POLITECNICO
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Master's Thesis

COVID-19 Impact on Global Supply Chains and Environment- A Systematic Literature Review

A Thesis in the Field of Supply Chain Management for the Degree of
Master of Management Engineering

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ABSTRACT: (ENGLISH)

Over the past few months, the COVID-19 pandemic has caused a severe disruption to the global supply chains, it has halted the economies and has challenged the environmental sustainability. As decision-makers around the world are scrambling to respond to the coronavirus crisis and the severe and potentially prolonged recession that follows, analysts have called on them to take advantage of the opportunity to further their progress on climate change mitigation, which most people agree is as significant a crisis as the coronavirus.

There is an increasing number of research being done to cope up with this unprecedented event that the mankind has never faced before. In this thesis the I have drawn upon early research performed on the crisis and sought to explain the methods and methodologies that have been used, assessed, and evaluated by academics on the aim of presenting COVID-19 Impacts on Global supply chains and its environmental implications by considering the time, status to date, and present the findings that illustrate the problems, fill the gaps, and recognize potential advances in future research agendas.

Keywords: Supply chain, Global Supply Chain, COVID-19, Supply Chain Disruption

ABSTRACT: (ITALIAN)

Negli ultimi mesi, la pandemia COVID-19 ha causato una grave interruzione delle catene di approvvigionamento globali, ha bloccato le economie e ha sfidato la sostenibilità ambientale.

Mentre i responsabili delle decisioni in tutto il mondo si stanno affrettando per rispondere alla crisi del coronavirus e alla recessione grave e potenzialmente prolungata che segue, gli analisti li hanno invitati a sfruttare l'opportunità per promuovere i loro progressi sulla mitigazione dei cambiamenti climatici, che la maggior parte delle persone concorda è una crisi significativa come il coronavirus.

C'è un numero crescente di ricerche in corso per studiare questo evento senza precedenti che l'umanità non ha mai affrontato prima. In questa tesi l'autore attinge alle prime ricerche condotte sulla crisi e cerca di spiegare i metodi e le metodologie che sono stati utilizzati, valutati e valutati dagli accademici allo scopo di presentare gli impatti COVID-19 sulle catene di approvvigionamento globali e le sue implicazioni ambientali considerando il tempo, lo stato attuale e presentare i risultati che illustrano i problemi, colmano le lacune e riconoscono potenziali progressi nelle future agende di ricerca.

Parole chiave: Supply chain, Global Supply Chain, COVID-19, Supply Chain Disruption

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I commence by thanking Almighty Allah who is the most merciful & most beneficent and to whom I am very grateful. I am thankful to my friends and family especially my Parents, for their unconditional love, Generous support, and consistent belief without whom everything would have been a dream.

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This thesis work closes two and a half years journey at Politecnico di Torino and I really want to say thanks to everyone that gave me motivation, inspiration, and love to carry on, may God bless them all.

ACRONYMS

COVID-19	Corona Virus Disease
GSC	Global Supply Chains
SC:	Supply Chain
SCM	Supply Chain Management
SL:	Service Level
SLR	Systematic Literature Review

1. INTRODUCTION

1.1 Background

On 3 April 2020, the Director General of the WHO stated: [COVID-19] is much more than a health crisis. We are all aware of the profound social and economic consequences of the pandemic (WHO, 2020)". Until January 2021, 95 million people are infected by the Corona Virus disease (COVID-19) in which 2 million people are reported to be dead, affecting 213 countries and territories worldwide. The initial onslaught of this virus was in China and then in EU countries with Italy, Spain, and France hard hit in terms of death counts before it is found a new epicenter to the United States (US) where the death tolls exceed a hundred thousand already. The virus is now spreading at an alarming rate in Brazil and Russia and the South Asian countries. [19] As of know there is no official vaccination available for this viral disease, though there is tremendous amount of research being done on finding the vaccine for this. There has been some early success, but none of these vaccines have been declared official cure by the authorities.

Over the past few months, the COVID-19 pandemic has caused severe disruption to the global economy, supply chains, society and has significantly challenged the running of urban areas. [1] This would in turn would cause significant changes to the supply chains, its operations, strategies and bring significant changes to the environment sustainability of our globe. This thesis is being written to understand the research being done on the topic of Covid-19 impact on the global supply chains and its environmental implications.

1.2 Problem Definition and Objective of the Thesis

The COVID-19 Shows that the pandemics and epidemics can seriously cause damage to the global supply chains and can bring the top-notch economies at their knees. Previously, significant research has been done to gauge the effects of a pandemic on the supply chains and its environmental implications. However, this is a new era with an unprecedented event that

mankind has never faced before. Researchers are working day in and out to understand this novel virus and its effect on the supply chains and the environment.

To progress in this direction, I present a systematic analysis of the impact of COVID-19 on the global supply chains and its environmental implications guided by a systematic literature review that collated a unique set of publications. The streamlining of literature will help to reveal several new research topics and novel classifications.

Therefore, this systematic literature review seeks to explain the methods and methodologies that academics have so far used, quantify, and assess their time and status of evolution to date, and present the findings to recognize potential advances in future studies and aims to analyze the following research questions.

- RQ1: What are the early lessons learned from covid-19 impact on the supply chains and environment.
- RQ2: Identify possible future research agendas.

1.3 Structure of the thesis

The structure of the thesis is as followed. In the first chapter I will proceed with framing the scenario and provide with a panoramic view of what is the objective of the thesis and questions that it aims to answer.

In the second chapter, we will enter more into the specificity and will review and analyze the available literature written on the topic at issue.

In the third- and fourth chapter I will go into the actual analysis: chapter third will be dedicated to defining the methodology, which helped in carrying out analysis. while the fourth chapter will show the analysis carried out, through graphs and the main results.

Finally, the chapter five in which I will discuss the results and the topics that emerged from the analysis and highlight the various research agendas that can be carried out in the future.

2. LITERATURE REVIEW

2.1 Covid-19, A Humanitarian Crisis

A worldwide pandemic has long been expected by the experts through technical cadres to strain the components of the global supply chains and demands, igniting a cross-border economic catastrophe due to the increasingly interconnected world in which we now live. The developing havoc caused by the pandemic, by all accounts, surpassed the forecasts in those commentaries .[2] In history books all over the world, the date of November 17, 2019 will be recorded. It was on that day that a 55-year-old man was infected with the SARS-CoV-2 coronavirus, described as patient '0'. There were already 60 patients by the end of December, but the worst was to come a little later. The virus attacked the entire planet in just 5 months. By the end of May 2020, more than 5 million people were still sick and there were over 328,000 recorded deaths due to infection. At present, there is no country where the virus can be managed by the health care system because there is no effective cure for battling the infection yet, although an effective vaccine might not be effectively available until next year for methodological reasons for laboratory testing. Isolation from the world in which there may be other individuals is the only successful defense against infection. This is what has happened: those who can work remotely, work from home, those who cannot do so with personal protective equipment, like a whole host of programs that take care of our safety and health (PPE)[3] To minimize the risk of exposure to SARS-CoV-2, organizational prevention and protection strategies have been developed and implemented.[4] Some firms have stopped their activities. Some divisions of the economy is going bankrupt or could go bankrupt in the near future; there is a downturn in the entire tourism and hotel market, land and air transport.[5]

At the end of March, just at the beginning of the pandemic, stock markets across the world hit levels not seen for 30 years, with the Wall Street main index losing over 12 percent on March 17 alone. The crisis has placed 38.6 million Americans in line for benefits. one in five people has lost their jobs. Unemployment in the U.S. was 14% at the end of April. And it could be much higher. According to the latest U-Cov unemployment rate, Reuters released Federal Reserve FED

estimates on May 5, its value exceeds 30%. The economic condition is similar or barely better all over the world, where COVID-19 emerged, as this is the coronavirus' social name declared by the World Health Organization. There is no such dramatic desolation of the labor markets in individual countries in the European results. The unemployment rate is largely below 10%, with Spain leading by 14%. [20]. However, the readings come from March, when the spread of the disease was just developing. In the entire European Union, GDP is forecast to fall to -7.7%. In the first half of 2020, the U.S. economy shrank by 5.0% year-on-year and the Chinese economy by 6.8%.[21] The scale of the decline in several selected European countries in relation to the previous year 2019 is shown in the Figure (1) below. [22]

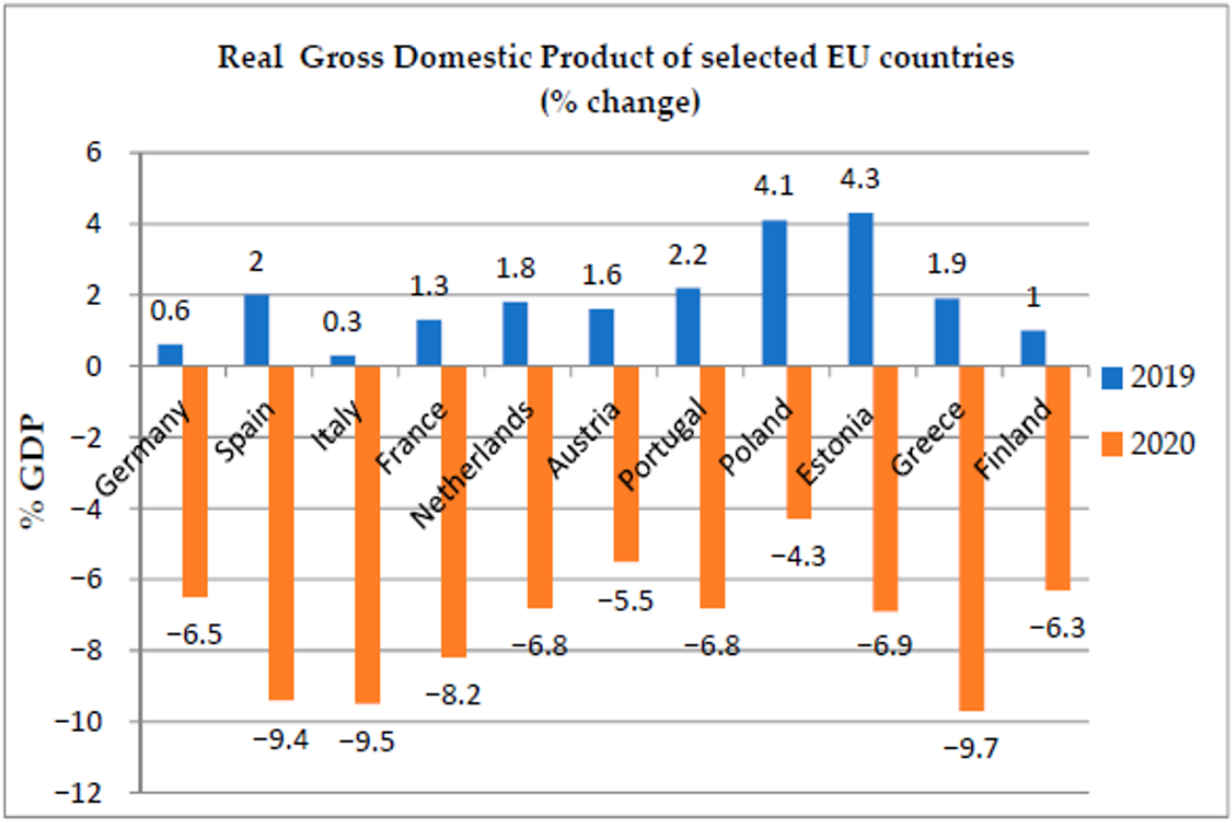

Figure 1: Real Gross Domestic Product of Selected EU Countries

2.2 A Brief History of Globalization

Globalization has a long history, beginning with the Silk Roads (1st century B.C.-5th century A.D. and 13-14 centuries).1 When Chinese products first reached Rome, the first Silk Road marked the introduction of trade over long distances. The protection by strong world powers of these trade routes was an essential feature. The first Silk Road came after the Islamic tradesmen, the Spice Routes (7th-15th), who went as far as Indonesia. Global trade (with large volumes of trade) really started in the so-called age of' discovery' by Europeans (in the 15th-18th centuries) according to [23] when trade became truly global. Still, because trade was mainly between European empires and their colonies, this could not properly be called globalization. In the first industrial revolution in the UK, when Britain made products (e.g. iron and textiles) for which there was global demand, the first true wave of globalization took place. Moreover, massive investments were made. To facilitate trade, made in various locations around the world (e.g. the Suez Canal, and a massive expansion of the railways). {23**]** argues that the USA's hegemony led to the second wave of globalization after the Second World War. After the fall of the Iron Curtain and the creation of the WTO, the world then arrived at what is called the third wave of globalization. World exports increased to 25% of the world's GDP during this time. This has benefited most of the global population during this time. “more people than ever before belong to the global middle class, and hundreds of millions achieved that status by participating in the global economy” [23].

The current period has been referred to as globalization 4.0, a world dominated by China and the US. E-commerce and digital content are the core features. Nevertheless, the negative aspects of globalization are being increasingly known, and deforestation and pollution are two of the major environmental issues. [24]. Moreover, growing awareness of rising inequality both across and within countries is now being raised and there is a belief that mass immigration can have a negative effect on indigenous communities. Once we consider both the 'sending' and the 'receiving' countries, one may also question if immigration has a positive or negative impact overall. We have also entered in an era where trade wars and increased protectionism, guided, in part, by the US, are once again seen.

Withdrawing from the international arena more and more. Since the previous waves prevailed by virtue of the help provided to them by the current world power at that time, such geo-political posturing may pose a problem for globalization.

2.3 Rethinking Globalization Versus-Deglobalization

Rethinking globalization takes place on many fora nowadays. Although normally economists do not agree, there is much agreement now. Almost all economists acknowledge that there are both positive and negative effects of globalization, but also think that the present era is the right moment to take proper action. **[6]** One exception is [25] **who** sees Covid-19 as the third major blow to globalization after the 2008 crisis and the US-China trade war and who concludes: “Wave goodbye to the greatest era of globalization- and worry about what is going to take place”. There are also suggestions that, coupled with significant urban sprawl, the current approach to international trade and increasing urbanization has increased the chances of a communicable disease like Covid-19 arriving on the world scene [26].

In addition, climate change is estimated to increase the likelihood of more of these communicable diseases spreading around the planet [27] If, with climate change, the probability of a communicable disease increases, then this is an indirect effect that needs to be considered. This can be modelled through a stochastic method, where.

Climate change is driven with increase in carbon emissions, which then increases the likelihood of infectious diseases. This, in turn, has an additional development impact. This would combine the optimal control of a communicable disease with future research along these lines.

[28], with integrated models of evaluation [29].

An additional possibility is to model infectious diseases as a random, endogenous shock. One could model this in the form of an endogenous discount rate [30]

The participants, including Dani Rodrik, are generally not in favor of erecting barriers to trade as a solution in this crisis in a discussion of the risks of deglobalization [31]and argue that it would cause a serious loss of welfare that would hit the developing world. At the same time, all participants in the discussion emphasize the necessity for cooperation and illustrate this by pointing to, among other things, climate change and sustainability. At the same time, the need for collaboration is stressed by all the participants in the discussion and highlighted by referring,

among other things, to climate change and sustainability. [31]. In an interview with AFP Gopinath argues that “The system is not perfect Going backwards is not a good strategy for growth and not a good strategy for alleviating poverty around the world” Her predecessor at IMF Maurice Obstfeld (on VOA news) (on VOA news) argues that the crisis would not necessarily hamper globalization, since companies will want to minimize risks of local crises by spreading their operations more equally across the globe**.**[32] Nevertheless, there is also widespread consensus that it seems unavoidable that countries would need to create continuity and resilience in certain strategic sectors, especially the health sector.

The rise in certain inequalities that have resulted from the opening of countries to trade, capital flows and the free movement of labor is one of the main drawbacks associated with globalization and the increasing interconnectedness of economies. We go into these problems briefly because they are also relevant to our field.[6]

A characteristic of globalization is the growing interdependence between economies. For example, firms can sell their final products in many markets, with these final products also consisting of parts and intermediate inputs that may have been produced in other countries and sourced from many different sectors. In a world where there are no great shocks or sudden policy changes, the increased interconnectedness poses no problems. However, the world is not free from such events**.[6]** Referring to the Covid-19 crisis, EU president Von der Leyen said in her address to the European Parliament of April 16 2020: “Investing in large scale renovation, renewables, clean transport, sustainable food and nature restoration will be even more important than before. This is not only good for our economies, it is not only good for our environment, but it reduces dependency by shortening and diversifying supply chains”. Similarly, the French president, Emmanuel Macron, has argued for a strengthening of French and European “economic sovereignty” by investing at home in the high tech and medical sectors. [33] mentions a variety of challenges to globalization and supply chains in a report on the rethinking of globalized supply chains, including China's 2010 export quotas for rare earth elements, Japan's 2011 earthquake, and the ongoing US-China trade war. [34]

The question emerges as to what effects the crisis of COVID-19 would have in this regard. As indicated by his contribution title, Shih recommends rethinking supply chains. Where suppliers to a business are based in the same geographical area, businesses may consider adopting a

greater degree of regionalization. The creation of so-called second sources of additional safety stocks can also be given further consideration. He also supports rethinking the industrial size as well as the mix of manufactured goods. [33]

Sforza and Steininger (2020) who study a large model with 44 countries and 56 sectors, are carrying out a first quantitative study of the potential disruption due to coronavirus and show that the Covid-19 shock implies a drastic reduction of income in all countries and in all sectors. Global linkages play a crucial role here**.** [35]. Müller-Fürstenberger and Schumacher (2017) point to another issue, namely the consequences of capital mobility. Although these publications do not specifically address environmental issues there are obvious lessons to learn for environmental economists. The reduction in income and production, and the possible reallocation of production because of deglobalization, will have significant environmental effects at a global scale that are potentially positive and negative. Hence, an important research question is how to model and calculate these effects. [36] We also note [37], who claims that in relation to supply chains, the Covid-19 epidemic should help us rethink the values of globalization. She points to the fact that globalization has arisen in a world of corporate monopolies and without adequate control to disrupt main markets, such as the health sector. She mentions that large numbers of medicines, such as penicillin and paracetamol, are now only produced in one or two countries. Returning to globalization induced inequality. Increased international trade necessarily leads to winners and losers, not only across the countries participating in trade, but also within countries.[6] Piketty's publications have made this perfectly clear. Piketty has also put forward: "Why didn't democracy reduce inequality? Well, in my view probably because you have multi-dimensional inequality structures, in particular globalization and migration on one hand, and educational expansion on the other hand. They have created new multidimensional conflicts about inequality.[38] Moreover, it is well known that the poor suffer from pollution, which means rising inequalities in the environment [39]. The similarity between the globalization losers and the likely losers of Covid-19 and those most adversely impacted by climate change is that the poor and marginalized are likely to be the most affected. In both cases, international cooperation is needed but in the case of climate change, appears further away than ever.[7]

2.4 Supply Chain a Brief background

First, I would like to discuss about some basic concept of supply chain before moving on.
Business in which supply chain is a core, requires the analysis of each component if they are efficiently optimized or not. In such uncertain environment companies ranging from banking sectors to pharmaceutical industry are looking for cost cutting activities by maintaining or increasing quality standards of their product and services. They are using different techniques such as automation, collaboration and information sharing in value stream, just in time inventory, offshoring, outsourcing and performance measurement system.
Moreover, overall group of economic agents such as trader, consumer, legal entities, and everyone along value chain that directly contributes to final products are referred to term supply chain.

"Thus, the chain encompasses the complete sequence of operations which, starting from the raw material, or an intermediate product, finishes downstream, after several stages of transformation or increases in value, at one or several final products at the level of the consumer" **[40]**

Companies are growing and their production process at different stages in value chain are spread out across different continents, trade blocs and countries. So, distinct locations where value added activities are performed, make a supply chain process from scratch (raw material) to finished goods by delivering final product or services to final customer [41].Better technologies available in different regions & access for competence development, increase in competition, bargaining power of buyers, reduced entry barriers, business & market expansion, risk balancing for business portfolio, search for efficiency and effectiveness & positioning benefits are the main rationale behind fragmentation of production stages around the globe. Moreover, selection of foreign direct investments (FDI's), outsourcing and offshoring depends on firm's long-term goals based on their globalization strategies if firms are pursuing effectiveness or efficiency.
In detail, it has been observed that firms tend to keep their production facilities in low wage countries and more strategic functions are kept in countries where skilled workforce is available.

Author is referring R&D, marketing, finance & management as a strategic function. For instance, more production units are installed in China, India, Brazil, Bangladesh & Poland due to less labor cost while activities related to R&D, innovation & designs are kept in USA or other countries where skilled workforce is available to be competitive in market. In case of positioning benefit, is not solely based on profitability but the presence of firms in certain countries brings reputation to another level, for instance presence of Samsung in USA is important for overall image of firm by serving niche markets with high service level and to bring innovation excellence with the help of skilled workforce as already mentioned above.

Moreover, internal markets are saturating to firms are looking for larger markets to intensify the revenue streams for instance a lot of firms belongs to Nordics and DACH regions in EU are international i.e., Philips is international born. For efficiency, Companies extend beyond to national boarder for economies of scales as it helps to reduce the unitary production cost, moreover, benefits also can be attained with the help of economies of scope by sharing resources in case of production lines for internally homogeneous product while in transportation and distribution for multiple markets.

Despite of having such advantages mentioned above there are also some risks associated to globalization. Currently the supply chains are facing immense pressure due to the disruption caused by the COVID-19. Costs are increasing day by day due to high delivery and inventory costs incurred since lead times are more due to large distance from production facilities to the final customers. Wages are rising as labor cost in china is getting increased day by day. In case of outsourcing & offshoring transactional costs are getting increased as well. Loss of control leading towards less flexibility in case of outsourcing. Moreover, delayed deliveries from outsource suppliers are root cause of penalties. Now a day, firms need to be compliant with sustainability KPI's not only for focal company but also responsible for upstream and downstream entities and there is cost associated to it in case of violation. Sustainability KPI's entails economic, environmental & social parameters. For instance, Nike's supplier was accused of child labor in 1996 which overall demolished the image of firm. Culture barrier, investment of time in building relationship with the outsource provider, information asymmetries could be problematic for focal firm.

