

Systematic Literature Review: The Relationship between FDI and Carbon Dioxide Emissions

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Abstract

This article provides a systematic and comprehensive review of the existing empirical literature on FDI and carbon dioxide emissions for 2000-2021. The review covers articles published in the Web of Science and SCOPUS, provides a content analysis of their study, the findings show that it as a more popular cross-disciplinary research area in recent years. The field (a) emphasizes quantitative analysis, relevant modelling through data, and causal research design; (b) focuses on single-country studies, mainly conducted in Asia and Europe; (c) tends to use relatively large samples; and (d) uses relatively complex models for analysis. This report provides guidelines for researchers to focus on the relationship between FDI and Carbon Dioxide Emissions and suggestions for potential new research topics.

Keywords: Foreign Direct Investment; CO2; Global Economy; International Trade; Climate Policy

1. Introduction

In recent years, carbon dioxide emissions from the massive consumption of fossil energy have been increasing year by year, resulting in a more pronounced greenhouse effect and increasingly frequent climate disasters worldwide. Low carbon economy is a socio-economic form based on market mechanism, using efficient energy technology, renewable energy technology, greenhouse gas emission reduction technology and industrial transformation to reduce the consumption of energy with high carbon content as much as possible and achieve the synergistic development of economic development and environmental protection. All countries have recognized the importance and urgency of carbon emission reduction. The global economy has shifted from the stage of high-speed growth to the stage of high-quality development, and the pressure of high energy consumption and carbon emission reduction has put forward new requirements for the adjustment of current foreign trade policies. Specific emission reduction policies are widely divergent among countries, and the delay in reaching international carbon emission reduction agreements has seriously hindered the achievement of global emission reduction targets. Therefore, studying the relationship between climate policy, trade, and carbon emissions is of great theoretical and practical significance. In this paper, based on the review of related literature, a descriptive statistical analysis of the climate policy

status of FDI and carbon emissions are conducted. In turn, we construct an analysis of the impact of climate policy, trade and carbon emissions.

2. Methodology

2.1 Source of database

This study uses a qualitative systematic literature review (SLR) as a research method to assess existing research based on research questions. As this paper aims to review the literature on FDI and CO₂ relationship through research questions, and a systematic literature review. Based on this field, the questions related to how to address sustainable economic development between countries or regions in the future are realized. The systematic literature review approach is particularly useful because it meticulously summarizes the existing studies' responses to the research questions. In addition, the search strategy database used by researchers is more organized and can serve as a good basis for their research (Bell, 2018).

In this paper, the systematic literature review (SLR) immensely helped in the search scope of the literature in this field by narrowing down the selection after searching for relational information (Shaffril, 2018). More precisely, the study explained five (5) subparts are PRISMA, which is resources, systematic evaluation process (identification, screening, and eligibility), quality assessment, and data abstraction and analysis. Overall, the steps of the systematic methodology provide a strong justification for the large number of articles in this field. Shaw and Watson (2019) argue that complete and perfect electronic databases do not exist and that a combination of at least two databases is sufficient for research. Therefore, two academic databases, Scopus and Web of Science (WOS), were used in this study. The Web of Science (WOS) series covers more than 12,000 real-time journals, 23 million patents, 148,000 congressional meetings, more than 40 million and 760 million references consisting of various disciplines such as environmental studies, science, social sciences and technology 1945. Bibliographic database covered in 1996 Scientific, multidisciplinary and international literature (Sánchez & García, 2016).

2.2 Preferred reporting items for systematic review and meta-analysis (PRISMA)

For this review, all articles were searched using Scopus and Web of Science (WOS), two databases that helped to make the search more accurate and logical. To enhance the systematic review and overall evaluation of the literature (Moher & Liberati, 2009), the purpose of using this method is to be able to categorize the methods, variables, and analyses of each article (Shaffrid, 2018). More precisely, PRISMA explains the resources of the study, the systematic evaluation process (identification, screening, and eligibility), the quality assessment and the data abstraction and analysis. Overall, the steps of the systematic methodology provide a strong justification for the large number of articles in the field.

