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## Article

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# Long-Term Investigation of Emissions and Economic Growth in Developed and Developing Countries: A Bibliometric Analysis

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## ABSTRACT

This study seeks to present a better knowledge mapping of emissions and economic growth by referring to literature reviews in developed and developing countries from 2000 to 2022. This study provides overviews of a bibliometric approach, namely: time analysis, journal, co-authorship, citation, country, and institution. The literature survey uses the causality's direction between (i) emissions and economic growth, and (ii) emissions in developed and developing countries. The degree of research contribution in developed and developing countries has an upward trend in recent years. Journal analysis reveals that Environmental Science and Pollution Research is the journal with the most contributions to analyses in developed and developing countries. Furthermore, the citation analysis shows that "Growth in Emission Transfers via International Trade from 1990 to 2008" has the highest author citations. This study suggests that research collaboration between developed and developing countries can be promoted in producing sustainable green economic growth.

**Keywords:** Emissions, Economic Growth, Bibliometric Approach, Developed and Developing Countries

**JEL Classifications:** A39, O44, O57

## 1. INTRODUCTION

The significant contribution of carbon emissions to economic growth has been discussed in the literature (Zou, 2018). Since the 1990s, the international community has recognized the seriousness of global warming due to increasing carbon emissions. Reducing greenhouse gas emissions, especially CO<sub>2</sub>, is the best way to solve global climate and ecological problems. As scarce natural capital, energy consumption can be a real constraint to economic growth. Consequently, economic development can only be achieved with the availability of energy. This condition means that there is a significant link between carbon emissions and economic growth in many countries.

Carbon emissions have a positive impact on economic growth (Acheampong, 2018). It means that more industrial and community activities in both developed and developing countries lead to more economic growth (Muhammad, 2019). Also, (Dogan and Turkekul,

2016) found a link between the amount of CO<sub>2</sub> gas emissions and GDP. When the intensity of greenhouse gas emissions drops by 5%, GDP will grow by 6% (Lin et al., 2019). In addition, Smith et al. (2021) found that every teragram of greenhouse gas reduction corresponds to a drop of 0.16% in GDP. Reducing the level of fossil fuel consumption by 20% results in a reduction in the level of carbon emissions per capita by up to 19.6% (Shabani et al., 2022). This condition encourages countries with policy frameworks for renewable energy and climate change mitigation to separate emission levels and GDP, especially emissions based on production and consumption (Cohen et al., 2018).

Alam (2013) found in 2013 that the amount of CO<sub>2</sub> emitted by developed countries is related to their economic growth and how much nuclear energy they use. On the other hand, developing countries have CO<sub>2</sub> emission levels closely related to GDP growth, energy use, industrialization, and urbanization. Basic carbon emissions, per capita energy consumption, and energy

use efficiency in developing countries are much lower than in developed countries, but CO<sub>2</sub> emissions per unit of energy use are higher (Niu et al., 2011). CO<sub>2</sub> emission levels in developed countries tend to be more stable than in developing countries, in which they continue to double (Peters et al., 2011). Therefore, developed and developing countries have different plans for reducing emissions and adapting to climate change to keep their economies growing. In addition, discussions about the impact of CO<sub>2</sub> emissions have become keywords widely used in the literature (Wei et al., 2021). In-depth literature studies with the keywords of emissions and economic growth can be mapped and revealed through a bibliometric approach (Ruiz-Real et al., 2018).

This study aims to improve the literature mapping on the relationship between emissions and economic growth in developed and developing countries from 2000 to 2022 by using a bibliometric approach. Literature reviews on emissions and economic growth have been published by Waheed et al. (2019), Haberl et al. (2020), and Zhang et al. (2022). Carbon emissions, economic growth and energy consumption are the keywords with the highest occurrence frequency. Most of the studies that have been done in the past have found that economic growth and energy use are major sources of carbon emissions. This issue is of great concern in developing countries. On the other hand, in developed countries, carbon emissions are considered unrelated to economic development. As long as economic growth is a key political goal, separating economic growth from resource use and emissions is a must for a sustainable net-zero emissions future. Green growth is a way to ensure that enough resources are used or that emissions are cut without changing the direction of growth. The findings from the literature encourage this study to better map empirical studies of emissions and economic growth in developed and developing countries during the 2000-2022 period.

The main point of this study is to use a bibliometric method to map the literature on emissions and economic growth in developed and developing countries over the past 22 years. Several stages of analysis in this study can be described as follows: (a) The time analysis revealed that the highest number of empirical papers in developed countries is 138 documents (2022), while in developing countries, there are 216 documents (2022). (b) The journal analysis identified 160 journals discussing emissions and economic growth with developed country samples and 158 journals with developing country samples. (c) The keyword analysis showed that there are 10 keywords related to developed country samples and 10 keywords related to developing country samples. (d) The co-authorship analysis showed that 10 authors made important contributions with developed country samples and 10 authors made significant contributions with developing country samples. (e) The citation analysis showed that there were 10 empirical papers with significant citations that used samples of developed countries and 10 empirical papers with samples of developing countries. (f) The country analysis expressed that 10 countries contributed significantly with samples of developed countries and 10 countries with samples of developing countries, and (g) the institution analysis indicated that there are 10 institutions (universities) that contributed significantly with developed country samples and 10 universities with developing country samples.

In terms of time analysis, the study's main findings reveal that research articles on emissions and economic growth in developed and developing countries show that both groups experience fluctuations, accompanied by faster increases in developing countries. Environmental Science and Pollution Research is the journal with the most significant contribution to analyses in developed and developing countries. Economic growth is a keyword with the most significant frequency of all related research articles in developed and developing countries. In authorship analysis, Wang, Q. is the author with the most significant contribution to the analysis in developed countries, and Zhang, X. is the author with the most significant contribution to the analysis in developing countries. "Growth in Emission Transfers via International Trade from 1990 to 2008" written by Peters et al., 2011 is a literary journal with the highest author citations in both analyses in developed countries and developing countries. China is the number one country contributing research articles on emissions and economic growth in both developed and developing countries, with the School of Management and Economics (Beijing Institute of Technology) as the supporting institution providing the most significant contribution.

This study is written in several sections. The first section is an introduction outlining the research's issue, aims, and contribution. The second section synthesizes the literature on emissions and economic growth. The third section describes the methodology. The fourth section presents the findings of the bibliometric analysis (empirical results). The fifth section is a discussion. The last section is the concluding remarks.

## 2. LITERATURE REVIEW

In 1990–2008, unidirectional causality from economic growth to energy consumption in the short term occurred in 12 Middle Eastern countries, while direct causality from energy consumption to economic growth occurred in the long term (Ozcan, 2013). Carbon dioxide (CO<sub>2</sub>) and sulphur dioxide (SO<sub>2</sub>) can be environmental indicators, while GDP can be an economic indicator. In Tunisia, emissions per person and GDP are linked in the long run (Fodha and Zaghdoud, 2010). The same finding occurs in South Africa, where there is unidirectional causality from pollutant emissions to economic growth, energy consumption to economic growth, and energy consumption to CO<sub>2</sub> emissions, all without feedback. Consequently, sacrifices of economic growth or reductions in energy consumption per unit of output, or both, are required to reduce emission levels (Menyah and Wolde-Rufael, 2010).

From 1990 to 2008, CO<sub>2</sub> emission levels in developed countries tended to be stable; meanwhile, emission levels in developing countries have doubled. The stability of emissions in some developed countries is due to increased imports from developing countries. International trade is an important factor in explaining changes in emissions in many countries, both in terms of production and consumption. Previous literature (Peters et al., 2011) suggested that each country monitors the transfer of emissions through international trade to stabilize global greenhouse gas emissions. Energy security and climate change are important challenges facing many countries. For example, China's emission rate of 57%

is attributed to goods consumed outside the province where the product is produced. About 80% of the emissions are associated with goods consumed in highly developed provinces imported from less developed provinces (Feng et al., 2013). Policies to reduce energy consumption and emission levels are likely to impact the gross domestic product (GDP) of developed countries more than developing countries (Chontanawat et al., 2008). There are 43 developing countries that have reduced their carbon dioxide emission levels due to increased incomes. Carbon emission taxes and restrictions on carbon dioxide emissions through emission trading schemes have become relevant policies (Narayan and Narayan, 2010).

### 3. METHODOLOGY

#### 3.1. Data

This study maps the literature on the link between emissions and economic growth in developed and developing countries. With the bibliometric approach, all research articles published in different journals and found in the Scopus Database were analysed using Vosviewer version 1.6.17. The observation period is from early 2000 to November 25, 2022. Some of the keywords used include “emissions,” “economic growth,” “developed countries,” and “developing countries.” The results of the literature search show that 707 research articles reveal the link between emissions and economic growth in developed countries and 1,040 articles in developing countries. The sample research articles use various languages: English, Chinese, Russian, Persian, Croatian, German, Polish, and Spanish.

Figure 1 describes the sampling procedure of 707 research articles on emissions and economic growth in developed countries. The

articles are a literature database analysed using a bibliometric approach. Figure 2 illustrates 1,040 research articles investigating emissions and economic growth in developing countries.