2.5 Global Emissions amid COVID-19

The pandemic and lockdown policies not only affect production activities and people's lifestyles but also lead to substantial changes in energy consumption and CO2 emissions. For example, global energy demand fell by 3.8% in the first quarter of 2020, compared with the previous year [42, Global energy review]

and industrial coal demand dropped by 8% due to a decrease in electricity needs [43], even though there was an increase in residential electricity demand.[44] Although there was a lack of official statistics on energy consumption and economic output, several studies have provided a range of estimates on global emission decline. For example, [45] estimated a decrease of fossil fuel-related emissions by 5.8% in the first quarter of 2020. They calculated the emissions inventories of countries based on activity data from power generation (for 29 countries), industry (for 73 countries), road transportation (for 406 cities), aviation and maritime transport and commercial and residential sectors (for 206 countries). [46] estimated a decline of 17% (or 17 million tons) in daily emissions for early April 2020 based on the extent of confinement for different countries. The International Energy Agency (IEA) projected a decline of global CO2 emissions by 8% (or 2.6 Gt) in 2020, which led the CO2 emissions level back to 10 years ago. However, the impacts of COVID-19 and recovery plans on global emissions is not settled. There may be several waves of the pandemic in the future, which is predicted potentially to last until 2024, and thus prolonged or intermittent social distancing are likely to be continued at least until 2022 [47]. Global supply chains have been seriously affected and the global economy may face a long-term recession even after the pandemic, with profound impacts on associated emissions. Lessons from history show, for example in a study on 15 major pandemics since the fourteenth century, that there are often significant macroeconomic after-effects of pandemics [48] Over recent decades, rapid globalization has connected producers and consumers around the globe. Even though the China–US trade conflict has led to a deceleration of globalization since 2018 and COVID-19 further impacted global supply chains, the world is still connected via a highly interdependent production system and Only the time will reveal the future of globalized supply chains and the environmental impact.

3. METHODOLOGY

3.1 Systematic Literature review:

I will first try to define the methodology that is being used in this thesis.

"*Systematic Literature Review is an efficient technique for hypothesis testing, for summarizing the results of existing studies, and for assessing consistency among previous studies; these tasks are clearly not unique to medicine.*" [8]

SLR study helps to put literature work in context of research and can help describe relationship of each work with that of another work under consideration. Helps to interpret the previous work in a novel way and present them in an order to identify the trends, to develop future areas of research development in that specific field.
The SLR has been successfully used in the SC subject recently. [9] That is eloquent proof that the SLR is considered a comprehensive tool for conducting literature reviews due to its systematic methodology. At the first stage of our approach. We thus defined the scope and objectivity to have reliability in the whole process. The research protocols are defined as followed.

3.1.1 Data collection and dataset construction

3.1.1.1 Inclusion / exclusion criteria

The first step was to decide the platform that will be used for the sake of its bibliographic research. Scopus.com portal was used for the course of this thesis as it offers a complete access to all sorts of data bases to the Politecnico students. A platform that collects summaries and citations for the articles in research publications. By using the platform's search feature one can easily skim through from within the title of the article, keywords, abstracts, by source, by author and by many other elements.

First, I proceeded with defining the search protocols and understanding of how the platform search protocols worked. As stated earlier it was in my interest to get complete understanding of the research protocols. For which various keywords were written in the search column and achieved the results. For the sake of understanding I wrote the following search protocols **Supply Chain** which showed results of up to (412,000) then utilizing the features of the platform it was decided to use inverted comas and search again using this method “Supply chain” and then it showed result of (297,000). A key understanding here is that in the former the platform search with the articles, abstract, titles etc. the words supply and chain. They can be in any order possible so you one can understand that how misleading the results can be while in the latter case platform searches for the words Supply chain together, that explains why there were fewer and more precise results.

First, it was decided to search for the articles written on the Covid-19. Which was defined as “COVID-19” and it showed up a result of up to 112,705 (Includes Articles, Press Articles, Editorials, Reviews, Book Chapters) Looking at the results which were quite a lot and did not make any sense for the sake of the analysis. I then proceeded with the insertion of another feature “AND” which makes the search protocols further tight and returns more accurate results. “AND” enables the platform to search for all those documents which falls into the protocol for example by writing “COVID” and “Supply Chain” it will give results of all the documents which will discuss both the COVID-19 and supply chain at the same time. So, this time it was decided to proceed with the following keywords “COVID” AND “COVID-19” AND “Supply Chain*”.

The insertion of * enables the system to search for terms supply chain and supply chains at the same time. It makes the search a little flexible and wide. This time it returned a result of (2215) (Includes Articles, Press Articles, Editorials, Reviews, Book Chapters). However, since the topic of the thesis included looking at the environmental impact as well. It was decided to search again but this time included “COVID” OR “COVID-19” AND “Supply Chain*” and “Environment*” and “Environmental Impact*”. For the sake of authenticity document and source type were limited to journal. The language of the article was set as English. A list of total 106 articles were displayed.

The table (1) Explains the research Protocols that are used.

Research protocol	**Detailed description**
Research database:	Scopus Database
Publication type:	Peer-review journals (indexed by Scopus)
Language:	Only papers written in English
Date range:	2020-2021
Search fields:	Titles, abstracts, and keywords
Search terms: applied in Titles in Scopus Database and Titles, abstracts and keywords	("COVID" OR "COVID-19" and "SUPPLY CHAIN*" AND "ENVIRONMENT*" AND "ENVIRONMENTAL IMPACT*")
Inclusion Criteria	Papers that presented COVID-19, supply chain and environmental Impact
Exclusion Criteria	Paper that involved the discussion without the protagonist of the COVID/SC and Environment
Data Extraction	Used Scopus Built in feature for data extraction

Table 1: Research Protocols

At this step, it was decided to download the list of these articles, thanks to the feature Scopus it was possible to get the bibliographic information of the articles.

This list of the articles was a little short to be considered for an early assessment, so, I decided to use another approach which is widely used in the literature review is called 'Snow balling" which is defined as

"The snowball method is a way of finding literature by using a key document on your subject as a starting point. Consult the bibliography in the key document (book or journal article) to find other relevant titles on your subject "[49]

So, I dug deep into the articles that were already in the list downloaded from Scopus and started skimming through the bibliography of the articles. Overall, looked at the titles of 80 articles which were selected from the bibliography.

. Initially articles were assessed by looking through the title and abstracts. Even though filters were carefully used to narrow down the margins and bring more relatable articles it was assessed that out of 106 articles of the SCOPUS list 66 were found to be out of the scope of the assessment as they were not covering the topic at all. That brought the numbers down to the 40.

From the other list that was made from the "Snowball" method 80 articles titles and abstracts were initially assessed and 60 were found to be out of the scope of the study that brought the number of articles down to 40. The figure (2) illustrates the initial inclusion and exclusion of the articles[1].

[1] Note that search was specifically designed considering two aspects, i.e. (i) focus on COVID-19 and supply chains (ii) Environmental impact of COVID-19 on Supply chains (i.e., it should be evident that it explicitly deals with an epidemic and SC issues; for example, the papers that just mention epidemics as a possible risk were not considered

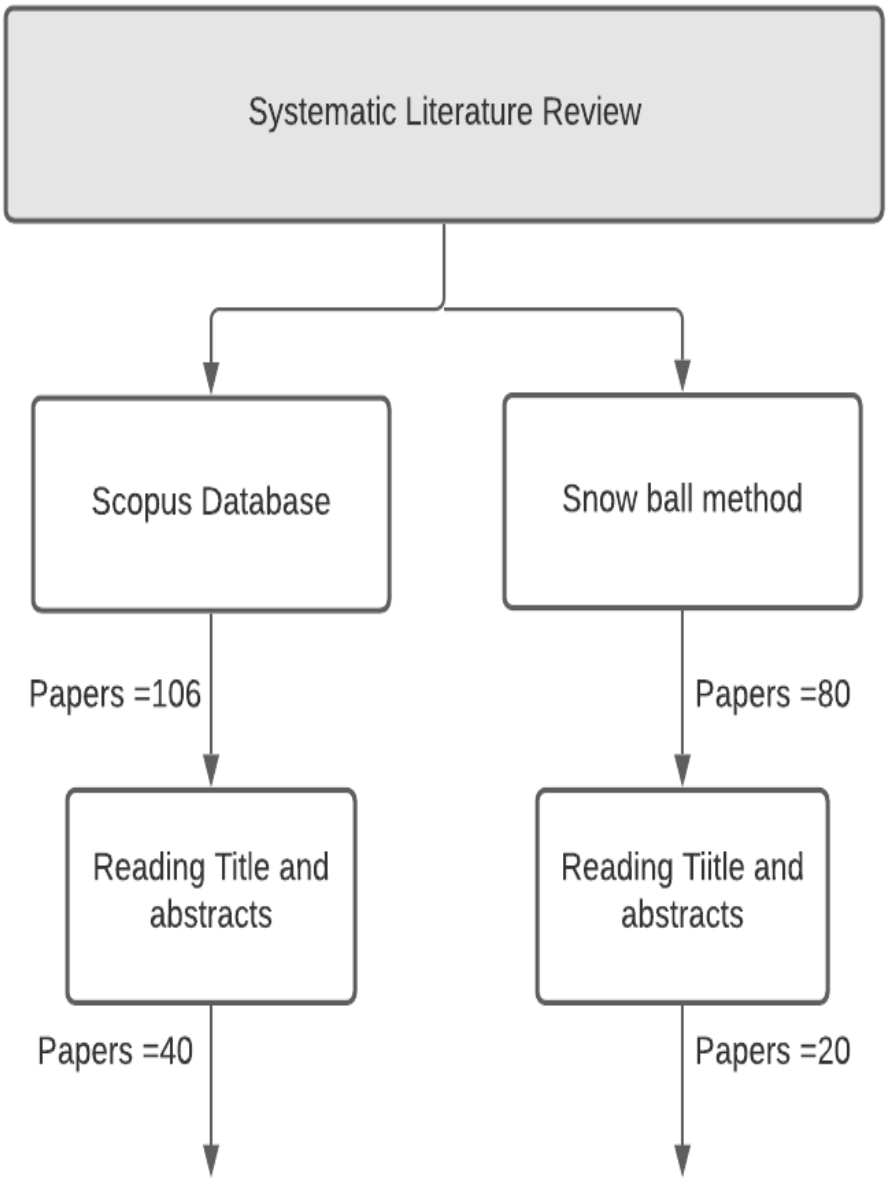

Figure 2: Systemic Selection of Articles

3.1.2. Article Analysis

The Fundamental step to be able to proceed in the bibliographic research was that all the articles would be read carefully, and the observation of the trends and methodological characteristics would be noted.

Considering the 60 articles which were selected after the initial screening. The 40 articles from the Scopus list were read thoroughly considering all the aspects of the scope of the thesis.

10 articles were found to be erroneously entered into the list despite careful consideration that was put at the initial stages of the search. Bringing the number down to 30.

~From the list of 30 articles 2 were eliminated because they just touched the subject rather discussed it. So, it brought the list down to 28 articles.

~The other list from the snowball was carefully considered and after reading the articles 10 were found to be out of the context of the scope of the thesis thus bring the number down to 10.

~Quality Assessment of the articles further reduced 3 articles thus bringing the number down to 7.

In the end a list of total 35 articles were considered for the final assessment. The Figure (3) visually represent the evaluation of the articles.

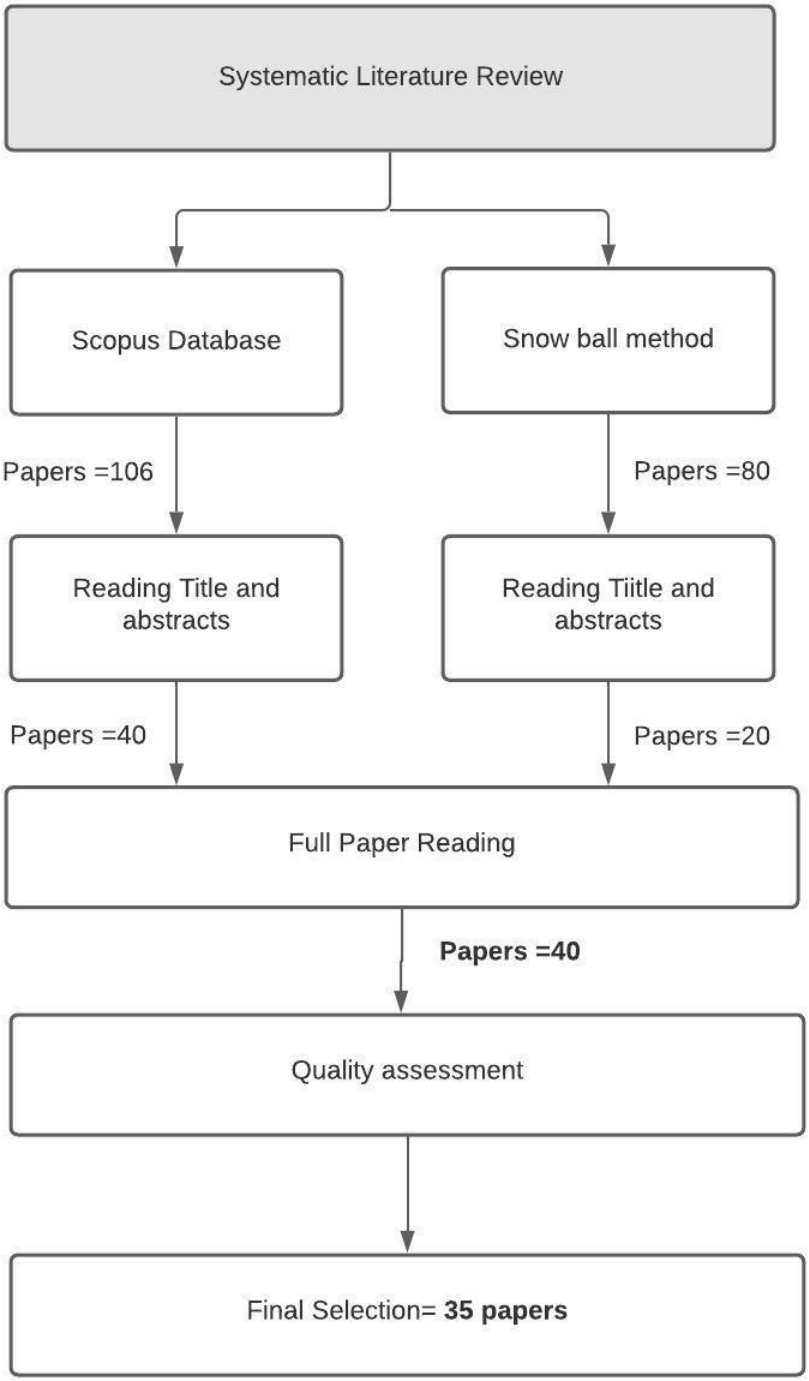

Figure 3: Final Article Selection

3.1.3 Overview

To carry out the analysis of the articles, an excel was structured as shown in the appendix. The table is structured as follow. Each article is listed on the row and the subsequent columns highlight a series of characteristics of the articles that were deducted after carefully reading of the articles. It will help the to categorize and index each single article, the list below explains the methodology.

1 Title: the title of the article has been listed down

2 Year and month of the publication. Since Covid-19 is a new topic so it was decided to add the month of the publication (available online)

3 Author: List of all the authors who contributed to the work.

4 Journal: Listed down the journals who published the articles.

5 Study Methodology

a. if the mode of the study is Quantitative, Wrote quantitative.

b. If the mode of the study is Qualitative, wrote qualitative.

c. Study Method, according to the main study method mentioned or used by the authors in the papers.

6 Technology that is being used for the scope of application otherwise It has been left with N/A.

7 Industrial Sector: Type of Industrial sector being studied, otherwise N/A.

8 Scope of the application: Discussed the application level of the study, it could be strategical, tactical or operation. Respective columns are filled or left empty otherwise.

9 Model Under Study

a. Predictive

b. Descriptive

c. Predictive and descriptive in case the article is covering both.

10. Short Term vs Long term

If the study is predominantly for short term horizon or for long run or for both.

11 Subtopics

List of the subtopics which author found were interesting and could lead to a future research agenda, it is to be noted that these subtopics were deducted after careful vetting of the articles.

12 Authors Affiliation

First Author Affiliated country was mentioned to understand which country is dominating in terms of the research work being done on the given topic.

13. Findings of the paper

A description of the result(s) obtained from the study of the respective article.

14. Authors keywords

3.1.4 Use of DATA SET

once the reading of each article was and we had done the cataloging according to the characteristics we had moved on the “Use phase” of the previously constructed data. This enabled to study the current state of the study and the analyze the data.

The most and the immediate method of the analysis was to create the visual graphs directly on the Microsoft excel. Firstly, available data had to be fined tune in the data source to make it more presentable and to make it easier for the analysis. It was decided to use the data set as the sheet form rather converting it into a table form because table format makes the working slow.

It was decided to use the Microsoft excel pivot table which is a built-in feature of the platform. It offers a variety of the analysis with simple and easier user interface.

Decision to use Excel pivot table was formed based on. My previous familiarity with and easier to use interface. Also, for the matter of modifying the data and easily refresh the graphs in the pivot table. Once the pivot tables are formed the graph data cannot be upgraded using the pivot table chart. One must go to the source file to make the changes if needed and then subsequently refresh the content on the pivot table sheet.

Creation of the charts is very easy. You need to select the data that you want to work on and put it in the filter section and form the charts using the pivot analyze tab. Once the chart has been formed it can easily be fine-tuned as per the liking of the user.

4: Results

4.1 Descriptive Analysis:

4.1.1. Overview:

The first step of the descriptive analysis as presented in the table in the appendix was to highlight the number of articles treated by the analysis methodology.

Looking at the figure (4) it can be deduced that the out of 35 articles were selected for the purpose of the analysis for this thesis. 19 articles deal with the quantitative and 16 articles use the qualitative

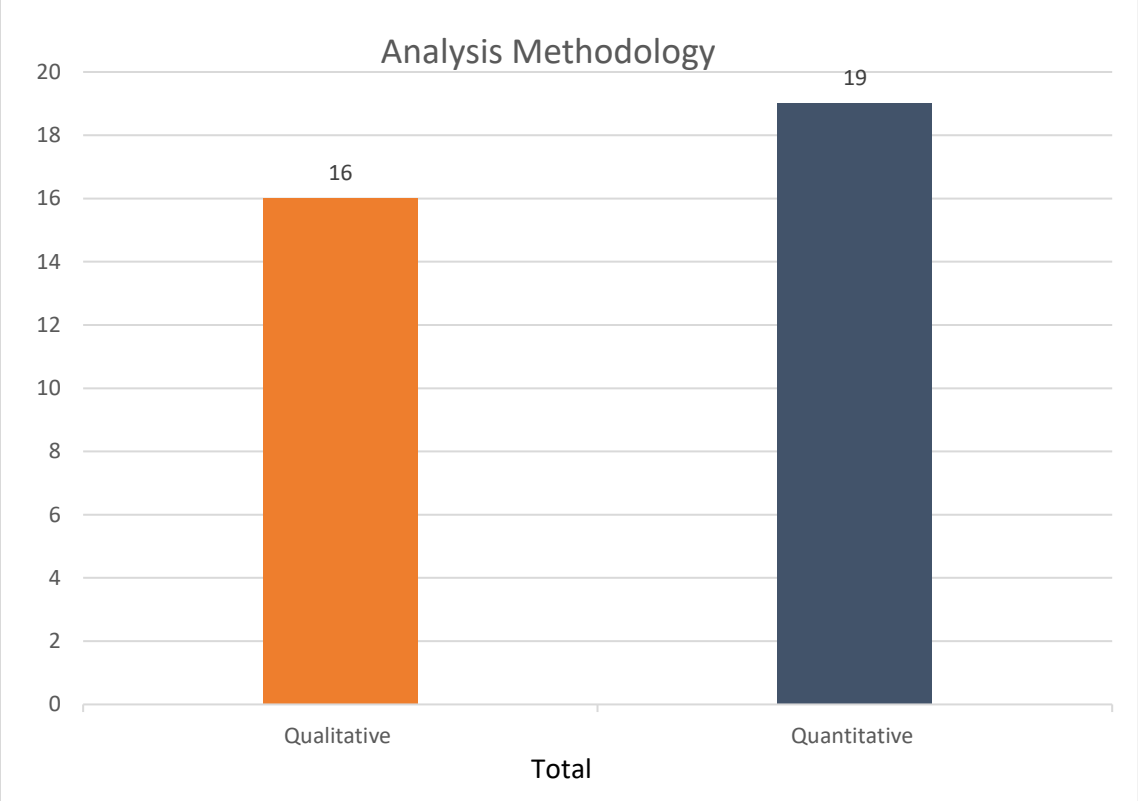

Figure 4: Analysis Methodology

Methodology. So, one can say that the researchers are more inclined towards the quantitative analysis of the situation.

The next step was to go and measure the incidence of the different study methods on the total of papers.

A Pie chart is being used here to present the study methods accurately in the figure (5). From the figure (5) the most used method is the literature review which tops at 43% of the entire articles that were considered for the sake of the research of this thesis. It is to be noted that these literature reviews were comprised of the various studies being done on the novel corona virus and its effect on the supply chains and the environment.

