systems (see Paital 2020).

359 Discussion and concluding remarks

360 In this work, we have dealt with bibliometric techniques with the scope to extract prime findings on
361 the intersection literature on the 2019 Coronavirus, the economy and the environment. The analysis
362 aimed to extract the most pertinent semantic cores (see Drago and Hoxhalli 2020). The use of the
363 semantic core aimed at the identification of the foremost groups of keywords within the publications
364 for detecting the literature development.

365 Bibliometric techniques (see Su et al. 2020, and Drago and Amidani Aliberti 2018) had relevant
366 applications in the study of the Coronavirus and Environmental Sciences (John et al. 2020, Lou et al.
367 2020). Amongst the advantages of the bibliometric techniques, it is paramount the capability to allow
368 the synthesis and the analysis of many scientific works and results. This approach can be usefully
369 applied to the analysis of the literature on environmental and economic issues related to the
370 Coronavirus.

371 Secondly, another important piece of information provided by bibliometrics is to allow some
372 replaceable analysis and metrics whilst investigating some of the most relevant literature findings.
373 More particularly, a bibliometric analysis allows assessing quantitative research, identifying the most
374 cited works and authors. This methodology permits to identify of the most relevant publication topics,
375 productive countries and patterns of scientific cooperation – responding to specific needs. Mapping
376 related scholarship, bibliometrics considers the co-occurrence amongst existing keywords, with the
377 aim to study the most relevant topics and their relationships.

378 The work presents some elements of novelty: it combines the existing literature to find meaningful
379 results from the previous findings in the existent one. The bibliometric studies and the literature
380 reviews are very relevant nowadays because they allow the combination and synthesis of the current
381 results. Simultaneously, these methodologies allow a better understanding of the relationships
382 between relevant concepts and themes. Following Ziegler (2009), the classification and arrangement
383 of information is the aim of the field of library and information science. Bibliometrics is fundamental

384 to analyse the different interlinkages between multiple fields and topics. By considering the citations
385 mentioned in each series of articles, bibliometrics may also be used to evaluate a specific article's
386 relevance to a particular field.

387 As limitations, bibliometric techniques do not necessarily cover all existing articles – for instance, it
388 does not include grey literature. Another limitation is that bibliometrics tends to take in to account
389 the scientific literature published in English with respect to papers published in other languages.
390 Lastly, citations are not necessarily associated with quality (Wallin 2005). The relationship between
391 quality and citation can largely deviate. Further criticisms exist when using bibliometric techniques:
392 primarily, it does not necessarily exist a statistical relationship between quality and citations. So from
393 one side, it is possible to observe that bibliometric indicators do not necessarily synthesise the “impact
394 of an article” or the “impact of a piece of research”, as a latent concept which is multidimensional by
395 nature and so it is difficult to be measured (see Haustein and Lariviere 2015). Finally, non-scientific
396 reasons can motivate the different citations behaviours. In this sense, research findings often show
397 other variables – partly non-scientific – which play a role in the citation decision (see Bornmann and
398 Daniel, 2008). So the networks of co-citations cannot reflect “true” representation of the existing
399 scientific linkages and references. The results indicate wide room for improvements on these topics.
400 We found evidence of possible gaps in this literature due to the fact we obtained different
401 communities. Furthermore, some interesting topics seem not to be fully covered. Another main
402 finding is that the journals in the investigated research field – the closest to Environmental Economics
403 – show a higher level of fragmentation: every journal has published on these topics at maximum one
404 article (with the exception of the Journal of Business Research with two publications). The trendiest
405 topics are connected with the Coronavirus (or COVID-19 or Covid) and health. Also in this case, it
406 is remarkable the existence of various possibilities to consider new topics and streams of research
407 related to the environment which are not considered in this literature. We can conclude that the

408 network analysis, and more importantly the community detection, is determinant to show prior
409 features of the inspected literature.

410 The outputs suggest that the primary nodes of networks are informative for detecting the relevant
411 literature gaps. The journals show higher fragmentation so they are not that relevant to show some
412 particular pattern. Conversely, the topics result of primary importance. This implies that this result is
413 rendered via the comparison of the community detection exercise with the structural analysis outputs.
414 This conclusion allows extrapolating the most central keywords within the network. Intuitively, these
415 are related to the Coronavirus. We also appreciate major interconnections with nodes that are related
416 to economic activity.

417 Selected Environmental Economics implications arise. Where the economic impact of the
418 Coronavirus is tremendous, the impact on the global environment should be investigated (Bateman
419 et al. 2020). In this respect, it is necessary to follow the reasoning of Helm (2020) and exploring the
420 environmental impacts of the COVID-19. These pieces of evidence are also related to the fact that
421 policies were usually directed on the containment of the spread of the outbreak. Evaluating a higher
422 range of impacts on the environment, it could be necessary to consider sound policies (OECD 2020).

