InTraders
International Trade Academic Journal

(InTraders Journal)

InTraders Journal

InTraders International Trade Academic Journal is peer reviewed academic journal, open access and accepts "PRINCIPLES OF TRANSPARENCY", follows the practice guidelines prepared by the Publication Ethics Committee (COPE).

About

InTraders, which started its publication period in 2018, offers open access. The journal is a publication type of the InTraders Academic Platform, which started its processes with trademark registration in 2017. Platform: It publishes in Congress, journal and book chapter types.

The journal's main subject is international trade. For 2024 and beyond, it accepts economy-based studies outside international trade and original studies on tourism issues.

Authors must upload plagiarism reports and copyright transfer forms to the system along with their work. The work uploaded to the system must be prepared by the journal writing rules. The uploads made outside the spelling rules will be returned at the pre-check stage. Obtaining necessary permissions from ethics committees or commissions for studies that require ethics committee permission (works that require a survey or scale application, contain interviews and observations, documents, pictures, questionnaires, etc., developed by others and require permission to use), specifying these in the study content or must be submitted in addition. Without these permissions, the publication is returned to the author at the preliminary examination stage.

InTraders runs all its processes through Dergipark.

Broadcast range: July-December

Manuscript language: English (Should not include abstracts in languages other than English.).

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*-English studies are accepted for 2024 and later. Studies in English should not include abstracts in languages other than English.

Aim

InTraders International Trade Academic Journal will be able to publish scientific studies of researchers; aims to create an international platform that can contribute to their academic development and increase the number of qualified academic studies.

Scope

InTraders International Trade Academic Journal is peer-reviewed by international referees and an international journal that publishes original scientific research in English, primarily in international trade.

The journal's main subject is international trade. For 2024 and beyond, it accepts economy-based studies outside international trade and original studies on tourism issues. The journal is available free and open access to all researchers. The language, scientific, legal, and ethical responsibilities of the articles published in the journal belong to the authors. The articles published in the journal can only be used when showing the source.

Review Process

1- Editor assignment is made for the field of the article uploaded to the system.

2- Editor: checks the files—checks whether the article is within the scope of InTraders Journal. If there are missing or incomplete files, send the article to the author and request the completion of the deficiencies. After the deficiencies are completed, the editor reads the article. Decide whether the article is suitable for evaluation. If the article is unsuitable for evaluation, the reason is detailed, and the editor rejects the article. If the article is suitable for evaluation, a secretariat is assigned to check the spelling and bibliography of the article.

2- Secretariat: receives the spelling-language report of the article with the paid Grammarly Program and uploads it to the additional files section of the system. The spelling-language report is expected to be 95% and above. A bibliography check is performed. If corrections are necessary in the article, the secretariat indicates the notes on the article. Uploads the correction request file to the additional files section in the system. Completes the process by directing the article to the editor.

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5- The spelling and grammar secretariat checks whether the requested revision has been made and obtains a spelling and grammar report again with the Grammarly Program. If the report is 95% and above, it is accepted. If the deficiencies are completed, the secretariat completes the process. The study takes on the role of editor. If the necessary corrections are not completed, the editor is informed, and a recommendation is made to reject the study.

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7-Referees: They choose one of four options: rejection, acceptance, major revision, or minor revision. They fill out the evaluation form, and the reasoning for the decision is stated in detail in the report.

For the study to be published, it must be accepted by both referees.

7.1 The referees' reports are examined. The referees must detail their reports. The editor sends the article to new referees when he/she decides that the decisions of both or one of the referees are insufficient, even if both give a favourable decision. Referees who do a superficial review cannot be articleed with in the following periods and are removed from the journal board.

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8. A "doi" assignment is made for the article whose processes are completed positively. After the doi is obtained, it is sent to the "final reader editor." The Final Reader Editor reads the study and may request the necessary corrections. If a correction is necessary, upload the report to the system. This completes the process.

9. If there is a correction request in accordance with the final reader editor report, the editor sends the study to the author. The author completes the necessary corrections. If the editor deems it necessary, the study is sent back to the final reader for control purposes.

10. The final reader checks again and completes the process if the corrections are complete. Sends the article to the editor.

11. The editor sends the completed study to the "layout editor," who prepares the article for publication.

12. The article, which has completed all processes positively, will be included in the earliest issue to be published.

*The editor reserves the right to reject all processes. The editor rejects the article for a reason. Reasons for rejection by the editor may be the author uploading incomplete files, not responding

to the necessary revision requests or not doing so within the given time, recommendations and justifications of the referees and the secretariat.

The articles submitted for publication in InTraders must have never been published before, not been accepted for publication, and not submitted for publication.

**The Editor has the right to reject the work/deem it unsuitable for publication at each stage.

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It is published twice a year. It is published in July and December. If it is deemed necessary, specific numbers / supplements may be issued for specific topics and for expanded notifications qualified by InTraders subject to conventions. Articles may always be accepted by InTraders.

Writing Rules

Preliminary Information

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-InTraders Journal Article Writing Format

-APA 7 Reference Style Sample File

-Author Information File (Refer to item 4). At the end of the page, it should be stated whether there is a conflict of interest, whether there is an institution from which financial support is received, and the contribution rates of the authors.

-Copyright Agreement Form

-Ethics Committee Permission (Ethics Committee approval is mandatory for studies sent from Turkey (researchers located within the borders of the Republic of Turkey). Ethics committee approval is the author's responsibility due to the country's own management and systems.). In studies that do not require ethics committee permission, the author must upload the signed document stating "I declare that the study does not require ethics committee permission" by stating the study title and author information on a form while uploading the article to the system.

-Decleration of Artificial Intelligence (Valid for 2025 studies)

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2. The APA 7 system should be used for article citations and source indication. The journal's rules will be followed for other article-writing rules.

3. Articles must be written on A4-sized paper with 1.5 spacing, in Times New Roman font, 12-point font, and not to exceed 25 pages. Submissions made from outside the DergiPark platform are strictly not accepted. Your article must be edited using the Article Writing Template. You can download the Article Writing Template here. (Author information should be excluded from the Article File).

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5. Tables, figures and graphs should be given titles and numbers. Table titles should be placed above the tables, and titles of figures and graphs should be placed below the relevant figure or graph. References should be written below the tables, figures and graphs. Commas must separate decimal fractions in numbers. The sequence number to be given to the equations should be placed in parentheses at the far right of the page. If the derivation of equations is not clearly shown in the manuscript, the derivation process with all its steps should be given on a separate page for the referees' evaluation. Times New Roman type and 11-point font should be used in

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6 Footnotes regarding the references made in the articles should be included at the bottom of the page.

7. At the end of the text, a list of sources used in the study is given under the heading REFERENCES. This bibliography lists the references used in the study and is prepared alphabetically according to the author's surname.

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"Baral, G. (2023). Kiracı Konumundaki Şirketlerin Finansal Kiralama İşleyişlerindeki Muhasebeleştirme Hataları veya Hileleri. InTraders International Trade Academic Journal, 6 (1), 26-43.DOI:10.55065/intraders.1288268"

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Paper Size: A4 Vertical (Landscape pages should not be included in the article)
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Font: Times New Roman

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13 Images: They should be included in the text in high-resolution, print-quality scans. When naming pictures, the rules in figures and tables must be followed.

14. Advice(Not compulsory): At least 3 sources each from WOS/Scopus and TR Index, at least 3 sources from journals in Dergipark that cannot be included in the TR Directory, sources from congress books and books must be used, and the Doi of the sources used must be stated in the bibliography section. Wos/Scopus sources should be included in the bibliography in red text, TR Index sources should be listed in orange, and sources not in the TR Index but in Dergipark should be included in the bibliography in blue text.

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1. Obtaining the necessary permissions from the ethics committees or commissions for studies that require permission from the Ethics Committee (for studies that require the application of a questionnaire or scale, including interviews and observations; documents, pictures, questionnaires, etc., developed by others and require permission to use), and these should be stated in the article content. or as an addendum. Without these permissions, the publication is returned to the author at the preliminary examination stage. Ethics Committee approval is mandatory for studies sent from Turkey (researchers located within the borders of the Republic of Turkey). Ethics committee approval is the author's responsibility due to the country's own management and systems.

2. It is essential that the raw data regarding the research in the peer reviews be submitted when requested by the referees. It is obligatory to provide the data after the article's publication when necessary.

3. The authors accept that the contact information (mail, institution, ORCID) specified in their article will be included to be published/published in InTraders. InTraders agrees not to publish the authors' information anywhere other than the journal issues and not to share it with third parties for commercial and advertising purposes.

A. Ethical Principles for Authors

1. Authors guarantee that their work is original, and when they include ideas, languages, pictures, graphics and tables of other researchers in their work, they must indicate this as a quotation. Quoting without specifying the source is plagiarism.

2. Each author named in the study is equally responsible for the content of the study. It is unacceptable to not include the name of the researcher who contributed to the study or his name unjustly, even though he did not contribute.

3. Authors should stick to their research findings. It is out of the question to change the findings, make up findings and results, and conduct research based on them. Situations such as tampering with data and materials, deleting, removing, or skipping the interpretation of difficult data are distrustful.

4. Simultaneous submission of the study to journals is not possible. Authors cannot send their previously published works to the journal.

As of 2020, the TR Index-Journal Evaluation criteria have been updated. The articles related to the ethics committee permission, which should be in scientific research, have been detailed. The "documents and information requested for studies requiring ethics committee approval" is not expected to be applied to studies submitted in previous years, the evaluation process of which has been completed but has not yet been published, and for which research data before 2020 has been used, although the evaluation process is still ongoing. The process will start in 2020, and research data will be mandatory for articles starting in 2020. The articles for which the Ethics Committee Permission Document is required are explained below. EXPLANATION AND INFORMATION on the Ethical Rules Made by TR Index: The articles related to the Code of Ethics, which were included in the previous years' criteria, were detailed with explanations in 2020, and the issue of "includes information about the permission in the article" was added to the criteria, assuming that the permissions were obtained for the studies

Requiring ethics committee permission in the research field. QUESTION: Is ethics committee approval required for all articles? No. The criteria state that it applies to "articles that require the permission of the Ethics Committee."

Studies that require the approval of the Ethics Committee are as follows:
• All kinds of research conducted with qualitative or quantitative approaches require data collection from the participants using surveys, interviews, focus group work, observation, experiments, and interview techniques.

• The use of humans and animals (including material/data) for experimental or other scientific purposes,

• Clinical studies on humans,

• Research on animals,

• Retrospective studies by the law on the protection of personal data,

Also;

• Indicating that an "informed consent form" was received in case reports,
• Obtaining and specifying permission from the owners for the use of scales, questionnaires, photographs belonging to others,

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No. Non-university researchers can also apply to the Ethics Committees in their regions. Also;

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B. Ethical Principles for Referees

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2. The referees must submit an objective, impartial, scientific, understandable and constructive evaluation report about the study within the specified time.

3. Referee reports will also include an assessment of the scientific nature of the article (the subject covered, the method used, or the appropriate use of the relevant literature). This evaluation must be made about the content, whether positive or negative.

4. It is not recommended or considered unethical for the reviewer to request citations for their work. If the referee's studies are related to the study he is examining, he can specify one or two studies, but the studies mentioned are advisory, and it is up to the author whether to use the specified studies or not.

5. When it is understood that the work is plagiarized or has been previously published elsewhere, the referees should notify the editor.

2. Publication Policy

1. InTraders International Trade Journal (InTraders) is an international, peer-reviewed and scientific journal. It is published using the publication principles listed below.

2. InTraders aims to contribute to developing science at the national and international levels by creating a platform for publishing scientific studies.

3.InTraders publishes original scientific research in international trade, economics, business, supply chain management, law, and international relations, presenting congress papers, book reviews, and letters to the editor.

4. InTraders publishes scientific studies in English.

5. InTraders is published electronically twice a year, in the Summer (July) and Autumn (December) terms. It also publishes a special issue if deemed necessary.

6. InTraders does not accept articles for any issue, but articles can be submitted to the journal anytime.

7. InTraders publishes using the TÜBİTAK ULAKBİM DergiPark system. All transactions related to the article are carried out through the DergiPark system.

8. InTraders publishes at https://dergipark.org.tr/tr/pub/intraders. In addition, it offers all issues in the archive section of its congress pages free of charge to open access. www.intraders.org

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16. InTraders undertakes not to publish in violation of publication ethics, and all articles submitted to the journal are subject to plagiarism/similarity control by the editor.