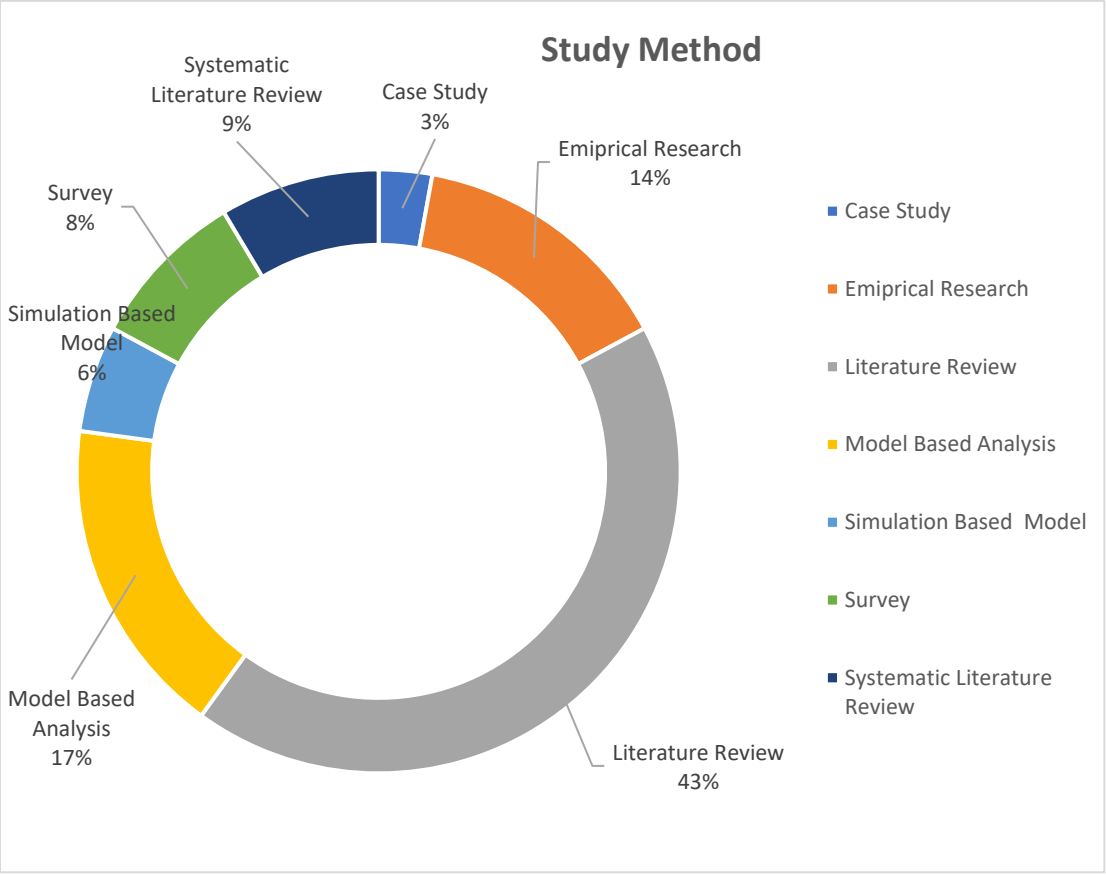

Figure 5: Study Method

It is second by the model-based analysis which takes 17% of the whole chunk and subsequently empirical research which stands at 14%. The subsequent study methods as highlighted in the figure (6) which take less than 10% each of the pie are systematic literature review, survey, simulation based, case study.

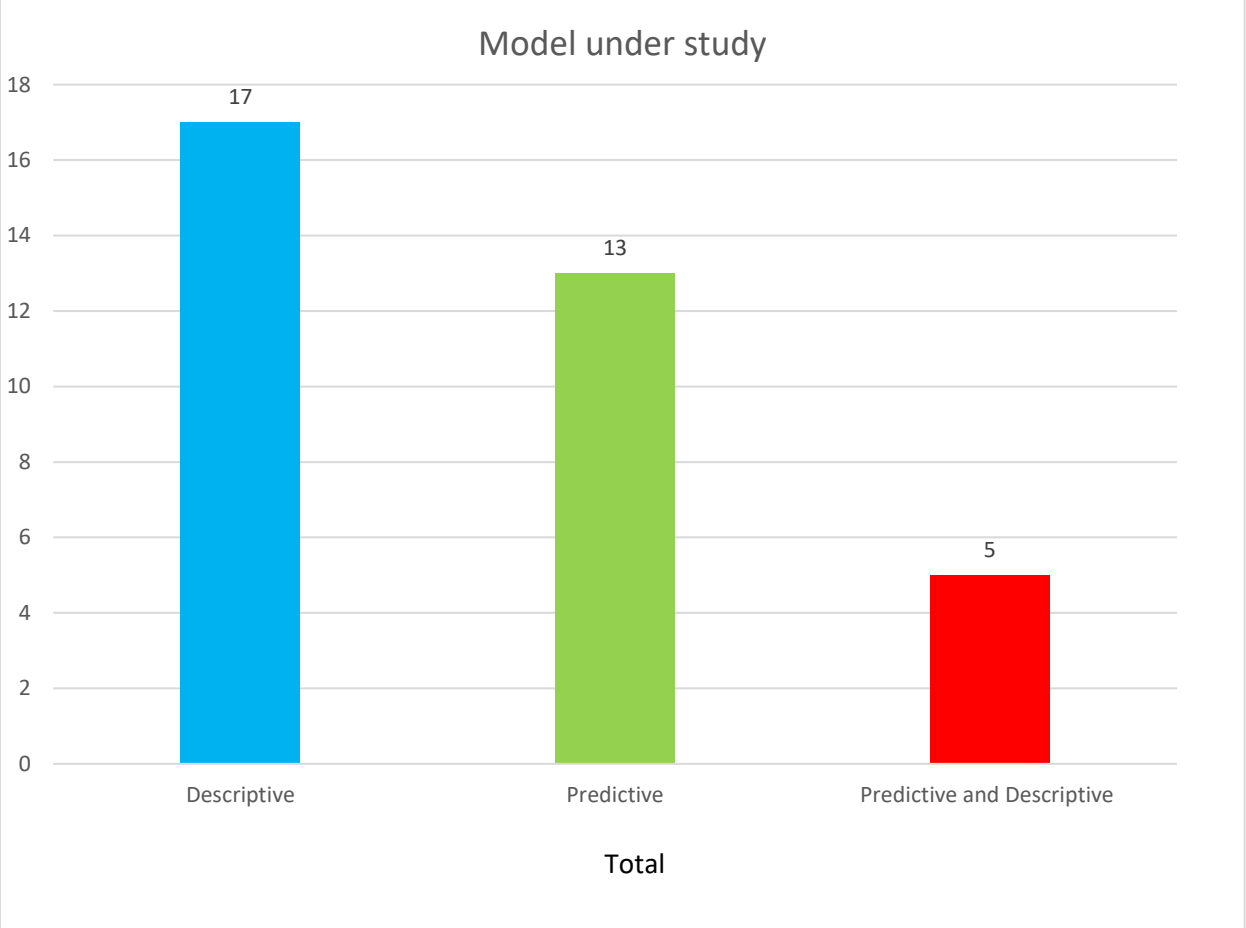

Figure 6: Model Under Study

From the figure () it emerges that most of the studies that are being done on the subjected topic is descriptive study which is being done in total 17 of the articles studied in the research. 13 papers used the predictive approach in the articles. It is to be noted that some of the papers discussed both predictive and descriptive approach. These papers explicitly talked about the current situation and the future situation as per the understanding of the authors.

An interesting fact emerges from the following graph that there is obviously a correlation between the study methodology and the used approach as highlighted in figure (7) and figure().

More studies are based on the quantitative studies which are backed by the fact that major studies are done using descriptive approach.

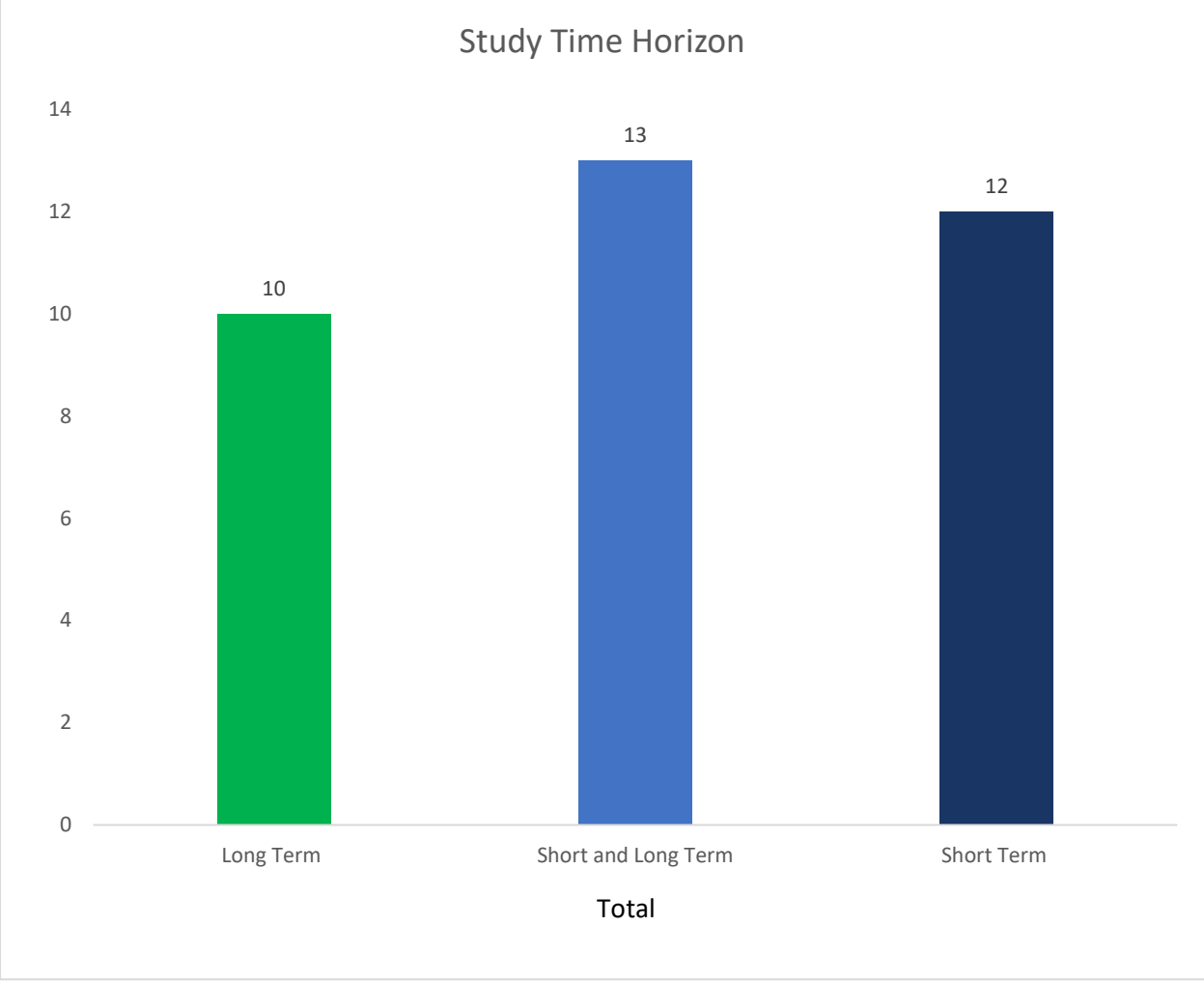

Figure 7: Study Time Horizon

An interesting analysis was to look at the fact that what kind of time horizons the researchers are considering while studying the topic. The figure () presents the following data. From the figure it can be noted that most of the researchers are not targeting one specific period and they are

predicting and analyzing the situation for both and short terms. For this reason, out of 35 articles 13 articles discuss both terms. While 12 articles discuss the short-term situation. In total only 10 articles discussed the long-term horizon.

4.2 Content Analysis.

Another interesting insight that was decided to look at was to study the countries which are doing most of the research on the subjected topic. The analysis looks at the author's affiliated institute country origin. For this purpose, I have decided to look at it in two different ways. The first step was to look at the countries of the first author's affiliation. First authors are those that were leading the research and have been listed on top on the author's list in the research papers. It is to be noted that at times there were more than 1 authors in the research paper. Secondly, it was decided to also look at the other researchers who are also involved in the research paper and their contribution to the research makes it worth it to consider them for the analysis as well.

USA tops the list of the countries which is doing the most research on this topic. It is intuitive that the most badly effected countries with a greater number of effected people than the rest of the world is emphasizing most on the research of this virus. taking the lead in the research on the topic. Out of 35 articles only 2 articles presented the first author's affiliation with the chine.

Second to USA on the list are Australia, India, and UK. Which stand at 3 articles by each country.

Remaining countries on the list are Italy, Poland, Japan etc. which have 1 articles contribution per country. Figure (8) demonstrates the list.

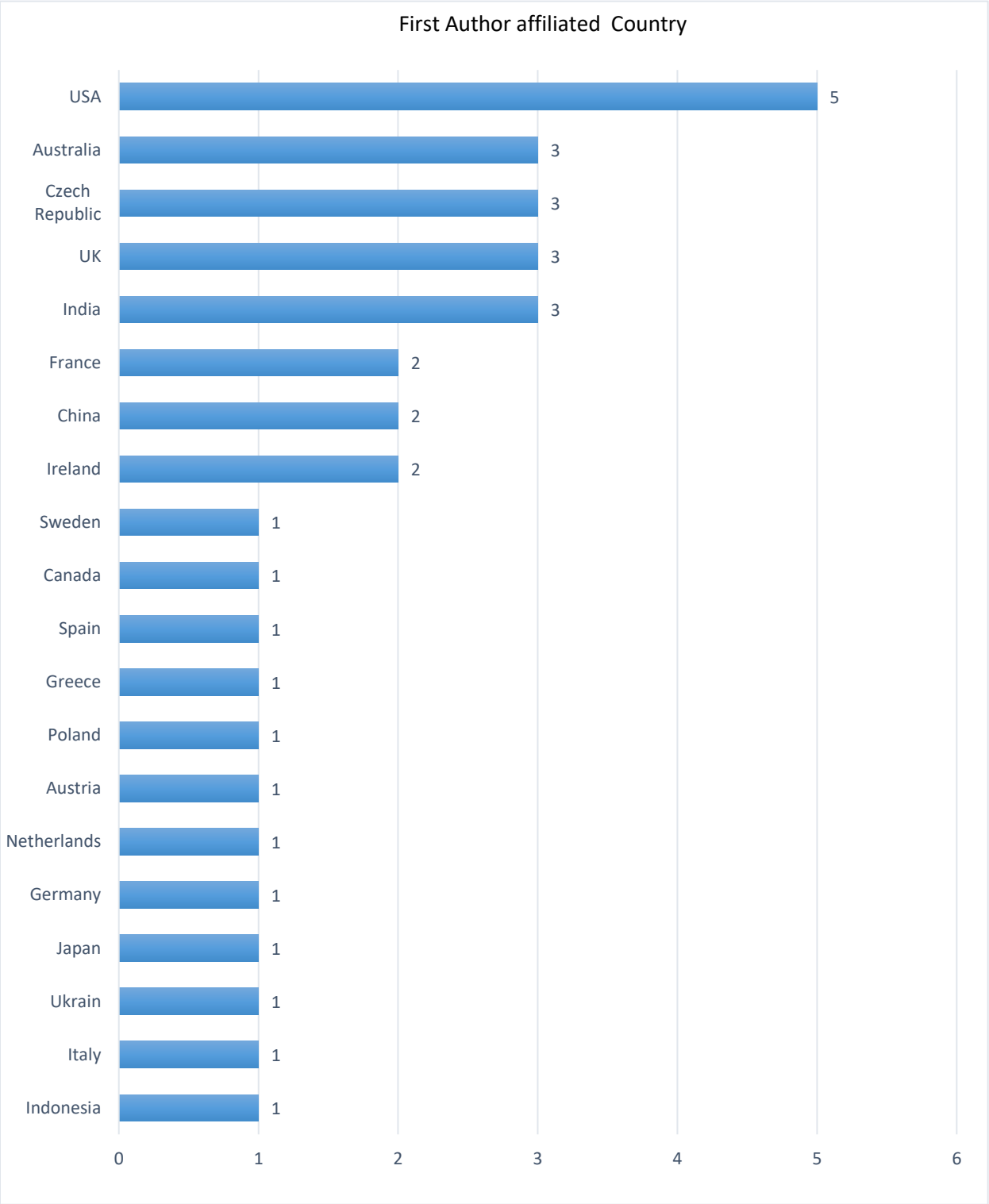

Figure 8: First Author Affiliated Country

Looking at the bigger picture the results are quite striking and different. In terms of the lead researchers India is on top of the table followed by UK, USA, China, and Australia. Articles that have been studied. From the list of chosen 35 articles, India has 16 authors contributing to subjected topic. UK is slightly below the par with 14 researchers working on the topic.

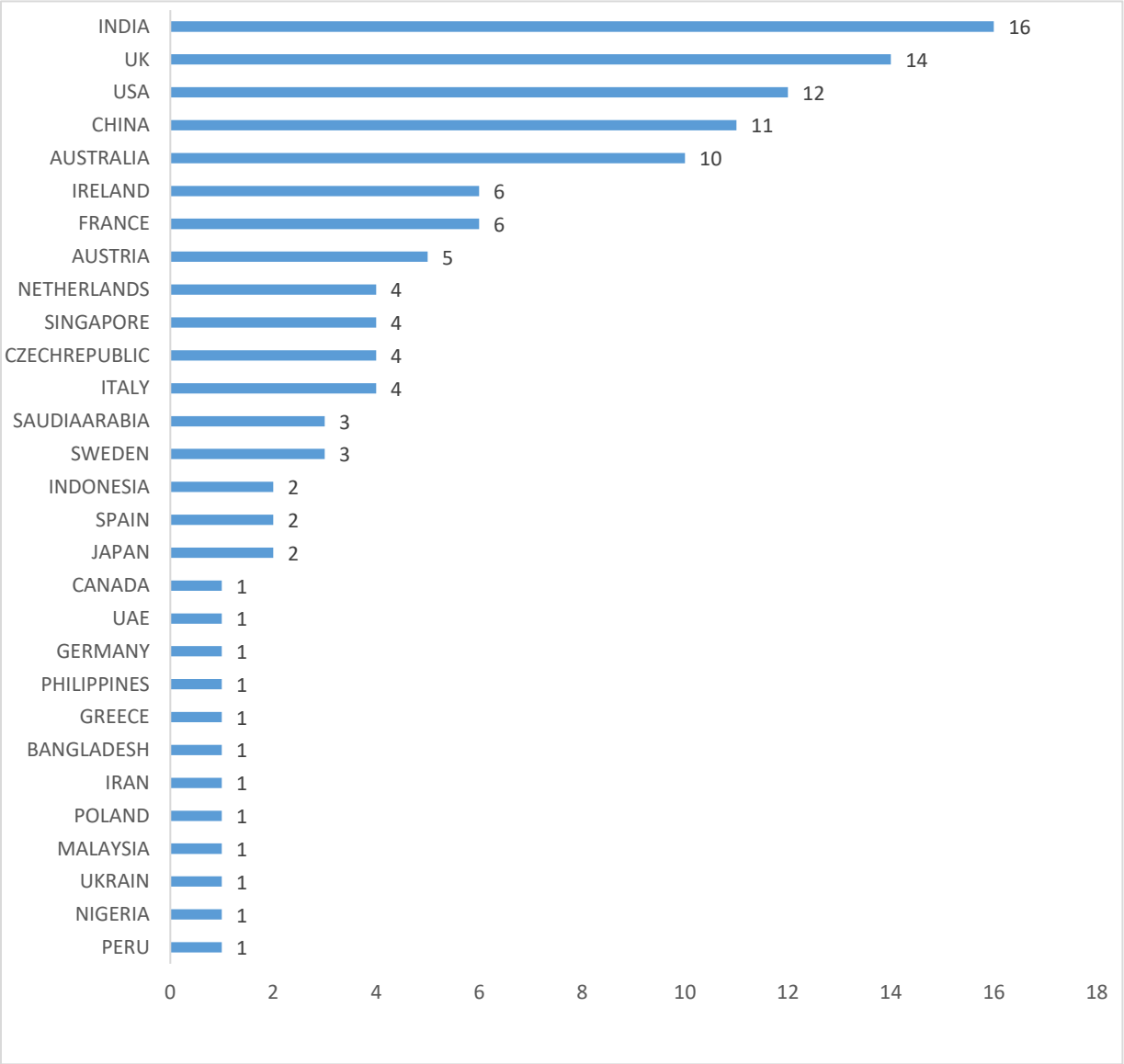

Figure 9: All Authors Affiliated Countries

USA is third on the leader board with a total of 12 researchers contributing to this topic. Figure (9) illustrates the list of the countries.

4.2.1. Keywords:

The following table (2) a list of the keywords frequently used in the research articles that the author studied. These keywords are extensively given by the authors in the research papers. The most used keywords are the Covid-19, supply chain, sustainability, environmental protection etc. Covid-19 is the most used keyword which has been used by the authors 15 times and second to that is supply chain which is used in total 5 times. These keywords can give interesting insight into the emerging future topics that will be discussed in the future research agenda section. In total 117 keywords were used in all the articles studied.

Key words	**Rep**	**Key words**	**Rep**
covid-19	15	environmental economics	1
supply chain	5	coronavirus (covid-19)	1
sustainability	5	environmental footprints	1
coronavirus	4	land use	1
circular economy	4	environmental footprints reduction	1
ppe	3	bats	1
climate change	3	carbon tax	1
supply chain resilience	2	local food systems	1
sars-cov-2	2	environmental sustainability	1
pandemic	2	material flow	1
carbon pricing	2	epidemic outbreak	1
waste management	2	municipal solid waste	1
sustainable development	2	face coverings	1
environmental protection	2	new indicators of wealth	1
life cycle assessment	2	financial crisis	1
green economy	2	pandemic plan	1
personal protective equipment (ppes)	1	first nations	1
wildlife markets	1	personal protective eq	1
short food supply chain	1	food safety	1
covid-19 fighting measures	1	plastic waste	1
migration	1	food supply chain	1
covid-19 pandemic	1	bibliometric analysis	1
recycling	1	food waste	1
covid-19 waste	1	public health	1
sustainable construction	1	fragmentation	1
crisis capitalism	1	recession	1
limits to growth	1	g20 economies	1

criticality	1	research agenda	1
clean energy	1	gas emissions	1
deforestation	1	reuse	1
ppes decontamination	1	gender	1
deglobalisation	1	climate policy	1
risk management	1	global circular economy	1
digital twin	1	ship recycling	1
solid waste management	1	globalization	1
disease	1	simulation	1
virus detection	1	youth	1
disinfection	1	social-ecological transformation	1
landfill	1	zoonoses	1
disruption response	1	clusters	1
lockdown	1	green recovery	1
drought	1	cooperation	1
neoliberalism	1	green stimulus	1
dynamic waste management	1	biomedical waste	1
pathogen spillover	1	green transition	1
economic	1	swab tests	1
plastic waste footprint	1	greenhouse	1
economic crisis	1	visualization software	1
public housing	1	health equity	1
economic development	1	welfare payments	1
resilience	1	incineration	1
economic shock	1	agriculture	1
scenario analysis	1	international cooperation	1
economic value	1	after lockdown	1
single-use plastics (sups)	1	green new deal	1
emissions trading	1	**Grand Total**	**155**
comparison study	1		
energy consumption	1		
sustainable plastic waste management	1		

I decided to look at the industry sectors that the articles were talking about. This data has been deduced after carefully reading all the articles. Some articles explicitly talked about an industry sector while some articles talked about multiple industrial sectors. In that case It was decided to make another column specifying multiple industries sector. There were some articles which did not specify any industrial sector. The articles were dominated by the food supply chain and second to that is Medical sector. Figure (10) illustrates the industrial sectors highlighted In the papers.