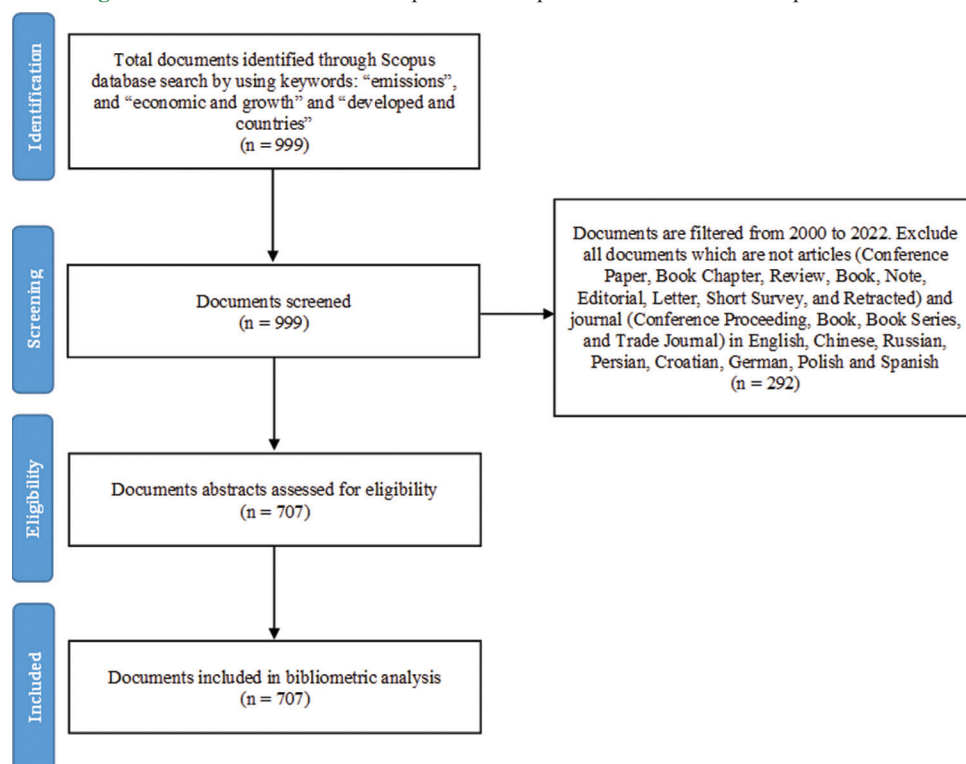
In detail, a literature search with the keywords “developed countries, emissions and economic growth” found 999 titles of research articles. The number of eligible papers to be reviewed using the bibliometric approach is 707. The same literature search was carried out with the keywords “developing countries, emissions and economic growth,” which resulted in 1,563 titles of research papers. The number of eligible papers to be researched using the bibliometric approach is 1,040 titles.

Bibliometric is a way to look at literature data that can be put into different analyses. First, time analysis describes the number of research articles that reveal the linkage between emissions and economic growth in each observation period. Second, journal analysis shows the total number of journals relevant to the study objectives. Third, keyword analysis describes the number of most commonly used keywords. Fourth, co-authorship analysis explains the number of authors who have contributed significantly to uncovering the link between emissions and economic growth. Fifth, citation analysis reveals the highest number of citations to papers that discuss emissions and economic growth. Sixth, country analysis describes the countries that are used as samples. Finally, institutional analysis identifies the number of universities or research institutes that have significantly contributed to uncovering the link between emissions and economic growth.

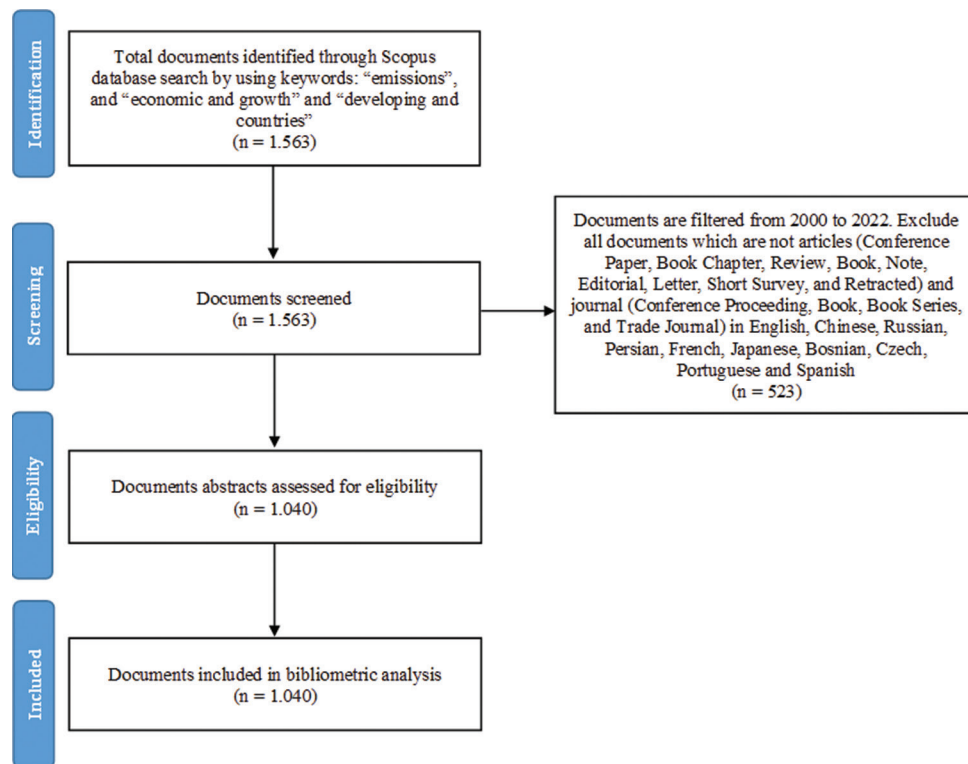
#### 3.2. Bibliometric Approach

Bibliometric analysis reveals subject area as well as publication and citation trends. In the literature (Huang et al., 2019),

**Figure 1:** PRISMA flow chart sample of developed countries. Source: Scopus database





**Figure 2:** PRISMA flow chart sample of developing countries. Source: Scopus database

knowledge mapping is often used to show how knowledge in a field has changed in a clear and complete way over time, making it easier to see groups of similar ideas or strange features and trends. Bibliometric studies enable and empower researchers to obtain thorough reviews, identify knowledge gaps, derive new ideas for inquiry, and position desired contributions to the field (Donthu et al., 2021).

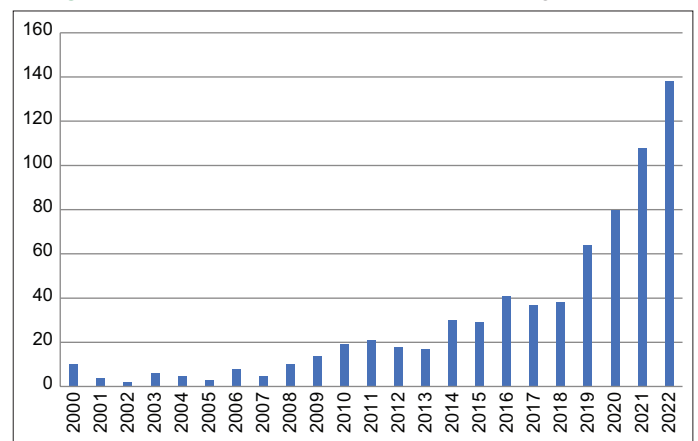
Bibliometric approach is ideal for handling large volumes of bibliographical data, and its quantitative nature helps eliminate author bias (Donthu et al., 2021). Bibliometric analysis provides an inclusive visualization of relationships between articles, journals, keywords, citations, and shared citation networks (Feng et al., 2017). The authorship analysis is based on three categories: countries, organizations, and individuals. Keyword analysis was carried out to map research groups and their intellectual structure in existing publications (Wimbadi and Djalante, 2020). The parameters include publication evolution over time, citation analysis for core publications and authors, collaboration analysis for countries and institutions, bibliographic coupling network analysis for data grouping, and shared word analysis to identify hotspots presented in statistical research (Ranjbari et al., 2021)

## 4. EMPIRICAL RESULTS

### 4.1. Emissions and Economic Growth in Developed Countries

#### 4.1.1. Time analysis

The time analysis showed how the number of research articles published each year in developed countries changed during the

**Figure 3:** Number of selected research article during 2000-2022

study time frame. Figure 3 illustrates that in 2000, the number of published research articles was 10 documents, while in 2022, and the number of research articles increased by 13 times to 138 documents. The fewest number of documents were published in 2002 (2 documents), and the most were published in 2022 (138 documents).

The findings of this study contribute to the link between emissions and economic growth in developed countries in several ways. First, the time analysis shows how much information about emissions and economic growth in developed countries is available each year. Second, time analysis presents a distribution pattern of literature that tends to fluctuate during the observation period. Third, this analysis shows the highest and lowest levels of literature availability in certain year periods.