2.3 A Systematic review process

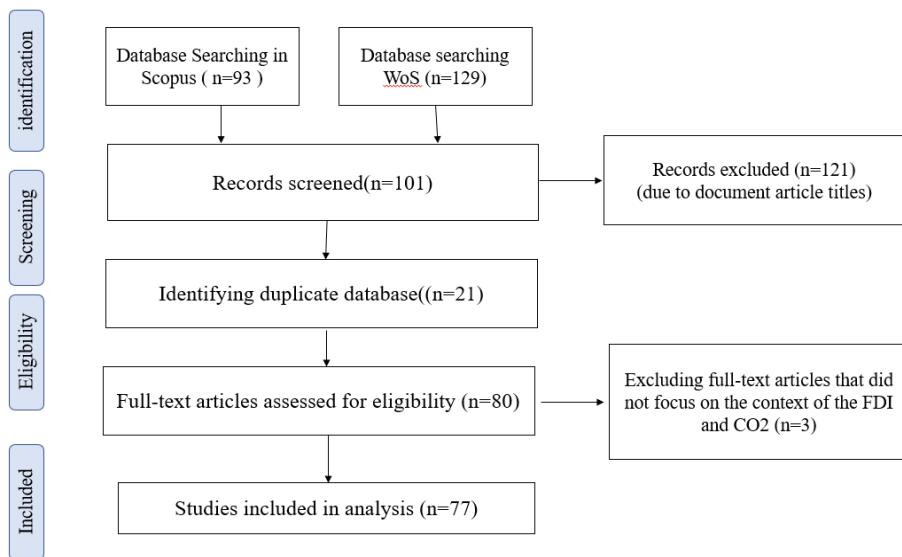
Firstly, it involves identifying the research questions. For this scoping review, two research questions were asked: (1) What is the relevance of FDI to CO₂? (2) What are the themes in the context that are closely related to FDI and CO₂?

Secondly, it involved identifying relevant studies. Researchers were conducted from the Web of Science (WoS), Scopus databases. The search strategy included: a comprehensive keyword search for (1) FDI related to CO₂, i.e. (1) FDI, CO₂, economics (Combining OR and AND), the selected literature is in English, this selected categories in economics and management, with a time cut off of 2000-2021. (see Table 1)

Table 1*The inclusion and exclusion criteria*

Criterion	Eligibility	Exclusion
Literature type	Journal (research articles)	Journal(review), book series, book, and Conference articles
Language	English	Non-English
Timeline	2000-2021	> 2000
Subject area	Economics, Management Finance	Environmental Sciences Environmental Study Engineering Environmental

Thirdly, it involves screening to remove redundant articles. To perform operation, the first selection of criteria for the correlation between FDI and CO₂ was the focus of this study. For the depth of the survey, only journal articles were studied as the main source of evidence for analysis and all selected publications were in English. Since the research direction is interdisciplinary and the focus is on economics, the categories selected are economics and management, and the timeline of published articles spans the period 2000 to 2021. According to the search of both repositories, 222 articles on related topics were available. Based on the titles of the articles, 121 articles were excluded. The literature from both databases was further excluded for duplicate literature, and 21 papers were further excluded for two rounds of elimination, resulting in a target of 80 articles constituting the results of this review. Based on the focus of the full text combined with the correlation between FDI and CO₂, three more articles were excluded from these 80 articles, so the final number of articles that could be analyzed was 77, ranging from 2012 to 2021. the steps involved are identification, screening, eligibility and the steps involved are identification, screening, eligibility and included as per Figure 1. The findings are obtained in the next section.

Figure 1*Process in Systematic Literature Review***3. Review and Discussion***3.1 Review of articles database**3.1.1 Review of articles in Scopus database*

Based on the screening and analysis of the papers, combined with the titles of the articles, this section focuses on the 101 articles that meet the subject matter requirements.

The process of browsing journal articles in the Scopus database used several keywords to find journal articles 53 articles. These keywords were searched based on the characters in Table 2, the focus of the query was based on the relationship between the two and the alignment with the theme of economic development.