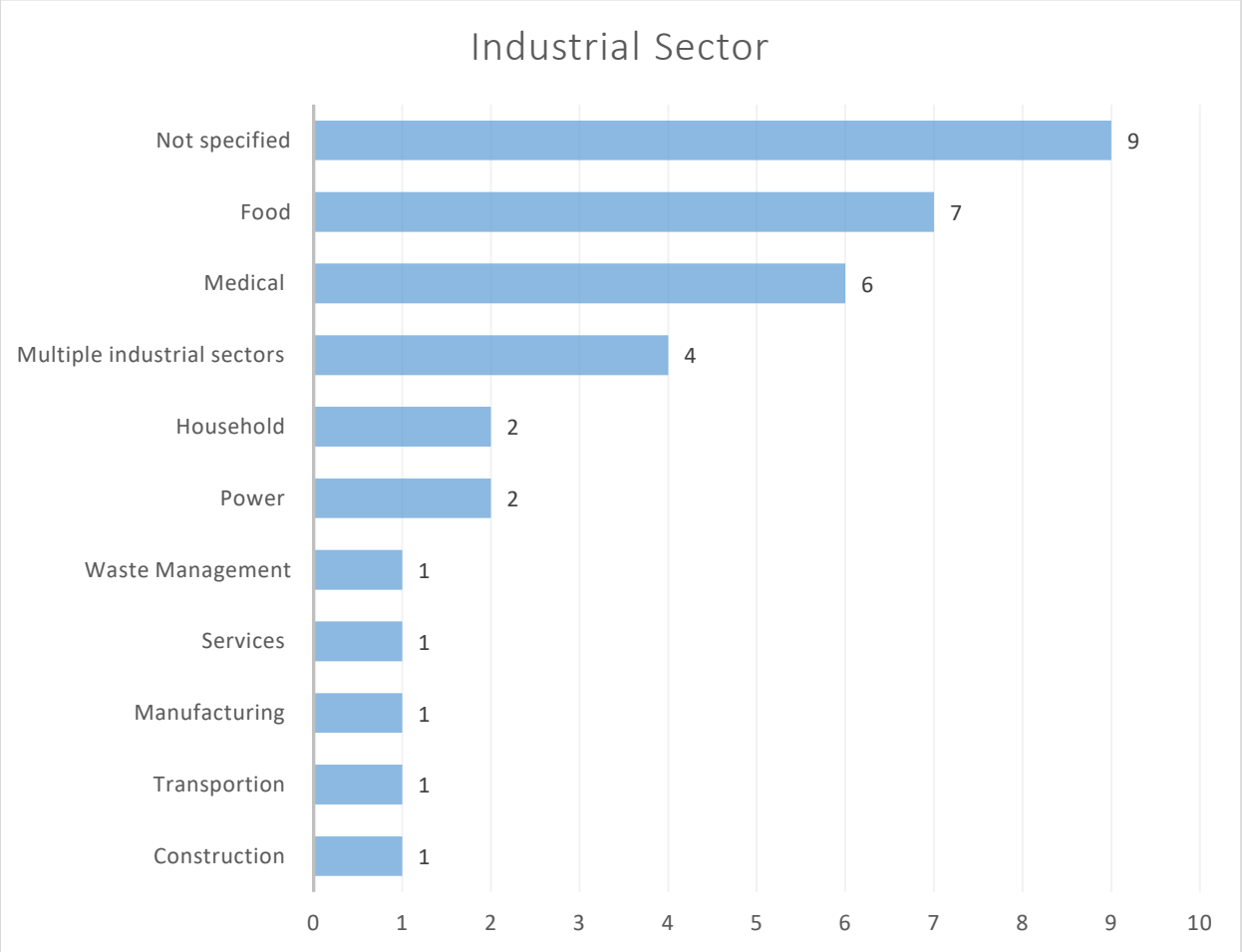

Figure 10: Industrial Sector

4.2.2 Publications By journal

The figure (11) shows the number of the papers published by each journal. The journal devoted to the environmental protection topped the chart. Science of the total environment and environmental and resource economics published 6 articles each. Resources,

Our SLR analysis discovered that there are limited number of research papers written on the topic of covid-19 impact on the global supply chains and its environmental implications. Thus, it is evident that more publications are needed by these journals.

The Top journals with regular publications on these topics are environmental and resource economics, Science of total environment, Resource conservation and recycling, Sustainability (Switzerland). These articles comprised on the 57% of the articles written on this topic. Given that this is a very new topic, and it is still in the developing phase and constantly changing over time. It is expected that more and more studies would be done on this topic and in future more journals would be able to match up with these top journals. Figure (11) illustrates the journals.

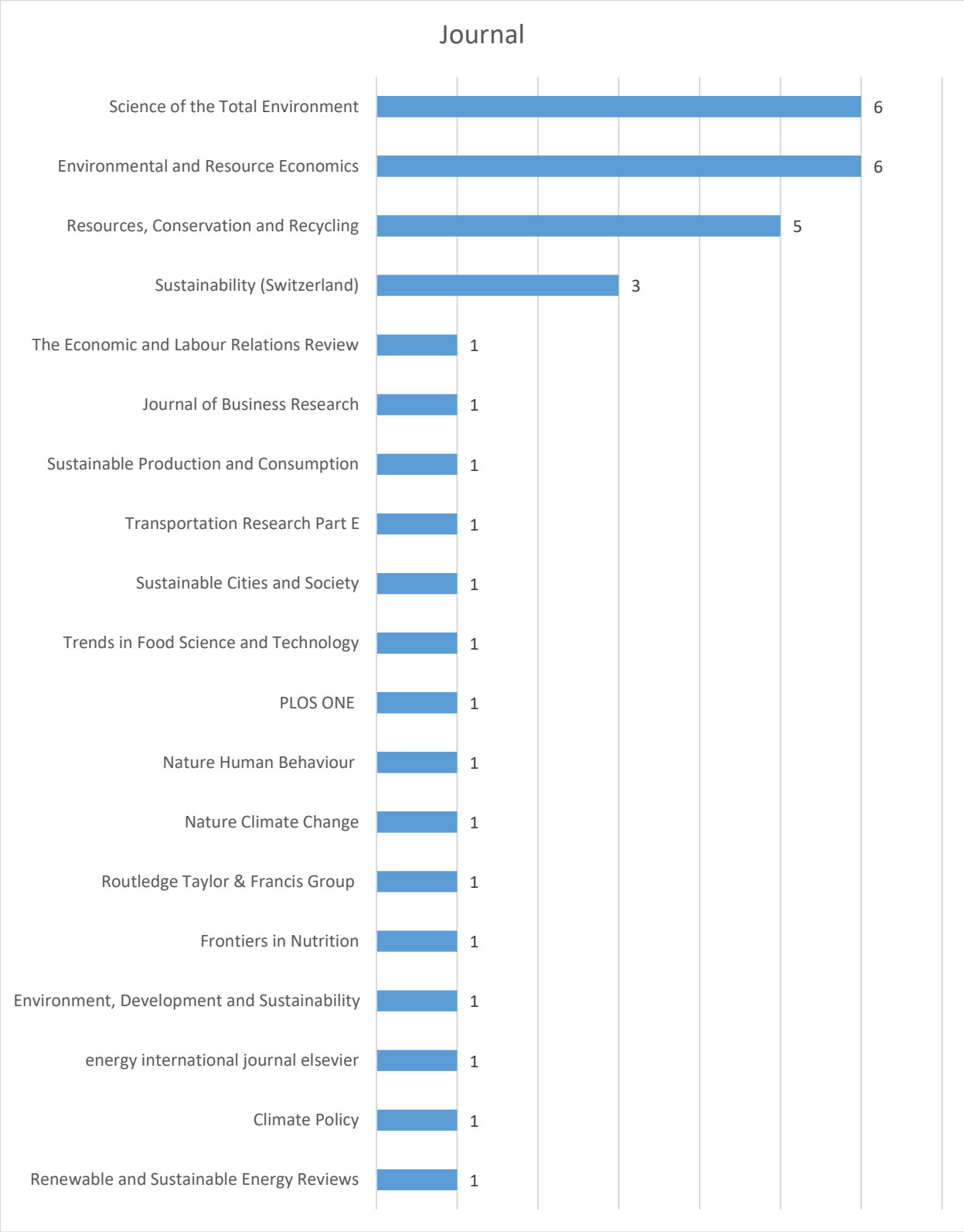

Figure 11: Journal

Another interesting study that was to understand the scope of the application of the research articles. A list was prepared of the application scope. Some articles presented more than one application area, but it was decided to use the one that perfectly fit the content of the research papers. It came with no surprise that the list was topped by the Environmental protection management, which was used 6 times in the articles. Second to that was supply chain management which was used 4 times in the research papers. In the third place we have

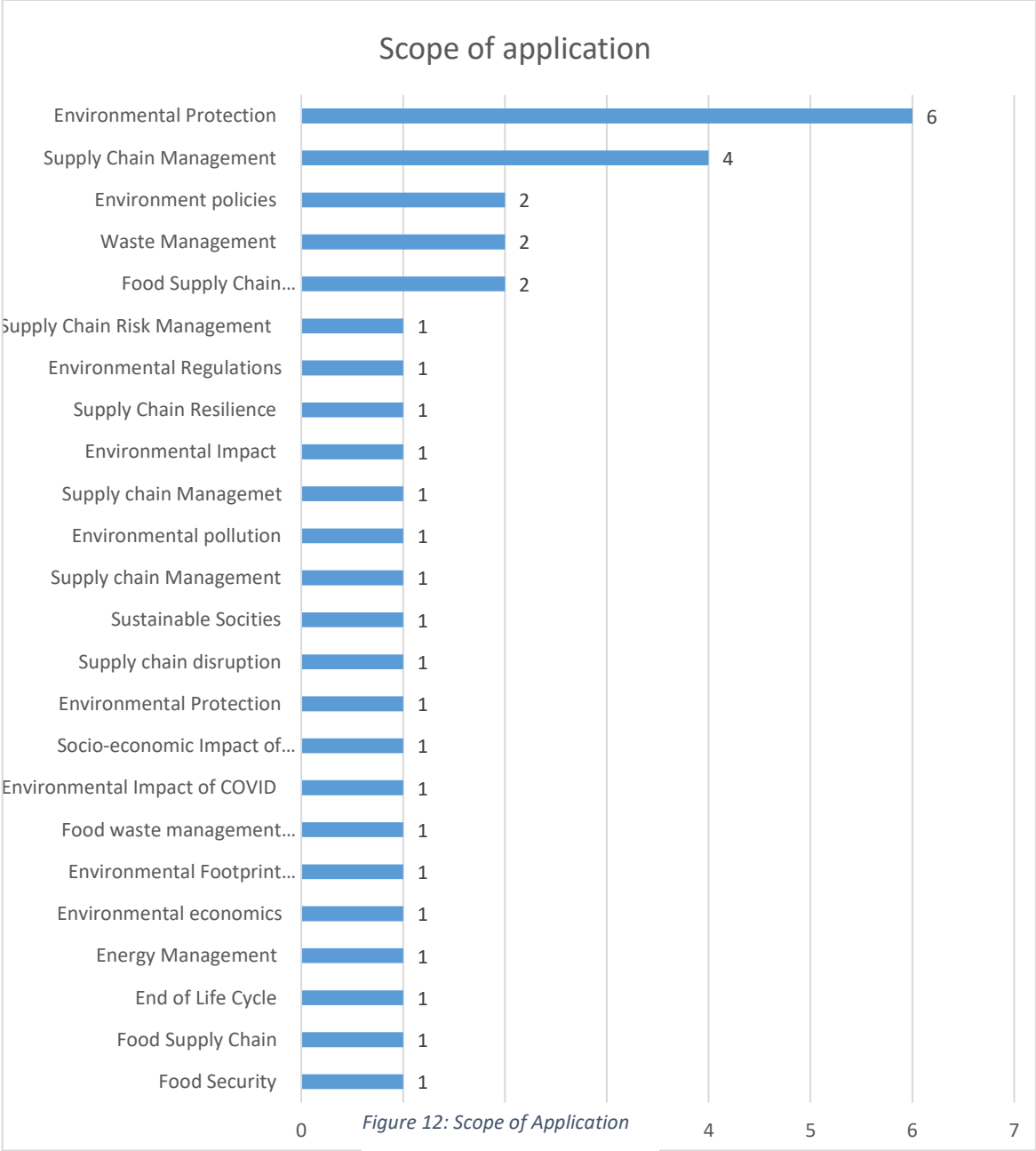

Figure 12: Scope of Application

environmental policies and waste management. Figure (12) illustrates the list of application scope.

The figure (13) presents the insight of the technology that been used for the purpose of the research analysis in the articles. It is obvious from the table that this graph does not give any trend of the technology that has been considered by the researchers but still interesting to know the use of it in research.

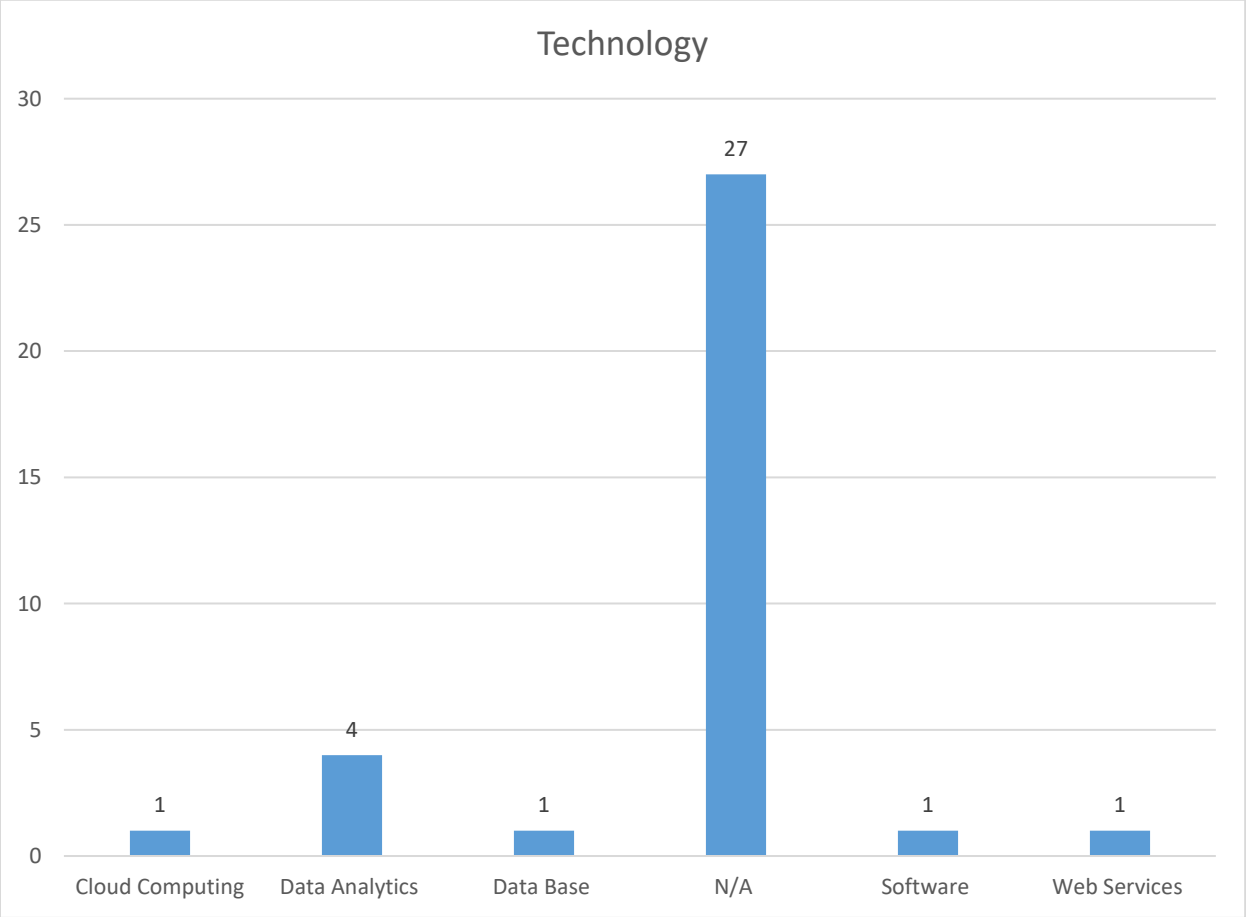

Figure 13: Technology

27 articles did not use or refer any technology, while 4 articles used data analytics. Cloud computing, software application, webservices and data base were used or refer once.

4.3 Chronological Analysis

The third part of observation of the results focuses on evolution time of the concepts with which the literature under analysis was described and developed in order like the one just illustrated. It is to be noted from the figure that the Covid-19 was first reported in December and the earliest research result that could be found from the data base is published and available online in March. In the first two months of 2020 there was no publication done on the topic of Environmental impact of covid-19 on global SC. This is intuitive as there was limited or no data present at that time. Figure (14) illustrates the articles per month.

The graph seems to be going steadily up before taking a dip and then rose once again at the end of the year 2020.

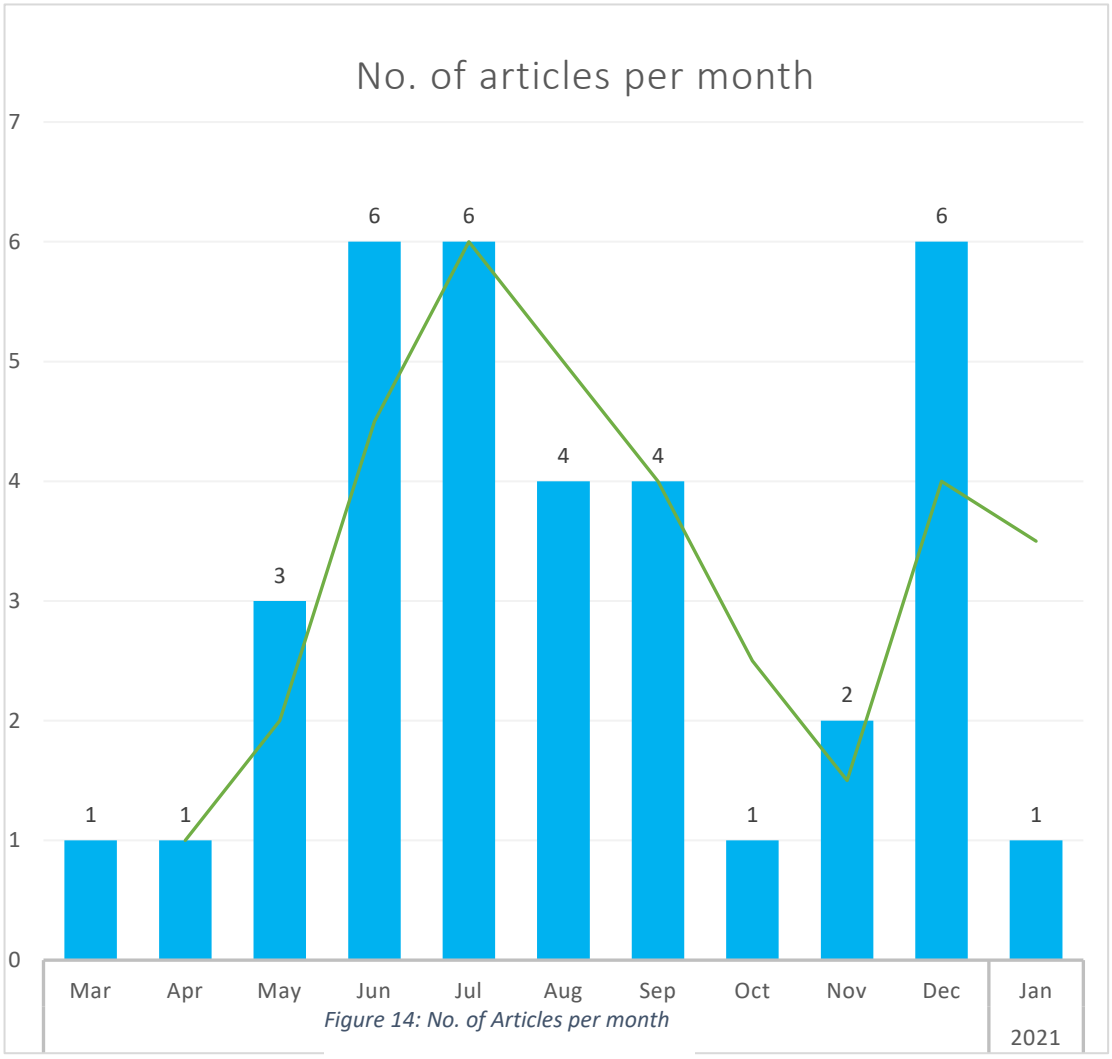

Figure 14: No. of Articles per month

The number of research articles written on this subject more than doubles in next few months. The Peak was achieved in the month of June and July. The graph seems to have dip in the month of oct which could be of various reasons. One might say that during last quarter of 2020 research related to COVID-19 became very well-known and for that reason the publication of the articles was slowed because of the backlog. From November onwards the trend starts going up and it is expected that 2021 will be great year for the researchers as data related to covid-19 will be more accurate and widely available.

The figure (15) Shows the trend of the analysis methodology over the year 2020 and 2021. It testifies the growth of both of the methodology over the period. The early research articles talked about quantitative analysis; with the coming months the study also incorporated the qualitative analysis as well. Overall, the quantitative analysis has dominated the research articles.