17. Whether the article submitted to InTraders is covered by the journal; the editor checks whether it is uploaded to the system correctly and completely and is prepared properly.

18. InTraders uses a double-blind referee evaluation system. The "positive" opinion of at least two referees is sought for the article's acceptance for publication. If one of the referees gives a "positive" opinion and the other a "negative" opinion, the article is sent to a third referee. The editor completes the referee evaluation process by sending two "positive" referee opinions to the Editorial Board.

19. The Editorial Board decides to publish all articles with two "positive" referee opinions.

20. For articles accepted for publication, the editor sends a "Certificate of Acceptance for Publication" signed by the author upon the author's request.

21. Uses information such as names, titles and e-mail addresses shared on the journal website only for the stated purposes of this journal; It is not used for any other purpose or made available to other people.

22. InTraders accepts the Open Access Principles outlined in the Budapest Open Access Initiative. The journal has accepted   the Budapest Open Access Initiative.

23. InTraders is committed to applying publication ethics to the highest standards and following the practice guide prepared by the Committee on Publication Ethics (COPE: Committee on Publication Ethics).

24. Articals in InTraders are archived with   the Dergipak system.

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https://dergipark.org.tr/en/pub/intraders/archive

https://intraders.org/archive/

Indexes

EBSCOhost (Contract Date: June 13,2022)

Index Copernicus (2022, 2024)

ERIH PLUS (Approved 2024-01-03)

Sherpa Romeo (Approved 2024-02-15)

Index of Academic Documents

For questions, suggestions and comments, you may contact to intradersorg@gmail.com

Appreciation

I am gratified to have the honor to put forward the vote of thanks to all the InTraders Journal Committees and Authors who provided the intensive work performance for the InTraders Journal under the name of InTraders Academic Platform.

The journal's main subject is international trade. For 2024 and beyond, it accepts economy-based studies outside international trade and original studies on tourism issues. In upcoming next issue, waiting your studies.

Wish to meet you all in this new international conferences…

Kürşat ÇAPRAZ

Publisher of InTraders Journal

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Contents

Inflation, Exchange Rate and Foreign Trade: Long and Short Run Relationships In The Turkish Economy[1]

Bahadır Murat ÇAKMAKLI[2]

Abstract

Inflation, exchange rate, imports, exports and GDP per capita are key indicators that play a key role in assessing the health and stability of a country's economy. Inflation directly affects price stability and purchasing power, while the exchange rate has a significant impact on international trade and capital flows. Imports and exports reflect an economy's trade balance and competitiveness, while GDP per capita is an important indicator of economic growth and welfare. Understanding the relationships between these variables is of great importance for the effective design of economic policies. The aim of this study is to analyse the relationships between inflation, exchange rate, imports, exports and GDP per capita in the Turkish economy between 1994 and 2023 and to reveal how these variables affect each other and their long-run equilibrium relationships. In this context, the study examines the long-run relationships between the variables using the Johansen Co-integration Test and analyses the short-run dynamics with the Vector Error Correction Model (VECM). The findings of the study show that there are long run cointegration relationships between exchange rate and imports, exports and GDP per capita. However, no significant cointegration relationship was found between inflation and exchange rate and exchange rate and exports. This can be explained by the fact that inflation is affected by structural problems and exogenous shocks, while exports are dependent on global demand conditions and imports. Short-run dynamics reveal that exchange rate fluctuations increase import costs, while there is a bidirectional causality relationship between exports and GDP per capita.

Keywords: *Imports, Exports, Inflation, Exchange Rate*

JEL Codes: *F14, F14, E31, F31*

INTRODUCTION

The Turkish economy experienced significant fluctuations in key macroeconomic indicators, including inflation, exchange rates, imports, exports, and GDP per capita, during the period 1994-2023. High and chronic inflation, exchange rate shocks, changes in the balance of trade and fluctuations in economic growth characterize this period. While the 1994 and 2001 crises, in particular, deeply shook economic stability, the stabilization programs implemented in the early 2000s achieved partial success in controlling inflation and stimulating economic growth (Boratav, 2003, p. 78; Yeldan, 2006, p. 89). However, exchange rate shocks and rising inflation after 2018 have again disrupted economic balances, leading to a slowdown in GDP per capita (CBRT, 2022, p. 23).

Inflation was one of Turkey's most important macroeconomic problems during this period. High inflation was

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[1] There is not a conflict of interest.
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fueled by factors such as an uncontrolled increase in money supply, fiscal indiscipline and exchange rate fluctuations (Akyüz & Boratav, 2003, p. 1549). Especially during the 1994 and 2001 crises, inflation rates exceeded 70%, which seriously damaged economic stability (Boratav, 2003, p. 78).

The effect of inflation on the exchange rate can be explained within the framework of the Purchasing Power Parity (PPP) theory. According to PPP, an increase in the inflation rate in a country leads to a depreciation of the local currency (increase in the exchange rate) (Dornbusch, 1976, p. 1161). In Turkey, although this relationship was partially brought under control with the stabilization programs implemented after 2001, the exchange rate shocks experienced after 2018 showed that the effect of inflation on the exchange rate persists (CBRT, 2022, p. 23). Exchange rate fluctuations also have a direct impact on imports and exports. Depreciation of the local currency may increase exports by making them cheaper, while it may decrease imports by making them more expensive (Dornbusch, 1976, p. 1161). In Turkey, the relative stability in the exchange rate in the post-2001 period contributed to the increase in exports (Yeldan, 2006, p. 89). However, exchange rate shocks after 2018 increased import costs and negatively affected the foreign trade balance (CBRT, 2022, p. 23). While increased exports support economic growth, the rising costs of imports can lead to a current account deficit, threatening economic stability (Boratav, 2003, p. 78).

GDP per capita is a key indicator that measures a country's economic welfare level. In Turkey, controlling inflation and increasing exports in the 2000s led to an increase in GDP per capita (Yeldan, 2006, p. 89). However, economic instability, rising inflation and exchange rate shocks in the post-2018 period slowed down the growth rate of GDP per capita (CBRT, 2022, p. 23).

This study aims to evaluate the effects of these indicators on economic performance by analyzing the relationships between inflation, exchange rates, imports, exports and GDP per capita in Turkey over the period 1994-2023

The contribution of this study to the literature is that it provides both a theoretical and an empirical framework by comprehensively analyzing the relationships among these variables for Turkey. Moreover, the findings of this study provide important guidance for policymakers on controlling inflation, maintaining exchange rate stability, and implementing effective foreign trade policies. In particular, ensuring exchange rate stability and supporting export-led growth strategies will play a key role in improving Turkey's economic performance.

In line with the study's purpose, the second section explains inflation, exchange rates, imports and exports, and GDP per capita, while the third section examines the relationship between these variables. After reviewing the literature on the subject in the fourth section, the data set used in the analysis, analysis methods, and analysis results are evaluated in the fifth section. In the sixth and final section, the results of the analysis are evaluated, and necessary policies are presented to contribute to the literature.

INFLATION, EXCHANGE RATE, IMPORTS AND EXPORTS, GDP PER CAPITA

Inflation

Inflation is defined as a sustained rise in the general price level of an economy and is one of the major problems threatening economic stability, especially in developing countries. Turkey stands out as a country that struggled with high and chronic inflation from 1994 to 2023. The primary causes of inflation include uncontrolled growth in the money supply, a lack of fiscal discipline, and exchange rate fluctuations (Akyüz & Boratav, 2003, p. 1549). Especially during the 1994 and 2001 crises, inflation rates exceeded 70%, which seriously shook economic stability (Boratav, 2003, p. 78). (Graph 1)

Graph 1: Türkiye's Inflation Rates Between 1965 and 2025

Source: https://tr.tradingview.com/chart/MzDnadiV/?symbol=ECONOMICS%3ATRIRYY
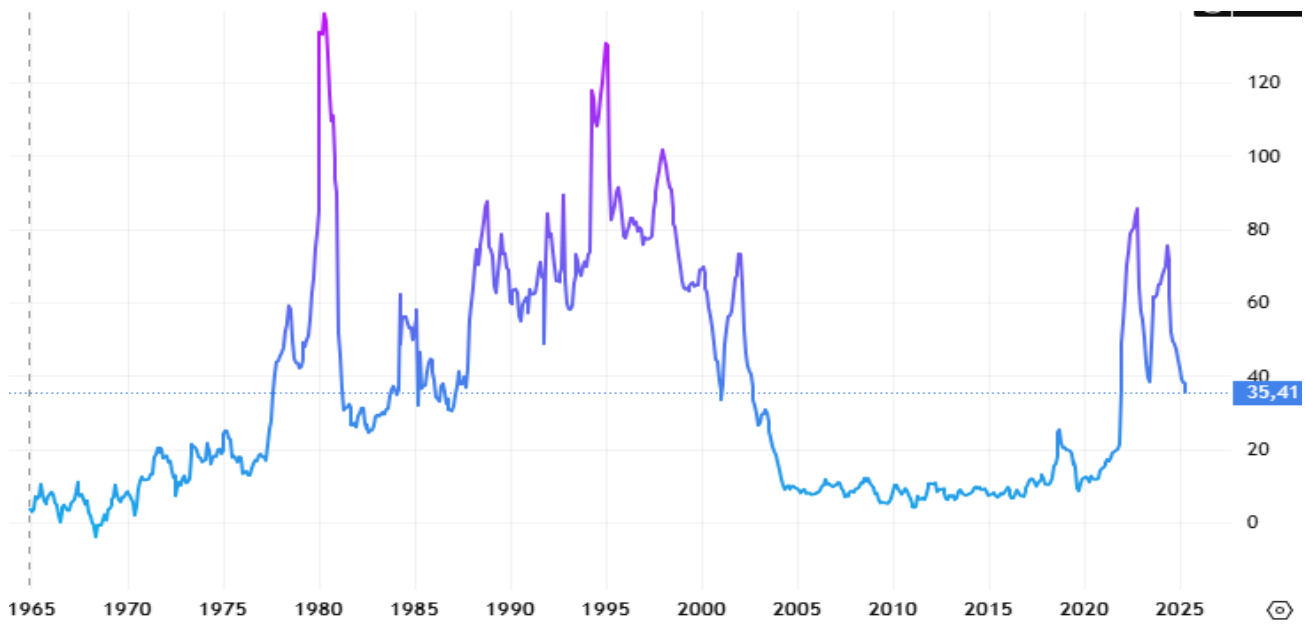
The effect of inflation on the exchange rate can be explained by the Purchasing Power Parity (PPP) theory. According to PPP, an increase in the inflation rate in a country leads to a depreciation of the local currency (an increase in the exchange rate) (Dornbusch, 1976, p. 1161). In Turkey, although this relationship was partially brought under control with the stabilization programs implemented after 2001, the exchange rate shocks experienced after 2018 revealed that the effect of inflation on the exchange rate persists (CBRT, 2022, p. 23). Moreover, Özatay and Sak (2003, p. 45) argue that the relationship between inflation and the exchange rate in Turkey varies depending on the presence of structural breaks.

The impact of inflation on economic growth is a controversial issue. While some studies suggest that low and stable inflation supports economic growth (Fischer, 1993, p. 485), it is emphasized that high inflation negatively affects growth by making investment decisions uncertain (Bruno & Easterly, 1998, p. 12). In Turkey, the

reduction of inflation to single digits in the 2000s had a positive impact on economic growth (Yeldan, 2006, p. 89). However, the increase in inflation after 2018 led to a slowdown in economic growth (CBRT, 2022, p. 23).