Table 2*Criteria Search in Web of Science Database*

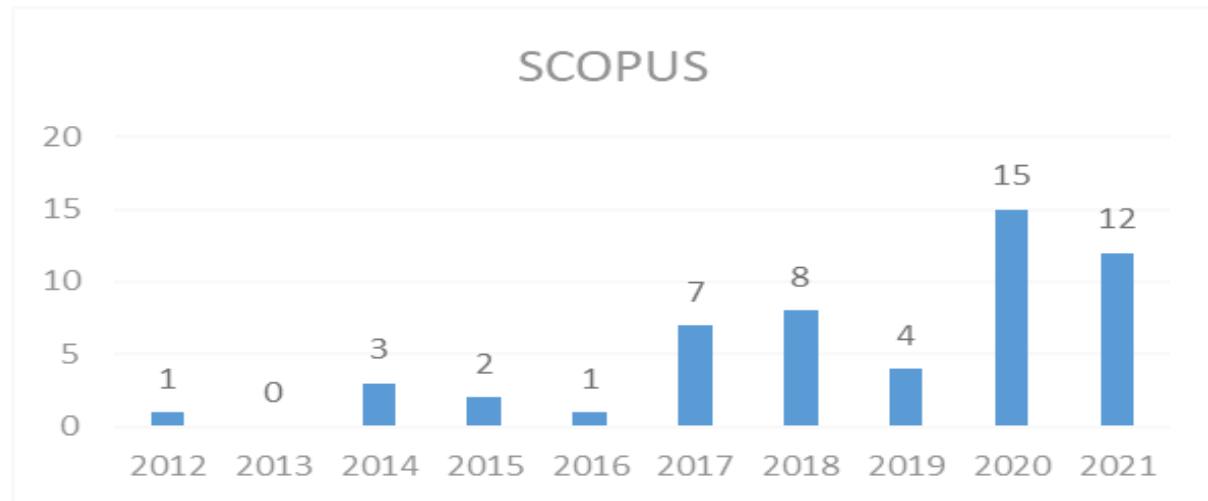
Database	Query string search
Scopus	TS= (“FDI AND CO ₂ ” OR “Foreign Direct Investment” OR “Economic Growth” OR “CO ₂ Emissions”)

The 53 articles found according to Scopus are shown in Figure 2. Starting in 2012, one paper was published, and from 2013 to 2016, the overall number of articles was low, including none in 2013. However, the number of articles rose significantly from 2017 and continued to

rise from 2017 to 2018, but only four relatively few articles conformed to the topic in 2019. 2020 saw a linear upward trend in the number of articles, with 11 more than in 2019, and although there were three fewer articles in 2020, the overall number was still above ten, and it is worth mentioning that after 2020 The number of articles on this topic is relatively high, which can also be seen that this topic is a relatively popular research area in the past two years.

Figure 2

Number of Articles in Scopus Database



3.1.2 Review of articles in Web of Science database

The process of browsing the journal articles in the Web of Science database used several keywords to find journal articles 48 articles. These keywords were searched based on the characters in Table 3, and the focus of the query continued to be based on the relationship between the two and the alignment with the theme of economic development, with the addition of economic growth.