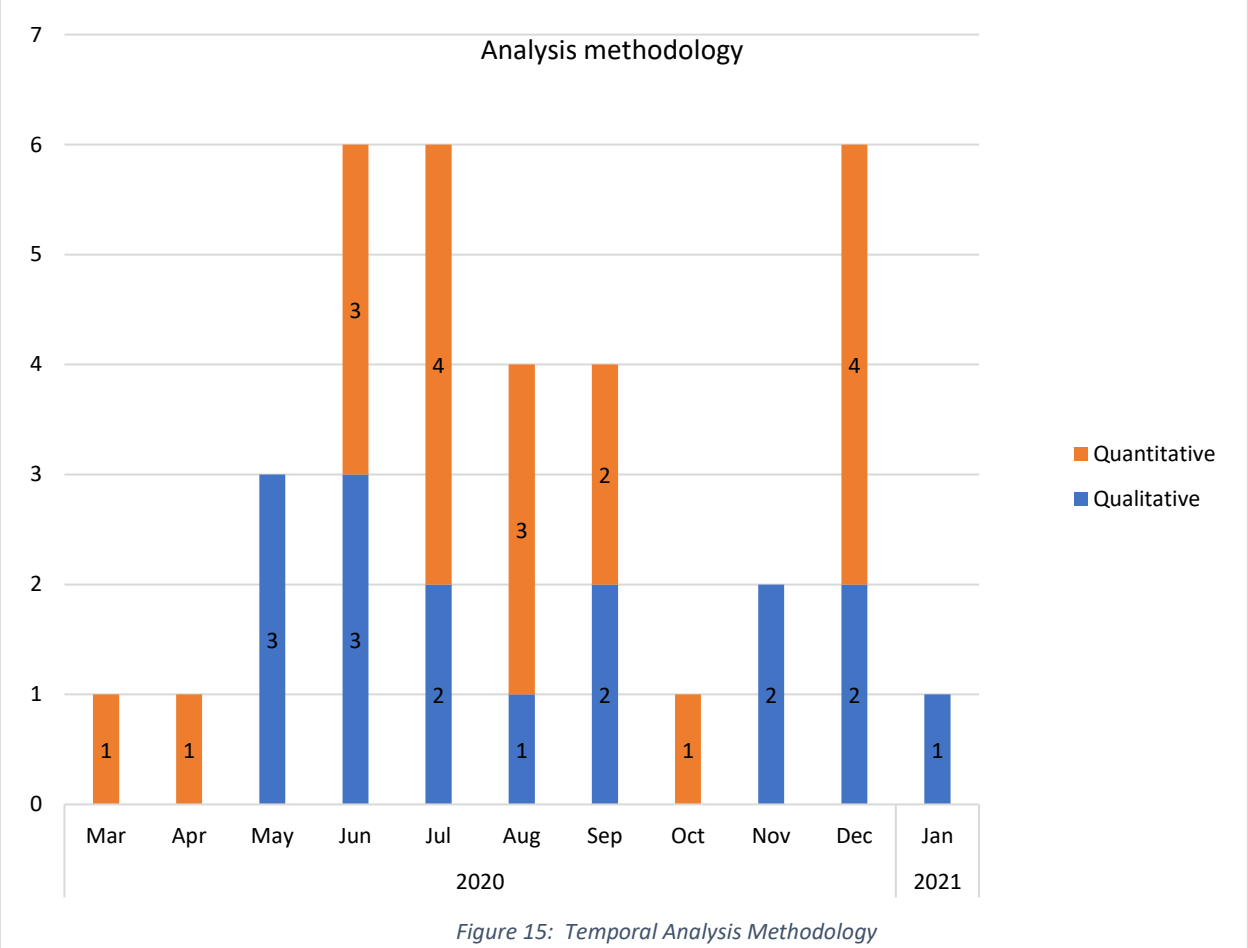

Figure 15: Temporal Analysis Methodology

The figure (16) shows the trend of the study type evolvement over the period. One trend that can be deduced from this graph is that the study type is dominated by the literature review. Which has been done 14 times out of 35 articles that the author has considered for the purpose of analysis. Literature review comprised of the topics studied on the previous epidemics and their impact on the environment and the SC. It should be noted that the second to literature review the study was based on the empirical research where the authors quantified the impact. It can be said that the study type is quite open yet and it can go in either of the direction in the future.

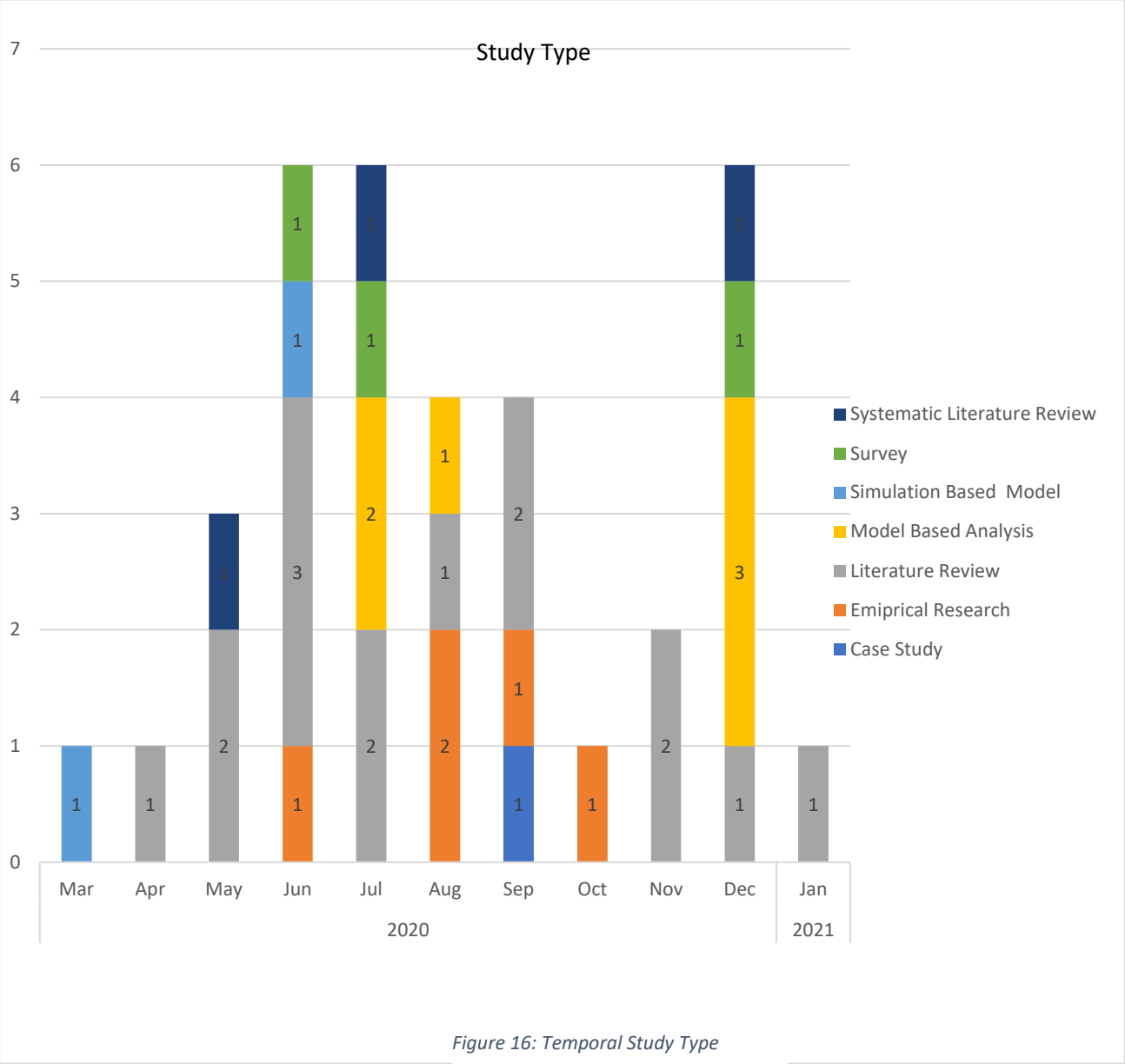

Figure 16: Temporal Study Type

The Figure (17) illustrates the trend of the study analysis over the period. Study is dominated by the descriptive analysis which presents what has happened already. Instead, the predictive study which predicts the future of the studied subject is less studied. It is hard to find a general trend in the study on where the study analysis is leading. As all the study types have a steady growth over the period. It is intuitive that with the passage of time the more accurate data and statistics will be available which will lead to more descriptive approach. While the understanding of the

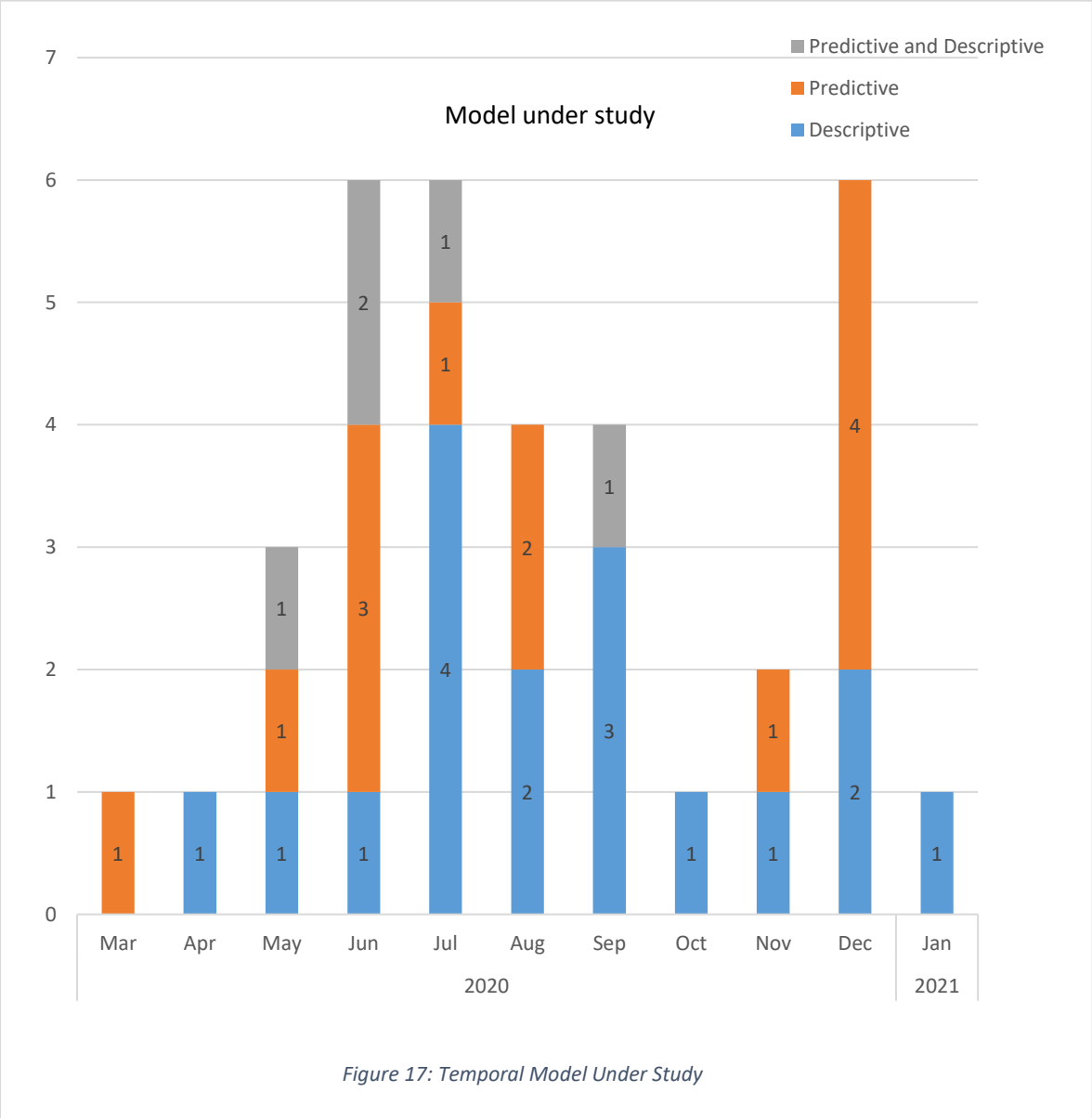

Figure 17: Temporal Model Under Study

situation will also be enhanced which will lead to better prediction by the researchers. Hence it can go in both ways.

The figure (18) illustrates the trend analysis of the study time horizon over the period. The study is dominated by the articles which discussed both short- and long-term time horizon. At beginning of the year more research where focused towards long term and bot short and long term. But from June and onwards the researchers also started considering the short-term horizon. The reason for that could be because initially the data related to the impact of covid-19 was not available, so the researchers used more literature to map the impact of the epidemic using the previous studies but with the progression more and more data started adding up and made it possible to monitor the short-term impact as well. Which is also evident from the trend as the year came to an end research was dominated by the short-term time horizon.

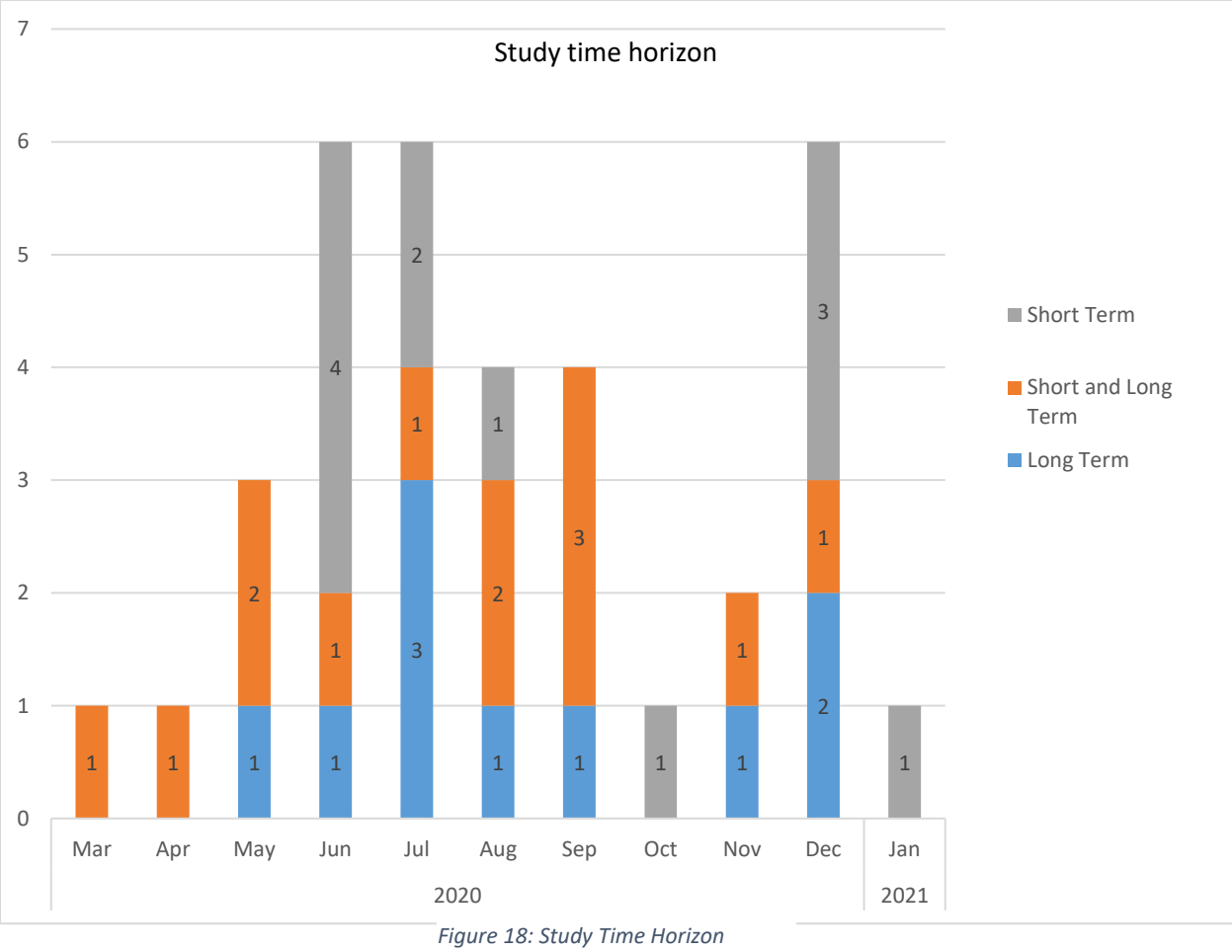

Figure 18: Study Time Horizon

5. DISCUSSION

5.1. Main Topics and interpretation

Based on the analysis carried out and the results presented in the previous chapter it is decided to discuss the topics emerged from the analysis of the articles. One significant topic was what could be the future of global supply chains and its impact on the environment?

The emergence of China and its unprecedented economic growth, calculated in traditional GDP terms, has been a significant cause of environmental harm to the atmosphere and biodiversity over the last thirty years, both directly and indirectly.[8] China now burns half the world's coal [50] It has caused significant impact to the environment.

Most of this emission has been related to the manufacturing of goods for consumption by other nations, especially the US and EU countries, which make up a large share of the world's GDP. There has been much discussion about the Chinese development paradigm, but at its early heart was the export of fossil and energy-intensive goods.[1 pan et al] The corollary of this was the relative decrease in domestic production of steel, fertilizers, petrochemicals, aluminum and even cement (the major five traded carbon-intensive goods) in the US and in particular in the EU, partially supplanted by Chinese exports.[8] In other words, in China, all of this waste has been for the benefit of customers in the US and EU.

This causal link has been masked using territorial carbon output measures for the climate change goals and painted an unduly rosy image of EU attempts to minimize pollution, while at the same time increasing global warming by increasing carbon emissions in China and hence the relentless growth in the concentration of carbon in the atmosphere. The supply of large quantities of cheap and compliant labor migrating from the countryside to the cities, and the ability to extract a substantial savings surplus from them, which the Chinese state then recycled for investment, are a key reason why China has succeeded in gaining export markets in the past. US and European companies have been encouraged by cheap labor to outsource production to China and then import the products back into their home markets. This has been the case for a wide range of

products, from mobile phones to clothes and shoes. The result was the globalization of manufacturing and the widening of supply chains. The fragility of some of these, and the extent to which the US and the EU are dependent on everything from face masks and medical equipment to communication technologies, has been highlighted by the coronavirus. Some commentators argue that, since environmental standards are higher in the US and Europe in general, the coronavirus will encourage a retreat to a greater emphasis on national production and domestic security of supply, which will in turn reduce pollution from shipping and aviation and reduce global pollution, and coal is a much smaller proportion of energy inputs for this production.[8]

It assumes that globalization has been bad for the environment, that compared to globalization, deglobalization will improve environmental outcomes. Again, the counter-factual concerns are what the contribution of the virus will be: the rise of world trade has already stalled in 2019 [51] and the introduction of new technology is expected to have further slowed it down. Robots replace cheap labor; they replace skilled labor. They do not sleep or need reimbursement for welfare, and do not catch coronavirus. Economic development, with robotics and 3D printing playing facilitating positions, will decouple from the paradigm that depends on finding output close to cheap input costs as opposed to close to consumers. [52]

You ought to disaggregate the arguments. First, there is the general issue of the relation between globalization in general and the consequences of the climate. Second, the question is whether the experience of the virus contributes to stronger deglobalization. Thirdly, there is a particular concern as to whether the protection of supply of higher domestic demand is often good for the climate.

The two environment-specific characteristics of the general partnership are: environmental emissions associated with shipping and aviation (including infrastructure funding, port services and on-land transport, extra passenger travel to handle global shipping and aviation), The supply chains and the increased tourism arising from the globalized development of China); And the disparity in the composition of the input component (in particular coal and fertilizers) for output in China as opposed to for production in the importing region.[8]

An additional beneficial environmental effect of a more national approach to trading is that a drive towards the incorporation of environmental costs and border carbon adjustment could be promoted. Before the pandemic, the European Commission had already suggested such a measure [53] European Commission 2019]. It is distorting trade not to involve carbon and other environmental costs in trade, and this is nowhere clearer, more than for carbon, where higher carbon prices in Europe have given imports from China an additional distorting competitive edge [76]. It could be that if China is put on a fair footing, the US would consider returning to a global carbon system. This was Obama's requirement, and the unfair nature of the commitments has been a major factor in the reluctance of the US Senate to ratify the Kyoto Protocol and its tacit ratification. Veto on the negotiation of subsequent multinational treaties on environment.[8]

The opportunity presented by the pandemic to argue against trade and for greater national security of supplies has not been lost on lobbyists, and in particular farming groups. The coronavirus arose in the context of the trade war between the US and China, and trade negotiation between the EU and the US, the UK and the EU, and UK and the US. Resilience of supply chains is, however, not the same thing as food self-sufficiency, and the lockdown experience in the UK has been much more concentrated on food supply and logistics rather than food production. The case for a carbon border tax is that it removes distortion to trade; the case for enhanced agricultural production subsidies is about rent capture and the protection of vested interests. The former improves environmental outcomes; the latter typically does not.[8]

5.2 Demand and supply of PPEs during the pandemic

In addition to frontline health staff, the human-to-human nature of coronavirus transmission includes the obligatory use of plastic-based PPEs for average people to shield themselves against viral infection. The COVID-19 pandemic has since resulted in a skyrocketing Demand for critical PPE kits, which shows a massive increase in demand In the processing and sale of plastic all over the world. [54] To deal with the viral infection in the current pandemic,

the WHO has projected a monthly demand of 89 million of facial masks, 76million of gloves, 30million of gowns, and 1.6million of goggles along with 2.9 million of hand sanitizers as a part of safety measures for frontline health workers [55].

In addition, a monthly rise of 40 percent in the supply chain of numerous medical protection items worldwide during the pandemic has been estimated by the WHO. Similarly, the CAGR to produce PPEs is expected to display a rise of about 20% between 2020 and 2025. [56] The monthly consumption of facial masks and medical gloves has been reported to be around 129 billion and 65 billion, respectively, for 7.8 billion populations across the globe. [9] The daily use of medical kits has reached a remarkable level, according to the World Economic Forum (WEF), also in areas with comparatively minor reported cases of COVID-19 in the UK. For instance, during February 2020, in the UK, about 39,500 facial masks, 11,500 medical gloves, 1500 gowns, and 4200 filtering facepiece respiratory masks (FFP3) were used in the UK [55]. In addition, the expected demand in the UK is between 10 and 16 million PPEs per day, considering the government's existing supply of 14 million PPEs per day [57]. The Freedonia Group, a leading US-based market research company, has predicted that the existing demand for face shields during the pandemic will rise by about 312 percent [58].