Exchange Rate

The exchange rate refers to the Value of a country's currency against foreign currencies and plays an important role in economic stability. Exchange rate fluctuations are influenced by macroeconomic factors, particularly inflation, interest rates and the balance of trade (Dornbusch, 1976, p. 1161). In Turkey, the exchange rate increased significantly during the 1994 and 2001 crises, which undermined economic stability (Boratav, 2003, p. 78). Moreover, the relationship between exchange rate and inflation can be explained within the framework of the Purchasing Power Parity (PPP) theory. According to PPP, an increase in the inflation rate in a country leads to a depreciation of the local currency (increase in the exchange rate) (Dornbusch, 1976, p. 1161). Although the stabilization programs implemented in Turkey after 2001 partially mitigated the relationship between the exchange rate and inflation, the exchange rate shocks experienced after 2018 demonstrated that this effect persisted (CBRT, 2022, p. 23). (Graph 2)

Graph 2: Changes in the Exchange Rates of the US Dollar and the Euro in Türkiye Between 2018 and 2025
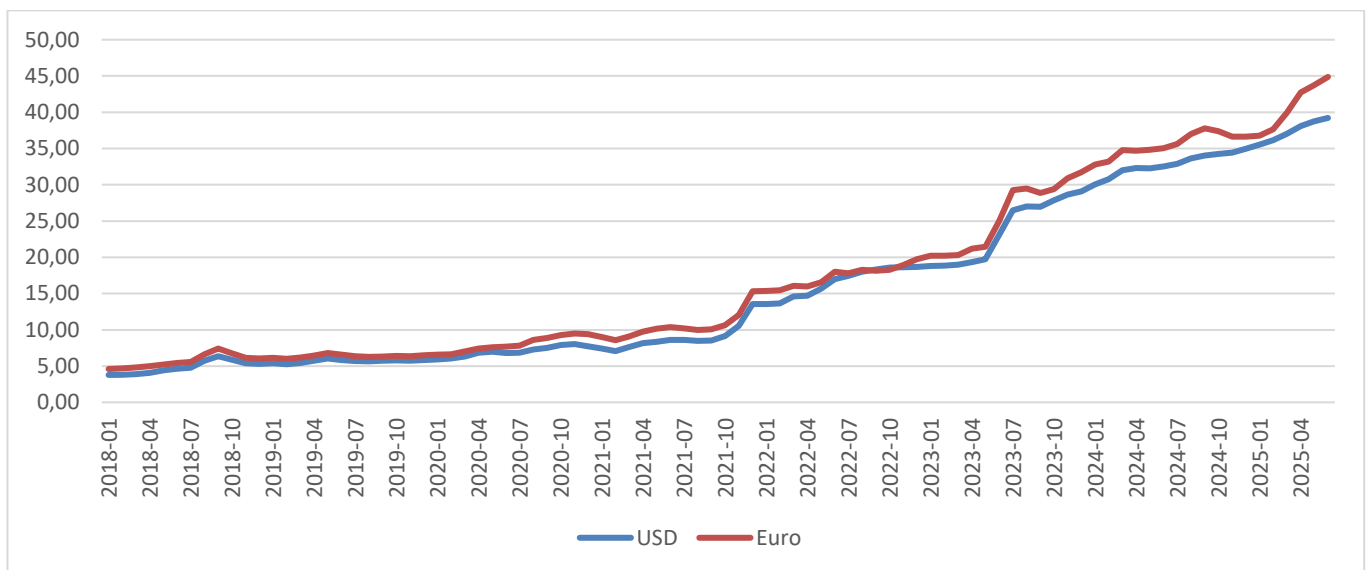
Source:https://evds2.tcmb.gov.tr/index.php?/evds/serieMarket/collapse_2/5868/DataGroup/turkish/bie_rktufey/#collapse_2

Özatay and Sak (2003) argue that the relationship between the exchange rate and inflation in Turkey varies depending on the presence of structural breaks. This reveals how sensitive the exchange rate is to economic shocks.

Import and Export

Imports and exports are the leading indicators of a country's foreign trade balance and have a significant impact

on economic growth. Turkey experienced significant changes in its import and export balance from 1994 to 2023. Export-led growth strategies play a crucial role in enhancing economic welfare, particularly in developing countries (Helpman & Krugman, 1985, p. 67).

Exports support economic growth by increasing a country's production capacity. The export-oriented policies implemented in Turkey in the 2000s have achieved significant success in increasing GDP per capita (Yeldan, 2006, p. 89). However, the structure of exports is also important. Exports of high-value-added products support economic growth more (Rodrik, 2008, p. 23).

Imports, on the other hand, play a crucial role in supplying the investment goods and intermediate goods necessary to enhance a country's production capacity. However, imports of consumption goods may lead to a current account deficit (Akyüz & Boratav, 2003, p. 45). During the 1994 and 2001 crises in Turkey, sudden increases in exchange rates led to higher import costs and reduced imports (Boratav, 2003, p. 80). However, the failure to stabilise the exchange rate in the long run led to fluctuations in the balance of trade (Öniş & Rubin, 2003, p. 112).

GDP Per Capita

GDP per capita is one of the most important indicators of a country's economic welfare. Turkey experienced significant fluctuations in GDP per capita between 1994 and 2023. (Graph 3)

Graph 3: Change in GDP per capita in Türkiye Between 1975 and 2023

Source: https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.PCAP.CD&country=
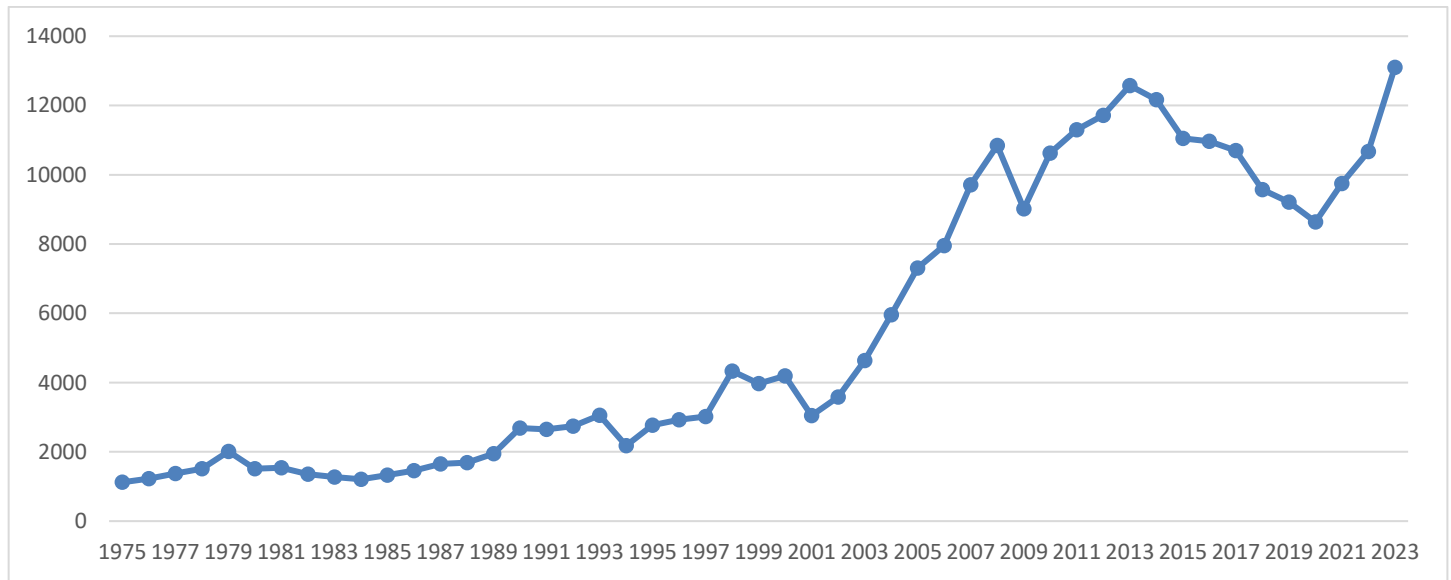
Factors such as economic growth, inflation, exchange rate and trade balance have a direct impact on GDP per capita (Rodrik, 2008, p. 23).

Export-led growth strategies play an important role in increasing GDP per capita. The export-oriented policies implemented in Turkey in the 2000s have achieved significant success in increasing GDP per capita (Yeldan, 2006, p. 89). However, the structure of imports is also a determinant of GDP per capita. Especially imports of

investment goods and intermediate goods support economic growth by increasing production capacity, while imports of consumption goods may cause current account deficit (Akyüz & Boratav, 2003, p. 45).

INFLATION, EXCHANGE RATE, IMPORT-EXPORT AND GDP PER CAPITA RELATIONSHIP

This study examines the relationship between inflation, exchange rates, imports and exports, and GDP per capita in the Turkish economy for the period 1994-2023. These relationships are analyzed in the light of macroeconomic theories and empirical studies. A framework of the theoretical foundations of these relationships and their place in the literature is presented below.

Inflation and Exchange Rate Relationship

The relationship between inflation and exchange rate can be explained by Parity Theories and Purchasing Power Parity (PPP). According to PPP, the inflation rate in a country causes a depreciation of the local currency (increase in the exchange rate) (Dornbusch, 1976, p. 116). In high-inflation countries like Turkey, the effect of inflation on the exchange rate is more pronounced. Mainly during the 1994 and 2001 crises, it was observed that inflation rapidly increased the exchange rate (CBRT, 2001, p. 45).

Exchange Rate and Import-Export Relationship

The exchange rate has a direct impact on imports and exports. According to the Marshall-Lerner Condition, an increase in the exchange rate (depreciation of the local currency) increases exports and decreases imports (Marshall, 1923, p. 345). However, this effect may occur with a lag in the short run due to the J-curve effect (Magee, 1973, p. 304). In Turkey, during the 1994 and 2001 crises, exchange rate spikes increased import costs and temporarily supported exports (Boratav, 2003, p. 78).

Import-Export and GDP Per Capita Relationship

Imports and exports have significant effects on a country's economic growth and GDP per capita. According to the Foreign Trade and Growth Theory, an increase in exports supports economic growth, while an increase in imports may hurt domestic production (Helpman & Krugman, 1985, p. 67). In Turkey, export-led growth strategies played a significant role in increasing GDP per capita during the 2000s (Öniş & Rubin, 2003, p. 112). However, the structure of imports (predominance of investment goods over consumption goods) also has an impact on growth (Yeldan, 2006, p. 89).

Dynamics Specific to Turkey

The economic crises, structural reforms and foreign trade policies in Turkey during the 1994-2023 period have been decisive in shaping these relations. Especially the stability programs implemented after the 2001 crisis were

effective in controlling inflation and ensuring exchange rate stability (Akyüz & Boratav, 2003, p. 45). However, exchange rate shocks and rising inflation after 2018 increased import costs and slowed economic growth (CBRT, 2022, p. 23).

LITERATURE REVIEW

Table 1: Literature Review

Study	Method	Conclusion
Aktas (2009)	Johansen Co-integration Test and VECM Analysis	In the short run, a bidirectional relationship was found between imports and exports, imports and GDP and exports and GDP.
Aliyu et al. (2009)	VAR Analysis	Exchange rate shocks have a higher impact on import prices than on inflation.
Ca'Zorzivd. (2007)	VAR Analysis	He found that the exchange rate effect affects import prices more than inflation.
Dornbusch (1976)	Theoretical analysis (Purchasing Power Parity)	Inflation leads to a depreciation of the domestic currency (an increase in the exchange rate). This is particularly pronounced in developing countries (p. 1161).
Edwards (1989)	Panel data analysis (Developing countries)	High inflation pushes up the exchange rate, raising import costs and further fueling inflation (p. 567).
Magee (1973)	Theoretical analysis (J-curve effect)	An increase in the exchange rate increases imports in the short run and exports in the long run. This effect is explained by the Marshall-Lerner Condition (p. 304).
Helpman & Krugman (1985)	Theoretical modeling (Foreign trade and growth)	Export-led growth strategies play a key role in boosting economic welfare, especially in developing countries (p. 67).
Bruno & Easterly (1998)	Panel data analysis (Inflation and growth)	High inflation negatively affects economic growth. Low and stable inflation, on the other hand, supports growth (p. 12).
Eichengreen & Leblang (2003)	Panel data analysis (Exchange rate and foreign trade)	Exchange rate fluctuations adversely affect the balance of trade, especially in developing countries (p. 89).
Rodrik (2008)	Panel data analysis (Real exchange rate and growth)	The impact of exports on economic growth varies depending on the level of industrialization of countries. High value-added exports support growth more (p. 23).
Rittenberg (1993)	Granger Causality Analysis	He found that there is a unidirectional causality (from inflation to exchange rate) between exchange rate and inflation.
Tuncer (2002)	Granger Causality Analysis	He found a bidirectional relationship between GDP and imports, and a unidirectional relationship from GDP to exports and from exports to imports.
Ozatay & Sak (2003)	Time series analysis (inflation and exchange rate in Turkey)	The relationship between inflation and the exchange rate in Turkey varies depending on structural breaks. High inflation increases the exchange rate (p. 45).
Akyüz & Boratav (2003)	Case studies (Turkey's 1994 and 2001 crises)	Exchange rate spikes increased import costs and temporarily supported exports. However, exchange rate stability could not be achieved in the long run (p. 45).
Yeldan (2006)	Time series analysis (neoliberal policies in Turkey)	Export-led growth strategies have had considerable success in raising GDP per capita. However, the structure of imports is also a determinant of economic growth (p. 89).
CBRT (2022)	Time series analysis (inflation and exchange rate in Turkey)	The post-2018 inflation surge and exchange rate shocks increased import costs and slowed economic growth (p. 23).