423 In order to analyse and discover holes in the literature, we tried to investigate the nodes or keywords
424 – namely, the members of the different communities extracted. More precisely, the approach is based
425 on identifying the communities and then testing the stability of the communities found. Following
426 Carissimo et al. (2018), we test the significance of the detected communities against random
427 perturbation of the network's initial structure. The computational procedure makes it possible to
428 conclude on the test whether there is a significant difference from the considered null model. The
429 results are represented in figure 4, 5, and 6, where we found the significance of the three identified
430 communities. That means a relevant semantic core on the topic, represented by the considered
431 interconnections of the co-occurrences, has been identified.

432 We found a set of co-occurrence communities that allow network decomposition. The first one relates
433 to the management of the emergence and focuses on the control of the disease spread, public health,
434 the environment and also the economic impact. The other communities are connected with lifestyle
435 and prevention of the disease, the role of education and also the importance of regulation in the long
436 run. The test allows concluding that these identified communities or semantic cores are statistically
437 significant and are not an effect. The procedures quantify where the clustering results obtained differs
438 significantly from the null hypothesis (or the null model, see Carissimo et al., 2018).

439 The first community can be interpreted as the one referring to health and environmental aspects on
440 the one hand and the longer-term economic ones on the other. The second community can be
441 conceived as the relationships between health and lifestyles. The third one focuses on the role of
442 education in the prevention of disease transmission. Lastly, the fourth community stresses the role
443 of regulation on disease prevention.

444 A first relevant point regarding the first community is the relevance of the “environmental factor” in
445 relation to the Coronavirus or the “disease spread”. To this end, resource sustainability, vulnerability
446 and resilience result crucial for environmental quality (Gatto and Busato, 2020; Gatto and Drago,
447 2020b). Various environmental factors can be considered relevant, for instance, climate and weather
448 (Shi et al. 2020). Another important “risk factor” (as a relevant keyword identified) is air pollution
449 (Martelletti and Martelletti 2020). Following Barceló (2020), air quality seems to be highly relevant
450 to the “Coronavirus infection”.

451 The themes on community 1 define in detail the aspects interconnected with the disease spread and
452 their dynamics that are associated with important risk factors as environmental factors. In line with
453 Barceló (2020), we find a mixture of different keywords related to the population (“population
454 growth”, “population risk”), the meteorological factors, linked also to mobility (“migration”) could
455 be interpreted as key elements in the articles covering the Covid-19 spread of the disease (“disease
456 transmission”).

457 To match this scope, we identify a group showing an intriguing relationship, being part of the same
458 group of relevant nodes as “environment”, “health care need” and “law”. Where these nodes are not
459 central considering in the centrality indexes, we can conclude that they are not only interesting due
460 to the specific innovative research topic they show – they are indicative of the modality of how to
461 manage the regulation attached to the environment and health care need. This is a significative piece
462 of scientific novelty, signalling the transition from the mere impact notification towards the
463 indications on how to manage the impact, paving the way for paramount public health and
464 environmental health advances.

465 SARS-CoV-2 induced significant changes in lifestyle and behaviour – not only in humans but also in
466 other living beings on the planet, the whole ecosystem and complex systems. Starting from the result
467 in community 2, in order to provide an overarching understanding of the problem and potential
468 solutions, we have also investigated aspects of life as part of the keywords extracted. In order to
469 explore more in-depth the aspects related to lifestyle as additional exploratory analysis, we perform
470 a second bibliometric analysis considering Coronavirus or Covid-19 and aspects of life.

471 Overall, in the long run, relevant economic and social aspects emerge (business management and
472 overall economic). These are accompanied by broad environmental topics which are also connected
473 with health issues. These results complete the analysis we have performed and clarify initial results:
474 the economic aspects are paramount to manage and sustain the social systems, but lifestyles have
475 been dramatically affected and drastically changed by SARS-CoV-2. The latter represents potentially
476 a striking result to be managed at a macro level.

477 These changes relate to various aspects of life – for instance, the control of the infection, the measures
478 against the transmission of the disease but also the medical practice. Similarly, the health and
479 environmental risk factor can decisively impact disease transmission and pandemic. This is why, in
480 the long run, lifestyles, health and environmental issue, along with economic aspects, should be
481 carefully managed both at a national and international level.

482 The finding signals a major gap in the literature that needs to be considered for the future. The
483 usefulness of the results is that these signals allow to summarise the most relevant core themes in
484 literature but also to identify the most relevant relationships between the different considered themes.
485 Future international research can usefully explore additional key-themes departing from the relevant
486 semantic-cores, which are the most structured publications on the topic.

487 As a limitation and incentive for proceeding with future studies in these streams of research, a typical
488 technique adopted in bibliometrics may be exploited – that is the use of various keywords. The latter
489 method can resemble the network analysis and returns more detailed information on the concepts
490 studied as literature topics.