#### 4.1.2. Journal analysis

Journal analysis describes the number of journals that pay more attention to publishing articles on emissions and economic growth

in developed countries during the observation period. The findings show that 160 research articles describe the link between emissions and economic growth (Table 1). In detail, several journals

**Table 1: Number of selected journals in developed countries**

Journal	Number of selected papers in each journal
Environmental Science and Pollution Research	68
Journal of Cleaner Production	40
Energy Policy	25
Sustainability Switzerland	24
Journal of Environmental Management	18
Science of The Total Environment	18
Applied Energy	16
Environment Development and Sustainability	14
Energies	13
Energy Economics	11
International Journal of Energy Economics and Policy	9
Atmospheric Environment; and Energy	8
Climatic Change; and Energy and Environment	7
Energy Reports; Environmental Science and Technology; Renewable Energy; Sustainable Development; and Technological Forecasting and Social Change;	6
Climate Policy; Ecological Economics; Environmental Research Letters; Journal of Environmental Studies; Journal of Industrial Ecology; Renewable and Sustainable Energy Reviews; and Resources Policy	5
Environmental Science and Policy; Frontiers in Environmental Science; Global Environmental Change; Plos One; Resources Conservation and Recycling; and Studies in Regional Science	4
Advances in Climate Change Research; Atmospheric Chemistry and Physics; Chemical Engineering Transactions; Ecological Indicators; Economic Research Ekonomika Istrazivanja; Frontiers in Energy Research; International Environmental Agreements Politics Law and Economics; International Journal of Environmental Research and Public Health; Journal of Environmental Economics and Policy; Mitigation and Adaptation Strategies for Global Change; and World Economy and International Relations	3
Biomass and Bioenergy; Carbon Management; Clean Technologies and Environmental Policy; Dili Xuebao Acta Geographica Sinica; Economia Politica; Economics Bulletin; Energy for Sustainable Development; Energy Sources Part B Economics Planning and Policy; Energy Sustainability and Society; Environmental and Resource Economics; Environmental Development; Environmental Engineering and Management Journal; Environmental Impact Assessment Review; Environmental Modeling and Assessment; International Journal of Energy Sector Management; International Journal of Environmental Science and Technology; International Journal of Global Environmental Issues; International Journal of Scientific and Technology Research; International Journal of Sustainable Development and World Ecology; International Journal of Sustainable Energy; International Organisations Research Journal; Journal of Economics Studies; Journal of Environmental Planning and Management; Journal of International Trade and Economic Development; Journal of Public Affairs; Journal of The Knowledge Economy; Natural Hazards; Natural Resources Forum; Nature Environment and Pollution Technology; Proceedings of The National Academy of Sciences of The United States of America; Progress in Nuclear Energy; Regional Environmental Change; Shengtai Xuebao; Shengtai Xuebao Acta Ecologica Sinica; Social Indicators Research; Structural Change and Economic Dynamics; Tourism Management; Transportation Research Part D Transport and Environment; Vision; Wit Transactions on Ecology and The Environment; World Development; and Zhongguo Renkou Ziyuan Yu Huan Jing China Population Resources and Environment	2
A Z ITU Journal of The Faculty of Architecture; Acta Geophysica; Administrative Sciences; Advances in Applied Energy; Advances in Environmental Biology; Aerosol and Air Quality Research; African Development Review; African Journal of Hospitality Tourism and Leisure; Agricultural Economics United Kingdom; Agricultural Systems; American Journal of Economics and Sociology; American Journal of Environmental Sciences; Applied Ecology and Environmental Research; Applied Economics; Applied Mathematical Sciences; Artificial Intelligence Review; Asia Pacific Journal of Regional Science; Asian Journal of Atmospheric Environment; Atmosfera; Atmosphere; Atoms For Peace; Batteries; Bioethics; Carbon Balance and Management; Chemosphere; Chinese Journal of Eco Agriculture; Chinese Science Bulletin; Climate and Development; Cogent Economics and Finance; Cogent Engineering; Computers in Industry; Construction and Building Materials; Current Issues in Tourism; Current Science; Ecological Informatics; Ecological Modelling; Economic Analysis and Policy; Economic Computation and Economic Cybernetics Studies and Research; Economics of Transition; Economics; Ecosystem Health and Sustainability; Ekoloji; Ekonomika Istrazivanja; Energy Conversion and Management; Energy Efficiency; Energy Exploration and Exploitation; Energy Journal; Energy Research and Social Sciences; Energy Strategy Reviews; Energy Systems; Engineering Intelligent Systems; Environment and Development Economics; Environment and Planning C Government and Policy; Environment Systems and Decisions; Environmental and Ecological Statistics; Environmental Economics and Policy Studies; Environmental Law and Management; Environmental Modelling and Software; Environmental Progress and Sustainable Energy; Environmental Research; Estuarine Coastal and Shelf Science; Eurasian Economic Review; European Transport Trasporti Europei; Finance Theory and Practice; Food Policy; Forest Ecology and Management; Forests; Frontiers in Public Health; Frontiers in Sustainable Cities; Frontiers of Earth Science; Frontiers of Environmental Science and Engineering; Frontiers of Environmental Science and Engineering in China; Gaodianya Jishu High Voltage Engineering; and Gcb Bioenergy	1
Total	160

published more than 10 research articles under this research's theme. The journals in order of the number of publications from the most are: (a) Environmental Science and Pollution Research (68 documents), (b) Journal of Cleaner Production (40 documents), (c) Energy Policy (25 documents), (d) Sustainability Switzerland (24 documents), (e) Journal of Environmental Management (18 documents), (f) Science of the Total Environment (18 documents), (g) Applied Energy (16 documents), (h) Environment Development and Sustainability (14 documents), (i) Energies (13 documents), and (j) Energy Economics (11 documents).

Journal literature can also be classified by subject area (Figure 4). The study findings reveal several journals that have published articles about the link between emissions and economic growth in developed countries, namely: (a) Environmental Science (32% or 443 documents), (b) Energy (16% or 222 documents), (c) Social Sciences (11% or 159 documents), (d) Engineering (9% or 127 documents), (e) Economics, Econometrics and Finance (9% or 123 documents), (f) Business, Management and Accounting (6% or 81 documents), (g) Earth and Planetary Sciences (4% or 49 documents), (h) Agricultural and Biological Sciences (3% or 36 documents), (i) Mathematics (2% or 28 documents), (j) Computer Science (2% or 24 documents), (k) Medicine (1% or 17 documents), (l) Chemical Engineering (1% or 15 documents), (m) Multidisciplinary (1% or 13 documents), (n) Chemistry (1% or 10 documents), (o) Psychology (1% or 8 documents), (p) Decision Sciences (1% or 8 documents), and (q) others (22 documents).

#### 4.1.3. Keyword analysis

The keyword analysis identified all keywords related to emissions and economic growth in developed countries during the 2000–2022 period. The total number of documents analysed with VOSViewer

was 707. The study findings revealed 1,000 keywords and 11 clusters, with each colour representing its respective cluster (Figure 5).

Of the 1,000 keywords examined, 10 have the highest frequency. The ten keywords are “Economic Growth, Carbon Dioxide, Carbon Emission, Economic Development, Climate Change, Economics, China, Sustainable Development, Developing Countries and Emission Control.”

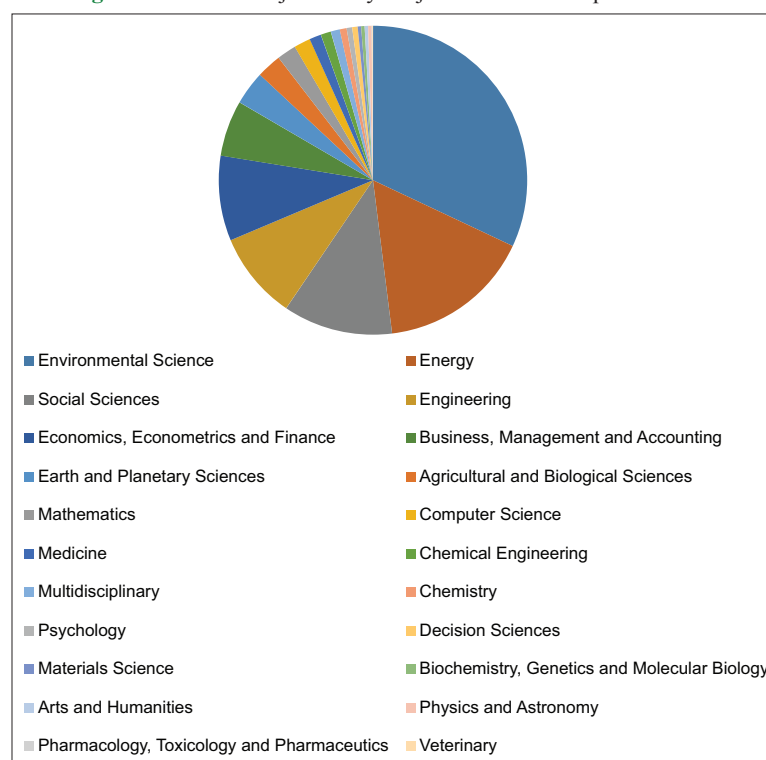
In particular, there are 3 keywords with the highest frequency in the analysed literature journals from 2014 to 2015: “climate change, developing world, and greenhouse gas.” The three keywords were more frequent from 2016 to 2017 are: “economic growth, carbon dioxide, and carbon emissions.” The three keywords appeared more frequently in 2018–2020 are: “economic development, carbon, and economic analysis.”