Source: Created by Author.

METHODOLOGY, DATA SET AND ANALYSIS

Methodology

In this study, the long-term and short-term relationships between inflation (INF), exchange rate (REXCR), imports (DIMPORT), exports (DEXPORT), and real GDP per capita (DGDP) variables were examined using annual data from the Turkish economy for the period 1994-2023. The analysis process was conducted in three stages:

First, the stationarity levels of the series were analyzed using the Augmented Dickey-Fuller (ADF) test. According to the test results, the GDP, imports, exports, exchange rate, and DVZUFE series are not stationary at the level but become stationary when their first differences are taken. In contrast, the inflation (INF) series was found to be stationary at the level. The fact that most of the series are I(1) provides suitability for multivariate cointegration analysis (Enders, 2015, p. 363).

In the second stage, long-term relationships between variables were examined using the Johansen cointegration test (Johansen, 1988; Johansen, 1991). The Johansen test determines the number of cointegration vectors and reveals long-term equilibrium relationships between economic variables.

After identifying long-term relationships, short-term dynamics were analyzed using the Vector Error Correction Model (VECM). VECM models both short-term deviations and long-term equilibrium processes between variables with cointegration relationships (Lütkepohl, 2005, p. 248). Additionally, the directional relationships between the variables were examined using the Granger causality test. This test examines the predictive power of past values of one variable on another (Granger, 1969; Gujarati & Porter, 2009, p. 652).

The hypotheses used in the analysis are as follows:

H1: There is a long-term cointegration relationship between inflation and the exchange rate.

H2: There is a long-term cointegration relationship between the exchange rate and exports.

H3: There is a long-term cointegration relationship between the exchange rate and imports.

H4: There is a long-term cointegration relationship between imports and per capita GDP.

H5: There is a long-term cointegration relationship between exports and per capita GDP.

H6: Exports are a Granger cause of per capita GDP.

H7: Per capita GDP is a Granger cause of exports.

H8: Per capita GDP is a Granger cause of imports.

H9: Imports are Granger causes of per capita GDP.

H10: The exchange rate significantly affects imports in the short term.

H11: Past values of imports affect the exchange rate in the short term.

All analyses were conducted using EViews software. This methodological approach ensures reliable results by employing methods appropriate for the time series characteristics of the data.

Data Set

Table 2: Data Set

Variables	Source
Inflation (INF)	World Bank
GDP per capita (GDP per capita)	World Bank
Export (EXPORT)	TUIK
Imports (IMPORT)	TUIK
Exchange Rate (Real Exchange Rate) (REXCR)	CBRT

Source: Created by Author.

Unit Root Test

The Dickey-Fuller test is a statistical method used to test whether a time series contains a unit root. A unit root indicates that the series is non-stationary. Non-stationary series do not have a constant mean and variance over time, which can lead to misleading results in conventional regression analysis (Dickey & Fuller, 1979, p. 427). The Dickey-Fuller test uses the following regression model to test the stationarity of the series:

$$\Delta_{y_t} = \alpha + B_t + \gamma y_{t-1} + \sum_{i=1}^{i_P} \phi_i \Delta_{y_{t-i}} + \varepsilon_t$$

Yt: Time Series

Δyt: First difference of the series

α: Constant Term

βt: Trend Component

γ: Unit Root Coefficient

ε(t): Error Term

The null hypothesis of the test γ:0 (existence of a unit root). If the test statistic is smaller than the critical values, the unit root hypothesis is rejected and the series is considered stationary (Dickey & Fuller, 1981, p. 1057).

Granger Causality Test:

Granger Causality Test is a statistical method used to etamine the causality relationship between two time series.

Developed by Clive Granger, this test assesses whether past values of one variable make a statistically significant contribution to predicting future values of another variable (Granger, 1969, p. 424). The test is based on the following regression model:

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{j=1}^{q} \beta_j x_{t-j} + \varepsilon_t$$

where;

Yt: Dependent Variable

χ(t): Explanatory Variable

αi and βj: Coefficients

Ɛ(t): Error Term

The main hypothesis of the test is βj = 0. If this hypothesis is rejected, it is concluded thatχ(t) is the Granger cause of Yt (Granger, 1980, p. 330).

Johansen Cointegration Test

Johansen co-integration test is a statistical method used to examine the long-run relationship between time series. This test is especially used to determine whether there is a cointegration relationship between more than one variable. Unlike the Engle-Granger (1987) two-stage method, the Johansen test allows us to test for the existence of more than one cointegration vector (Johansen, 1988, p. 231).

The Johansen test is based on a vector autoregressive (VAR) model. The test yields results based on two main statistics: Trace statistic and Maximum eigenvalue statistic. These statistics are used to determine the number of cointegration vectors. The null hypothesis of the test is that the number of cointegration vectors is zero. The alternative hypothesis asserts the existence of at least one cointegration vector (Johansen, 1991, p. 1553).

For example, when the Johansen test is applied to a bivariate system, if the test statistics exceed the critical values, it is concluded that there is a long-run relationship between the variables. This indicates that the variables are cointegrated.

VECM (Vector Error Correction Model)

The Vector Error Correction Model (VECM) is a model used to analyze the short-run dynamics and the long-run equilibrium relationship between cointegrated variables. The VECM is a customized version of the VAR model for cointegrated systems. Co-integrated variables move in an equilibrium relationship in the long run, while deviations (error terms) from this equilibrium can be observed in the short run. VECM focuses on modeling how

these deviations are corrected over time (Engle & Granger, 1987, p. 256).

The basic equation of the VECM is as follows:

$$\Delta_{y_t} = \Pi y_{t-1} + \sum_{i=1}^{P-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t$$

ΔYt: represents the first difference of the variables.

∏: is the matrix showing the long-run equilibrium relationship and includes cointegration vectors.

Γi: coefficient matrices capturing short-run dynamics.

Ɛt: Error Term

VECM is frequently used especially in economic and financial data. For example, when analyzing the relationship between interest rates and inflation rates, both short-run fluctuations and long-run equilibrium can be analyzed using VECM (Lütkepohl, 2005, p. 78).

Analysis

Unit Root Test Results

Table 3: Unit Root Test Results

Variable	Test Type	t-Statistic	p-Value	Stationarity (1%, 5%, 10%)
GDP	ADF (Level)	2.598774	0.9966	Not Stable
D(GDP)	ADF (1st Difference)	-4.618590	0.0056	Stationary (1%, 5%, 10%)
IMPORT	ADF (Level)	1.605874	0.9705	Not Stable
D(IMPORT)	ADF (1st Difference)	-4.341429	0.0001	Stationary (1%, 5%, 10%)
EXPORT	ADF (Level)	2.386222	0.9946	Not Stable
D(EXPORT)	ADF (1st Difference)	-4.276083	0.0001	Stationary (1%, 5%, 10%)
INF	ADF (Level)	-2.181024	0.0303	Stationary (5%, 10%)
REXCR	ADF (Level)	-0.579410	0.4572	Not Stable
D(REXCR)	ADF (1st Difference)	-7.464791	0.0000	Stationary (1%, 5%, 10%)

Note: Variables are stable at a 5% significance level.

Source: Created by Author.

In this analysis, unit root tests are used to determine the stationarity of the variables. According to stationarity tests, if the p-value of a series is > 0.10 in level tests, the series is considered non-stationary, while if the p-value is < 0.10 in first difference tests, the series is considered stationary. When significance levels are analyzed, critical values at 1% level are 2.65, critical values at 5% level are 1.95 and critical values at 10% level are 1.61.

According to the test results, GDP, IMPORT, EXPORT, DVZUFE and REXCR series are non-stationary at their levels. However, these series become stationary when their first differences are taken. On the other hand, INF (inflation) series is stationary at level and this stationarity is valid at both 5% and 10% significance levels. These findings suggest that the series have different stationarity properties, and this should be taken into account in the

analysis.

Granger Causality Results

Table 4: Granger Causality Results

Dependent Variable	Excluded Variable	Chi-square (χ^2)	df	p-Value	Causality (at 5% level)
INF	DREXCR	3.183820	2	0.2035	No
INF	All	3.183820	2	0.2035	No
DREXCR	INF	4.000236	2	0.1353	No
DREXCR	All	4.000236	2	0.1353	No
DREXCR	DEXPORT	0.199202	2	0.9052	No
DREXCR	DIMPORT	1.632879	2	0.4420	No
DREXCR	All	3.093426	4	0.5423	No
DEXPORT	DREXCR	2.444738	2	0.2945	No
DEXPORT	DIMPORT	5.966462	2	0.0506	Available (borderline)
DEXPORT	All	-	-	-	-
DIMPORT	DREXCR	2.705985	2	0.2585	No
DIMPORT	DEXPORT	1.147135	2	0.5635	No
DIMPORT	All	-	-	-	-
DEXPORT	DGDP	8.560508	2	0.0138	Available
DEXPORT	All	8.560508	2	0.0138	Available
DGDP	DEXPORT	6.678572	2	0.0355	Available
DGDP	All	6.678572	2	0.0355	Available
DIMPORT	DGDP	5.131527	2	0.0769	None (borderline)
DIMPORT	All	5.131527	2	0.0769	None (borderline)
DGDP	DIMPORT	13.51323	2	0.0012	Available
DGDP	All	13.51323	2	0.0012	Available

Source: Created by Author.

This analysis reveals the causal relationships between variables in the Turkish economy. There is no Granger causality relationship between inflation (INF) and exchange rate (DREXCR) (p> 0.05), which indicates that the relationship between inflation and exchange rate is weak. Similarly, there is no significant causality relationship between exchange rate (DREXCR) and exports (DEXPORT) and imports (DIMPORT) (p> 0.05), indicating that changes in exchange rate do not significantly affect exports and imports in the short run.

There is a borderline Granger causality relationship between imports (DIMPORT) and exports (DEXPORT) (p = 0.0506), suggesting that changes in imports can affect exports. There is a bidirectional causality relationship between exports (DEXPORT) and GDP per capita (DGDP). GDP per capita was found to be the Granger cause of exports (p = 0.0138), suggesting that economic growth favors exports. Likewise, exports are also found to be the Granger cause of GDP per capita (p = 0.0355), suggesting that increases in exports positively affect economic growth.

When the relationship between GDP per capita (DGDP) and imports (DIMPORT) is analyzed, it is seen that GDP per capita is the Granger cause of imports (p = 0.0012), indicating that economic growth increases imports. There

is a borderline Granger causality relationship between imports and GDP per capita (p = 0.0769), indicating that changes in imports may affect economic growth.

In conclusion, this analysis highlights the interdependence between economic growth and foreign trade by revealing the bidirectional causality relationship between GDP per capita, exports and imports in the Turkish economy. On the other hand, the absence of causality between inflation and exchange rate suggests that these variables have more complex dynamics.... These findings provide important insights for policymakers in the design of economic growth and foreign trade policies**.**

Johansen Cointegration Test Results

Table 5: Johansen Cointegration Test Results

Variables	Cointegration Relationship	Degree of Cointegration	Trace Test (p-value)	Max-Eigen Test (p-value)	Normalized Cointegration Coefficients
INF & DREXCR	**No**	0	0.0864	0.4156	INF = 1.000000, DREXCR = 29.62514
DREXCR & DEXPORT	**No**	0	0.0618	0.2196	DREXCR = 1.000000, DEXPORT = 8.76E-09
DREXCR & DIMPORT	**There is**	2	0.0454	0.1735	DREXCR = 1.000000, DIMPORT = -7.98E-10
DEXPORT & DGDP	**There is**	2	0.0004	0.0077	DEXPORT = 1.000000, DGDP = -3.461769
DIMPORT & DGDP	**There is**	2	0.0020	0.0082	DIMPORT = 1.000000, DGDP = -5.547905

Source: Created by Author.

This analysis examines the long and short run relationships between variables in the Turkish economy. There is no cointegration relationship between inflation (INF) and exchange rate (DREXCR) (Trace and Max-Eigen tests p> 0.05), indicating that there is no long-run equilibrium relationship between these two variables. Regarding the short-run dynamics, the adjustment coefficients for inflation and exchange rate are -0.036926 and -0.021288, respectively, indicating that both variables are in the process of returning to equilibrium, but this process is slow.