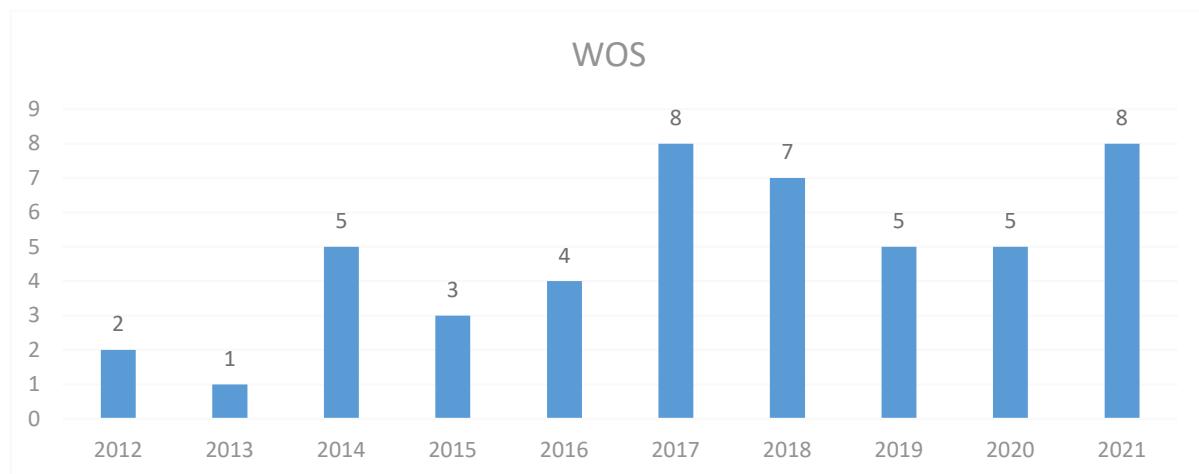
Table 3

Criteria Search in Web of Science Database

Database	Query string search
Web of Science	TS= (“FDI AND CO ₂ ” OR “Foreign Direct Investment” OR “Economic Development” OR CO ₂ Emissions”)

According to Web of Science, the number of 48 articles found is shown in Figure 3. From 2012 to 2021, the overall number of articles showed an increasing trend, but the number of publications in the middle part of the year was relatively small. Among them, there was only

one article in 2013. But there was an increase of 4 articles in 2014. From 2015 to 2017, the number of articles showed an upward trend, increasing twofold. However, the number of articles from 2017 is on a downward trend, including five articles in both 2019 and 2020. the number of articles on this topic in 2020 is the same as in 2017, both of which are eight. It can be seen that the number of Web of Science literature releases is generally relatively stable, and there is no sudden increase in the number of many articles.

Figure 3*Number of Articles in WOS Database*

3.2 Analysis of article's citation number

The number of citations is used as an indicator of success in research, indicating the effectiveness or consistency of the research analysis (Langfeldt, 2019). Tables 4 and 5 list the top 10 cited articles in Scopus and Web of Science in this article. Lau and Eng (2014) "Investigation of the environmental Kuznets curve for carbon emissions in Malaysia: do foreign direct investment and trade matter?" in Web of Science is 323 citations. In contrast, Shahbaz and Roubaud (2018) "Environmental degradation in France: the effects of FDI, financial development, and energy innovations." was cited 303 times in SCOPUS.

According to the analysis, Articles in the year of 2016 are more highly cited in Web of Science, with 4 of them, followed by the 2014 articles with three. The articles from 2017 have a higher citation rate in SCOPUS with 3 papers. Among these top 10 cited articles, it can be seen that the articles from the Web of Science repository are concentrated before 2017, while the articles from the SCOPUS repository are concentrated after 2017.

Based on the number of citations, one similar article in both databases is "Causal interactions between CO₂ emissions, FDI, and economic growth: Evidence from dynamic simultaneous- equation models." (Omri & Rault, 2014).

Table 4*Number of Citations in Web of Science Database*

Author/Year	Title	Number of citations
Lau and Eng (2014).	Investigation of the environmental Kuznets curve for carbon emissions in Malaysia: do foreign direct investment and trade matter?	323
Zhu and Yu (2016)	The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression.	286
Shahba and Roubaud (2018).	Environmental degradation in France: the effects of FDI, financial development, and energy innovations.	284
Lee (2013)	The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth.	277
Omri and Rault (2014)	Causal interactions between CO2 emissions, FDI, and economic growth: Evidence from dynamic simultaneous-equation models.	247
Ren and Chen (2014)	International trade, FDI (foreign direct investment) and embodied CO2 emissions: A case study of China's industrial sectors.	200
Paramati and Apergis (2016)	The effect of foreign direct investment and stock market growth on clean energy use across a panel of emerging market economies.	156
Baek (2016)	A new look at the FDI-income-energy-environment nexus: dynamic panel data analysis of ASEAN	128
Gökmenoglu and Taspinar (2016)	The relationship between CO2 emissions, energy consumption, economic growth and FDI: the case of Turkey.	117
Zhang and Zhang (2018).	The impacts of GDP, trade structure, exchange rate and FDI inflows on China's carbon emissions	115