491 **References**

- 492 Acter, T., Uddin, N., Das, J., Akhter, A., Choudhury, T. R., & Kim, S. (2020). Evolution of severe
493 acute respiratory syndrome coronavirus 2 (SARS-CoV-2) as coronavirus disease 2019 (COVID-19)
494 pandemic: A global health emergency. *Science of the Total Environment*, 138996.
- 495 Agovino, M., Cerciello, M., & Gatto, A. (2018). Policy efficiency in the field of food sustainability.
496 The adjusted food agriculture and nutrition index. *Journal of environmental management*, 218, 220-
497 233.
- 498 Ali, I., & Alharbi, O. M. (2020). COVID-19: Disease, management, treatment, and social
499 impact. *Science of the Total Environment*, 138861.
- 500 Aria, M. & Cuccurullo, C. (2017) bibliometrix: An R-tool for comprehensive science mapping
501 analysis, *Journal of Informetrics*, 11(4), pp 959-975, Elsevier.
- 502 Bader, D. A., Kintali, S., Madduri, K., & Mihail, M. (2007, December). Approximating betweenness
503 centrality. In *International Workshop on Algorithms and Models for the Web-Graph* (pp. 124-137).
504 Springer, Berlin, Heidelberg.
- 505 Bandala, E. R., Kruger, B. R., Cesarino, I., Leao, A. L., Wijesiri, B., & Goonetilleke, A. (2021).
506 Impacts of COVID-19 pandemic on the wastewater pathway into surface water: A review. *Science of*
507 *The Total Environment*, 145586.
- 508 Barceló, D. (2020). An environmental and health perspective for COVID-19 outbreak: Meteorology
509 and air quality influence, sewage epidemiology indicator, hospitals disinfection, drug therapies and
510 recommendations. *Journal of Environmental Chemical Engineering*, Aug; 8(4): 104006.
- 511 Bateman, I. J., Neetzow, P., Eisenack, K., & Meran, G. (2020). EAERE, ERE and the Research
512 Challenges of the Coronavirus Pandemic. *Environmental & Resource Economics*, 1.
- 513 Borgatti, S. P. (2005). Centrality and network flow. *Social networks*, 27(1), 55-71.

514 Bornmann, L., & Daniel, H. D. (2008). What do citation counts measure? A review of studies on
 515 citing behavior. *Journal of documentation*.

516 Carissimo, A., Cutillo, L., & De Feis, I. (2018). Validation of community robustness. *Computational*
 517 *Statistics & Data Analysis*, 120, 1-24.

518 Chakraborty, I., & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global
 519 environment and prevention. *Science of the Total Environment*, 138882.

520 Cisco, G., & Gatto, A. (2021). Climate Justice in an Intergenerational Sustainability Framework: A
 521 Stochastic OLG Model. *Economies*.

522 Csardi G, Nepusz T (2006) The igraph software package for complex network research, *InterJournal*,
 523 *Complex Systems* 1695. <http://igraph.org>

524 D'Adamo, H., Yoshikawa, T., & Ouslander, J. G. (2020). Coronavirus disease 2019 in geriatrics and
 525 long- term care: the ABCDs of COVID- 19. *Journal of the American Geriatrics Society*, 68(5), 912-
 526 917.

527 Drago C (2017). MCA Based Community Detection. *Classification, (Big) Data Analysis and*
 528 *Statistical Learning*. In: (a cura di): Francesco Mola, Claudio Conversano, Maurizio Vichi,
 529 *Classification, (Big) Data Analysis and Statistical Learning*. *Studies in Classification, Data Analysis*
 530 *and Knowledge*.

531 Drago C., Amidani Aliberti L. (2018) "Interlocking Directorship Networks and Gender: a
 532 Bibliometric Analysis *Advances in Gender and Cultural Research in Business and Economics: 4th*
 533 *Ipazia Workshop on Gender Issues 2018, Rome, Italy*

534 Drago C, Balzanella A (2015). Nonmetric MDS consensus community detection. In: (a cura di):
 535 Minerva T., Morlini I., Vichi M., *Studies in Classification, Data Analysis, and Knowledge*

536 Organization. *Studies in Classification, Data Analysis, and Knowledge Organization*, vol. 50, p. 97-
537 105, Kluwer Academic Publishers,

538 Drago C. Ricciuti R. (2017) Communities detection as a tool to assess a reform of the Italian
539 interlocking directorship network *Physica A: Statistical Mechanics and its Applications* 466, 91-104

540 Drago C. Hoxhalli G. (2020) *Bibliometric Big Data Analysis in Economics*. Conference: IFKAD
541 2020 "Knowledge in Digital Age" Rome, Italy 9-11 September 2020

542 El Mohadab, M., Bouikhalene, B., & Safi, S. (2020). Bibliometric method for mapping the state of
543 the art of scientific production in Covid-19. *Chaos, Solitons & Fractals*, 139, 110052.

544 Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed,
545 Scopus, web of science, and Google scholar: strengths and weaknesses. *The FASEB journal*, 22(2),
546 338-342.

547 Fernandes, N. (2020). Economic effects of coronavirus outbreak (COVID-19) on the world economy.
548 Available at SSRN 3557504.