There is also no cointegration relationship between exchange rate (DREXCR) and exports (DEXPORT) (Trace and Max-Eigen tests p> 0.05), which means that there is no long-run equilibrium relationship. In the short-run dynamics, the adjustment coefficients for exchange rate and exports are 0.018965 and -1.72E+08, respectively. These results indicate that changes in the exchange rate have a limited effect on exports in the short run.

There is a cointegration relationship between exchange rate (DREXCR) and imports (DIMPORT) (Trace test p

= 0.0454, Max-Eigen test p = 0.1735). This implies that there is a long-run equilibrium relationship between these two variables. The long-run relationship is expressed as DREXCR = 1.000000 and DIMPORT =-7.98E-10. In the short-run dynamics, the adjustment coefficients for exchange rate and imports are found to be -0.359583 and 1.13E+09, respectively. These results suggest that exchange rate changes have a significant impact on imports in both the long and short run.

There is also a cointegration relationship between exports (DEXPORT) and GDP per capita (DGDP) (Trace test p = 0.0004, Max-Eigen test p = 0.0077). This implies that there is a long-run equilibrium relationship between these two variables. The long-run relationship is expressed as DEXPORT = 1.000000 and DKBGSDPIH =-3.461769. In the short-run dynamics, the adjustment coefficients for exports and GDP per capita are 0.615039 and 0.862278, respectively. These results indicate that there is a strong relationship between exports and economic growth in both the long and short run.

There is also a cointegration relationship between imports (DIMPORT) and GDP per capita (DGDP) (Trace test p = 0.0020, Max-Eigen test p = 0.0082). This implies that there is a long-run equilibrium relationship between these two variables. The long-run relationship is expressed as DIMPORT = 1.000000 and DKBGDP =-5.547905. In the short-run dynamics, the adjustment coefficients for imports and GDP per capita are 0.575155 and 0.523424, respectively. These results indicate that there is a strong relationship between imports and economic growth in both the long and short run.

A cointegration relationship indicates the existence of a long-run equilibrium relationship between variables. Adjustment coefficients express the speed of return to equilibrium in the short run. While negative values support a return to equilibrium, normalized coefficients indicate the direction and magnitude of the long-run relationship. This analysis provides important insights for understanding the dynamic relationships between exchange rates, imports, exports and GDP per capita in the Turkish economy.

VECM Analysis Results

Table 6: VECM Analysis Results

Variables	Cointegration Relationship	Error Correction Term (ECT)	Short Run Dynamics	R²	Description
DREXCR & DIMPORT	**There is**	-0.359583 (DREXCR)	D(DREXCR(-1)): -0.851740	0.694194	DREXCR stabilizes faster than DIMPORT. Strong relationship in the short run.
		1.13E+09 (DIMPORT)	D(DIMPORT(-1)): 0.236281	0.544304	The rate of equilibration of DIMPORTE is slower.
DIMPORT & DGDP	**There is**	0.575155 (DIMPORT)	D(DIMPORT(-1)): -1.040021	0.598743	DIMPORT stabilizes faster than DKBGDP. Strong relationship in the short run.
		0.523424 (DGDP)	D(DGDP(-1)): 1.249289	0.748580	The rate of rebalancing of NGDP is slower.
DEXPORT & DGDP	**There is**	0.615039 (DEXPORT)	D(DEXPORT(-1)): -1.023073	0.617339	DEXPORT stabilizes faster than DKBGDP. Strong relationship in the short run.
		0.862278 (DGDP)	D(DGDP(-1)): 1.373984	0.709049	The rate of rebalancing of NGDP is slower.

Source: Created by Author.

This analysis reveals the long and short run relationships between exchange rate (DREXCR), imports (DIMPORT), exports (DEXPORT) and GDP per capita (DKBGSDP) in the Turkish economy. There is a cointegration relationship between the exchange rate and imports, indicating that there is a long-run equilibrium relationship between these two variables. The error correction term (ECT) coefficients are -0.359583 (significant, t =-1.75500) for exchange rate and 1.13E+09 (significant, t = 2.05040) for imports. In the short-run dynamics, past values of the exchange rate strongly affect the current change (D (DREXCR (-1)): -0.851740, t = -4.05943), while past values of imports affect the current change more weakly (D(DIMPORT(-1)): 0.236281, t = 0.65451). These results suggest that the exchange rate stabilizes faster than imports and that the exchange rate has a stronger effect on imports in the short run.

There is also a cointegration relationship between imports and GDP per capita. The error correction term

coefficients are 0.575155 (significant, t = 1.53032) for imports and 0.523424 (significant, t = 4.62974) for GDP per capita. In the short-run dynamics, past values of imports strongly affect the current change (D (DIMPORT (-1)): -1.040021, t = -2.71155), while past values of GDP per capita also significantly affect the current change (D(DGDP(-1)): 1.249289, t = 2.74121). These results suggest that imports rebalance faster than GDP per capita and that both variables strongly affect each other in the short run.

There is also a co-integration relationship between exports and GDP per capita. The error correction term coefficients are 0.615039 (significant, t = 2.06594) for exports and 0.862278 (significant, t = 4.65604) for GDP per capita. In the short-run dynamics, past values of exports strongly affect the current change (D (DEXPORT (-1)):-1.023073, t = -2.73556), while past values of GDP per capita also significantly affect the current change (D(DGDP(-1)): 1.373984, t = 2.69446). These results suggest that exports rebalance faster than GDP per capita and that both variables strongly affect each other in the short run.

In general, in this analysis, co-integration relationship is found in all models, which indicates that there is a long-run equilibrium relationship between the variables. Error correction term (ECT) coefficients indicate the speed at which variables return to equilibrium, and negative and significant ECT coefficients indicate that equilibrium has been achieved. In the short-run dynamics, past values of the variables significantly affect the current change, indicating a strong causality relationship between the variables. The explanatory power of the models is high ($R^2 > 0.5$), which increases the reliability of the analysis. This analysis clearly reveals the long and short run relationships between the variables.

CONCLUSION

In this study, Johansen Cointegration Test and VECM (Vector Error Correction Model) analyses were used to examine the relationships between inflation (INF), exchange rate (DREXCR), imports (DIMPORT), exports (DEXPORT), and per capita GDP (DGDP) in the Turkish economy between 1994 and 2023. The results of the analysis reveal long-term cointegration relationships between the exchange rate and imports, exports, and per capita GDP. However, no significant long-term relationship was found between inflation and the exchange rate or between the exchange rate and exports.

In this context, according to the results of the Johansen cointegration test, hypotheses H_1 (There is no long-term relationship between inflation and the exchange rate) and H_2 (There is no long-term relationship between the exchange rate and exports) were not rejected, meaning that there is no long-term cointegration relationship between these variables ($p > 0.05$). This situation can be explained by the fact that structural issues and external shocks influence inflation, while the exchange rate is susceptible to speculative movements, rendering it impossible to establish a long-term equilibrium relationship between the two variables. Similarly, the limited

impact of exchange rate changes on exports stems from Turkey's high dependence on imports and its vulnerability to global demand conditions.

On the other hand, hypotheses H_3 (There is no long-term relationship between the exchange rate and imports), H_4 (There is no long-term relationship between imports and per capita GDP), and H_5 (There is no long-term relationship between exports and per capita GDP) were rejected, and long-term cointegration relationships were determined between these variables ($p < 0.05$). According to these findings, increases in the exchange rate lead to higher import costs, thereby reducing import volumes. At the same time, both imports and exports have significant and lasting effects on per capita GDP.

According to the Granger causality test results, hypotheses H_6 and H_7 have also been rejected, indicating a bidirectional causality relationship between exports and per capita GDP ($p = 0.0138$ and $p = 0.0355$). In other words, increases in exports stimulate economic growth, which in turn increases export capacity.

Additionally, the H_8 hypothesis (per capita GDP is a Granger cause of imports) was rejected, and a significant causal relationship was identified ($p = 0.0012$). In contrast, hypothesis H_9 (imports are a cause of per capita GDP) was found to be marginally significant and was rejected to a limited extent ($p = 0.0769$). This indicates that the effect of imports on growth is weaker and more indirect.

In the VECM short-term analysis, the H_{10} hypothesis (That the Exchange rate does not significantly affect imports in the short term) was rejected. According to the model results, fluctuations in the exchange rate have a significant impact on imports in the short term, reducing the import volume ($t = -4.05943$). In contrast, the H_{11} hypothesis (past values of imports do not affect the exchange rate) was only partially supported. It was found that past values of imports have a weak effect on the exchange rate ($t = 0.65451$), indicating that the relationship is limited in the short term.

Based on these findings, some policy recommendations can be made for the Turkish economy. Monetary policy should be implemented more consistently and predictably within the framework of inflation targeting in order to strengthen the relationship between inflation and the exchange rate and ensure price stability. Macroeconomic stability should be ensured, and speculative capital movements should be controlled in order to reduce exchange rate fluctuations. The dependence of exports on imports should be reduced, and the structure of exports should be strengthened by encouraging the production of domestic intermediate goods. In addition, pricing strategies that increase exchange rate pass-through should be adopted, and cost structures should be reviewed. Export-oriented policies should be continued to support economic growth, and access to global markets should be facilitated. Furthermore, reducing dependence on energy and intermediate goods imports is important for the sustainability of the trade balance. Structural reforms and strengthening fiscal discipline are among the fundamental conditions for economic stability.

In conclusion, this study reveals the long-term and short-term relationships between key macroeconomic indicators in the Turkish economy, providing policymakers with important insights. In particular, the strong links between the exchange rate, imports, exports, and growth indicate the need for a comprehensive approach to economic policies. Future studies are recommended to deepen these relationships further using more up-to-date data sets, different methodological approaches, and sectoral analyses.

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Global Plastic Waste Trade: An Analysis of Sources and Trends (1996-2024)[1]

Handan ÖZTEMİZ[2], Kemal VATANSEVER[3]

Abstract

The trade in plastic waste plays a crucial role in the advancement of global waste management and recycling systems. Developed nations export plastic waste to developing countries, reducing environmental harm and creating economic opportunities. This study conducts a bibliometric analysis of 257 articles on plastic waste trade published between 1996 and 2024 in the Web of Science (WoS). The analysis highlights China's 2018 import ban as a key topic, with Chen, W.Q. identified as the most prolific author. Resources, Conservation and Recycling is the leading journal in this field. The study reveals China's unique academic characteristics compared to other countries, with the U.S. as the second most significant contributor. Key author keywords include waste, life cycle assessment, and circular economy. This research fills a gap in literature and aims to be a foundational resource for scholars in the field.

Keywords: *Plastic Waste Trade, Bibliometric Analysis, Bradford's Law, Citation Network Analysis.*

JEL Codes: *F10, F18*

INTRODUCTION

On a global scale, plastics have emerged as a significant commodity due to their advantageous properties, including lightweight nature, flexibility, and ease of shaping. Consequently, they are now ubiquitous in nearly every commercial product (Brooks et al., p.1; 2018; Liang et al., 2018, p.242). In contemporary society, plastics play a crucial role in the global economy as a fundamental material (Amadei et al., 2023, p.1). The United Nations Environment Programme (UNEP, 2022) reports that annual global plastic production increased dramatically, doubling from 234 million metric tons (mt) in 2019 to 460 million mt in 2020. According to the year-end statistics published by Plastics Europe in 2022, global plastic production amounted to 400.3 million metric tons (MT). An analysis of the distribution of this volume by country reveals that 32% is attributed to China, 17% to North America, 14% to European Union member states, and 19% to other Asian countries excluding China (Plastics Europe, 2022)[4]. Furthermore, UNEP projects that global plastic production will reach approximately 1,231 MT

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[4] https://plasticseurope.org/wp-content/uploads/2023/10/Plasticsthefastfacts2023-1.pdf

by the year 2060 (UNEP, 2022, p.1). The role of plastics in international trade is also significant. The United Nations Conference on Trade and Development (UNCTAD, 2022) highlighted this situation, stating that if the global plastics trade were considered a country, it would rank as the fourth largest export market in the world. Exports of plastic waste increased from 218.2 million tons in 2005 to 381.8 million tons by 2021, with a monetary value of USD 1.184 billion. Similarly, plastic waste imports rose from 268.9 million tons in 2005 to 334.4 million tons in 2021, valued at $1.179 billion (UNCTAD, 2022).