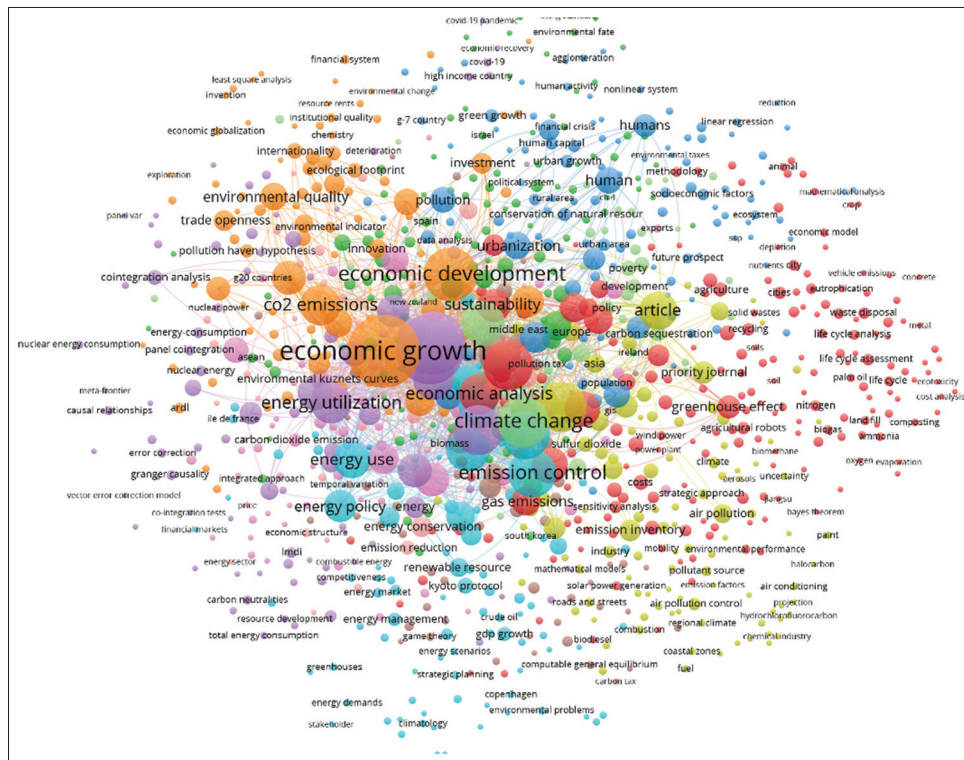
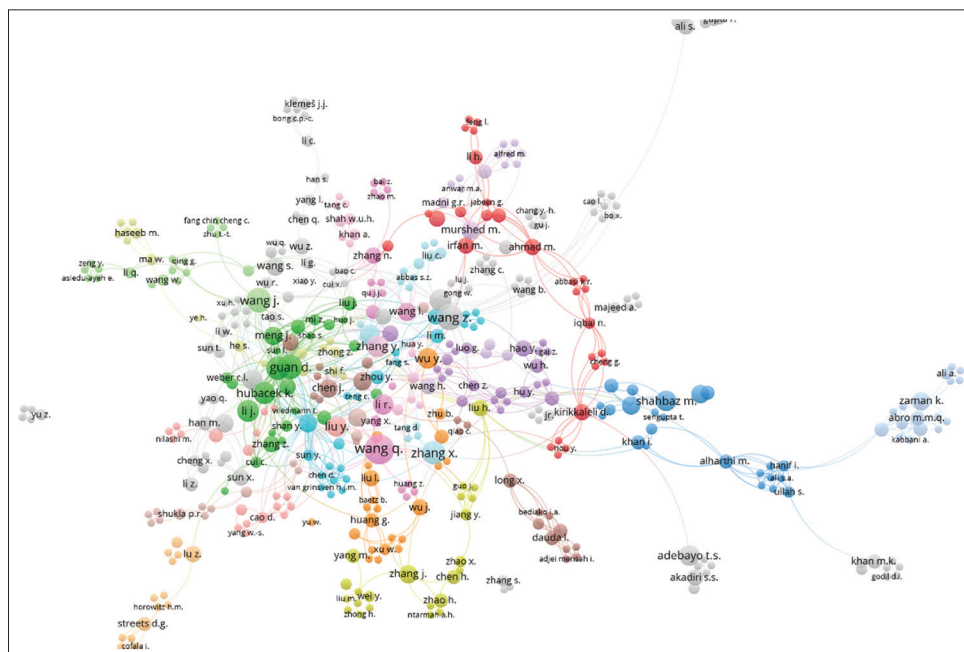
#### 4.1.4. Co-authorship Analysis

Co-authorship analysis focuses on investigating the names of authors who have significantly contributed to uncovering the link between emissions and economic growth in developed countries. There are 31 clusters, with each colour representing its own cluster (Figure 6).

There are 476 identified authors but only 10 authors contributed significantly. They are Wang, Q.; Wang, Z.; Guan, D.; Wang, J.; Feng, K.; Zhang, X.; Wang, Y.; Li, J.; Hubacek, K.; and Zhang, J. For example, Feng, K. was the author with the highest contribution from 2016 to 2017. He has 8 publication documents. Meanwhile, Wang, Q. was the author with the highest contribution from 2018 to 2019, with 13 publication documents. Furthermore, Zhang, X.

**Figure 4:** Number of journal by subject area in developed countries



**Figure 5:** Keyword network visualization in developed countries**Figure 6:** Co-authorship network visualization in developed countries

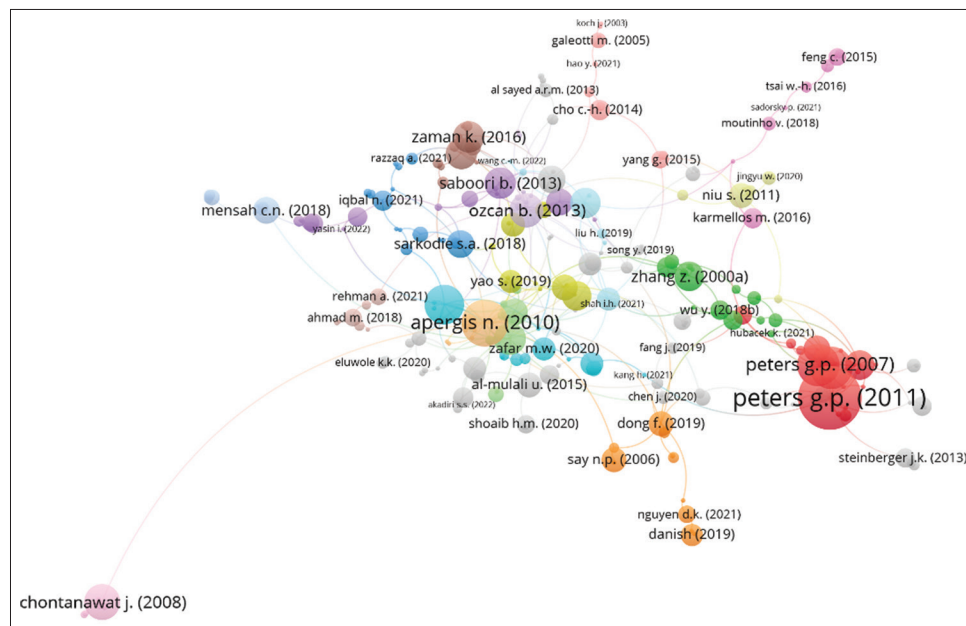
was the author with the highest contribution from 2020 to 2022, with 8 publication documents.

#### 4.1.5. Citation analysis

The citation analysis revealed a significant number of cited research articles on emissions and economic growth in developed countries during the observation period. There are 31 clusters, with each colour representing its own cluster (Figure 7).

The findings of this study reveal that 10 research articles have a significant number of citations. These research articles include: (a) Growth in Emission Transfers via International Trade From 1990 to 2008 (Peters et al., 2011); (b) On The Causal Dynamics Between Emissions, Nuclear Energy, Renewable Energy, and Economic Growth (Apergis, 2010); (c) China's Growing CO<sub>2</sub> Emissions – A Rare Between Increasing Consumption and Efficiency Gains (Peters, 2007); (d) Outsourcing CO<sub>2</sub> Within China (Feng et



**Figure 7:** Citation network visualization in developed countries

al., 2013); (e) Impact of Renewable Energy Consumption and Financial Development on CO<sub>2</sub> Emissions and Economic Growth in The Mena Region: A Panel Vector Autoregressive (PVAR) Analysis (Charfeddine, 2019); (f) Does Energy Consumption Cause Economic Growth? Evidence From A Systematic Study of Over 100 Countries (Chontanawat et al., 2008); (g) The Nexus Between Carbon Emissions, Energy Consumption and Economic Growth in Middle East Countries: A Panel Data Analysis (Ozcan, 2013); (h) CO<sub>2</sub> Emissions, Renewable and Non-renewable Energy Consumption, and Economic Growth: Evidence From Panel Data For Developing Countries (Ito, 2017); (i) Tourism Development, Energy Consumption and Environmental Kuznets Curve: Trivariate Analysis in The Panel of Developed and Developing Countries (Zaman, 2016); and (j) CO<sub>2</sub> Emissions, Energy Consumption and Economic Growth in Association of Southeast Asian Nations (ASEAN) Countries: A Cointegration Approach (Saboori, 2013).

#### 4.1.6. Country analysis

The country analysis described a number of countries that have conducted a lot of research through research articles on emissions and economic growth in developed countries (Figure 8). There are 15 clusters, with each colour representing its own cluster.

This study reveals that 10 countries published the most articles related to the research topic (Figure 9). These countries are China, the United States, Pakistan, the United Kingdom, India, Turkey, Japan, Australia, the Netherlands, and Malaysia.