At the same time, in countries like China with such a large population, demand for medical gloves is projected to grow by 12.5 percent in 2020, as per the forecast [57].In China alone, the production of facemasks rose in February 2020 to 116 million, which was 12 times greater than the previous month, i.e., January 2020.[10]. Given that China's total population is over 1.4 billion, the difference between increasing demand and related supply during the pandemic has been reported to be significant.[58] This pattern is no exception in other nations, where the increase in the number of cases of coronavirus, along with growing safety consciousness, has spurred the growth in demand for PPEs.[11]

Table(3) gives the breakdown of plastic-based PPEs demand and usage during the COVID-19 pandemic in various countries [11]

Demand and usage of plastic-based PPEs during COVID-19 pandemic in various countries.

Country	Demand and usage of plastic-based PPEs during COVID-19	References
China	• Plastic manufacturers are producing 116 million surgical masks per day • Around 14.8 million facial masks have been produced as of February 2020	ADB, 2020; BBC, 2020; LA Times, 2020; WEF, 2020
India	• Around 25 lakhs PPEs are required per day in the fight against COVID-19	ToI, 2020
Thailand	• Around 62% more plastic consumption in April 2020 as compared to the amount consumed in the last 12 months • About 1.5–2 million masks used daily nationwide	TEI, 2020
Bangladesh	• Around 455 million surgical masks and 1216 million gloves have been used during the first month of COVID-19 pandemic	ESDO, 2020
UK	• Per day demand of plastic medical kits ranges between 7.5 and 12 million in the fight against COVID-19 • National Health Service Hospital (NHS), UK uses more than 55 thousand masks, aprons, and gowns per day	BBC, 2020
France	• Around 40 million surgical masks are used weekly	BoF, 2020
Japan	• About 600 million facial masks produced per day as of April 2020	METI, 2020
Italy	• Monthly demand for facial masks and medical gloves has been increased to 1 billion and 0.5 billion, respectively in the fight against COVID-19	IMF, 2020

Table 2: Demand and Usage of plastic based PPEs during COVID-19 pandemic in various countries

5.3 Healthcare supply chains and its environmental footprint

Healthcare systems have been under the most unprecedented pressure in the crisis of COVID-19. There had been a struggle in term of PPE and medical supply as well as the bed capacity. For

example, Northern Italy, the European Union (EU) resourced health system, was reported to approach its breaking point. [59]. Hospital is regarded as one of the building sectors with high energy consumption [12] It was estimated that the healthcare industry accounted for 4.4% of global net GHG emissions.[60] and received considerable attention to shrink the carbon emissions even before the COVID-19 crisis. The high energy intensity is mainly contributed by the constant need for power supply, medical equipment usage, requirements for air quality (ventilation) and disease control. Several studies suggested that energy consumption.

is ranging from 8.9 to 17 MWh/bed depending on the hospital size according to the annual consumption. By considering the consumption by activities, it represents 0.20 MWh/hospitalization stay, 1.60 MWh/surgery and 0.07 MWh/emergency action. [13] It is expected that the energy usage and environmental footprint (vast use of resources) of the hospital are increased in this period. The rate of hospitalization and ICU admission were estimated to be 20.7 to 31.4%, and 4.9 to 11.5% of the reported cases.[14] By considering 34.25% (26.05% + 8.2%) of hospitalization stay and 22.2 M reported cases globally, the rough estimation shows that the energy consumption is 99 TWH (22.2 M X 0.345 X 12.95 MWh/bed), equivalent to 356 PJ, still depending on the number of stays.[14] Top emergency measures, such as the construction of new temporary hospital facilities, have not been included, however the construction requires significant electricity usage and release of pollution.[14]

Figure (19) summarizes the potential increase in environmental footprints related to healthcare SC. The increased demand for electricity, food packaging and disinfectants is caused by the rise in hospitalization, work changes and hygiene requirements.[15] Due to the infectivity of SARS-CoV-2 triggering COVID-19, massive testing (viral or antibody tests) are needed to diagnose and recognize the outbreak of the disease.[61] The tests carried out are as high as 390 M by extracting data from the countries recorded in Worldometer [62] (by 18 August 2020). The viral testing,

either molecular test, e.g., RT-PCS or antigen tests [63] is with an embodied environmental footprint, including from intranational or international transporting. The global trade network

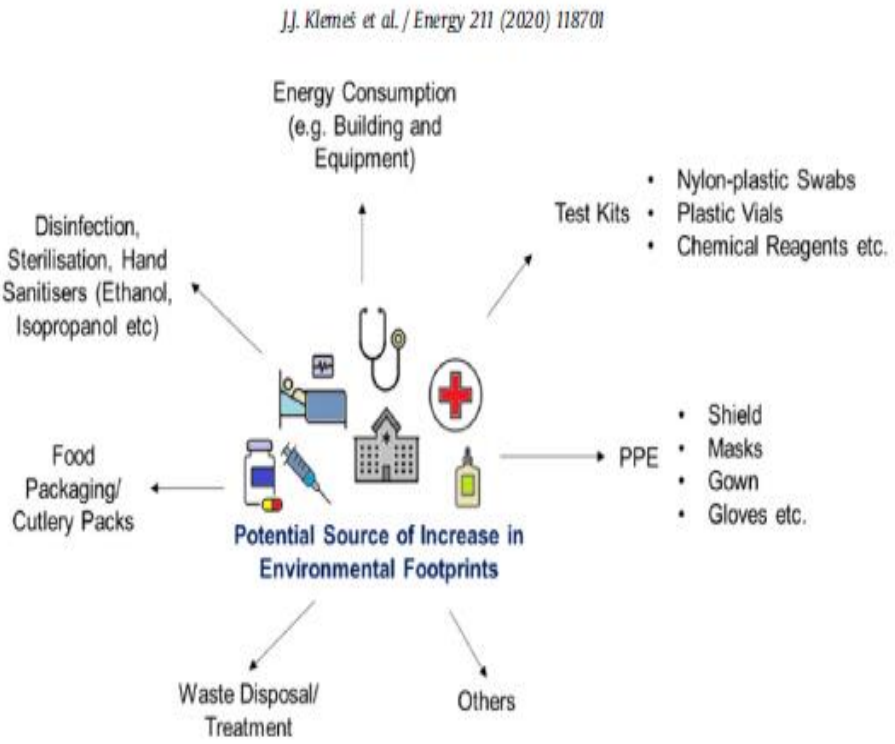

Figure 19: Environmenatal Footprint

and disruption of PPE supply chain have been discussed by the Asian Development Bank (ADB).[64 48,ADB] It should be remembered that, depending on the case, the energy use and environmental impact of the transport industry may be very different. For e.g., ships (~0.1-1.9 MJ/tkm [65] are used in a typical scenario. However, in the emergency, plane (~8.2-26 MJ/ tkm [65] is a better option even the cost and emission are higher, with an average of 17.1 times increases in energy consumption. The utilization of test kits is also associated with the consumption of resources, e.g., swabs, bottle/vials (plastic), chemical reagents, where proper waste treatment and disposal are required to minimize the environmental footprint.[16]

The estimated demand and energy consumption of PPE and test kits are summarized in table (4)

The PPE Demand and The Energy Consumption (estimated amounts are subject to fluctuations, mostly grows).

PPE/Devices and Weight	Estimated Demand	Estimated Energy Consumption
Mask  12–13 g/pcs[a]	129 G/month[b]	1.29 TWh/month = ~4.6 PJ/month (By considering the energy consumption for masks production is 0.000792–0.0342 kWh/pcs[c], taking 0.01 kWh/pcs for the estimation). Refer to Section 3 for further discussion on emissions
Gloves  ~7 g/pair[d]	65 G/month[b]	1.95 GWh/month = ~7.02 TJ/month (by considering the energy consumption for gloves production is 3×10^{-5} kWh/pair[g])
Fast Test kit (without gloves)  ~14 g/test[d]	390 M[e] (18 August 2020)	168 TJ (By considering the energy consumption of plastics production is 30.82 MJ/kg[f])
Shield  ~81 g/pcs[d]	1.59 M/month[b]	3.9 TJ/month (By considering the energy consumption of plastics production is 30.82 MJ/kg[f])

Table 3: The PPE Demand and Energy Consumption

Notes[2].

The largest proportion of materials for the PPE are plastics [69]. A part of the energy can be recovered, and the footprint can be mitigated if being treated appropriately. This aftermath of COVID-19, in consumption and waste management, has been still developing and is yet to be evaluated and dealt with as it is not a direct impact which could be quantified in a short run.[16]

[2] a [66]., b [67] , c [17], d [16] , e [62], f [18], g [68].

5.4 The reversal of single use plastics bans (SUPs) and its Impact on the plastic SC and environment

Plastic has been considered one of the key factors of environmental pollution because of its inability to decay. A rough estimation is that it takes almost 450 years for the plastic to fully decompose. Having said that it is important to know that the plastic that was produced on the very first day of its invention is still present somewhere on our planet and it will take centuries until it is fully decomposed. One of the most worrisome issue that has emerged from this pandemic is that the long battle that was fought to reduce the production and consumption of single use plastic has been reversed. Many countries had put bans on the SUPs but during COVID-19 times they had temporarily lifted the ban amidst the concerns of cross contamination by reusing the plastic bags and containers. [11] Earlier in 2020 USA was planning to ban the usage of plastic straws, takeout containers, citizens were advised to carry their own reusable bags in an effort to combat the pollution caused by the SUPs. [18] For example, as of May 2020, a potential state-wide ban on plastic bags in New York will be put on hold. More recently, the ban on plastic bags has been suspended by states such as California and Oregon, while Connecticut, Delaware, Hawaii, New Jersey, New Mexico, Oregon, Washington, etc. have stopped or postponed bans on SUP goods. [70] On the other hand, Massachusetts and New Hampshire have strongly discouraged the use of reusable plastic bags by reintroducing SUP products in anticipation of coronavirus transmission [71] Despite the ban on disposable plastic bags enforced earlier this year (January 2020) to cut Thailand's plastic waste production,

The nation is now seeing a 30 percent rise in its SUP output. [72]. In addition, the trade group European Plastics Converters (EuPC) has called on the EU regulatory agencies to repeal the ban levied on a collection of SUP products in the Member States of the European Union due to the COVID-19 pandemic [73].

The drastic decrease in the cost of plastic manufacturing due to the plummeting oil prices because of the reduced transportation has led to an increase in the production of the plastic thus disrupting the upstream supply chain. [74]

This has resulted in manufacturing companies deciding between plastic recycling and plastic production, and in the current scenario, the latter has emerged as an economically viable choice over the former. Because of this, the industrial sectors are returning to Produce fresh virgin plastic, contributing more to the excessive growth trend of plastic and the mismanaged generation of plastic waste with a reduced recycling rate of plastic. In South-East Asian countries, for example, a major decrease in demand in the range of 30-40 percent for recycled plastics has been recorded due to declining oil prices during the pandemic [75] In addition, more and more incremental improvements in the use of plastic items, such as replacing reusable bags with SUP bags as a precautionary step, the use of disposable wipes for disinfection, and much of the time carrying hand sanitizer bottles, are some of the severe reactions that exaggerating plastic output.[9] Consequently, the increased use of SUPs at the time of the pandemic led to a significant rise in plastic usage. As developed countries were struggling hard to handle their plastic waste even before the COVID-19 pandemic, Amore's serious challenge is now visible worldwide. In the sense of expanded plastic waste production since the pandemic, the relaxation or postponement of bans on SUPs and unprecedented use of PPEs have raised more rigid problems in terms of successful waste management.[11]

5.5 Research Gaps and Future Developments

Covid19 is a new topic and its impact on Global supply chains and environment needs to be studied thoroughly. As predicted this research work study has its limitation and it will take some time to understand the full extent of the impact of this novel corona virus. One of the main limitations of this study is the lack of sufficient research articles available on this topic. Though the research is being done on the supply chains effects but there exists a lack of holistic study. After reviewing, reading more than 100 articles only 35 articles qualified for the analysis. This indicates the lack of research available on one subject. For this reason, for the future research agenda A bigger data would be suggested for the scope of research that would enable more accurate research work. The second limitation of the research work was the lack of statistical data availability which made it difficult to dig deep and discuss in depth the actual impact on the environment. It will take a few years to understand the full extent of the damage. Third, query

used to search the keywords on the databases could be a barrier in exploring other SC-related themes. In the future, additional studies could adopt and extend our protocol for much better results.

All the articles critically were reviewed critically, and it was decided to extract key topics from each article that can become a possible future research agenda. These articles were put under the subtopics heading on the excel file. I have formed a list of all the subtopics that were deemed could become future research topics. Table (5) gives the list of all the subtopics.

Topic	Count
environmental footprint of covid-19	5
carbon pricing amid covid	5
environmental sustainability amid covid-19	4
food safety	4
circular economy	3
global circular economy	3
covid-19 impact on the energy demand	2
positive environmental impact of covid-19	2
environmental impact of ppe's usage	2
covid-19 impact international on cooperation	1
zero waste masterplan	1
sustainable inclusive growth and a green economy	1
demad-supply mismatch in covid-19 times	1
new generation supply chain	1
disease control measures	1
spill over effect	1
economical impact of covid-19	1
theory of planned behaviour	1
change in consumption habits due to covid-19	1
negative environmental implications of covid-19	1
covid-19 impact on the developing countries	1
opec nations income loss	1
ppe cradle to grave anlysis	1
risk of infectious disease transfer from indirect interaction with wildlife	1
precautionary measures to avoid corona transfer from food supply chain	1
climate change	1
short term environmental impact of covid	1
fiscal stimuli on global emissions amid covid	1

sustainable construction	1
food purchasing behaviour amid covid-19	1
sustainable supply chain challenges	1
compound natural and human disasters: drought and covid-19	1
waste recycling services amid covid	1
food safety regulations	1
long term environmental impact of covid	1
food waste depending on the socio demographic	1
negative macroeconomic impact of covid-19	1
future of the global economy	1
normative activation model	1
g20 economies	1
policies for mitigating the coronavirus pandemic	1
pricing reforms and public spendings for post covid-19 policies	1
positive impact of covid on green house emissions	1
public health policy choices	1
ppe recycling amid covid-19	1
recycling and sorting in covid-19 times	1
construction impact on the environment	1
re-shaping supply chian	1
public perception of environment regulations	1
green stimulus policy amid covid-19	1
reprocessing of ppe's amid covid-19	1
household energy consumption amid covid-19	1
rethinking globalization and deglobalization	1
impact on agri-food supply chains	1
ship recycling amid covid-19	1
increase in emissions from fiscal counter measures	1
social-ecological challenges in the wake of covid-19	1
international cooperation for environmental protection	1
supply chains deglobalization	1
inventory managemnt	1
sustainable food supply chains	1
is robust and localized supply chain solution of solid waste management at the time of pandemic	1
sustainable solution for ppe amid covid	1
just in time approach and its shortcomings in liu of covid-19	1
the biophysical basis of an economy	1
lca of ppe	1
waste management	1
life cycle assessment of food supply chain	1
wildlife market supply chain	1
local food supply chain	1
alternative material selection for conventional ppe's	1

long term economic impact of covid	1
Grand Total	**93**

This list illustrates the possible future research topics, it would be interesting to research on the carbon pricing strategies of the global economies in the years to come. Research on the food safety could become another agenda for the researchers, also the circular economy could become another topic. The main objective here is to give a list of these topics to the target audience who can then proceed to choose any of these research topics and present valuable contribution to the cause.

6. CONCLUSION

The covid-19 outbreak shows that the pandemic can seriously cause a wreak to global supply chains and it can have significant impact on the environment. In this study, I have presented a systematic literature review analysis of the epidemic outbreaks impacts on the supply chains and environment by using Scopus data base and presented a unique taxonomy which enabled to help find the answers, what are the early lessons learned from covid-19 impact on the supply chains and environment and proposed the future research topics that would not have been possible otherwise.

In terms of the findings and contributions this study has put an effort to put together all the literature published on the title of this thesis/ in a way that can be used to understand the kind of work being done on this topic. The global supply chains have been disrupted specially the supply chains of plastics and PPE's which has seen a supply and demand mismatch. The COVID-19 pandemic resulted in a skyrocketing Demand for critical PPE kits, which shows a massive increase in demand in the processing and sale of plastic all over the world. In addition, a monthly rise of 40 percent in the supply chain of numerous medical protection items worldwide during the pandemic has been estimated by the WHO. Energy demand by health sector has skyrocketed. This increase in the demand of Plastic which is a cancer for the sustainability of the environment will have a long-lasting impact and it will take years until its true effects will unfold.

As anticipated this study harbors a few limitations. The query used to search the keywords on the databases could be a barrier in exploring other SC-related themes. In the future, additional studies could adopt and extend our protocol for much better results. In addition, this work has been limited by the scarcity of research about the effects of Covid-19 on supply chains and environment. Only 35 research papers were found to fully meet our research protocol. Considering these limitations author has proposed a list of research topics deduced from the analysis of the articles. These topics can serve as a base for the future research considerations.

References:

[1] A. A. R. V, V. R, and F. Haghighat, “The contribution of dry indoor built environment on the spread of Coronavirus: Data from various Indian states,” *Sustain. Cities Soc.*, vol. 62, no. May, p. 102371, 2020, doi: 10.1016/j.scs.2020.102371.

[2] T. Ibn-Mohammed *et al.*, “A critical review of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies,” *Resour. Conserv. Recycl.*, vol. 164, no. May 2020, p. 105169, 2021, doi: 10.1016/j.resconrec.2020.105169.

[3] T. Kapecki, “Elements of Sustainable Development in the Context of the Environmental and Financial Crisis and the COVID-19 Pandemic,” pp. 1–12, 2020.

[4] L. Cirrincione *et al.*, “COVID-19 Pandemic: Prevention and protection measures to be adopted at the workplace,” *Sustain.*, vol. 12, no. 9, pp. 1–18, 2020, doi: 10.3390/SU12093603.

[5] C. L. Chang, M. McAleer, and V. Ramos, “A charter for sustainable tourism after COVID-19,” *Sustain.*, vol. 12, no. 9, pp. 10–13, 2020, doi: 10.3390/su12093671.

[6] R. J. R. Elliott, I. Schumacher, and C. Withagen, “Suggestions for a Covid-19 Post-Pandemic Research Agenda in Environmental Economics,” *Environ. Resour. Econ.*, vol. 76, no. 4, pp. 1187–1213, 2020, doi: 10.1007/s10640-020-00478-1.

[7] F. Sörgel *et al.*, *Accesibility and allocation of public parks and gardens during covid 19 social distancing in England and Wales. NOTE: This preprint reports new research that has not been certified by peer review and should not be used to guide clinical practice.* 2020.

[8] D. Helm, “The Environmental Impacts of the Coronavirus,” *Environ. Resour. Econ.*, vol. 76, no. 1, pp. 21–38, 2020, doi: 10.1007/s10640-020-00426-z.

[9] M. Kalina and E. Tilley, “‘This is our next problem’: Cleaning up from the COVID-19 response,” *Waste Manag.*, vol. 108, pp. 202–205, 2020, doi: 10.1016/j.wasman.2020.05.006.

[10] D. Wang *et al.*, “Can Masks Be Reused After Hot Water Decontamination During the COVID-19 Pandemic?,” *Engineering*, vol. 6, no. 10, pp. 1115–1121, 2020, doi: 10.1016/j.eng.2020.05.016.

[11] N. Parashar and S. Hait, “Plastics in the time of COVID-19 pandemic: Protector or polluter?,” *Sci. Total Environ.*, vol. 759, 2021, doi: 10.1016/j.scitotenv.2020.144274.

[12] K. Bawaneh, F. G. Nezami, M. Rasheduzzaman, and B. Deken, “Energy consumption analysis and characterization of healthcare facilities in the United States,” *Energies*, vol. 12, no. 19, 2019, doi: 10.3390/en12193775.

[13] J. García-Sanz-Calcedo, M. Gómez-Chaparro, and G. Sanchez-Barroso, “Electrical and thermal energy in private hospitals: Consumption indicators focused on healthcare activity,” *Sustain. Cities Soc.*, vol. 47, no. February, p. 101482, 2019, doi: 10.1016/j.scs.2019.101482.

[14] S. Bialek *et al.*, “Severe Outcomes Among Patients with Coronavirus Disease 2019 (COVID-19) — United States, February 12–March 16, 2020,” *MMWR. Morb. Mortal. Wkly. Rep.*, vol. 69, no. 12, pp. 343–346, 2020, doi: 10.15585/mmwr.mm6912e2.

[15] A. Gallego-Schmid, J. M. F. Mendoza, and A. Azapagic, “Environmental impacts of takeaway food containers,” *J. Clean. Prod.*, vol. 211, no. 2019, pp. 417–427, 2019, doi: 10.1016/j.jclepro.2018.11.220.

[16] J. J. Klemeš, Y. Van Fan, and P. Jiang, “The energy and environmental footprints of COVID-19 fighting measures – PPE, disinfection, supply chains,” *Energy*, vol. 211, no. x, 2020, doi: 10.1016/j.energy.2020.118701.

[17] M. Sapti, “**済無**No Title No Title,” *Kemamp. Koneksi Mat. (Tinjauan Terhadap Pendekatan Pembelajaran Savi)*, vol. 53, no. 9, pp. 1689–1699, 2019, doi: 10.14324/111.444/000031.v1.

[18] J. J. Klemeš, Y. Van Fan, R. R. Tan, and P. Jiang, “Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19,” *Renew. Sustain. Energy Rev.*, vol. 127, no. April, 2020, doi: 10.1016/j.rser.2020.109883.

[8] Petticrew, M. (2001). Systematic reviews from astronomy to zoology: Myths and misconceptions. *British Medical Journal, 322*(7278), 98–101. https://doi.org/10.1136/bmj.322.7278.98.

[9] Mustafa Kamal, M., & Irani, Z. (2014). Analysing supply chain integration through a systematic literature
review: A normative perspective. *Supply Chain Management: An International Journal*. https ://doi. org/10.1108/SCM-12-2013-0491

Citography:

[19] Worldometer. 2020. Available at www.worldometers.info/coronavirus/.

[20] Kieszek, N. Rynek Pracy w Europie w Dobie Koronawirusa, Czyli Jak Mocno Wzro´snie Bezrobociew Wybranych Pa´nStwach. Available online:https://strefainwestorow.pl/artykuly/gospodarka/20200430/bezrobocie-w-europie-epidemia-koronawirus

[21] 20 Million Economic Indicators for 196 Countries. Available online: https://tradingeconomics.com (accessedon 28 May 2020).