In the wake of extensive production and manufacturing activities, the issue of plastic waste has emerged as a significant environmental challenge that is pertinent to nations and governing bodies globally. The improper disposal of plastic waste results in significant environmental harm, including pollution, contamination of the food chain, degradation of biodiversity, waste of energy resources, and economic losses. Most critically, it poses a threat to human health (Chow et al., 2017, p.125). The issue of unmanaged and mismanaged plastic waste is especially pronounced in developing countries, where the infrastructure for collection, reuse, and recycling is frequently insufficient or nonexistent (Browning et al., 2021, p.1). The establishment of a circular plastic economy has become critically important. This involves implementing processes for secondary use, recycling, and the responsible disposal of plastic. It is essential to adopt methods that minimize environmental harm throughout the entire lifecycle of plastic and its derivatives, from production to disposal, in order to promote sustainable production and consumption practices.

In developing countries, these challenges result in the uncontrolled release of waste into the environment, polluting water resources and soil, and worsening the living conditions of local communities. The inadequate management of plastic waste has significant detrimental effects on both marine and terrestrial ecosystems. Microplastics present in oceanic environments pose a threat to marine organisms, while their accumulation in terrestrial settings diminishes soil fertility and disrupts ecological balance. Consequently, it is imperative to enhance plastic waste management systems in developing nations and to foster international collaboration alongside sustainable waste management practices. The establishment of a circular plastics economy has become critically important, necessitating the implementation of processes such as secondary use, recycling, and responsible disposal of plastics. It is essential to adopt methods that minimize environmental harm throughout the entire lifecycle of plastics and their derivatives, from production to disposal, in order to promote sustainable production and consumption practices. The circular plastics economy seeks to minimize waste, promote the reuse and recycling of materials, and concurrently reduce resource consumption and environmental impacts. The effective implementation of these processes mitigates the adverse effects of plastic waste on the environment, safeguards ecosystems, and fosters economic and social sustainability. Furthermore, plastics that are reintegrated into the manufacturing sector through secondary use or recycling may be subject to international trade, as they frequently function as cost-effective intermediate inputs or raw materials. Brooks et al. (2018) indicate that plastic

waste that is not properly disposed of, recycled, or has potential for secondary use is often favored for trade. In this context, the concept of a global circular plastic economy can be discussed, wherein recyclable plastics are imported and utilized for secondary applications. This process involves transferring substantial plastic waste from one country to another, thereby reintegrating it into production cycles. International trade in plastic waste has the potential to yield both environmental benefits and economic opportunities. By facilitating the more efficient utilization of resources, such trade can mitigate the adverse effects of plastic waste on the environment. As a result, the longevity of plastics can be increased, and waste management systems can be improved, leading to sustainable waste management practices and enhanced resource efficiency.

The statistical changes in the import, export, and foreign trade volume of plastic waste, crumb, and scrap classified under NACE code 3915 worldwide from 2004 to 2022 are illustrated in Fig. 1.
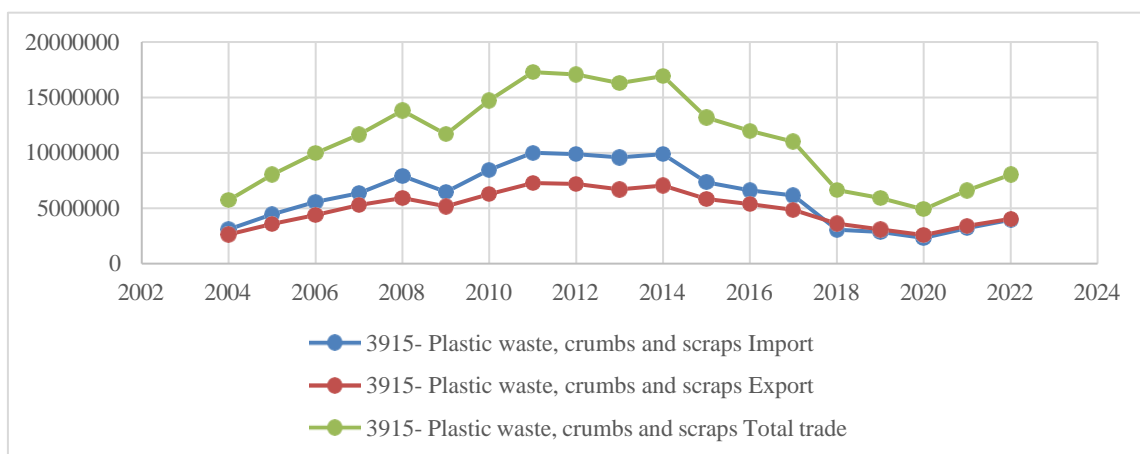

Figure 1: World 3915-Plastic Waste, Crumb and Scrap

Source: Plastics Waste, Crumbs and Scraps. www.trademap.org

According to statistics for the period from 2004 to 2022, as presented in Figure 1 and sourced from Trade Map, the total volume of foreign trade was approximately 5.7 million dollars in 2004, peaking at 17.2 million dollars in 2011. The trade in plastic waste exhibited relative stability, fluctuating between 16 and 17 million dollars from 2012 to 2014. However, following 2014, a notable decline ensued, with trade volumes falling below 6 million dollars in the years after 2017. The year 2017 is particularly significant for the evolution of the plastic waste trade, coinciding with China's implementation of a ban on plastic waste imports as part of its environmental protection policies. This ban, enacted in 2017, has had a profound impact on the sector, given that China accounted for 45% of plastic waste imports since 1992 (Brooks et al., 2018, p.2). The implementation of a ban on plastic waste imports by China, a significant contributor to both plastic production and imports, on January 1, 2018, resulted in a notable shift in the trajectory of plastic waste towards Malaysia and other Southeast Asian nations (Wang et al., 2019, p.9). However, as an increasing number of countries impose bans on plastic waste imports in response to environmental concerns, the dynamics of participation in this sector have evolved. Consequently, it has been observed that the global trade in plastic waste is predominantly concentrated among

Asian countries, as well as in North America, Europe, and Oceania (Zhao et al., 2021, p.9). According to statistics obtained from Trade map, prior to 2017, China accounted for nearly 50 percent of the world's plastic waste imports. However, following the implementation of a waste import ban in 2018, the United States and Hong Kong emerged as the leading importers of plastic waste. By 2020, it was observed that Hong Kong had nearly halved its plastic waste imports, with the United States and the Netherlands sharing the top position in plastic waste imports from 2020 onwards. By the year 2022, the Netherlands held the top position in plastic waste management, followed by the United States in second place and Turkey in third. Comprehensive data regarding the importation of plastic waste by countries is available in Appendix- 1.

There is an impression that the changing flow of plastic waste trade around the world has negative environmental and social impacts as well as economic impacts, and for this reason, countries have introduced some legal and regulatory obligations. It has been highlighted that, although public concern regarding plastic pollution is on the rise across various countries and regions, the scientific comprehension of this issue remains fragmented (Liang et al., 2021, p.243). From this perspective, it is essential to assess the extent of scientific research conducted by various countries regarding the trade of plastic waste, as well as their perspectives on this issue. In this context, it is important to examine how the evolving roles of countries in the plastic waste trade develop over time, in conjunction with research published in reputable academic journals. A systematic review of high-quality research in the field of plastic waste trade would be significantly advantageous. Such a review has the potential to enhance scientific understanding of the plastic waste trade and to identify existing knowledge gaps. Moreover, the current literature encompasses a diverse array of interdisciplinary studies that examine the plastic waste trade from various perspectives. However, it has been noted that the embodied and emerging aspects of plastic waste flows have not been thoroughly investigated, either quantitatively or qualitatively. This observation highlights the necessity for a more comprehensive and holistic analysis to better comprehend the dynamics and global implications of the plastic waste trade. Therefore, a meticulous examination of scientific research on the plastic waste trade is essential for understanding current challenges and for formulating future policy and practice recommendations. This approach can facilitate the development of more effective strategies for plastic waste management and promote international collaboration. To address this gap in literature and contribute to the advancement of the field, this study conducts a systematic review of the embodied flows associated with publications on plastic waste trade. In this review, bibliometric and social network analyses were employed. The primary objective of the research is delineated into the following four sub-objectives:

I. To elucidate the research dynamics within the field by examining the trends, developmental patterns, and characteristics of publications related to plastic waste trade from 1996 to 2024.

II. To identify existing perspectives and potential biases by evaluating the contributions of research on the trade of plastic waste, categorized by country, institution, author, and journal.

III.   Identifying New Areas of Research through Co-Citation Relationships: This section aims to identify novel and emerging research domains by analyzing keywords and co-citation relationships, while also evaluating their contributions to the scientific understanding of plastic waste trade.

IV.   To delineate prospective research directions and strategies pertaining to the trade of plastic waste and international trade research, with the objective of informing knowledge and practice within this field.

METHODOLOGY

Bibliometric analysis systematically examines publication and citation data within a specific research domain to evaluate research outputs and impacts, as well as to identify emerging trends (Khatun et al., 2021, p.2). This analytical approach, utilized to investigate and interpret extensive volumes of scientific data, provides a comprehensive overview of the evolutionary development of a particular field while also assisting in the identification of new directions and trends (Donthu et al., 2021, p.285). Bibliometrics constitutes an essential component of research evaluation methodologies across both scientific and applied disciplines (Ellegaard and Wallin, 2015, p.1809). The bibliometric methodology enables the discovery, organization, and analysis of substantial datasets (Daim et al., 2006, p. 985). Moreover, such analyses yield valuable insights for researchers aiming to assess scientific activities (Duque Oliva et al., 2006, p.231).

Hulme (1923) characterized bibliometrics as "statistical bibliography", Pritchard (1969) further defined bibliometrics as the application of mathematical and statistical methods to the analysis of books and other sources. Cobo et al. (2011) identified two primary approaches to bibliometric analysis: performance analysis and scientific mapping. Performance analysis assesses the impact and contributions of publications, authors, and journals within a specific research domain, whereas scientific mapping visualizes relationships and trends in the literature, thereby enhancing the understanding of the structure and evolution of the field (Cobo et al., 2011, p. 146). Various derived indicators, such as the number of publications and citations in the scientific literature, along with phenomena including citation, co- authorship, and concentration in influential journals, are collectively referred to as bibliometric indicators (Narin and Hamilton, 1996, p.293). To derive these indicators, a range of software options is available, including Bibeexcel, Citespace, Biblioshiny, Histcite, Ucinet, Pajek, Vivo, Gephi, Vantage Point, VOSviewer, and Scimat. In this study, the Biblioshiny program, which is part of the bibliometrics package (Derviş, 2019, p.158) in the R programming language—comprising over 16,000 open-source software packages—was employed.

ANALYSIS AND FINDINGS

Data for this bibliometric analysis were obtained from the Web of Science (WoS). Figure 2 presents the methodology flowchart. The searches are limited to the period from 1996 to February 2024.
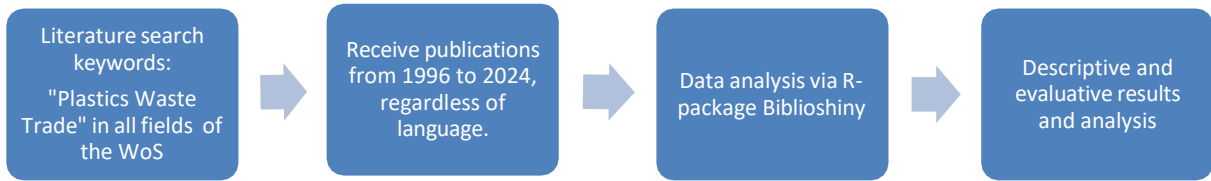
Figure 2: Methodology Flowchart

Source: Created by authors.

The primary statistics regarding scientific publications on the trade of plastic waste for the period from 1996 to 2024 are presented in Table 1.

Table 1: Main Information About Data

Description	Results
Timespan	1996:2024
Sources (Journals, Books, etc.)	144
Documents	257
Annual Growth Rate %	2,51
Document Average Age	5,24
Average citations per doc	31,24
References	12790
Document Contents	**Results**
Keywords Plus (ID)	684
Author's Keywords (DE)	868
Authors	**Results**
Authors	923
Authors of single-authored docs	32
Authors Collaboration	**Results**
Single-authored docs	35
Co-Authors per Doc International co-authorships	3,81
%	28,79
Document Types	**Results**
Article	208
Article; Early Access	1
Editorial Material	4
Proceedings Paper	13
Review	30

Source: Created by authors.