Table 5
Number of Citations in SCOPUS

Author/Year	Title	Number of citations
Shahbaz and Roubaud (2018)	Environmental degradation in France: the effects of FDI, financial development, and energy innovations.	303
Omri and Rault (2014)	Causal interactions between CO2 emissions, FDI, and economic growth: Evidence from dynamic simultaneous-equation models.	280
Sun and Xu (2017)	Investigation of pollution haven hypothesis for China: an ARDL approach with breakpoint unit root tests.	130
Paramati and Ummalla (2017)	Financing clean energy projects through domestic and foreign capital: The role of political cooperation among the EU, the G20 and OECD countries.	90
Haug and Ucal (2019)	The role of trade and FDI for CO2 emissions in Turkey: Nonlinear relationships.	84
Abdouli and Hammami (2017)	Investigating the causality links between environmental quality, foreign direct investment and economic growth in MENA countries	79
Kutan and Zakari. (2018)	Financing renewable energy projects in major emerging market economies: Evidence in the perspective of sustainable economic development.	70
Le and Taghizadeh-Hesary (2020).	Does financial inclusion impact CO2 emissions? Evidence from Asia.	53
Kim and Adilov (2012)	The lesser of two evils: an empirical investigation of foreign direct investment-pollution trade-off. .	51
Xie and Cong (2020)	How does foreign direct investment affect CO2 emissions in emerging countries? New findings from a nonlinear panel analysis	42

3.3 Analysis of study settings

According to Table 6, the researchers use the country as the setting for the research analysis. This analysis shows that the region where more attention is paid to the direct relationship between FDI and carbon emissions is in China, because China is the world's factory and its carbon emissions are among the highest in the world, so the analysis of the relationship between FDI and carbon emissions has also become the most important concern for scholars in this country. The development of environmental sustainability and green economy has also become a hot spot for scholars. In addition, the second most studied country is Tunisia, as it is one of the regional energy countries that has to commit to the world organization to reduce carbon emissions in its economic development and as a country rich in natural gas energy, energy development, and economic issues have also become an important direction for scholars in this country. As a developed country with good economic development, scholars in the United States are gradually focusing on the relationship between foreign direct investment (FDI) and carbon emissions, as many manufacturing industries in the United States require FDI. In addition, India, UK, and Malaysia also account for a certain proportion of the articles' attention in the two databases. It can be seen that the research on the relationship between OFDI and carbon emissions is not only a concern for countries with more developed economies and larger areas, but it is an issue of continuous concern for all regions of the world; therefore, scholars from Turkey, Vietnam, South Korea, Arab countries and other regions have relevant studies.

Table 6
Number of Study Based on Country

Country	Database	
	SCOPUS	WOS
China	12	13
Tunisia	8	9
United States	7	6
India	6	5
Malaysia	5	3
Turkey	5	3
United Kingdom	2	4
Viet Nam	3	2
Taiwan	2	1
South Korea	2	1
Saudi Arabia	1	1
Total	53	48

3.4 Methodology of study

In each study, a method is used to conduct analysis or a strategy is used for classification, processing, and interpreting information about the selected topic. Quantitative research uses mainly empirical measurements, statistical analysis, and modeling methods, expressed as data, patterns, and graphs; qualitative research uses mainly logical reasoning, historical comparisons, and other methods. Qualitative research is the basis of quantitative research and is its guide, but only when quantitative research is also applied can qualitative research be accurately characterized on the basis of precise quantification. In this analysis, the quantitative methods were used in the entire study, because the research in this field must be studied by building models and statistical analysis methods.

3.5 Unit of sample

In the context of the study, the sampling frame is part of the research methodology. According to this study, as shown in Table 7, the sample units that were mainly used for the topic of this study are regions. The sample size of regions in Scopus is mainly concentrated between 11-20, accounting for 81% of the total studies, and a total of 27 studies in Web of science have a sample size concentrated between 21-30, accounting for half of the total studies. It can be seen that the number of samples in both databases is concentrated between 11-30, and it can also be seen that this sample is more specific in terms of analyzed data. In the sample sampling of both repositories, more than 80% of the samples were selected from countries, which helps to study from a global perspective, and the data is more widely available and has a useful effect on different regions, and the samples of selected provinces and cities are mainly from the study in China, because of the large area of China and the existence of certain differences among regions.