[22] Oto Pa´nstwa UE, Które Czeka Najwi¸eKsze ZałAmanie Gospodarcze. Available online: https://forsal.pl/gospodarka/galerie/1474759,duze-zdjecie,2,prognozy-ke-pkb-strefy-euro-skurczysie-o-7-7-proc-najwieksze-zalamanie-na-poludniu.html (accessed on 31 May 2020).

[23] Vanham P (2019) World Economic Forum https ://www.wefor um.org/agend a/2019/01/how-globa lizat ion-4-0-fits-into-the-histo ry-of-globa lizat ion

[24] Gardiner B (2020) Why COVID-19 will end up harming the environment, National Geographic. https :// www.natio nalge ograp hic.co.uk/envir onmen t-and-conse rvati on/2020/06/why-covid -19-will-end-upharmi ng-the-envir onmen t

[25] Barry M (2020) Globalization unwound. Has covid-19 killed globalization, The Economist, May 14,2020, The Economist Today, daily newsletter

[26] Gruszczynski L (2020) The COVID-19 pandemic and international trade: temporary turbulence or paradigm shift? Euro J Risk Regul 11(2):337–342

[27] Shope R (1991) Global climate change and infectious diseases. Environ Health Perspect 96:171–174

[28] Boucekkine R, Aude P, Fabien P (2013) Optimal regime switching and threshold effects. J Econ Dyn Control 37(12):2979–2997

[29] Nordhaus W (2014) Estimates of the social cost of carbon: concepts and results from the DICE-2013R model and alternative approaches. J Assoc Environ Res Econ 1(1/2):273–312

[30] Schumacher I (2009) Endogenous discounting via wealth, twin-peaks and the role of technology. Econ Lett 103(2):78–80 Steger TM (2005) Stochastic growth under Wiener and Poisson uncertainty. Econ Lett 86(3):311–316

[31] See https ://www.proje ct-syndi cate.org/bigpi cture /deglo baliz ation -s-dange rs?barri er=acces spayl og.

[32] See https ://menaf n.com/11003 80753 /COVID -crisi s-exace rbate s-globa lizat ion-worri es-IMF-econo mist.

[33] https ://www.ft.com/conte nt/3ea8d 790-7fd1-11ea-8fdb-7ec06 edeef 84.

[34] Shih W (2020) Is it time to rethink globalized supply chains? MITSloan Management Review. https ://sloanrevie w.mit.edu/artic le/is-it-time-to-rethi nk-globa lized -suppl y-chain s/

[35] Sforza A, Steininger M (2020) Globalization in the time of COVID-19. CESifo working paper 8184

[36] Müller-Fürstenberger G, Schumacher I (2017) The consequences of a one-sided externality in a dynamic, two-agent framework. Eur J Oper Res 257(1):310–322

[37] Calmette MF (2020) Globalization: the day after, TSE Magazine special issue Spring, pp2022

[38] https ://www.rug.nl/feb/blog/thoma s-piket ty-on-inequ ality -and-globa lisat ion-17-07 2018.

[39] Lipfert FW (2004) Air pollution and poverty: does the sword cut both ways? J Epidemiol Commun Health58(1):2–3

[40] (FAO, 2005a [1]): http://www.marinespecies.org/introduced/wiki/Supply_chain_analysis

[41] Evolution, T. H. E., The, O. F., & Loses, W. H. O. (2006). Chain : Who Gains and Who Loses ? ∗. *International Economic Review*, *47*(3), 811–836.

[42] Global Energy Review 2020 (IEA, 2020); https://www.iea.org/reports/ global-energy-review-2020

[43] Broom, D. 5 things to know about how coronavirus has hit global energy. World Economic Forum https://www.weforum.org/agenda/2020/05/covid 19-energy-use-drop-crisis/ (2020).

[44] Hinson, S. COVID-19 is changing residential electricity demand. Renewable Energy World https://www.renewableenergyworld.com/2020/04/09/ covid-19-is-changing-residential-electricity-demand/ (2020).

[45] Liu, Z. et al. Near-real-time monitoring of global CO2 emissions reveals the effects of the COVID-19 pandemic. Nat. Commun. 11, 5172 (2020).

[46] Le Quéré, C. et al. Temporary deep reduction in daily global CO2 Emissions from the COVID-19 confinement. Nat. Clim. Change 10, 647–653 (2020)

[47] Kissler, S. M., Tedijanto, C., Goldstein, E., Grad, Y. H. & Lipsitch, M. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. Science 368, 860–868 (2020).

[48] Jorda, O., Singh, S. R. & Taylor, A. M. Longer-run Economic Consequences of Pandemics Report No. 0898-2937 (National Bureau of Economic Research, 2020).

[49]https://libguides.rug.nl/c.php?g=470628&p=3218096#:~:text=The%20snowball%20method%20is%20a,relevant%20titles%20on%20your%20subject

[50] https ://www.iea.org/news/decou pling -of-globa l-emiss ions-and-econo mic-growt h-confi rmed IEA (2019) Coal 2019: Analysis and Forecasts to 2024. Available from https ://www.iea.org/repor ts/coal-2019

[51] See for background Ortiz-Ospina and Beltekian (2018).

[52] See Ford (2015). For an alternative view see World Trade Organization (2018).

[53] European Commission (2019) The European Green Deal, Communication from the Commission to the European Parliament, the European Council, The Council, The European Economic and Social Committee and the Committee of the Regions COM(2019) 640 final, 11 December. Available from https ://ec.europ a.eu/info/sites /info/files /europ ean-green -deal-communicat ion_en.pdf

[54] Prata, J.C., Silva, A.L.P., Walker, T.R., Duarte, A.C., Rocha-Santos, T., 2020. COVID-19 pandemic repercussions on the use and management of plastics. Environ. Sci. Technol. 54, 7760–7765. https://doi.org/10.1021/acs.est.0c02178.

[55] WHO, 2020b. Shortage of Personal Protective Equipment Endangering Health Workers

Worldwide. The World Health Organization (WHO) https://www.who.int/newsroom/detail/03-03-2020-shortage-of-personalprotective-equipment endangering healthworkers-worldwide. (Accessed 9 July 2020)

[56] WEF, 2020. The Plastic Pandemic Is Only Getting Worse During COVID-19. World Economic Forum (WEF) https://www.weforum.org/agenda/2020/07/plastic-wastemanagement-covid19-ppe/. (Accessed 9 July 2020).

[57] BBC, 2020. COVID-19: How Long Does the Coronavirus Last on Surfaces. Brtish BroadcastingCorporation (BBC) https://www.bbc.com/future/article/20200317-covid-19-how-long-does-the-coronavirus-last-on-surfaces/. (Accessed 21 August 2020).

[58] LA Times, 2020. The COVID-19 Pandemic Is Unleashing a Tidal Wave of PlasticWaste. Los Angeles Times (LA Times) https://www.latimes.com/world-nation/story/2020-06-13/coronavirus-pandemic-plastic-waste-recycling. (Accessed 9 August 2020).

[59] McCarthy N. The countries with the most critical care beds per capita. Statista; 2020. www.statista.com/chart/21105/number-of-critical-care-beds-per-100000-inhabitants. [Accessed 26 July 2020].

[60] HCWH (Health Care Without Harm). Health care's climate footprint: how the health sector contributes to the global climate crisis and opportunities for action. 2019. noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimate Footprint_090619.pdf, . [Accessed 26 July 2020].

[61] Walensky RP, Del Rio C. From mitigation to containment of the COVID-19 pandemic: putting the SARS-CoV-2 genie back in the bottle. Jama 2020;323(19):1889e90.

[62] Worldometer. Coronavirus cases. 2020. www.worldometers.info/coronavirus/#countries. [Accessed 24 July 2020].

[63] FDA. Coronavirus testing basics. 2020. www.fda.gov/consumers/consumerupdates/coronavirus-testing-basics. [Accessed 26 July 2020].

[64] ADB. Global shortage of personal protective equipment amid COVID-19: supply chains, bottlenecks, and policy implication. 2020. www.adb.org/sites/default/files/publication/579121/ppe-covid-19-supply-chains-bottleneckspolicy. [Accessed 26 July 2020].

[65] LISPASTO. Unit emissions. 2017. lipasto.vtt.fi/yksikkopaastot/indexe.htm. [Accessed 26 July 2020].

[66] Ecochain. The rise of the face mask: what's the environmental impact of 17 million N95 masks?. ecochain.com/knowledge/footprint-face-maskscomparison. [Accessed 26 July 2020].

[67] Prata JC, Patrício Silva AL, Walker TR, Duarte AC, Rocha Santos T. COVID-19 pandemic repercussions on the use and management of plastics. Environ Sci Technol 2020;54(13):7760e5.

[68] Goorej. Case study e glove manufacturing. 2020. www.godrejcas.com/casestudies/ pharmaceutical-industry/glove-manufacturing. [Accessed 26 July 2020].

[69] Kleme_s JJ, Fan YV, Jiang P. Plastics: friends or foes? The circularity and plastic waste footprint, energy sources, Part A: recovery. Utilization, and Environmental Effects 2020. https://doi.org/10.1080/15567036.2020.1801906.

[70] U.S.A. Today, 2020. Plastic bag bans reversed: states, cities, stores are suddenly banning reusable bags during coronavirus. https://www.usatoday.com/story/money/2020/ 04/08/plastic-bag-bans-reversed-coronavirus-reusable-bags-covid-19/2967950001/. (Accessed 23 August 2020).

[71] World Bank, 2020. Plastics: the coronavirus could reset the clock. https://blogs. worldbank.org/voices/plastics-coronavirus-could-reset-clock. (Accessed 12 September 2020).

[72] TEI, 2020. Solid Waste During COVID-19. Thailand Environment Institute (TEI) http:// www.tei.or.th/en/blog_detail.php?blog_id=49. (Accessed 9 August 2020).

[73] Financial Times, 2020. Plastic straws and stirrers ban delayed because of coronavirus. https://www.ft.com/content/8182d6db-f903-49a1-9e68-43341ad932ce. (Accessed 14 September 2020).

[74] Eco-Business, 2020. Coronavirus-induced oil price plunge is hurting the circular economy for plastic. https://www.eco-business.com/news/coronavirus-induced-oil-priceplunge-is-hurting-the-circular-economy-for-plastic/. (Accessed 11 July 2020).

[75] BIR, 2020. Covid-19 Update: Fragmented Picture for Under-Pressure Recycling Industry. Bureau of International Recycling (BIR) https://www.eco-business.org/news-press/

covid-19-infocenter/item/covid-19-update-fragmented-picture-for-under-

pressurerecycling-

industry. (Accessed 28 August 2020).

[76] Pan J, Phillips J, Chen Y (2009) China's Balance of Emissions Embodied in Trade: Approaches to Measurement
and Allocating International Responsibility. Chapter 8 of The Economics and Politics of Climate Change, edited by Helm D and Hepburn C. Oxford University Press, Oxford

[76] Helm DR, Hepburn C, Ruta G (2012) Trade, climate change and the political game theory of border carbon
adjustments. Oxf Rev Econ Policy 28(2):368–394

Appendix

Title	Authors	Year	Month	Date	Journal	Metodology	Qualitative vs Quantitative	Technology	Industry Sector	Scope of Application	Predictive vs. descriptive	Short-Term vs Long-Term
Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak	Dmitry Ivanov	2020	Mar	3/1/2020	Transportation Research Part E	Simulation Based Model	Quantitative	N/A	Household	Supply Chain Management	Predictive	Short and Long Term
Global supply-chain effects of COVID-19 control Measures	Dabo Guan,Daoping Wang, Stephane Hallegatte	2020	Jun	6/1/2020	Nature Human Behaviour	Simulation Based Model	Quantitative	Data Base	Multiple industrial sectors	Supply Chain Risk Management	Predictive and Descriptive	Short Term
Global socio-economic losses and environmental gains from the Coronavirus pandemic	Manfred Lenzen, Mengyu Li	2020	Jul	7/1/2020	PLOS ONE	Model Based Analysis	Quantitative	Cloud Computing	Not specified	Supply Chain Management	Descriptive	Short Term
Covid-19's impact on supply chain decisions: Strategic insights from NASDAQ 100 firms using Twitter data	Amalesh Sharma, Anirban Adhikary	2020	Jun	6/1/2020	Journal of Business Research	Survey	Qualitative	Data Analytics	Not specified	Supply Chain Management	Predictive and Descriptive	Short and Long Term
The economy' as if people mattered: revisiting critiques of economic growth in a time of crisis	Clive L. Spash	2020	May	5/1/2020	Routledge Taylor & Francis Group	Systematic Literature Review	Qualitative	N/A	Multiple industrial sectors	Environmental Impact	Descriptive	Long Term
The energy and environmental footprints of COVID-19 fighting measures e PPE, disinfection, supply chains	Ji ri Jaromír Kleme, Yee Van Fan, Peng Jiang	2020	Aug	8/1/2020	energy international journal elsevier	Empirical Research	Quantitative	N/A	Power	Energy Management	Descriptive	Short and Long Term
Food waste management during the COVID-19 outbreak: a holistic climate, economic and nutritional approach	R. Aldaco, D.Hoehn, J. Laso	2020	Jun	6/1/2020	Science of the Total Environment	Empirical Research	Quantitative	Data Analytics	Food	Food Supply Chain	Descriptive	Short Term
The COVID-19 pandemic: Lessons on building more equal and sustainable societies	Kristin van Barneveld, Michael Quinlan, Peter Kriesler, Anne Junor	2020	May	5/1/2020	The Economic and Labour Relations Review	Literature Review	Qualitative	N/A	Not specified	Socio-economic Impact of COVID-19	Predictive and Descriptive	Short and Long Term
Uncovering people's mask-saving intentions and behaviors in the post-COVID-19 period: Evidence from China	Si H., Shen L., Liu W., Wu G.	2020	Dec	12/1/2020	Sustainable Cities and Society	Model Based Analysis	Quantitative	N/A	Medical	Supply Chain Management	Predictive	Short Term
Disruption in Circularity? Impact analysis of COVID-19 on ship recycling using Weibull tonnage estimation and scenario analysis method	Rahman S.M.M., Kim J., Laratte B.	2020	Aug	8/1/2020	Resources, Conservation and Recycling	Model Based Analysis	Quantitative	N/A	Transportion	End of Life Cycle	Predictive	Short and Long Term
A critical review of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies	Ibn-Mohammed T., Mustapha K.B., Godsell J., Adamu Z., Babatunde K.A., Akintade D.D., Acquaye A., Fujii H., Ndiaye M.M., Yamoah F.A., Koh S.C.L.	2020	Sep	9/1/2020	Resources, Conservation and Recycling	Empirical Research	Quantitative	N/A	Multiple industrial sectors	Supply Chain Resilience	Predictive and Descriptive	Short and Long Term
Impact of Covid-19 on Household Food Waste: The Case of Italy	Pappalardo G., Cerroni S., Nayga R.M., Jr., Yang W.	2020	Dec	12/1/2020	Frontiers in Nutrition	Survey	Quantitative	N/A	Food	Food waste management system	Descriptive	Short Term
Sustainable food supply chains: Is shortening the answer? a literature review for a research and innovation agenda	Chi Pfoleau Y., Dourian T.	2020	Nov	11/1/2020	Sustainability (Switzerland)	Literature Review	Qualitative	N/A	Food	Food Supply Chain Management	Descriptive	Short and Long Term
Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic	Sharma H.B., Vanapalli K.R., Cheela V.S., Ranjan V.P., Jaglan A.K., Dubey B., Goel S., Bhattacharya J.	2020	Jul	7/1/2020	Resources, Conservation and Recycling	Systematic Literature Review	Quantitative	N/A	Waste Management	Waste Management	Predictive and Descriptive	Short and Long Term
International collaboration in the field of environmental protection: Trend analysis and covid-19 implications	Chernysh Y., Roubik H.	2020	Dec	12/1/2020	Sustainability (Switzerland)	Systematic Literature Review	Qualitative	N/A	Not specified	Environmental Protection	Descriptive	Long Term
Suggestions for a Covid-19 Post-Pandemic Research Agenda in Environmental Economics	Elliott R.J.R., Schumacher I., Withagen C.	2020	Aug	8/1/2020	Environmental and Resource Economics	Literature Review	Qualitative	N/A	Not specified	Environmental economics	Predictive	Long Term
What Policies Address Both the Coronavirus Crisis and the Climate Crisis?	Engström G., Gars J., Jaakkola N., Lindahl T., Spiro D., van Benthem A.A.	2020	Jul	7/1/2020	Environmental and Resource Economics	Literature Review	Qualitative	N/A	Not specified	Environment policies	Descriptive	Long Term
Elements of sustainable development in the context of the environmental and financial crisis and the COVID-19 pandemic	Kapecki T.	2020	Jul	7/1/2020	Sustainability (Switzerland)	Literature Review	Quantitative	N/A	Construction	Environmental Protection	Descriptive	Long Term
COVID-19 Creating another problem? Sustainable solution for PPE disposal through LCA approach	Kumar H., Azad A., Gupta A., Sharma J., Bherwani H., Labhsetwar N.K., Kumar R.	2020	Sep	9/1/2020	Environment, Development and Sustainability	Case Study	Quantitative	N/A	Medical	Environmental Protection	Descriptive	Long Term
Carbon pricing and COVID-19	Mintz-Woo K., Dennig F., Liu H., Schinko T.	2020	Nov	11/1/2020	Climate Policy	Literature Review	Qualitative	N/A	Not specified	Environment policies	Predictive	Long Term
Impacts of COVID-19 and fiscal stimuli on global emissions and the Paris Agreement	Shan Y., Ou J., Wang D., Zeng Z., Zhang S., Guan D., Hubacek K.	2020	Dec	12/1/2020	Nature Climate Change	Model Based Analysis	Quantitative	Data Analytics	Household	Environmental Impact of COVID	Predictive	Long Term
Disease Risk from Human–Environment Interactions: Environment and Development Economics for Joint Conservation-Health Policy	Heidi J. Albers1 · Katherine D. Lee2 · Jennifer R. Rushlow1 · Carlos Zambrana-Torrselio3	2020	Jul	7/1/2020	Environmental and Resource Economics	Model Based Analysis	Qualitative	N/A	Food	Environmental Protection	Predictive	Long Term
Greening the Post-pandemic Recovery in the G20	Edward B. Barbier1	2020	Jun	6/1/2020	Environmental and Resource Economics	Literature Review	Quantitative	N/A	Power	Sustainable Socities	Predictive	Long Term
Environmental and Regulatory Concerns During the COVID - 19 Pandemic : Results from the Pandemic Food and Stigma Survey	Kecinski, Maik, Messer, Kent D, Mcfadden, Brandon R, Malone, Trey	2020	Jul	7/1/2020	Environmental and Resource Economics	Survey	Quantitative	Web Services	Food	Environmental Regulations	Descriptive	Short Term
The Environmental Impacts of the Coronavirus	Helm, Dieter	2020	May	5/1/2020	Environmental and Resource Economics	Literature Review	Qualitative	N/A	Not specified	Environmental Protection	Predictive	Short and Long Term
Environmentally friendly non-medical mask: An attempt to reduce the environmental impact from used masks during COVID 19 pandemic	Hartanto, Broto Widya Mayasari, Dyah Samti	2020	Dec	12/1/2020	Science of the Total Environment	Model Based Analysis	Qualitative	Software	Medical	Environmental Protection	Predictive	Short and Long Term
Impact of COVID-19 on the social, economic, environmental and energy domains: Lessons learnt from a global pandemic	Mofijur M., Fattah I.M.R., Alam M.A., Islam A.B.M.S., Ong H.C., Rahman S.M.A., Najafi G., Ahmed S.F., Uddin M.A., Mahlia T.M.I.	2020	Oct	10/1/2020	Sustainable Production and Consumption	Empirical Research	Quantitative	Data Analytics	Multiple industrial sectors	Environmental pollution	Descriptive	Short Term
Plastics in the time of COVID-19 pandemic: Protector or polluter?	Parashar, Neha Hait, Subrata	2020	Dec	12/1/2020	Science of the Total Environment	Literature Review	Quantitative	N/A	Medical	Environmental Protection	Predictive	Short Term
COVID-19 impacts on metal supply: How does 2020 differ from previous supply chain disruptions?	Habib, Komal Sprecher, Benjamin Young, Steven B.	2021	Jan	1/1/2021	Resources, Conservation and Recycling	Literature Review	Qualitative	N/A	Manufacturing	Supply chain disruption	Descriptive	Short Term
Compound natural and human disasters: Managing drought and COVID-19 to sustain global agriculture and food sectors	Mishra, Ashok Bruno, Ellen Zilberman, David	2020	Sep	9/1/2020	Science of the Total Environment	Literature Review	Qualitative	N/A	Food	Food Security	Descriptive	Short and Long Term
An update of COVID-19 influence on waste management	Fan, Yee Van, Jiang, Peng, Hemzal, Milan Klemeš, Jiří Jaromír	2020	Aug	8/1/2020	Science of the Total Environment	Empirical Research	Quantitative	N/A	Services	Waste Management	Descriptive	Short Term
Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic – Implications for efficacy, re-use and sustainable waste management	Rowan N.J., Laffey J.G.	2020	Sep	9/1/2020	Science of the Total Environment	Literature Review	Qualitative	N/A	Medical	Supply chain Managemet	Descriptive	Short and Long Term
Safety of foods, food supply chain and environment within the COVID-19 pandemic	Rizou, Myrto, Galanakis, Ioannis M., Aldawoud, Turki M.S., Galanakis, Charis M.	2020	Jun	6/1/2020	Trends in Food Science and Technology	Literature Review	Qualitative	N/A	Food	Food Supply Chain Management	Predictive	Short Term
COVID-19: A pandemic with positive and negative outcomes on resource and waste flows and stocks	Dente, S. M.R. Hashimoto, S.	2020	Jun	6/1/2020	Resources, Conservation and Recycling	Literature Review	Qualitative	N/A	Not specified	Supply chain Management	Predictive	Short Term
Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19	Klemeš, Jiří Jaromír, Fan, Yee Van, Tan, Raymond R., Jiang, Peng	2020	Apr	4/1/2020	Renewable and Sustainable Energy Reviews	Literature Review	Quantitative	N/A	Medical	Environmental Footprint reduction	Descriptive	Short and Long Term