According to Table 1, a total of 257 studies across various research types have been published over a span of approximately 30 years, with 208 of these being articles authored by 923 researchers in the field. This calculation yields an average of 9 publications per year concerning plastic waste trade. Furthermore, the annual growth rate for publications in this area is calculated to be 2.51%. Notably, it was found that only 32 authors have contributed to the literature independently. The average age of the publications is 5.24 years, suggesting that interest and awareness in this research domain are relatively recent.

Figure 3 illustrates the annual distribution and number of citations for studies published in the field of plastic waste trade since 1996.
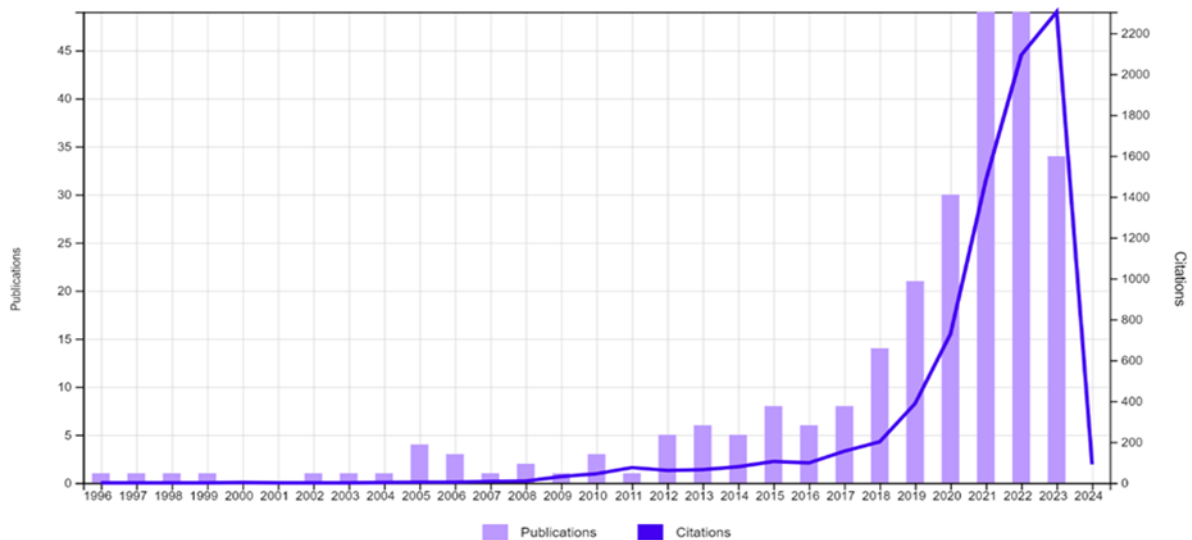
Figure 3: Annual Scientific Production and Citations

Source: Created by authors.

According to Figure 3, while there was a notable increase in the number of publications in the years 2005, 2006, and 2010, the most significant growth occurred after 2012. On the other hand, it is observed that the number of citations has exhibited an upward trend since 2008, culminating in a total of 2,200 citations in 2021 and 2022, and approximately 1,600 citations in 2023[5]. These statistics indicate that the trade of plastic waste is emerging as a subject of intensive scholarly inquiry.

The analysis of the distribution of publications by country reveals a notable concentration of academic interest in the trade of plastic waste, particularly in nations that are significantly affected by the environmental repercussions and resource implications associated with this trade. In these countries, the challenges posed by plastic waste are directly encountered, leading to an increased volume of academic research on the subject. Table 2 illustrates the 15 countries that have produced the highest number of publications regarding the plastic waste trade since 1996.

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[5] Since the data obtained from the WoS was downloaded on February 6, 2024, the number of citations and publications has not yet been established. Consequently, in Figure 3, both the number of citations and the number of studies appear to exhibit a downward trend after 2023.

Table 2: The Most Relevant Countries for Plastics Waste Trade

Countries	No. of Publications	Percent (%)
China	113	43,9%
USA	85	33,1%
UK	58	22,6%
Japon	32	12,5%
Canada	31	12,1%
Italy	24	9,3%
Netherlands	23	8,9%
Germany	21	8,2%
Australia	19	7,4%
India	17	6,6%
Pakistan	17	6,6%
Sweden	12	4,7%
Brazil	12	4,7%
Nigerya	11	4,3%
Türkiye	9	3,5%

Source: Created by authors.

Among the countries examined, China exhibits the highest volume of publications in the domain of plastic waste trade, accounting for nearly half (113) of the total 257 publications attributed to researchers from various nations. The United States ranks second, with 85 publications. The United Kingdom (58) distinguishes itself in terms of publication volume among other countries, while Japan (32) and Canada (31) collectively contribute approximately 12-13% of the total publications. It is noteworthy that a portion of these publications arise from collaborative efforts between countries. Cross-national collaborations are illustrated in Figure 4, which delineates the extent to which countries engage in both national and international cooperation in their publications concerning plastic waste trade. Specifically, each country is categorized into two distinct authorship classifications: Single Country Production (SCP) and Multi-Country Production (MCP).
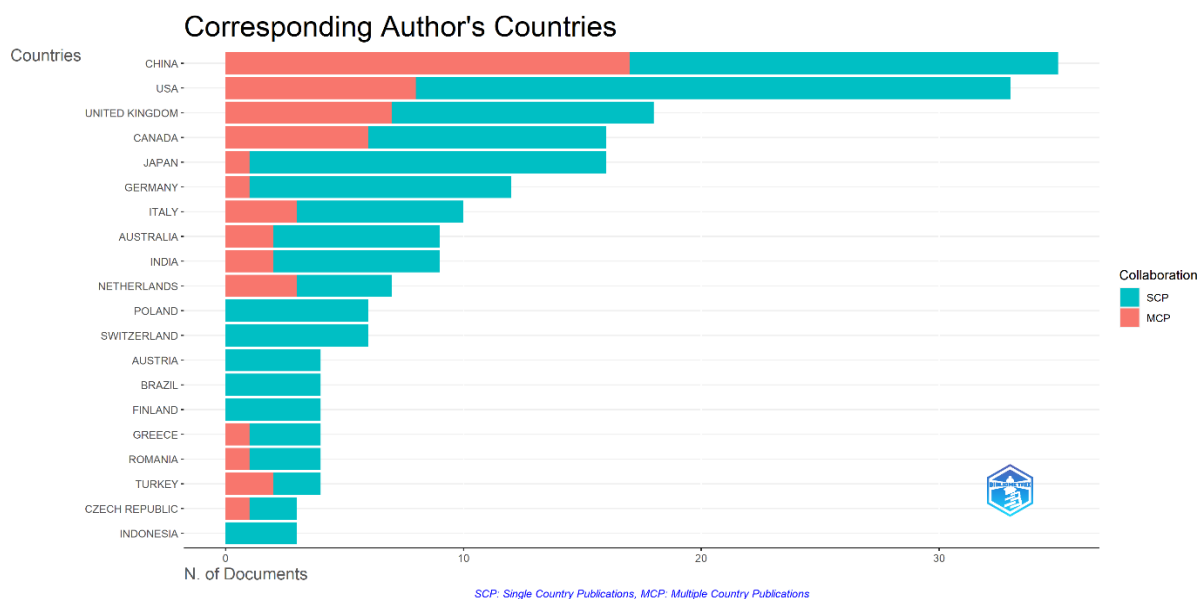
Figure 4: Local and Global Collaborations Among Authors in Countries Addressing Plastic Waste Trade
Source: Created by authors.

An analysis of the collaboration among the authors' respective countries reveals that China leads in both international and national production. It is the nation with the highest number of publications in this field. Notably, 18 out of the 35 active authors have published exclusively within China, indicating a focus on national collaboration. In contrast, the remaining 17 researchers have engaged in collaborative efforts with scholars from other countries. Among the 20 countries with the highest number of publications, as illustrated in Figure 4, it was observed that Poland, Switzerland, Austria, Brazil, Finland, and Greece exclusively engaged in national collaborations. In contrast, authors from other countries demonstrated a tendency to conduct joint studies with collaborators from at least one other nation. However, it is noteworthy that national collaboration (SGP) was generally favored over international collaboration (MGP).

Conversely, Figure 5 presents an analysis of the countries with the highest number of cited publications.
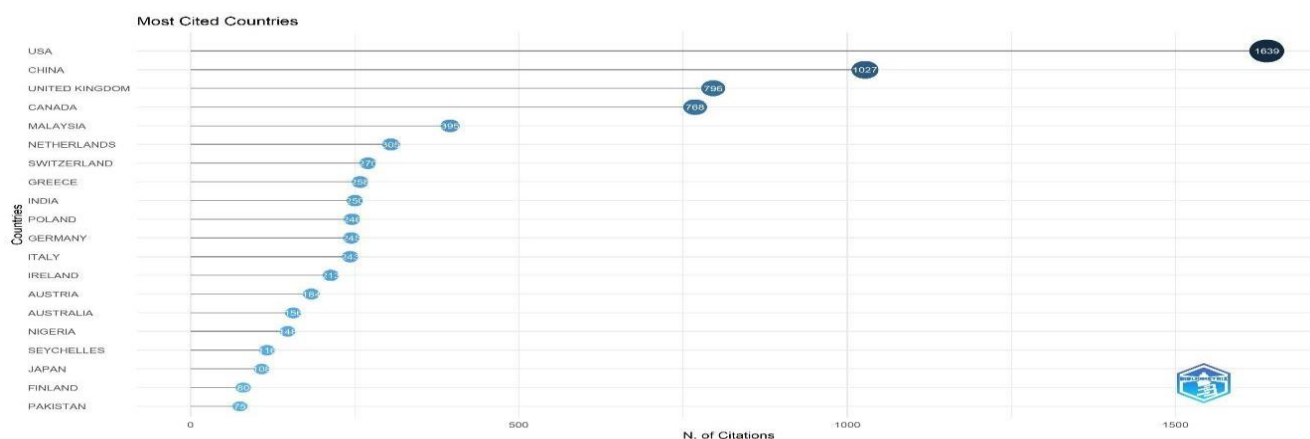
Figure 5: Most Cited Countries
Source: Created by authors.

Among the 20 countries exhibiting the greatest citation counts, the United States holds the leading position with 1,639 citations, followed by China, which has recorded 1,027 citations. When assessing the level of scientific research across various countries, it can be observed that while China is the most productive and engaged nation in this domain, it falls short of the United States in terms of scientific impact, as evidenced by citation counts. Nevertheless, China remains a leader in scientific impact relative to other countries, and the substantial volume of research conducted indicates a significant level of expertise in the field.

Another outcome of bibliometric analyses is the assessment of the output produced by affiliations within countries that are specific to the subject under investigation. The findings of this analysis are presented in Table 3. Table 3 demonstrates that China leads in the realm of academic institutions, as five of the top ten institutions with the highest publication output are in China. This phenomenon can be attributed to China's longstanding preference for the importation of plastic waste. However, researchers are increasingly considering the saturation of economic benefits derived from this practice, alongside the associated environmental challenges it poses as a detrimental outcome**.**

Table 3: Most Relevant Affiliations

No. of Publications	Affiliations	Countries
15	Chinese Academy of Sciences	China
6	Eth Zurich	Germany
6	Institute Of Urban Environment, CAS	China
6	Shanghai Jiao Tong Unıversıty	China
6	Tsinghua University	China
5	Swiss Federal Institutes of Technology Domain	Sweden
5	United States Department of Energy (DOE)	USA
4	Beijing Normal University	China
4	Brunel University	England
4	Comsats University Islamabad (CUI)	Pakistan

Source: Created by authors.

Following an examination of the contributions made by various countries and institutions, researchers within the field were also analyzed. In addition to the quantity of publications produced by the authors, the total number of citations and other references to a scientific publication are among the most commonly utilized bibliometric indicators for evaluating the quality of an author's work (Duque Oliva et al., 2006, p.231). It is essential to recognize that the mere quantity of publications does not adequately reflect the quality or impact of these works. In this context, the h-index serves as a metric that encapsulates both the impact and quality of publications. Moreover, the h-index illustrates the academic influence of countries, regions, institutions, and authors within the field (Bornmann et al., 2011, p.346). Table 4 displays the number of publications, total citations, h-index values, and citation-to- publication ratios for the 15 researchers with the highest publication counts in the respective field.