Table 7
Sampling Frame in Database

Sampling	WOS	SCOPUS
1-10	2	3
11-20	22	15
21-30	17	27
> 30	8	8
<hr/>		
Sampling Scope		
City	3	5
Province	6	8
Country	39	40

3.6 Underpinning theory in study

This research area uses quantitative research analysis, so all literature relies on economic model analysis with multivariate variables. Further investigation is required by combining different mathematical models with multiple variables.

The ARDL model is one of the more commonly used models in this field of study, with 33 studies using it, especially during 2019-2021, when almost a third of the articles used it. There are also 14 and 12 of articles using the VAR model and the Generalized Moment Method, respectively. The second most commonly used model is the Vector Error Correction Model, especially in 2015-2019, which incorporates allows for cross-sectional specific coefficient vectors and cross-sectional correlations in the residual. (E.g. Kim, 2019).

It is worth noting that there has been an increase in the use of other types of mathematical models in the last two years to analyze the field. 20 articles use different methods. For example, Chen (2021) constructs a multi-period DID model to study, and Udemba (2021) based on the STIRPAT model.

Since all the models are quantitative, the collected data need to be purified and tested by analyzing of the stability and correlation of the data, etc. for a better analysis. Depending on the model, 77 articles used the unit root test according to the model, the articles underwent the application of this test was most used in the articles during 2015-2019. The Granger causality test and the Cointegration test are also more commonly applied due to the more frequent use of the ARDL model and the Vector Error Correction Model. In particular, 72 articles used the cointegration test, and 37 articles also use Robustness Test to check its robustness because of the need of some specific variables. (see figure 4&5)

Figure 4

Number of Model Use in Database

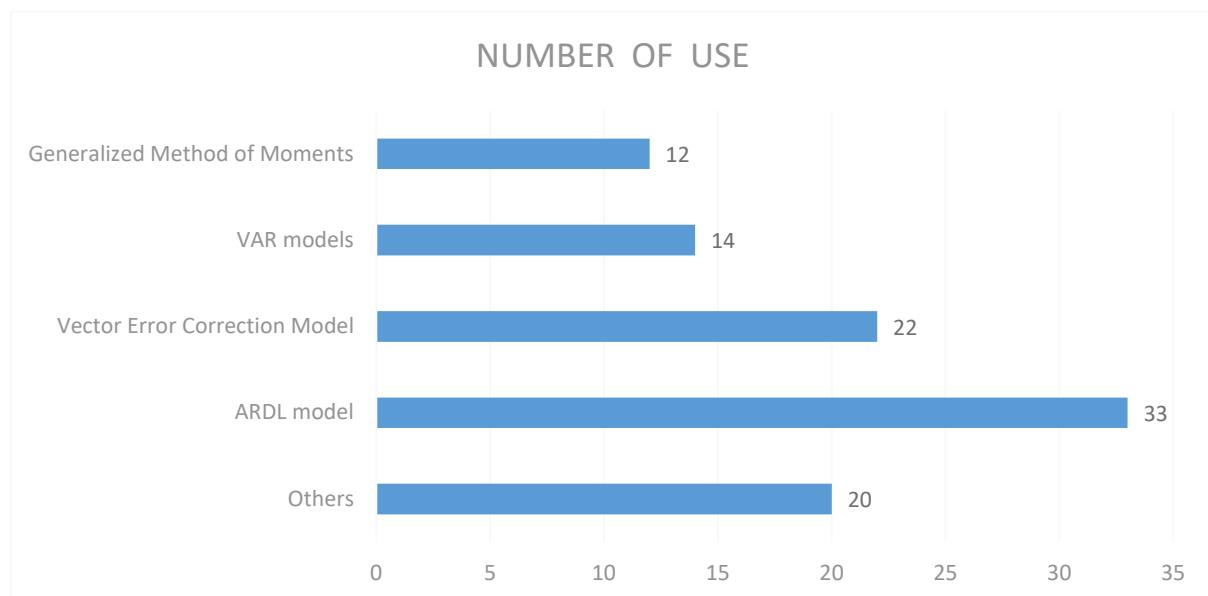
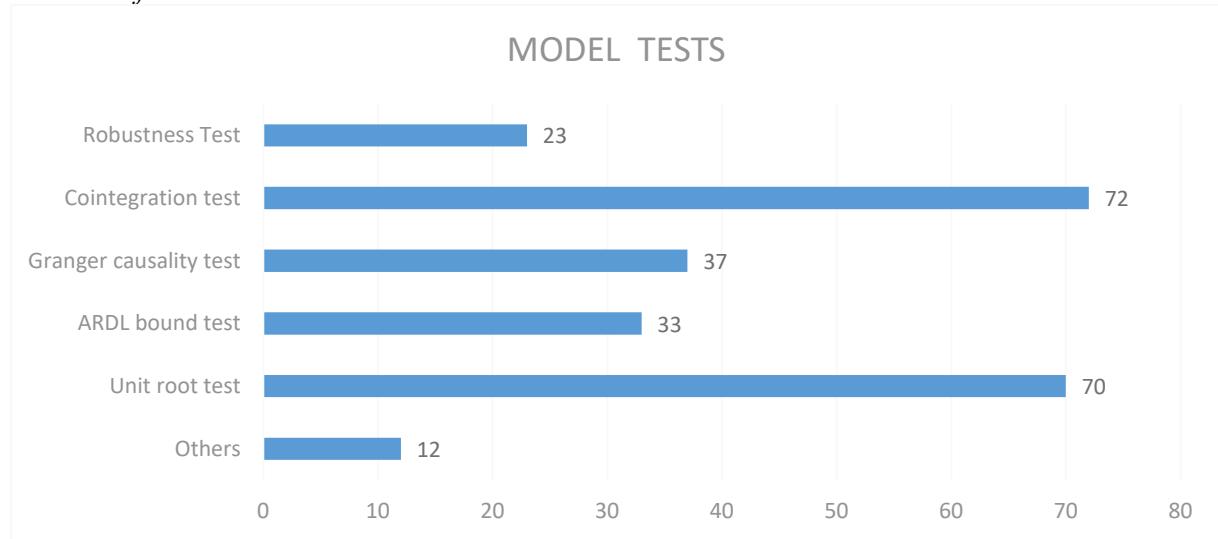