Topic 1	Topic 2	Topic 3	Findings	Authors Affiliation
Lead Time	Logistics Infrastructure	Inventory Management	The epidemic outbreaks create a lot of uncertainty and companies need a guided framework in developing their pandemic plans for their SC.	Berlin School of Economics and Law, Department of Business Administration, Professor for Supply Chain and Operations Management, Berlin, 10825, Germany
Disease Control measures	Public Health Policy choices		A practical decision support system was proposed to classify community members and, accordingly, manage the demand and control the epidemic outbreaks in the healthcare supply chain.	Department of Earth System Sciences, Tsinghua University, Beijing, China; The Bartlett School of Construction and Project Management, University College London, London, United Kingdom; School of Urban and Regional Science, Shanghai University of Finance and Economics, Shanghai, China; The World Bank, Washington, DC, United States; Department of Earth System Science, University of California, Irvine, Irvine, CA, United States; Institute of Blue and Green Development, Weihai Institute of Interdisciplinary Research, Shandong
Spill Over Effect	Positive Impact of COVID on Green House Emissions	OPEC Nations Income loss	the loss of connectivity imposed to prevent the spread of the COVID-19 has triggered an economic "contagion", with the crisis precipitated by the COVID-19 pandemic cascading across socio-economic sectors, and causing major disruptions to trade, tourism, energy and finance sectors.	School of Physics, University of Sydney, Integrated Sustainability Analysis, Sydney, NSW, Australia; School of Business, University of Sydney, Discipline of Accounting, Sydney, NSW, Australia; Resource Efficient Built Environment Lab, United Kingdom, Edinburgh Napier University, Edinburgh, United Kingdom; Business School, University of Queensland, Brisbane, QLD, Australia; School of Civil and Environmental Engineering, Uncw Sydney, Sydney, NSW, Australia; Fiscal Policy Agency, Ministry of Finance of the Republic of Indonesia, Jakarta
Demad-supply mismatch	Sustainable Supply Chain Challenges	New generation supply chain	The firms are realizing the role of the sustainable supply chain, dynamic response strategies, value of technology deployment and culture of collaboration, diversified supply base and synchronized strategic processes that are vital for success during rare events such as Covid-19.	Mays Business School, Texas A&M University, College Station, TX 77843, United States; Indian Institute of Management Udaipur, Udaipur, India; Indian Institute of Management Ahmedabad, Ahmedabad, India
sustainable inclusive growth and a green economy	The biophysical basis of an economy	social-ecological Challenges in the wake of COVID-19	Economic growth has always trumped environmental protection.	Institute for the Multi-Level Governance & Development, Department of Socioeconomics, WU Vienna University of Economics and Business, Vienna, Austria
Economical Impact of COVID-19	Covid-19 Impact on the Energy	Environmental Footprint of COVID-19	A proper restructure on various existing systems, e.g. production, energy, supply chain, waste management, in new norms during and after COVID-19 is required	Sustainable Process Integration Laboratory – SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology - VUT Brno, Technická 2896/2, Brno, 616 69, Czech Republic; Department of Systems Science, Institute of High Performance Computing, Agency for Science, Technology and Research (A*STAR), Singapore 138632, Singapore
Life Cycle Assessment of Food Supply Chain	Change in consumption habits due to COVID-19	Positive Environmental Impact of COVID-19	The COVID-19 pandemic has stressed the relevance of performing a deep review regarding the robustness of current food production and consumption systems.	University of Cantabria, Avda. de los Castros s/n, Santander, 39005, Spain; Peruvian LCA Network (PELCAN), Department of Engineering, Pontificia Universidad Católica del Perú, Av. Universitaria 1801, San Miguel, Lima, 15088, Peru; EnergyLab, Fonte das Abelleiras s/n, Campus Universitari de Vigo, Vigo, Galicia, 36310, Spain; UNESCO Chair in Life Cycle and Climate Change, Escola Superior de Comerç Internacional (ESCI-UPF), Pg. Pujades 1, Barcelona, 08003, Spain
Just in time approach and its shortcomings in liu of COVID-19	Economical Impact of COVID-19	COVID-19 Impact on the Developing Countries	The pandemic demonstrates the failures/dangers of neoliberalism and rising global inequality	UNSW Sydney, Australia; Flinders University, SA, Australia; UNSW Canberra, Australia; The University of Sydney, Australia; The Australian National University, Australia; International University College of Turin, Italy; University of South Australia, Australia; Western Sydney University, Australia
Normative activation Model	Theory of Planned behaviour		Reducing the frequency of going out is the main approach to saving masks in China, and the majority of people reuse a mask from two to five times	Si, H., School of Public Administration and Policy, Shandong University of Finance and Economics, Jinan, China; Shen, L., Humanities and Management School, Hebei Agricultural University, Cangzhou, China; College of Economics and Management, Hebei Agricultural University, Baoding, China; Liu, W., College of Economics and Management, Hebei Agricultural University, Baoding, China; Wu, G., School of Public Affairs, Chongqing University, Chongqing, China
Global Circular Economy	Ship Recycling	Global Circular Economy	a formalized global scale, paralleled with favorable policies, may reduce supply chain disruption and improve sustainable development in the receiving nations.	Rahman, S.M.M., University of Bordeaux, CNRS, Arts et Métiers Institute of Technology, Bordeaux INP, INRAE, I2M Bordeaux, Talence, F-33400, France; Kim, J., CREIDD Research Center on Environmental Studies & Sustainability, Department of Humanities, Environment & Information Technology, Institut Charles Delaunay, University of Technology of Troyes, CNRS-LIMB 6281, France; Lacitte, B., Arts et Métiers Institute of Technology, University of Bordeaux, CNRS, Bordeaux INP, INRAE, I2M Bordeaux, Talence, F-33400, France; Department of
Circular economy (CE) framework.	Climate change	Negative macroeconomic impact of COVID-19	Covid-19 will re-shape the aviation sector, The inadequacies of modern healthcare delivery systems to cope with mass casualties and emergencies are universally acknowledged, Changes in consumer behaviour with social distancing have necessitated	Ibn-Mohammed, T., Warwick Manufacturing Group (WMG), The University of Warwick, Coventry, CV4 7AL, United Kingdom; Mustapha, K.B., Faculty of Engineering and Science, University of Nottingham (Malaysia Campus), Semenyih, Selangor 43500, Malaysia; Godsell, J., Warwick Manufacturing Group (WMG), The University of Warwick, Coventry, CV4 7AL, United Kingdom; Adamu, Z., School of The Built Environment and Architecture, London South Bank University, London, SE1 0AA, United Kingdom; Babatunde, K.A., Faculty of Economics and
Food purchasing Behaviour Amid COVID-19	Food security	Food Waste depending on the Socio Demographic	The amount of household food waste decreased in Italy during the Covid-19 lockdown despite an increase in the amount of food purchases. This result could suggest that the emergency period experienced in Italy during the lockdown increased awareness among the population to avoid or at least reduce food waste that has significant economic and environmental implications.	Pappalardo, G., Department of Agriculture, Food and Environment (DiSA), University of Catania, Catania, Italy; Cerroni, S., Department of Economics and Management (CSA, University of Trento, Trento, Italy, Institute of Global Food Security and Gibson Institute, Queen's University Belfast, Belfast, United Kingdom; Nayga, R.M., Jr., Department of Agricultural Economics and Agribusiness, University of Arkansas, Fayetteville, AR, United States; Xiao, W., Department of Agricultural Economics and Agribusiness, University of Arkansas,
sustainable Food Supply chains	local food systems	Food security	the social benefits of SFSCs, their economic and environmental impacts typically elicit more heterogeneous outcomes,	Ch Fioleau, Y., UMR Innovation, Institut National de la Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE), Montpellier, 34060, France; Dourian, T., UMR Innovation, Institut National de la Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE), Montpellier, 34060, France
Negative Environmental implications of COVID-19	Is robust and localized supply chain solution of solid waste management at the time of pandemic	Circular Economy based models in solid waste management	Inevitably, plastic usage is bound to increase due to the increased use of personal protection and healthcare items, and little can be done to avoid it.	Sharma, H.B., Environmental Engineering and Management, Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal 721302, India; Vanapalli, K.R., School of Environmental Science and Engineering, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, 721302, India; Cheela, V.S., Environmental Engineering and Management, Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, 721302, India; Sustainable Engineering Group, Curtin
International Cooperation for environmental protection	Covid-19 Impact International Cooperation	Positive Environmental Impact of COVID-19	This paper presents an analysis of the dynamics of international cooperation in the field of environmental research, including a thematic area of research on different sources of publication, which shows its connection with different scientific directions.	Department of Ecology and Environmental Protection Technologies, Sumy State University, Sumy, 40007, Ukraine; Department of Sustainable Technologies, Faculty of Tropical AgriSciences, Czech University of Life Sciences, Prague, 16500, Czech Republic
Pricing the Carbon Externality	Rethinking Globalization and Deglobalization	Re-shaping supply chian	the Covid-19 crisis has shown us that international cooperation easily breaks down during a crisis, and that without global cooperation the costs for the poorer or less able countries may be very high.	Department of Economics, Birmingham University, Birmingham, United Kingdom; IPAG Business School, 184 Bld St Germain, Paris, 75006, France; Department of Spatial Economics Vrije Universiteit Amsterdam, Amsterdam, Netherlands
Green Stimulus Policy amid COVID	Policies for Mitigating the Coronavirus Pandemic	Carbon Pricing amid COVID	The most effective policies involve revenue-neutral tax reforms towards carbon pricing, which would be excellent climate policies and also help deal with the coronavirus crisis by allowing reductions to labor taxes	Beijer Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Box 50005, Stockholm, 10405, Sweden; Department of Economics, University of Bologna, Piazza Scaravilli 2, Bologna, 40 126, Italy; Stockholm Resilience Centre, Stockholm University, Kräftriket 2B, Stockholm, 10691, Sweden; Department of Economics, Uppsala University, Box 256, Uppsala, 75105, Sweden; The Wharton School, University of Pennsylvania, 327 Vance Hall, 3733 Spruce Street, Philadelphia, PA, 19104, United States; National Bureau of
Construction Impact on the environment	Environmental Crises amid COVID-19	Sustainable Construction	the Covid-19 pandemic has changed the way we work and rest, has turned upside down the old patterns and ways of using public and private spaces; closed for weeks in our own homes and offices	Faculty of Architecture, Institute of Architectural Design, Cracow University of Technology, Krakow, 31-155, Poland
LCA of PPE	Environmental sustainability	PPE cradle to grave Anlysis	the use is absolutely essential and justified, it is to be noted that disposal of these PPEs might become a problem in the near future, for which we should finding solutions today.	CSIR-National Environmental Engineering Research Institute, CSIR-NEERI, Nagpur, Maharashtra 440 020, India; Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, Uttar Pradesh 201 002, India; United Nations Environment Programme, New Delhi, 110 003, India
Carbon Pricing	Environmental sustainability	Cost and benefits of carbon pricing	The COVID-19 crisis presents challenges, but also opportunities. In particular, the EU's Green Deal should be implemented in such a way that it boosts economic recovery while putting the EU on a low-carbon pathway.	Philosophy and Environmental Research Institute, University College Cork, Cork, Ireland; University Center for Human Values, Princeton School of Public and International Affairs and Princeton Environmental Institute, Princeton University, Princeton, United States; Yale-NUS, Singapore; Risk and Resilience Program (RISK), International Institute for Applied Systems Analysis, Laxenburg, Austria
Fiscal Stimuli on Global Emissions Amid COVID	Household Energy consumption Amid COVID-19	Increase in Emissions from fiscal counter Measures	The lockdown policies in response to the COVID-19 pandemic will lead to substantial changes in energy consumption and CO2 emissions. Total emissions of 79 countries will decrease by 3.9 to 5.6% in 5 yr (2020 to 2024), compared with a no-pandemic baseline scenario and bring the global emissions 2020 to the level before 2007.	Integrated Research on Energy, Environment and Society (IREES), Energy and Sustainability Research Institute Groningen, University of Groningen, Groningen, Netherlands; Department of Sociology, Utrecht University, Utrecht, Netherlands; School of International Development, University of East Anglia, Norwich, United Kingdom; School of Urban and Regional Science, Shanghai University of Finance and Economics, Shanghai, China; College of Management and Economics, Tianjin University, Tianjin, China; School of Economics and
Wildlife market supply chain	Risk of infectious disease transfer from indirect interaction with wildlife		The risk of disease spread is a function of people's choices and of how those choices lead to pathogen exposure, which implies that economic models must be paired with data and models of those disease risks	Department of Economics, University of Wyoming, Department of Agricultural Economics and Rural Sociology, University of Idaho, EcoHealth Alliance, New York
Carbon Pricing	Pricing Reforms and public Spendings for post COVID-19 Policies	G20 economies	an important lesson from the green stimulus packages enacted during the 2008–2009 Great Recession is that policies for a sustained economic recovery amount to much more than just short-term fiscal stimulus. Transitioning from fossil fuels to a sustainable, low-carbon economy after the COVID-19 crisis will require long-term commitments (5–10 years) of public spending and pricing reforms.	Department of Economics, Colorado State University, Fort Collins, CO, 80523-1771, USA
Food Safety Regulations	Public perception of Environment regulations		People who are most directly affected by the pandemic, such as those who have gone without food and people who are most concerned about spreading and contracting the virus, are more likely than others to be concerned about protecting the environment	Department of Applied Economics and Statistics, University of Delaware, 531 S. College Ave, Newark, DE 19716, USA; Department of Agricultural, Food, and Resource Economics, Michigan State University, 446 W Circle Dr, East Lansing, MI 48824, USA
Supply chains deglobalization	Long term Economic Impact of COVID	Short term Environmental Impact of COVID	The impacts of the coronavirus will be argued about for decades to come. It may turn out to be one blip in the long battles between humans and viruses throughout human history, just as Spanish Flu was largely forgotten by historians in the 1920s and 1930s.	New College, Oxford, UK
Sustainable Solution for PPE amid COVID	Alternative Material Selection for conventional PPE's		AHP has become a suitable method and selection tool of material alternatives for making non-medical mask	Faculty of Industrial Engineering, Institut Teknologi YogyakartaDIY 55198, Indonesia; Departement of Cardiology and Vascular Medicine, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah MadaDIY 55281, Indonesia
Long term environmental Impact of COVID	Future of the Economy	Waste recycling services amid COVID	A comprehensive analyses of energy, environmen- tal pollution, and socio-economic impacts in the context of health emergency events and the global responses to mitigate the ef- fects of these events have been provided.	School of Information Systems and Modelling, Faculty of Engineering and Information Technology, University of Technology SydneyNSW 2007, Australia; School of Chemical Engineering, Zhengzhou University, Zhengzhou, 450001, China; Department of Civil and Construction Engineering, College of Engineering, Imam Abdulrahman Bin Faisal University, Dammam, 31451, Saudi Arabia; Biofuel Engine Research Facility, Queensland University of Technology (QUT), Brisbane, QLD, 4000, Australia; Turbiot Members, University, P.O Box: 14115-111
Circular economy	Environmental Impact of PPE's usage	PPE Recycling amid COVID-19	The COVID-19 crisis has highlighted the essentiality of plastic as a protector in the healthcare sector and public health safety owing to its intrinsic properties. However, the general perception about plastic as an evil polluter has been further strengthened due to its mismanagement and underutilization of resource value considering the pandemic-induced surge in plastic usage and waste generation	Department of Civil and Environmental Engineering, Indian Institute of Technology PatnaBihar 801 106, India
Environmental protection	Extractive industry permits	Environmental Footprint of COVID-19	One of the key differences in 2020 compared to the past is that the supply chain players are different. Whereas historically it was downstream users who suffered the most from supply disruptions and needed to respond to a crisis, now it is upstream suppliers and in-between actors who are also adjusting to maintain resilience.	School of Environment, Enterprise and Development (SEED), University of Waterloo, 200 University Ave West, Waterloo, ON N2L3G1, Canada; Institute of Environmental Sciences (CML), Leiden University, Einsteinweg 2, 2333 CC, Leiden, Netherlands
Impact on agri-food supply chains	Compound natural and human disasters: drought and Covid-19		There are several common challenges in addressing droughts and pandemics. Both disasters feature great uncertainty in the timing of onset, duration, and degree of severity	Glenn Department of Civil Engineering, Clemson University, Clemson, United States; Department of Agricultural and Resource Economics, University of California, Berkeley, United States
Recycling and sorting in COVID Times	Circular Economy	Zero Waste Masterplan	Approaching the peak of the pandemic, the waste management had not been receiving the priorityhich is needed to minimise the harmful effect on the environment.	Sustainable Process Integration Laboratory – SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology - VUT Brno, Technická 2896/2, Brno, 616 69, Czech Republic; Department of Systems Science, Institute of High Performance Computing, Agency for Science, Technology and Research (A*STAR), Singapore, 138632, Singapore
Reprocessing of PPE's amid Covid	Environmental impact of existing PPE	Environment sustainability	There is extraordinary pressure to meet shortages in single-use PPE supply for our frontline clinicians and healthcare workers. PPE treatment is challenging as the constituent material, including single-use plastics (SUPs), are sensitive to harsh decontamination processes.	Department of Nursing and Healthcare, Athlone Institute of Technology, Ireland; Centre for Disinfection, Sterilization and Biosecurity, Athlone Institute of Technology, Ireland; Empower Eco Sustainability Hub, Lough Boora, Co. Offaly, Ireland; Lung Biology Group, Regenerative Medicine Institute at CURAM Centre for Medical Devices, National University of Ireland Galway, Galway, Ireland; Anaesthesia and Intensive Care Medicine, University Hospital Galway, Galway, Ireland
Food Safety	Precautionary measures to avoid Corona transfer from food supply chain		Researchers and professionals in the food sector have many challenges ahead, e.g., ensuring food safety, detecting SARS-CoV-2 in environments where food is produced, processed and delivered, sanitizing surfaces and working environments adequately, and others.	Research & Innovation Department, Galanakis Laboratories, Chania, Greece; College of Science, King Saud University, Riyadh, Saudi Arabia; Food Waste Recovery Group, ISEKI Food Association, Vienna, Austria
Food safety	Energy demand in covid-19 time		In conclusion, many uncertainties remain on the positive and negative effects of the pandemic on the resources and waste flows and stocks as transfer of environmental impact between sectors and regions may be expected.	Department of Environmental system engineering Ritsumeikan University, 1-1-1 Noji-higashi, kusatsu japan
Waste Management	Environmental Footprint reduction		Among the many adverse consequences of the COVID-19 pandemic is the sudden surge in the volume of plastic waste, particularly for products used for personal protection and healthcare purposes.	Sustainable Process Integration Laboratory – SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology - VUT Brno, Technická 2896/2, Brno, 616 69, Brno, Czech Republic; Chemical Engineering Department, De La Salle University, 2401 Taft Avenue, 0922, Manila, Philippines; Department of Systems Science, Institute of High Performance Computing, A*STAR, Singapore, 138632, Singapore

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Berlin School of Economics and Law, Department of Business Administration, Professor for Supply Chain and Operations Management, Berlin, 10825, Germany	Germany	Germany	COVID-19; Coronavirus; Digital twin; Epidemic outbreak; Pandemic plan; Resilience; Risk management; SARS-CoV-2; Simulation; Supply chain	10.1016/j.tre.2020.101922
Department of Earth System Sciences, Tsinghua University, Beijing, China; The Bartlett School of Construction and Project Management, University College London, London, United Kingdom; School of Urban and Regional Science, Shanghai University of Finance and Economics, Shanghai, China; The World Bank, Washington, DC, United States; Department of Earth System Science, University of California, Irvine, Irvine, CA, United States; Institute of Blue and Green Development, Weihai Institute of Interdisciplinary Research, Shandong	China	China, UK, China, USA		https://doi.org/10.1038/s41592-020-0896-8
School of Physics, University of Sydney, Integrated Sustainability Analysis, Sydney, NSW, Australia; School of Business, University of Sydney, Discipline of Accounting, Sydney, NSW, Australia; Resource Efficient Built Environment Lab, United Kingdom; Edinburgh Napier University, Edinburgh, United Kingdom; Business School, University of Queensland, Brisbane, QLD, Australia; School of Civil and Environmental Engineering, Unsw Sydney, Sydney, NSW, Australia; Fiscal Policy Agency, Ministry of Finance of the Republic of Indonesia, Jakarta	Australia	Australia, Australia, UK, UK		https://doi-org.ezproxy.biblio.polito.it/10.1371/journal.pone.0235654
Mays Business School, Texas A&M University, College Station, TX 77843, United States; Indian Institute of Management Udaipur, Udaipur, India; Indian Institute of Management Ahmedabad, Ahmedabad, India	USA	USA, India, India		https://doi-org.ezproxy.biblio.polito.it/10.1016/j.ijpsycho.2020.05.005
Institute for the Multi-Level Governance & Development, Department of Socioeconomics, WU Vienna University of Economics and Business, Vienna, Austria	Austria	Austria	Coronavirus (COVID-19); Green economy; crisis capitalism; economic value; limits to growth; social-ecological transformation	https://doi-org.ezproxy.biblio.polito.it/10.1080/14747731.2020.1761612
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UNSW Sydney, Australia; Flinders University, Australia; UNSW Canberra, Australia; The University of Sydney, Australia; The Australian National University, Australia; International University College of Turin, Italy; University of South Australia, Australia; Western Sydney University, Australia	Australia	Australia, Australia, Australia, Australia, Australia, Australia, Australia, Italy	COVID-19; Coronavirus; First Nations; economic development; environmental sustainability; gender; health equity; migration; resilitherialism; pandemic; public health; public housing; recession; supply chains; welfare payments; youth	https://doi-org.ezproxy.biblio.polito.it/10.1177/1035719X20930927107
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Department of Economics, Birmingham University, Birmingham, United Kingdom; IPAG Business School, 184 Bvd St Germain, Paris, 75006, France; Department of Spatial Economics Vrije Universiteit Amsterdam, Amsterdam, Netherlands	UK	UK, France, Netherlands	Cooperation; Covid-19; Environmental economics; Globalization; Green stimulus; Green transition; Research agenda	10.1007/s10640-020-00478-1
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Department of Economics, Colorado State University, Fort Collins, CO, 80523-1771, USA	USA	USA	COVID-19; Carbon pricing; Clean energy; G20 economies; Green New Deal; Green economy	10.1007/s10640-020-00437-w
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New College, Oxford, UK	UK	UK	Climate change · Coronavirus · Deglobalisation · Economic shock · Greenhouse	10.1007/s10640-020-00426-z
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