#### 4.1.7. Institution analysis

The institutional analysis outlines a number of universities (research institutions) that have contributed significantly to uncovering the link between emissions and economic growth in developed countries during the observation period (Figure 10). There are 6 clusters, with each colour representing its own cluster.

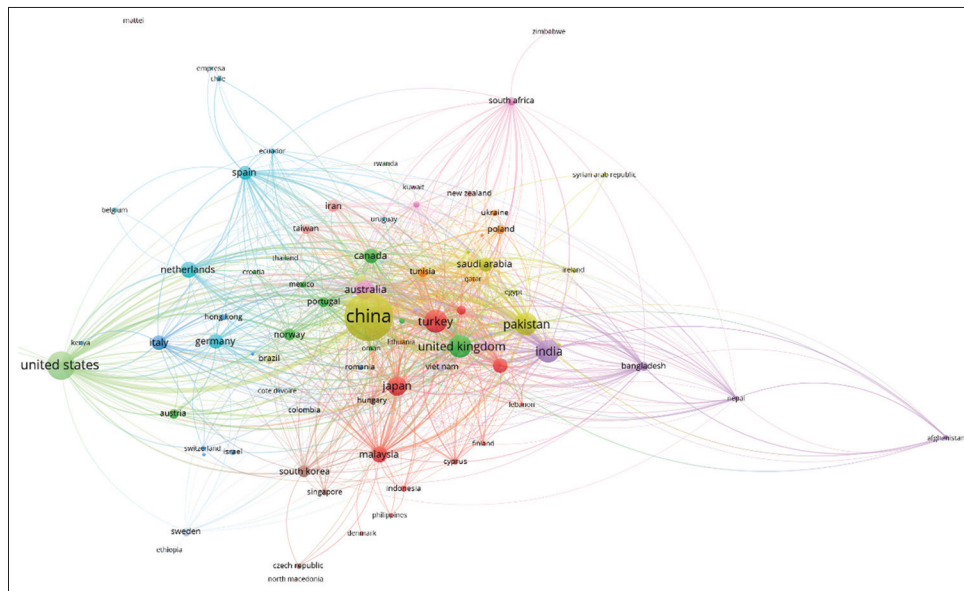
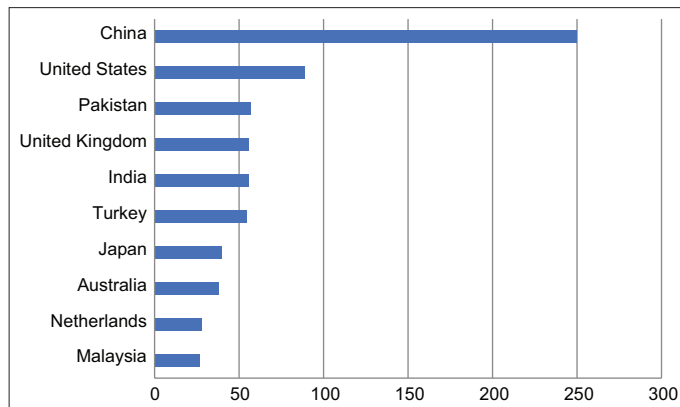
The study findings reveal that 10 institutions have contributed significantly. These institutions include the School of Management and Economics (Beijing Institute of Technology), the Centre for Energy and Environmental Policy Research (Beijing Institute of Technology), the Department of Geographical Sciences (University of Maryland), the Collaborative Innovation Centre of Electric Vehicles in Beijing (Beijing, China), Sustainable Development Research Institute for Economy and Society of Beijing (Beijing, China), School of Management (Jiangsu University), School of Management and Economics (Beijing Institute of Technology), School of Economics and Management (China University of Petroleum), Institute for Energy Economics and Policy (China University of Petroleum), and School of Management (China University of Mining and Technology, Beijing).

## 4.2. Emissions and Economic Growth in Developing Countries

### 4.2.1. Time analysis

Time analysis revealed the movement in the number of published research articles for each year in developing countries during the observation period. Figure 11 illustrates that in 2000, the number of research articles was 10 documents; in 2022, and the number of research articles increased by 21 times to 216 documents. The fewest number of documents were published in 2004 (4 documents), and the most were published in 2022 (216 documents).

The findings of this study contribute to the link between emissions and economic growth in developing countries in several ways. First, the time analysis describes the availability of literature on emissions and economic growth in developing countries each year. 2<sup>nd</sup>, time analysis presents a distribution pattern for the amount of literature that tends to fluctuate during the observation period. Third, it shows the highest and lowest levels of available literature in a given year.

**Figure 8:** Countries network visualization in developed countries**Figure 9:** Selected countries under the highest contribution

Environmental Science (32% or 657 documents), (b) Energy (17% or 342 documents), (c) Social Sciences (11% or 232 documents), (d) Economics, Econometrics and Finance (10% or 196 documents), (e) Engineering (9% or 175 documents), (f) Business, Management and Accounting (5% or 107 documents), (g) Earth and Planetary Sciences (3% or 68 documents), (h) Agricultural and Biological Sciences (2% or 41 documents), (i) Mathematics (2% or 40 documents), (j) Computer Science (2% or 32 documents), (k) Medicine (1% or 29 documents), (l) Multidisciplinary (1% or 19 documents), (m) Chemical Engineering (1% or 16 documents), (n) Chemistry (1% or 14 documents), (o) Psychology (1% or 12 documents), (p) Decision Sciences (1% or 11 documents), (q) Biochemistry, Genetics and Molecular Biology (1% or 11 documents), and (r) others (27 documents).

#### 4.2.2. Journal analysis

The journal analysis described the number of journals that paid more attention to the publication of emissions and economic growth in developing countries during the observation period. The findings show that 158 research articles specifically describe the link between emissions and economic growth (Table 2). In detail, several journals publish a significant number of research articles under the research topic, including: (a) Environmental Science and Pollution Research (122 documents), (b) Journal of Cleaner Production (53 documents), (c) Energy Policy (46 documents), (d) Sustainability Switzerland (34 documents), (e) Climate Policy (22 documents), (f) Energy Economics (20 documents), (g) International Journal of Energy Economics and Policy (20 documents), (h) Energy (20 documents), (i) Applied Energy (20 documents), and (j) Environment Development and Sustainability (19 documents).

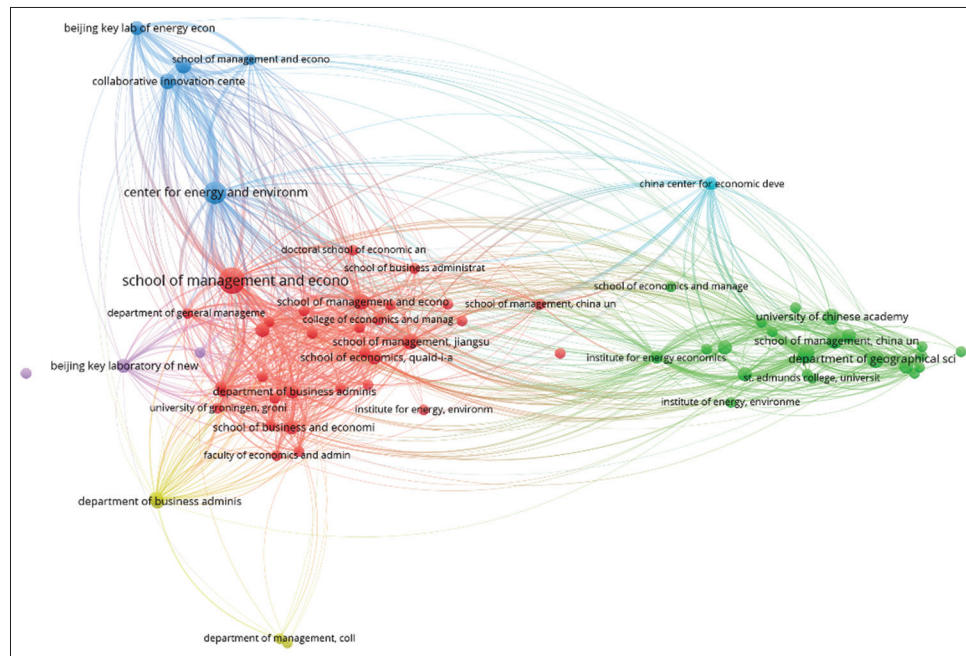
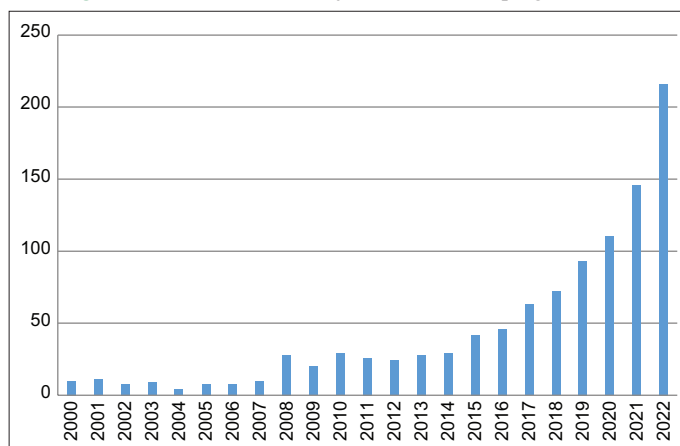
Journal literature can also be classified by subject area (Figure 12). The study findings reveal that there are several journals that have published more than 10 articles about the link between emissions and economic growth in developing countries, namely: (a)

#### 4.2.3. Keyword Analysis

The keyword analysis identified all keywords related to emissions and economic growth in developing countries during the period 2000–2022. The amount of literature analysed using VOSViewer was 1,040 documents. The study findings reveal that there are 973 keywords and 13 clusters, with each colour representing its respective cluster (Figure 13).