549 Fortunato, S., & Castellano, C. (2007). Community structure in graphs. *arXiv preprint*
550 *arXiv:0712.2716*.

551 Fortunato, S. (2010). Community detection in graphs. *Physics reports*, 486(3-5), 75-174.

552 Gatto, A., & Busato, F. (2020). Energy vulnerability around the world: The global energy
553 vulnerability index (GEVI). *Journal of Cleaner Production*, 253, 118691.

554 Gatto, A., & Drago, C. (2020a). A taxonomy of energy resilience. *Energy Policy*, 136, 111007.

555 Gatto, A., & Drago, C. (2020b). Measuring and modeling energy resilience. *Ecological Economics*,
556 172, 106527.

557 Gatto, A., Drago, C., & Ruggeri, M. (2020). On the frontline—Sustainability and development
558 research amidst the COVID-19 pandemic. Under review, World Development.

559 Haustein, S., & Larivière, V. (2015). The use of bibliometrics for assessing research: Possibilities,
560 limitations and adverse effects. In *Incentives and performance* (pp. 121-139). Springer, Cham.

561 The Lancet Digital Health (2021). Technology: the nexus of climate change and COVID-19?.Helm,
562 D. (2020). The environmental impacts of the coronavirus. *Environmental & Resource Economics*, 1.

563 Ho, Y. S, & Gatto, A. (2020). A Bibliometric Analysis of COVID-19 Research. Under review,
564 Nature.

565 Homolak, J., Kodvanj, I., & Virag, D. (2020). Preliminary analysis of COVID-19 academic
566 information patterns: a call for open science in the times of closed borders. *Scientometrics*, 1-15.

567 John, I., Kwofie, E.M. & Ngadi, M. Two decades of eco-efficiency research: a bibliometric
568 analysis. *Environmental Sustainability* 3, 155–168 (2020). [https://doi.org/10.1007/s42398-020-](https://doi.org/10.1007/s42398-020-00105-1)
569 [00105-1](https://doi.org/10.1007/s42398-020-00105-1)

570 Kumar, H., Azad, A., Gupta, A., Sharma, J., Bherwani, H., Labhsetwar, N. K., & Kumar, R. (2020).
571 COVID-19 Creating another problem? Sustainable solution for PPE disposal through LCA
572 approach. *Environment, Development and Sustainability*, 1-15.

573 Kurian, M. (2017). The water-energy-food nexus: trade-offs, thresholds and transdisciplinary
574 approaches to sustainable development. *Environmental Science & Policy*, 68, 97-106.

575 Lancichinetti, A., & Fortunato, S. (2009). Community detection algorithms: a comparative
576 analysis. *Physical review E*, 80(5), 056117.

577 Liu, J., Hull, V., Godfray, H. C. J., Tilman, D., Gleick, P., Hoff, H., ... & Li, S. (2018). Nexus
578 approaches to global sustainable development. *Nature Sustainability*, 1(9), 466-476.

579 Lou, J., Tian, S. J., Niu, S. M., Kang, X. Q., Lian, H. X., Zhang, L. X., & Zhang, J. J. (2020).
 580 Coronavirus disease 2019: a bibliometric analysis and review. *Eur Rev Med Pharmacol Sci*, 24(6),
 581 3411-21.

582 Lu, J., Gu, J., Li, K., Xu, C., Su, W., Lai, Z., ... & Yang, Z. (2020). COVID-19 outbreak associated
 583 with air conditioning in restaurant, Guangzhou, China, 2020. *Emerging infectious diseases*, 26(7),
 584 1628.

585 Martelletti, L., & Martelletti, P. (2020). Air pollution and the novel Covid-19 disease: a putative
 586 disease risk factor. *SN Comprehensive Clinical Medicine*, 1-5.

587 OECD (2020) "From containment to recovery: Environmental responses to the COVID-19
 588 pandemic" version 20 April 2020 [http://www.oecd.org/coronavirus/policy-responses/from-](http://www.oecd.org/coronavirus/policy-responses/from-containment-to-recovery-environmental-responses-to-the-covid-19-pandemic-92c49c5c/)
 589 [containment-to-recovery-environmental-responses-to-the-covid-19-pandemic-92c49c5c/](http://www.oecd.org/coronavirus/policy-responses/from-containment-to-recovery-environmental-responses-to-the-covid-19-pandemic-92c49c5c/) accessed
 590 the 12/6/2020.

591 Paital, B. (2020). Nurture to nature via COVID-19, a self-regenerating environmental strategy of
 592 environment in global context. *Science of The Total Environment*, 139088.

593 Pons, P., Latapy, M. (2005) Computing communities in large networks using random walks. In:
 594 Yolum, p., Güngör, T., Gürgen, F., Özturan, C. (eds.) *ISCIS 2005*. LNCS, vol. 3733, pp. 284–293.
 595 Springer, Heidelberg.

596 Saadat, S., Rawtani, D., & Hussain, C. M. (2020). Environmental perspective of COVID-19. *Science*
 597 *of The Total Environment*, 138870. Sharfuddin, S. (2020). The world after covid-19. *The Round*
 598 *Table*, 109(3), 247-257.