Figure 5

Number of Model Tests in Database



4. Limitations and recommendations

Every study has limitations. This study does not exclude its limitations either. This study focuses on a systematic literature review to explore and develop future research abilities. Although the overall findings found that CO2 emissions affect the total amount and industrial structure of OFDI in some regions, the variability is significant. First, in terms of the scope of studies, there are no large-scale studies, but rather more detailed studies even focused on one country. Although the scope of research is covered in each country, many articles still focus on the Asian region and the European region, especially China in the Asian region, because China's CO2 emissions are higher in the global ranking, so many Chinese scholars study this area more, and other neglected (but important) countries, such as the United States and Canada, still need to be expanded with multiple approaches. This will help to compare the results of studies from different regions. Also, the CO2 emissions sample should be chosen for a longer period of time, which will help to get a more accurate comparison and analysis in future studies. The existing studies are based on official data from various countries or organizations, and the samples are also more biased towards countries, and it is not possible to obtain more accurate local data. In the future, the scope of the data can be narrowed down a bit, so that the analysis will be more specific and representative, and the scope of OFDI can be better determined.

In terms of data analysis, this study is mainly a quantitative study, and many scholars choose different mathematical models to analyze, except for the ARDL model which is a common model, the rest of the models are slowly tried and improved, and some scholars add new variables to the study, such as GDP, which can effectively measure the influence of CO2 on FDI, which is also the positive significance of this study. In addition, some model evaluations were also conducted to ensure the accuracy of the data, which provides references for future studies.

5. Conclusion

This literature review shows that the study of the FDI-CO2 relationship, a popular cross-disciplinary area in the last two years, has been largely influenced by global regional economic policies and sustainable economic development policies. The relationship and its characteristics have a causal effect on the relationship. However, a more complete research system has not yet been formed in this field, and there is still room for expansion of in-depth research ideas in this field, which is influenced by regional economic, political, and cultural aspects, as well as some of the studies. The results can help individual countries or regional organizations develop specific measures suitable for the region's development.

Acknowledgements

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