Of the 973 analysed, 10 (ten) keywords have the highest occurrence frequency. The ten keywords are “Economic Growth, Developing Countries, Carbon Dioxide, Carbon Emissions, Developing World, Economic Development, Climate Change, Environmental Economics, China and Emission Control.”

Specifically, the 3 keywords with the highest frequency of occurrence in all the analysed literature journals from 2014 to 2015 are “Climate Change, Emission Control and Greenhouse Gas.” Meanwhile, the 3 keywords with a more frequent appearance from 2016 to 2017 include “Economic Growth, Developing Countries and Carbon Dioxide.” The three keywords with more frequent appearance from 2018 to 2020 are “Carbon Emissions, Economic Development and Environmental Economics.”

**Figure 10:** Institution network visualization in developed countries**Figure 11:** Chart of selected journal of developing countries

#### 4.2.4. Co-authorship Analysis

The co-authorship analysis focused the investigation on the names of authors who have contributed significantly to uncovering the link between emissions and economic growth in developed countries. There are 20 clusters, with each colour representing its own cluster (Figure 14).

There were 322 identified authors but only 10 authors contributed significantly. They are Zhang, X.; Wang, Y.; Wang, Q.; Liu, Y.; Li, X.; Wang, Z.; Wang, X.; Zhang, Y.; Li, J.; and Li, Y. For example, He, J. was the author with the highest contribution from 2014 to 2015. He has 8 publication documents. Meanwhile, Wang, Z. was the author with the highest contribution from 2016 to 2017, with a total of 12 documents. Zhang, X. and Wang, Y. were the authors with the highest contributions from 2018 to 2019, with 16 documents each. Besides, Zhang, Y. was the author with the highest contribution from 2020 to 2022, with 10 documents.

#### 4.2.5. Citation analysis

The citation analysis revealed a significant number of cited research articles on emissions and economic growth in developing countries during the observation period. 1,040 research articles form 36 clusters, with each colour representing its own cluster (Figure 15).

The study's findings reveal that 10 research articles have a significant number of citations. These research articles include: (a) Growth in Emission Transfers via International Trade from 1990 to 2008 (Peters et al., 2011); (b) Multivariate Granger Causality Between CO<sub>2</sub> Emissions, Energy Consumption, FDI (Foreign Direct Investment) and GDP (Gross Domestic Product): Evidence From A Panel of BRIC (Brazil Russian Federation, India, and China) Countries (Pao, 2011); (c) Energy Consumption, Economic Growth and CO<sub>2</sub> Emissions in Middle East and North African Countries (Arouri, 2012); (d) Carbon Dioxide Emissions and Economic Growth: Panel Data Evidence From Developing Countries (Narayan and Narayan, 2010); (e) On The Causal Dynamics Between Emissions, Nuclear Energy, Renewable Energy, and Economic Growth (Apergis N 2010); (f) Outsourcing CO<sub>2</sub> Within China (Feng et al., 2013); (g) Economic Growth and Pollutant Emissions in Tunisia: An Empirical Analysis of The Environmental Kuznets Curve (Fodha and Zaghdoud, 2010); (h) Energy Consumption, Pollutant Emissions and Economic Growth in South Africa (Menyah and Wolde-Rufael, 2010); (i) Does Energy Consumption Cause Economic Growth?: Evidence From A Systematic Study of Over 100 Countries (Chontanawat et al., 2008); and (j) The Impact of Renewable Energy and Agriculture on Carbon Dioxide Emissions: Investigating The Environmental Kuznets Curve in Four Selected ASEAN Countries (Liu, 2017).

#### 4.2.6. Country analysis

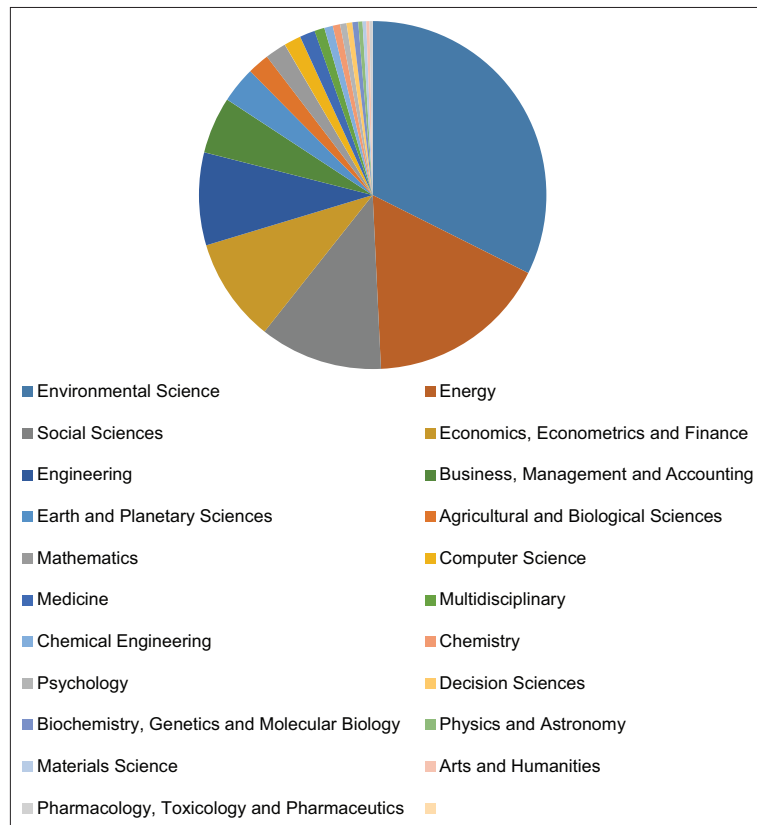
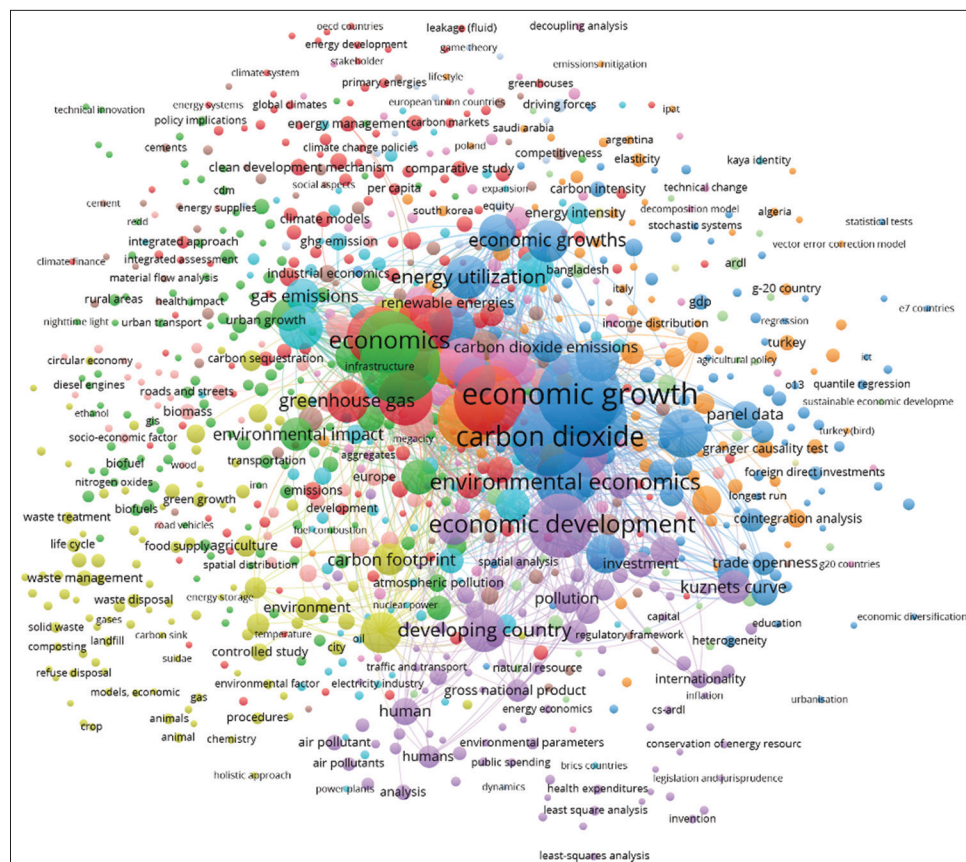
The country analysis describes a number of countries that have done a significant number of research on emissions and economic