599 Sharifi, A., & Khavarian-Garmsir, A. R. (2020). The COVID-19 pandemic: Impacts on cities and
 600 major lessons for urban planning, design, and management. *Science of the Total Environment*,
 601 142391.

602 Shi, P., Dong, Y., Yan, H., Li, X., Zhao, C., Liu, W., ... & Xi, S. (2020). The impact of temperature
603 and absolute humidity on the coronavirus disease 2019 (COVID-19) outbreak-evidence from
604 China. MedRxiv.

605 Su, Y., Yu, Y., & Zhang, N. (2020). Carbon emissions and environmental management based on Big
606 Data and Streaming Data: A bibliometric analysis. Science of The Total Environment, Volume 733, 1
607 September 2020, 138984.

608 UN News (2020). “Urgency to act’ for sustainable development, greater than ever as coronavirus
609 pandemic continues” <https://news.un.org/en/story/2020/05/1063742> page accessed the 12/6/2020

610 UN (2021). “High Level Session: The Environmental Dimension of COVID-19 Sustainable
611 Development Recovery” XXII Meeting of the Forum of Ministers of Environment of Latin America
612 and the Caribbean Bridgetown, Barbados 1-2 February 2021

613 Van Eck, N.J., & Waltman, L. (2014). Visualizing bibliometric networks. In Y. Ding, R. Rousseau,
614 & D. Wolfram (Eds.), Measuring scholarly impact: Methods and practice (pp. 285–320). Springer.

615 Wallin, J. A. (2005). Bibliometric methods: pitfalls and possibilities. Basic & clinical pharmacology
616 & toxicology, 97(5), 261-275.

617 Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications (Vol. 8).
618 Cambridge university press.

619 WHO (2020) “COVID 19 Strategy Update” [file:///C:/Users/Unicusano%20admin/Downloads/covid-](file:///C:/Users/Unicusano%20admin/Downloads/covid-strategy-update-14april2020.pdf)
620 [strategy-update-14april2020.pdf](file:///C:/Users/Unicusano%20admin/Downloads/covid-strategy-update-14april2020.pdf) accessed 12/6/2020

621 Zambrano-Monserrate, M. A., Ruano, M. A., & Sanchez-Alcalde, L. (2020). Indirect effects of
622 COVID-19 on the environment. Science of the Total Environment, 728, 138813.

623 Zayas, G., Chiang, M. C., Wong, E., MacDonald, F., Lange, C. F., Senthilselvan, A., & King, M.
624 (2013). Effectiveness of cough etiquette maneuvers in disrupting the chain of transmission of
625 infectious respiratory diseases. *BMC Public Health*, 13(1), 811.

626 Ziegler, B. E. (2009). *Methods for bibliometric analysis of research: renewable energy case*
627 *study* (Doctoral dissertation, Massachusetts Institute of Technology).

628 **Appendix**

629 **Table 1. Statistical analysis of the literature**

630	\$MainInformationDF		
631		Description	Results
632	1	Documents	15
633	2	Sources (Journals, Books, etc.)	14
634	3	Keywords Plus (ID)	94
635	4	Author's Keywords (DE)	86
636	5	Period 2020 - 2020	
637	6	Average citations per documents	0.1333
638	7	Authors	110
639	8	Author Appearances	110
640	9	Authors of single-authored documents	3
641	10	Authors of multi-authored documents	107
642	11	Single-authored documents	3
643	12	Documents per Author	0.136
644	13	Authors per Document	7.33
645	14	Co-Authors per Documents	7.33
646	15	Collaboration Index	8.92
647	16		
648	17	Document types	
649	18	ARTICLE	12
650	19	CONFERENCE PAPER	1
651	20	EDITORIAL	1
652	21	REVIEW	1
653			

654	\$AnnualProduction				
655	Year		Articles		
656	1	2020	15		
657					
658	\$AnnualGrowthRate				
659	[1] 0				
660					
661	\$MostProdAuthors				
662	Authors		Articles	Authors	Articles Fractionalized
663	1	ALEXANDRID I M	1	EGGERS F	1.000
664	2	ALI H	1	SICHE R	1.000
665	3	ALLAM Z	1	USHKALOVA DI	1.000
666	4	ASCHNER M	1	ALLAM Z	0.500
667	5	ASHIRU-OREDOPE D	1	CHAKRABORTY I	0.500
668	6	BABAR ZUD	1	HEITMAN E	0.500
669	7	BEDFORD J	1	JONES DS	0.500
670	8	BOONYABANCHA S	1	LITEWKA SG	0.500
671	9	CALINA D	1	MAITY P	0.500
672	10	CHAKRABORTY I	1	DWIVEDI RK	0.333

673

674 \$MostCitedPapers

675	Paper		TC	TCperYear
676	1	TRAN T, 2020, SUSTAINABILITY	1	1
677	2	SICHE R, 2020, SCIENTIA AGROPECU	1	1
678	3	ALLAM Z, 2020, LAND USE POLICY	0	0
679	4	CHAKRABORTY I, 2020, SCI TOTAL ENVIRON	0	0
680	5	WANG Y, 2020, J BUS RES	0	0

681	6	EGGERS F, 2020, J BUS RES	0	0
682	7	TSATSAKIS A, 2020, FOOD CHEM TOXICOL	0	0
683	8	CHAN AHY, 2020, J PHARM POLICY PRACT	0	0
684	9	MAHTO G, 2020, INT J ADV SCI TECHNOL	0	0
685	10	EL ZOWALATY ME, 2020, INFECT ECOL EPIDEMIOLOG	0	0

686

687 \$MostProdCountries

688 Country Articles Freq SCP MCP MCP_Ratio

689	1	INDIA	2	0.333	2	0	0
690	2	CHINA	1	0.167	1	0	0
691	3	PERU	1	0.167	1	0	0
692	4	USA	1	0.167	1	0	0
693	5	VIETNAM	1	0.167	0	1	1

694

695 \$TCperCountries

696 Country Total Citations Average Article Citations

697	1	PERU	1	1
698	2	VIETNAM	1	1
699	3	CHINA	0	0
700	4	INDIA	0	0
701	5	USA	0	0

702

703 \$MostRelSources

704 Sources Articles

705	1	JOURNAL OF BUSINESS RESEARCH	2
706	2	CYTOKINE AND GROWTH FACTOR REVIEWS	1
707	3	DEVELOPING WORLD BIOETHICS	1

708	4	ENVIRONMENT AND URBANIZATION	1
709	5	FOOD AND CHEMICAL TOXICOLOGY	1
710	6	INFECTION ECOLOGY AND EPIDEMIOLOGY	1
711	7	INTERNATIONAL JOURNAL OF ADVANCED SCIENCE AND TECHNOLOGY	1
712	8	INTERNATIONAL JOURNAL OF PSYCHOSOCIAL REHABILITATION	1
713	9	JOURNAL OF PHARMACEUTICAL POLICY AND PRACTICE	1
714	10	LAND USE POLICY	1

715

716 \$MostRelKeywords

717	Author Keywords (DE)		Articles	Keywords-Plus (ID)		Articles
718	1	COVID 19	11	CORONAVIRUS DISEASE 2019		3
719	2	PANDEMIC	5	PANDEMIC		3
720	3	CORONAVIRUS	3	ARTICLE		2
721	4	HEALTH	2	ECONOMIC ASPECT		2
722	5	SARS COV 2	2	EPIDEMIC		2
723	6	2019 NCOV	1	GLOBAL HEALTH		2
724	7	AGRICULTURE	1	HUMAN		2
725	8	AUTOMOBILE INDUSTRY	1	PUBLIC HEALTH		2
726	9	BAYESVL	1	RISK FACTOR		2
727	10	BUSINESS ENVIRONMENT	1	SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2		2

728

729

Figure 3: Keyword occurrences (keywords n=20)

730

731 **Main statistics about the network**

732 Table 2. Network statistics

733

734	Size	94
735	Density	0.383
736	Transitivity	0.859
737	Diameter	2
738	Degree Centralization	0.488
739	Average path length	1.506

740

741	degree.netstat.graph. ris.membership	
742	CORONAVIRUS DISEASE 2019	81 1
743	PANDEMIC	81 1
744	PUBLIC HEALTH	71 1

745	ARTICLE	71	1
746	ECONOMIC ASPECT	71	1
747	HUMAN	71	1
748	RISK FACTOR	71	1
749	SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2	71	1
750	GLOBAL HEALTH	50	1
751			
752		betweenness.netstat.graph. ris.membership	
753	CORONAVIRUS DISEASE 2019	409.5417	1
754	PANDEMIC	409.5417	1
755	PUBLIC HEALTH	127.8750	1
756	ARTICLE	127.8750	1
757	ECONOMIC ASPECT	127.8750	1
758	HUMAN	127.8750	1
759	RISK FACTOR	127.8750	1
760	SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2	127.8750	1
761	GLOBAL HEALTH	126.6667	1

762

763

764 **Table 3. Network community structure**

765

766 Communities

767 \$`1`

768 [1] "VIRUSES"

769 [2] "ANTI-VIRAL DRUGS"

770 [3] "GLOBAL ECONOMIES"

771 [4] "GLOBAL ENVIRONMENT"