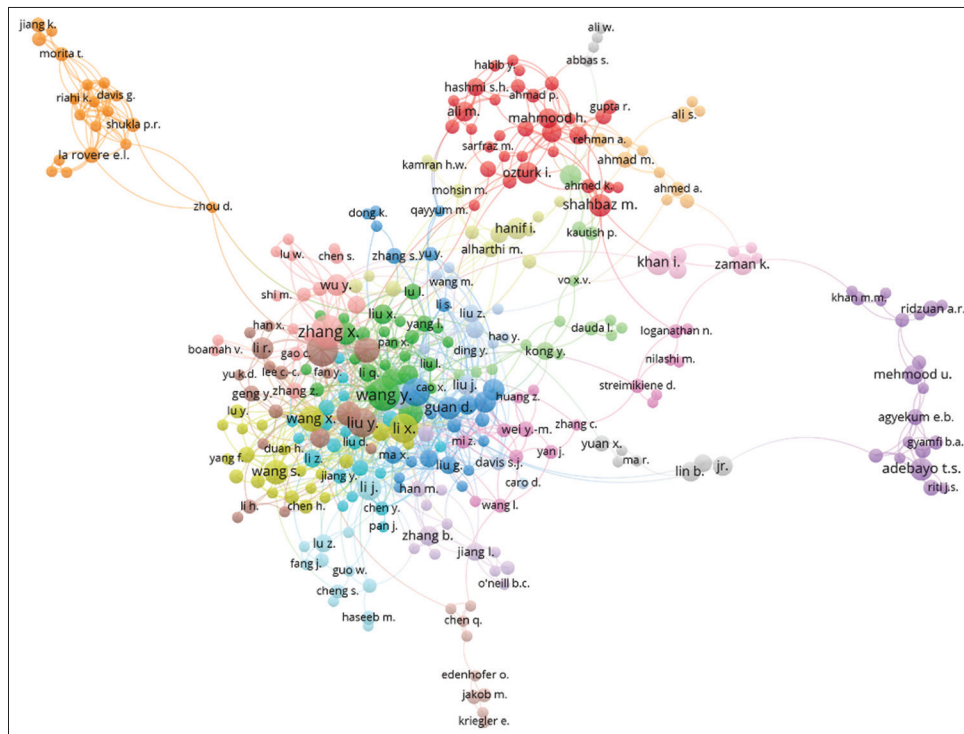
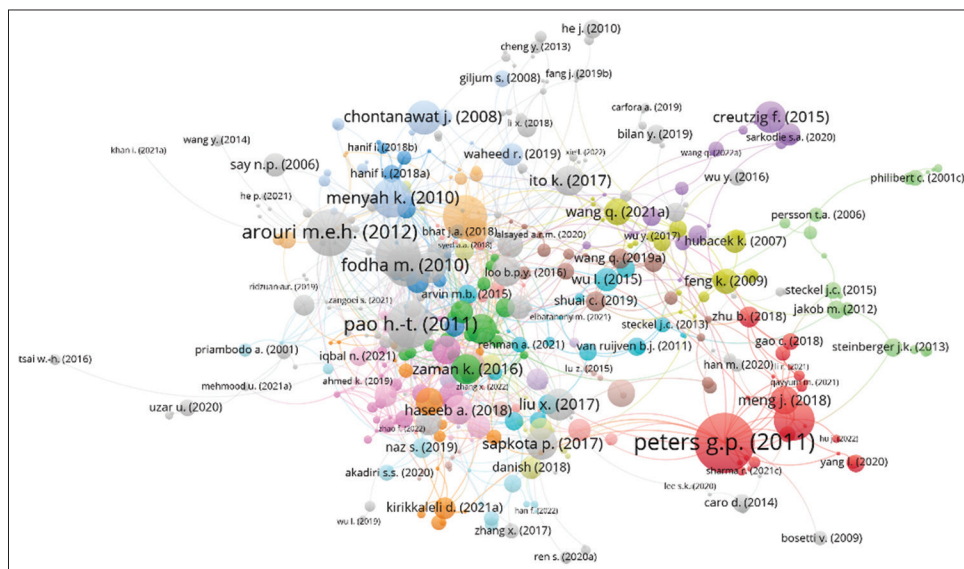


**Table 2: Number of selected journals in developing countries**

Journal title	Number of selected papers in each journal
Environmental Science and Pollution Research	122
Journal of Cleaner Production	53
Energy Policy	46
Sustainability Switzerland	34
Climate Policy	22
Energy Economics	20
International Journal of Energy Economics and Policy	20
Energy	20
Applied Energy	20
Environment Development and Sustainability	19
Journal of Environmental Management	19
Energy and Environment	17
Science of The Total Environment	17
Energies	14
Frontiers in Environmental Science	12
Technological Forecasting and Social Change	10
International Journal of Environmental Research and Public Health	10
Climate Change	9
Sustainable Development; and Resources Conservation and Recycling	8
Plos One; Ecological Economics; Energy Reports;	7
International Journal of Sustainable Development and World Ecology; Renewable Energy; Mitigation and Adaptation Strategies for Global Change; and Journal of Industrial Ecology	6
Ecological Indicators; Global Environmental Change; Sustainable Cities and Society; Environmental Research Letters; International Journal of Energy Sector Management; Management of Environmental Quality an International Journal; Wit Transactions on Ecology and The Environment; and Journal of Environmental Economics and Policy	5
Chinese Journal of Population Resources and Environment; Atmospheric Environment; Nature Communications; Economic Research Ekonomika Istrazivanja; Processes; International Journal of Green Economics; Applied Economics; Studies in Regional Science; Energy for Sustainable Development; Waste Management; International Journal of Global Environmental Issues; Journal of Environmental Studies; Environment and Development Economics; Environmental Science and Technology; Environmental Impact Assessment Review; Proceedings of The National Academy of Sciences of The United States of America;	4
World Development; Sustainable Energy Technologies and Assessments; Resources Policy; Heliyon; Frontiers in Energy Research; Natural Hazards; Environmental Economics and Policy Studies; International Environmental Agreements Politics Law and Economics; Energy Strategy Reviews; Carbon Management; Natural Resources Forum; Chemical Engineering Transactions; Renewable and Sustainable Energy Reviews; Environmental Science and Policy; Iranian Economic Review; and World Economy and International Relations.	3
Climate and Development; Chinese Journal of Urban and Environmental Studies; Current Issues in Tourism; Atmosphere; Applied Ecology and Environmental Research; Vision; Economia Politica; Energy Sustainability and Society; Energy Sources Part A Recovery Utilization and Environmental Effects; Energy Research and Social Sciences; Dili Xuebao Acta Geographica Sinica; Environmental Modeling and Assessment; Wiley Interdisciplinary Reviews Climate Change; Waste Management and Research; Tropical Conservation Science; Global Business Review; Transportation Research Part D Transport and Environment; Sustainable Production and Consumption; South African Journal of Animal Sciences; Shengtai Xuebao Acta Ecologica Sinica; Revue De L Energie; Oxford Review of Economic Policy; Zhongguo Renkou Ziyuan Yu Huan Jing China Population Resources and Environment; Livestock Research for Rural Development; Land Use Policy; Journal of The Knowledge Economy; Journal of Environment and Development; Journal of Economic Studies; International Journal of Sustainable Energy; International Journal of Social Economics; International Journal of Environmental Studies; Habitat International; Fuel; Eurasian Geography and Economics; Journal of International Trade and Economic Development; Environmental and Resource Economics; Energy Efficiency; Mathematical Problems in Engineering; Cogent Economics and Finance;	2
Democratization; Atoms For Peace; Asian Journal of Atmospheric Environment; Carbon Balance and Management; Building Research and Information; Aims Energy; Ciencia Florestal; Atmosfera; Applied Mathematical Sciences; Brazilian Journal of Political Economy; Acta Geophysica; Buildings; Computers in Industry; Business Strategy and Development; Atmospheric Chemistry and Physics; Ain Shams Engineering Journal; E A M Economia A Management; Current Research in Environmental Sustainability; Asia Pacific Review; Australasian Journal of Environmental Management; Applied Mathematics and Nonlinear Sciences; Climate Change Economics; China Economic Review; Communications Scientific Letters of The University of Zilina; Development Studies Research; Current Science; AI and Society; Air Quality Atmosphere and Health; Chemosphere; Bioethics; Administrative Sciences; Construction and Building Materials; Annals of Operations Research; Desalination and Water Treatment; Biomedical and Pharmacology Journal; Agricultural Economics United Kingdom; Alexandria Engineering Journal; Dynamic Games and Applications; African Journal of Hospitality Tourism and Leisure; Biomass Conversion and Biorefinery; China Population Today; China and World Economy; Advances in Decision Sciences; Asia Europe Journal; African Development Review; Asian Journal of Water Environment and Pollution; American Journal of Environmental Sciences; Chinese Geographical Science; Cities; Asia Pacific Journal of Regional Science; Cogent Engineering; and Building and Environment	1
Total	158



**Figure 12:** Number of journals by subject area in developing countries**Figure 13:** Keyword network visualization in developing countries

**Figure 14:** Co-authorship network visualization in developing countries**Figure 15:** Citation network visualization in developing countries

growth in developing countries through the published research articles (Figure 16). There are 15 clusters, with each colour representing its own cluster.