772	[5] "HUMAN CIVILIZATION"
773	[6] "HUMAN POPULATION"
774	[7] "SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS"
775	[8] "SOCIAL CHALLENGES"
776	[9] "WORLD HEALTH ORGANIZATION"
777	[10] "DISEASES"
778	[11] "COVID-19"
779	[12] "DISEASE SPREAD"
780	[13] "EPIDEMIC"
781	[14] "HEALTH IMPACT"
782	[15] "HEALTH RISK"
783	[16] "PUBLIC HEALTH"
784	[17] "RESPIRATORY DISEASE"
785	[18] "VIRAL DISEASE"
786	[19] "ARTICLE"
787	[20] "CORONAVIRUS DISEASE 2019"
788	[21] "CORONAVIRUS INFECTION"
789	[22] "DISEASE TRANSMISSION"
790	[23] "ECONOMIC ASPECT"
791	[24] "ENVIRONMENTAL FACTOR"
792	[25] "GLOBAL HEALTH"
793	[26] "HUMAN"
794	[27] "INFECTION CONTROL"
795	[28] "INFECTION PREVENTION"
796	[29] "INFECTION RATE"
797	[30] "MIGRATION"
798	[31] "PANDEMIC"

799	[32]	"POPULATION GROWTH"	
800	[33]	"POPULATION RISK"	
801	[34]	"PRIORITY JOURNAL"	
802	[35]	"RISK FACTOR"	
803	[36]	"SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2"	
804	[37]	"CHINA"	
805	[38]	"HUBEI"	
806	[39]	"WUHAN"	
807	[40]	"CORONAVIRUS"	
808	[41]	"SARS CORONAVIRUS"	
809			
810			
811	\$`2`		
812	[1]	"ANGIOTENSIN CONVERTING ENZYME 2"	"AROMATIC HYDROCARBON RECEPTOR"
813	[3]	"FOSSIL FUEL"	"HEAVY METAL"
814	[5]	"MULTI WALLED NANOTUBE"	"PESTICIDE"
815	[7]	"XENOBIOTIC AGENT"	"AIRBORNE PARTICLE"
816	[9]	"BIOCHEMISTRY"	"BIOPHYSICS"
817	[11]	"CELL FUNCTION"	"CELL LEVEL"
818	[13]	"CHRONIC DISEASE"	"DIETARY SUPPLEMENT"
819	[15]	"IMMUNE DEFICIENCY"	"IMMUNE SYSTEM"
820	[17]	"IMMUNOPATHOLOGY"	"IMMUNOTOXICITY"
821	[19]	"INTESTINE FLORA"	"IONIZING RADIATION"
822	[21]	"LIFESTYLE"	"LONG TERM EXPOSURE"
823	[23]	"MACROPHAGE"	"PARTICULATE MATTER"
824	[25]	"POLLUTANT"	"PREVALENCE"
825	[27]	"PROTEIN EXPRESSION"	"SIGNAL TRANSDUCTION"

826

[29] "ULTRAVIOLET B RADIATION" "VIRUS IMMUNITY"

827

[31] "VULNERABLE POPULATION"

828

829

\$`3`

830

[1] "BAYESIAN ANALYSIS" "DATA SET" "EDUCATION"

831

[4] "KNOWLEDGE" "LEARNING" "LITERACY"

832

[7] "STUDENT" "SUSTAINABLE DEVELOPMENT GOAL" "TEACHING"

833

[10] "UNESCO" "UNITED NATIONS" "VIET NAM"

834

835

\$`4`

836

[1] "ENVIRONMENT" "HEALTH CARE NEED" "HEALTH INSURANCE"

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[4] "INFORMATION TECHNOLOGY" "JUVENILE" "LAW"

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[7] "MANAGEMENT" "PHARMACEUTICAL CARE" "PROCESS OPTIMIZATION"

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[10] "REVIEW"

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Table 4..Additional bibliometric Exploratory Analysis

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[1] "VIRUSES"

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[2] "CORONAVIRUSES"

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[3] "GLOBAL HEALTH"

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[4] "INFECTIOUS DISEASE"

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[5] "JOHNS HOPKINS UNIVERSITIES"

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[6] "PREVENTIVE MEASURES"

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[7] "RESEARCH ACTIVITIES"

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[8] "SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS"

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[9] "WUHAN"

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[10] "CHINA"

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[11] "DISEASES"

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[12] "ANTIINFECTIVE AGENT"

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[13] "ANTIPYRETIC AGENT"

857 [14] "COVID-19"

858 [15] "DISEASE CONTROL"

859 [16] "DISEASE SPREAD"

860 [17] "EPIDEMIC"

861 [18] "SEVERE ACUTE RESPIRATORY SYNDROME"

862 [19] "VIRAL DISEASE"

863 [20] "ADULT RESPIRATORY DISTRESS SYNDROME"

864 [21] "ARTIFICIAL VENTILATION"

865 [22] "CONTAMINATION"

866 [23] "CORONAVIRUS DISEASE 2019"

867 [24] "DISINFECTION"

868 [25] "EMERGENCY"

869 [26] "ENVIRONMENTAL FACTOR"

870 [27] "EVOLUTION"

871 [28] "FEVER"

872 [29] "GENE SEQUENCE"

873 [30] "GEOGRAPHIC DISTRIBUTION"

874 [31] "HAND WASHING"

875 [32] "HEALTH HAZARD"

876 [33] "HUMAN"

877 [34] "INFECTION PREVENTION"

878 [35] "NONHUMAN"