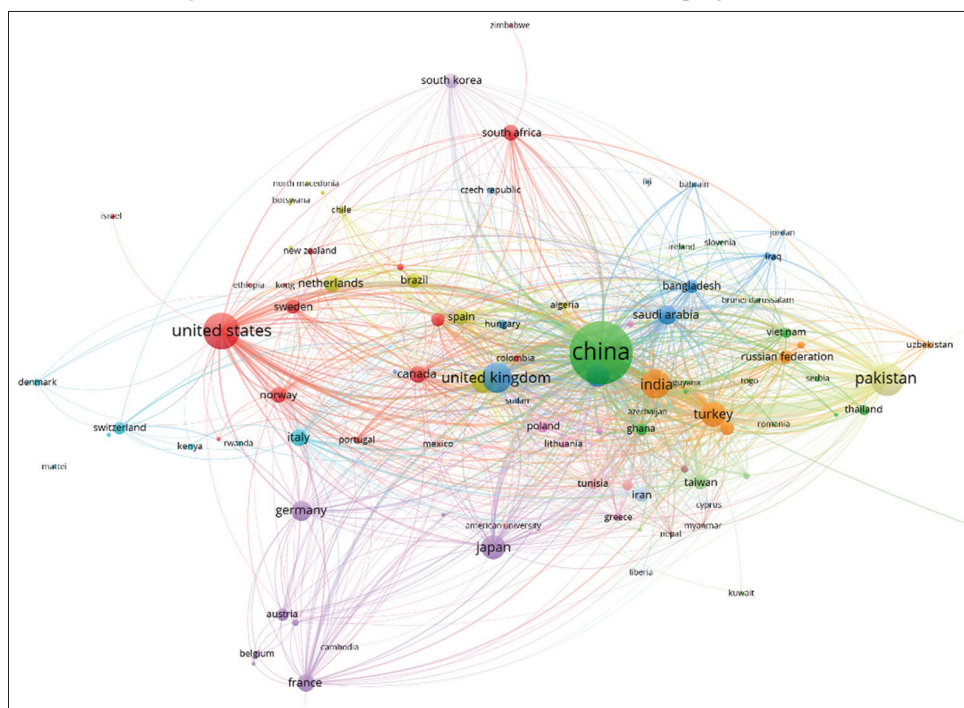
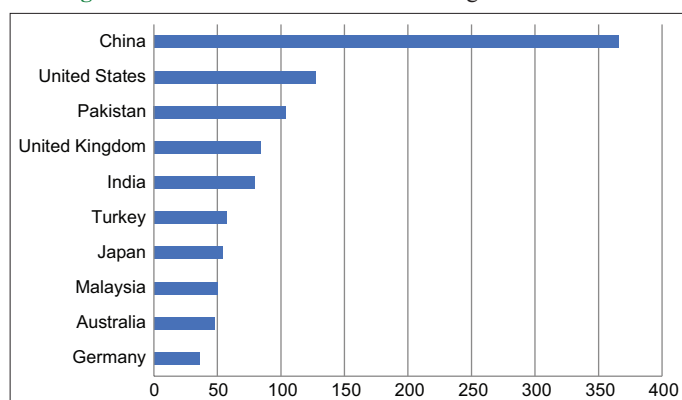
This study shows that 10 countries carried out the most study related to the research topic (Figure 17). These countries include China, the United States, Pakistan, the United Kingdom, India, Turkey, Japan, Malaysia, Australia and Germany.

#### 4.2.7. Institution analysis

The institution analysis outlined a number of universities (research institutions) that have contributed significantly to uncovering

the link between emissions and economic growth in developing countries during the observation period (Figure 18). There are 11 clusters, with each colour representing its own cluster.

The study findings reveal that 10 institutions have contributed significantly. These institutions include the School of Management and Economics (Beijing Institute of Technology), the Centre for Energy and Environmental Policy Research (Beijing Institute of Technology), the School of Economics and Management (China University of Petroleum), the Institute for Energy Economics and Policy (China University of Petroleum), Department of Geographical Sciences (University of Maryland), Sustainable

**Figure 16:** Countries' network visualization in developing countries**Figure 17:** Selected countries under the highest contribution

Development Research Institute for Economy and Society of Beijing (Beijing), University of Chinese Academy of Sciences (Beijing), School of Business and Economics (North South University), School of Economics (Huazhong University of Science and Technology), and School of Management (Jiangsu University).

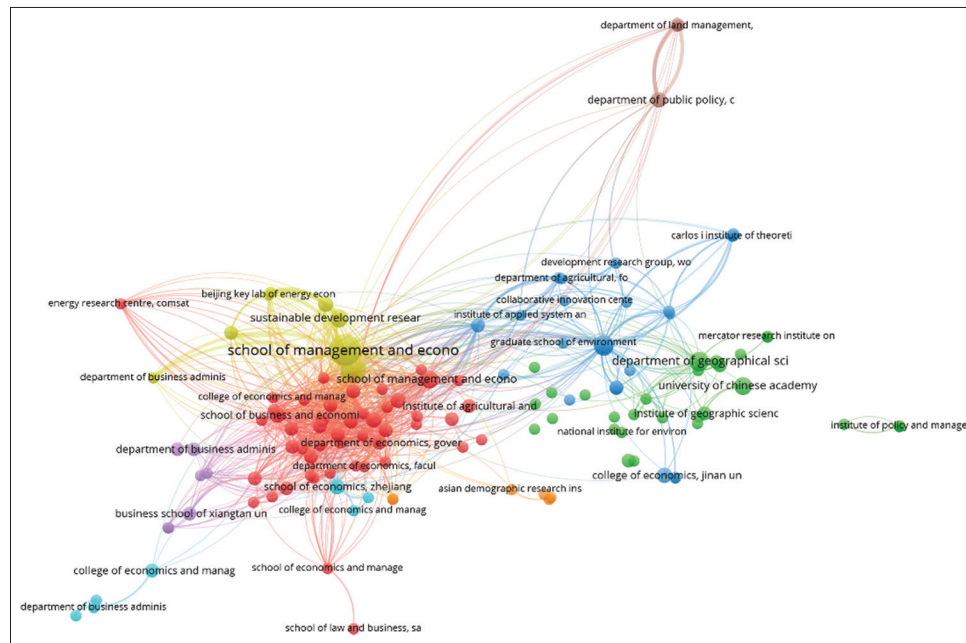
## 5. DISCUSSION AND CONCLUDING REMARKS

The time analysis results show that research articles on emissions and economic growth in developed and developing countries initially experienced fluctuations and then increased significantly. The increase was greater in developing countries. Developing countries have begun to focus on emission issues related to economic growth in the last 10 years. They can reduce carbon dioxide emissions because their income increases, as happened in 43 countries in the Middle East and South Asia (Narayan and

Narayan, 2010). Environmental Science and Pollution Research is the journal that has made the most significant contribution to the analysis of developed and developing countries, with the majority of research articles falling under the purview of Environmental Science. The word “economic growth” comes up most often in research articles about emissions and economic growth in both developed and developing countries, with the most articles written in 2016 and 2017. Keywords such as “carbon emissions” and “economic growth” have high frequencies, centrality, and persistence (Yin and Jin, 2022).

In the authorship analysis, Wang, Q. is the author with the most significant contribution to the analysis of developed countries, and Zhang, X. is the author with the most significant contribution to the analysis of developing countries. “Growth in Emission Transfers via International Trade from 1990 to 2008,” written by Peters et al., 2011 is the journal article with the highest number of author citations for both analyses in developed and developing countries. Peters found that the stabilization of emissions in developed countries was largely due to increased imports from developing countries. International trade is an important factor in explaining changes in emissions in many countries from both production and consumption perspectives (Peters et al., 2011). China is the number one country contributing research articles on emissions and economic growth in both developed and developing countries, with the School of Management and Economics (Beijing Institute of Technology) as the supporting institution providing the most significant contribution. China’s concern about emission issues and economic growth is closely related to the fact that China has become the world’s largest CO<sub>2</sub> emitter. The country has struggled to balance rapid economic growth and environmental sustainability across provinces in very different stages of development (Feng et al., 2013). Renewable energy consumption is the main solution in China’s carbon emission reduction strategy



**Figure 18:** Institution network visualization in developing countries

(Chen et al., 2019). Long-term energy and economic policies are also effective in tackling the greenhouse effect in China, putting China on a low-carbon growth path (Wang et al., 2016).

This study reveals and maps the findings of the literature on the impact of emissions on economic growth in developed and developing countries. These findings can guide researchers in developing and improving studies on the linkages between emissions and economic growth at the country level and across countries. In addition, policymakers can benefit from the findings of this study to reduce emission levels and stimulate long-term economic growth.

The time analysis results in literature journals regarding the relationship between emissions and economic growth in developed and developing countries show that the two groups experienced fluctuations at the beginning and then an increase. This increase has been faster in developing countries in the last 10 years. The results of the journal analysis show that *Environmental Science and Pollution Research* is the journal with the most contributions to analyses in developed and developing countries. “Economic growth” is the keyword with the highest frequency of occurrence in all literary journals analysed in developed and developing countries. In the author analysis, Wang Q is the author with the most contributions to the analysis of developed countries, and Zhang X is the author with the most contributions to the analysis of developing countries. In terms of journal articles with the highest author citations, “Growth in Emission Transfers via International Trade from 1990 to 2008,” written by Peters et al., 2011, was the journal article with the highest author citations in both developed and developing countries. China is the number one country in terms of contribution to the publication of literature on the relationship between emissions and economic growth in both developed and developing countries, with the School of Management and

Economics (Beijing Institute of Technology) as the supporting institution providing the highest contribution.

The limitations of this study lie in several factors. First, this study does not specify various indicators of CO<sub>2</sub> emissions and pollution sources that cause environmental damage and economic growth. Second, this study does not emphasize periods of economic crisis and investment expansion policies that are not environmentally friendly. Third, this study does not consider how international trade and investment policies impact various countries’ emission production and environmental damage. Therefore, future researchers can examine the impact of emissions on economic growth in developed and developing countries more comprehensively.

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