879 [36] "NUCLEIC ACID AMPLIFICATION"

880 [37] "OXYGEN THERAPY"

881 [38] "PRIORITY JOURNAL"

882 [39] "QUARANTINE"

883 [40] "REVIEW"

884 [41] "SEPSIS"

885 [42] "SEROLOGY"

886 [43] "SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2"

887 [44] "SOCIAL ISOLATION"

888 [45] "SYMPTOMATOLOGY"

889 [46] "THORAX RADIOGRAPHY"

890 [47] "VIRUS PATHOGENESIS"

891 [48] "VIRUS REPLICATION"

892 [49] "VIRUS TRANSMISSION"

893 [50] "WINTER"

894 [51] "BALTIMORE"
895 [52] "MARYLAND"
896 [53] "UNITED STATES"
897 [54] "CORONAVIRUS"
898 [55] "SARS CORONAVIRUS"
899 [56] "ARTICLE"
900 [57] "REAL TIME REVERSE TRANSCRIPTION POLYMERASE CHAIN REACTION"
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903 \$`2`
904 [1] "DISEASE TRANSMISSION"
905 [2] "ENDOTRACHEAL INTUBATION"
906 [3] "PANDEMIC"
907 [4] "BETACORONAVIRUS"
908 [5] "CORONAVIRUS INFECTION"
909 [6] "VIRUS PNEUMONIA"
910 [7] "CORONAVIRUS INFECTIONS"
911 [8] "PANDEMICS"
912 [9] "PNEUMONIA"
913 [10] "VIRAL"
914 [11] "ADVANCE CARE PLANNING"
915 [12] "AWARENESS"
916 [13] "CLINICIAN"
917 [14] "GERIATRIC CARE"
918 [15] "GERIATRICS"
919 [16] "HEALTH BEHAVIOR"
920 [17] "HEALTH PERSONNEL ATTITUDE"
921 [18] "LIVING WILL"
922 [19] "LONG TERM CARE"
923 [20] "MEDICAL DECISION MAKING"
924 [21] "PATIENT MONITORING"
925 [22] "SCREENING"
926 [23] "STAKEHOLDER ENGAGEMENT"
927 [24] "VITAL SIGN"
928 [25] "AGED"
929 [26] "ATTITUDE TO HEALTH"
930 [27] "COMORBIDITY"

931 [28] "DECISION MAKING"
932 [29] "HEALTH CARE PERSONNEL"
933 [30] "INFECTION CONTROL"
934 [31] "PSYCHOLOGY"
935 [32] "RESIDENTIAL HOME"
936 [33] "RISK FACTOR"
937 [34] "HEALTH KNOWLEDGE"
938 [35] "ATTITUDES"
939 [36] "PRACTICE"
940 [37] "HEALTH PERSONNEL"
941 [38] "HUMANS"
942 [39] "LONG-TERM CARE"
943 [40] "RESIDENTIAL FACILITIES"
944 [41] "RISK FACTORS"
945 [42] "HEALTH IMPACT"
946 [43] "HEALTH RISK"
947 [44] "PUBLIC HEALTH"
948 [45] "ADULT"
949 [46] "ANXIETY"
950 [47] "CLINICAL PROTOCOL"
951 [48] "CROSS-SECTIONAL STUDY"
952 [49] "DENTAL PRACTICE"
953 [50] "DENTIST"
954 [51] "FEAR"
955 [52] "FEMALE"
956 [53] "KNOWLEDGE"
957 [54] "MALE"
958 [55] "PRACTICE GUIDELINE"
959 [56] "PRIVATE HOSPITAL"
960 [57] "PUBLIC HOSPITAL"
961 [58] "CLINICAL PRACTICE"
962 [59] "CORONAVIRINAE"
963 [60] "MENTAL STRESS"
964 [61] "QUESTIONNAIRE"
965 [62] "CROSS-SECTIONAL STUDIES"
966 [63] "DENTISTS"
967 [64] "DISEASE OUTBREAKS"

968 [65] "PRACTICE PATTERNS"
969 [66] "DENTISTS' "
970 [67] "STRESS"
971 [68] "PSYCHOLOGICAL"
972 [69] "SURVEYS AND QUESTIONNAIRES"
973 [70] "BELGIUM"
974 [71] "END STAGE LIVER DISEASE"
975 [72] "LIVER TRANSPLANTATION"
976 [73] "DATA ANALYSIS"
977 [74] "MEDICAL EDUCATION"
978 [75] "NURSING EDUCATION"
979 [76] "EDUCATION"
980 [77] "NURSING"
981 [78] "FELLOWSHIPS AND SCHOLARSHIPS"
982 [79] "NURSING EDUCATION RESEARCH"
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Figure 4: Keyword occurrences (keywords n=20)

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Figure 5: Keyword occurrences (keywords n=20)

Figure 6: Keyword occurrences: first bibliometric analysis (keywords $n=20$)

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Figure 6: Keyword occurrences: second bibliometric analysis)

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