Table 4: Authors Publishing on Plastic Waste Trade: 1996-2024.

Ranking	Author	No. of Publications	Total Citation	h- index	Citation/Publication
1	Chen, WQ.	6	369	6	61,5
2	Walker, TR.	4	141	3	35,25
3	Briassoulis, D.	3	197	3	65,66
4	Dauvergne, P.	3	223	1	74,33
5	Hellweg, S.	3	141	3	47
6	Hiskakis, M.	3	197	3	65,66
7	Iacovidou, E.	3	176	3	58,66
8	Ma, ZJ.	3	171	3	57
9	Abbasi, S.	2	32	1	16
10	Adams, M.	2	125	2	62,5
11	Babou, E.	2	156	2	78
12	Barnes, SJ.	2	158	2	79
13	Beckham, GT.	2	127	2	63,5
14	Bing XY	2	152	2	76
15	Borrelle, SB.	2	11	2	5,5

Source: Created by authors.

According to Table 4, Wei-Qiang Chen (Chen, W.Q.) from the Chinese Academy of Sciences is identified as the most prominent researcher in the field, having authored a total of six publications and garnered 369 citations. The author with the highest h-index value was Chen, W.Q. His h-index is 6. Chen, W.Q. is followed by Tony R. Walker (Walker, T.R.) from Dalhousie University in Canada, who has authored four publications and garnered 141 citations. Walker, T.R.'s h-index is 3. The third most significant researcher is Demetres Briassoulis (Briassoulis, D.) from the Agricultural University of Athens in Greece, with three publications and 197 citations. An overall analysis of Table 4 indicates that a substantial majority (95%) of authors engaged in the field of plastic waste trade have published only a single article; specifically, 887 out of 932 authors have contributed to just one publication.

The distribution of publication years for the authors within the specified research period is illustrated in Figure 6. Notably, Chen, W.Q. emerges again as one of the most prominent figures among the top 15 researchers, Chen, W.Q.'s inaugural publication was released in 2019, followed by three publications in 2020 and two in 2021. Importantly, Chen, W.Q. achieved a total of six publications over the span of three years, which were the most cited among the top 15 authors. This may suggest that these publications have made significant scientific contributions to the field.
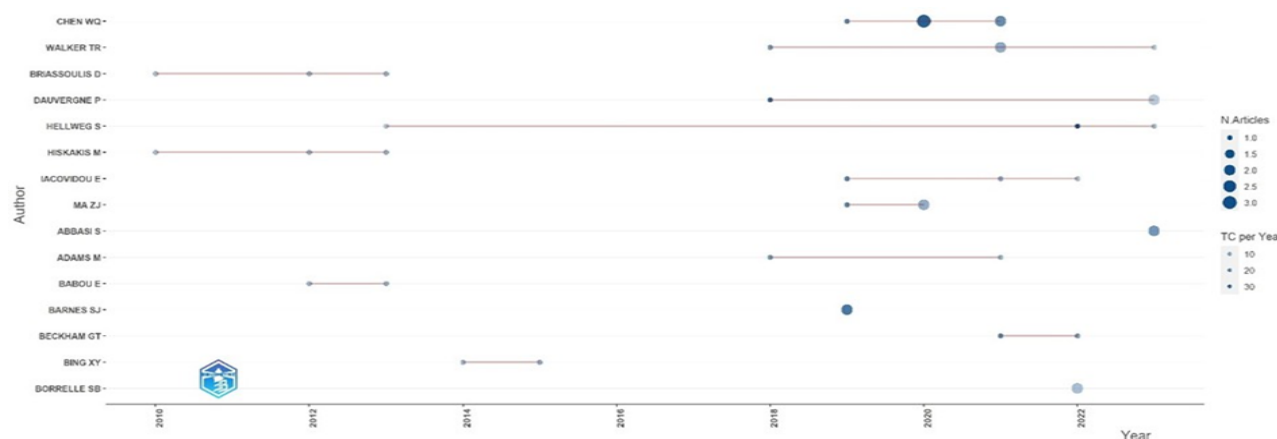
Figure 6: Authors' Production over Time

Source: Created by authors.

Chen, W.Q.'s inaugural article, entitled "Implications of China's Foreign Waste Ban on the Global Circular Economy," was published in 2019 and has been cited 125 times in discussions pertaining to the trade of plastic waste. This article examines the ramifications of China's 2018 prohibition on plastic waste trade for the global circular economy. Additionally, another study authored by Chen, W.Q in 2020, titled "Structure of the Global Plastic Waste Trade Network and the Impact of China's Import Ban," delineates the global plastic waste trade networks from 1988 to 2017 and assesses the implications of China's ban on plastic waste imports for these networks.

Additionally, in the same year, Chen published "Sustainable Cycles and Management of Plastics: A Brief Review of RCR Publications in 2019 and Early 2020." This publication presents a meta-analysis of 11 articles on plastic circularity published in *Resources, Conservation and Recycling*. Another article from 2020, titled "Evolution of the Global Polyethylene Waste Trade System," examines the mapping of polyethylene waste trade networks in the context of China's plastic waste import bans implemented in 2017.On the other hand, when the most cited publications in the field are analyzed, it is seen that the study titled "The Chinese Import Ban and Its Impact on Global Plastic Waste Trade" by Brooks et al. in 2018 received more citations than the study by Chen, W.Q. This article received 459 citations in total, making it the most cited publication on the subject. In the same year, Chen, W.Q. published the article titled "Sustainable Cycles and Management of Plastics: A Brief Review of RCR Publications in 2019 and Early 2020." This publication provides a meta-analysis of 11 articles concerning plastic circularity that were published in *Resources, Conservation and Recycling*. Another article from 2020, entitled "Evolution of the Global Polyethylene Waste Trade System," investigates the mapping of polyethylene waste trade networks in light of China's plastic waste import bans that were enacted in 2017.

Conversely, an examination of the most frequently cited publications within the field reveals that a particular publication by another researcher has garnered more citations than those authored by Chen, W.Q. This notable

work is the article titled "The Chinese Import Ban and Its Impact on Global Plastic Waste Trade, by Brooks et al. in 2018, which has accumulated a total of 459 citations. However, this article examines China's ban on plastic waste imports and the subsequent alterations in the flow of plastic waste trade resulting from these prohibitions. Additionally, it highlights the significance of global initiatives and actions aimed at the reduction, recycling, and local management of non-recyclable plastic waste, viewed through the lens of a circular economy.

The other most cited publications in the field are presented in Table 5.

Table 5: Top 10 Most Cited Publications

Author/ Authors	Citations
Brooks, A. L., Wang, S., & Jambeck, J. R. (2018).	459
Rosenboom, JG., Langer, R. & Traverso, G. (2022)	395
Sumathi S, Chai, S.P., & Mohamed, A.R. (2008)	384
Nguyen, B., Claveau-Mallet, D., Hermandez, L.M., Xu, E.G., Farner, J.M. & Tufenkji, N. (2019).	339
Urbanek, A.K., Rymowicz, W. & Mirończuk, A.M (2018)	228
Dauvergne, P. (2018).,	222
Domenech, T., Bleischwitz, R., Doranova, A., Panayotopoulos, D., & Roman, L. (2019).	159
Vanegas, P., Peeters, J. R., Cattrysse, D., Tecchio, P., Ardente, F., Mathieux, F., ... & Duflou, J. R. (2018).	138
Wen, Z., Xie, Y., Chen, M. (2021)	137
Sharkey M, Harrad, S., Elwafa Abdallah, M.A., Darage,D.S. & Berresheim, H. (2020), .	136

Source: Created by authors.

An additional observation regarding the most frequently cited articles presented in Table 5 is that these articles encompass central themes, including the circular plastic economy and marine pollution resulting from plastic waste. Furthermore, they underscore China's prohibition on the importation of plastic waste.

The most relevant journals and sources pertaining to the trade of plastic waste are presented in Table 6.

Table 6: Most Relevant Sources

Journals/ Sources	No of Publications	Total Citations
Resources Conservation and Recycling	23	1298
Journal of Cleaner Production	16	524
Waste Management	16	723
Sustainability	8	73
Sustainable Production and Consumption	8	79
Science of the Total Environment	7	87
Journal of Environmental Management	6	109
International Journal of Environmental Research An Public Health	5	47
ACS Sustainable Chemistry & Engineering	4	119
Environmental Science & Tecnology	4	125

Source: Created by authors.

Table 6 indicates that *Resources, Conservation and Recycling* was the most frequently cited source, with a total of 1,298 citations. This journal is primarily edited by individuals from the United States (19 editors) and

China (16 editors)[6]. Following this, both the *Journal of Cleaner Production* and *Waste Management* contributed 16 publications related to plastic waste trade. Nevertheless, *Waste Management* exhibited a higher scientific impact, recording 723 citations, in contrast to the 524 citations attributed to the *Journal of Cleaner Production*. An additional output of the bibliometric analysis is the identification of core sources pertinent to the researched topic. The distribution of publications concerning plastic waste trade, in relation to their sources, was examined utilizing Bradford's Law, as illustrated in Figure 7. According to this law, the concept of core publications implies that approximately one-third of the articles on the subject are disseminated by a specific group of journals, another one-third by a second group of journals, while the remaining articles are published by a larger array of journals (Garfield, 1980, p.477). On the other hand, this law indicates the core area of the most relevant journals for a particular field (Venable, et al. 2016, p.569).

| Core sources Total | 89 |
| percent | %34 |
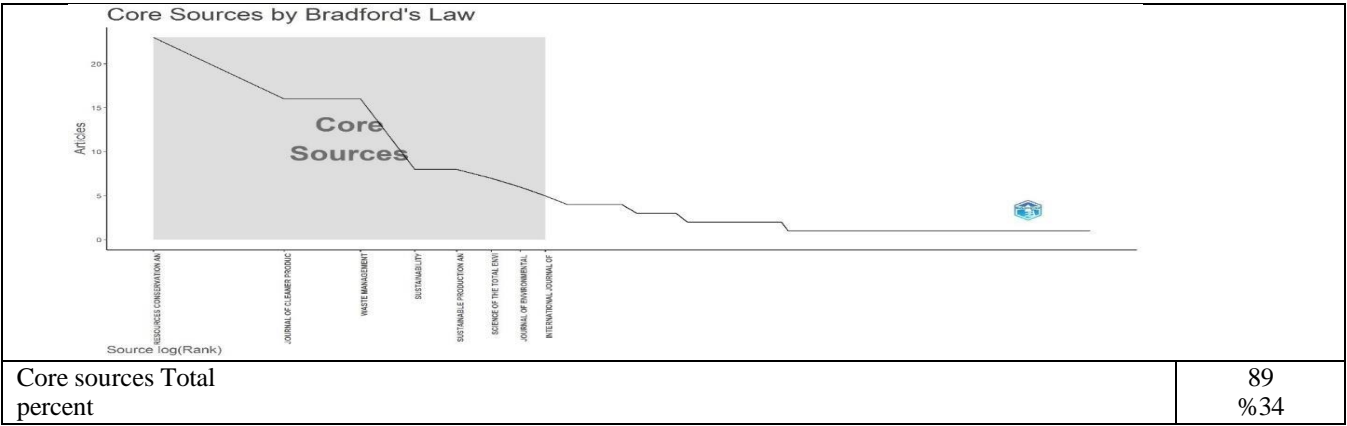
Figure 7: Core Sources on Trade in Plastic Waste: Bradford Law

Source: Created by authors.

Core sources pertaining to the trade of plastic waste encompass the following journals: Resources Conservation and Recycling (23 publications), Journal of Cleaner Production (16), Waste Management (16), Sustainability (8), Sustainable Production and Consumption (8), Science of the Total Environment (7), Journal of Environmental Management (6), and International Journal of Environmental Research and Public Health (5). Collectively, these journals account for 89 of the 257 total publications, thereby illustrating their substantial influence and alignment with Bradford's law. This finding highlights the primary sources that researchers interested in investigating the subject should consult.

Figure 8 illustrates the most utilized keywords pertaining to the primary theme of plastic waste trade. Accordingly, the first of the most frequently used keywords in the field is the word "waste" with a frequency of 32. The word "management" is second with a frequency of 27, and the word "life-cycle economy" is third with a frequency of 24. Another keyword that shows the frequency of studies that characterize plastic waste trade as a

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[6] https://www.sciencedirect.com/journal/resources-conservation-and-recycling/about/editorial-board

measure, or a sub- concept of the circular economy is "circular economy" with a frequency of 15.
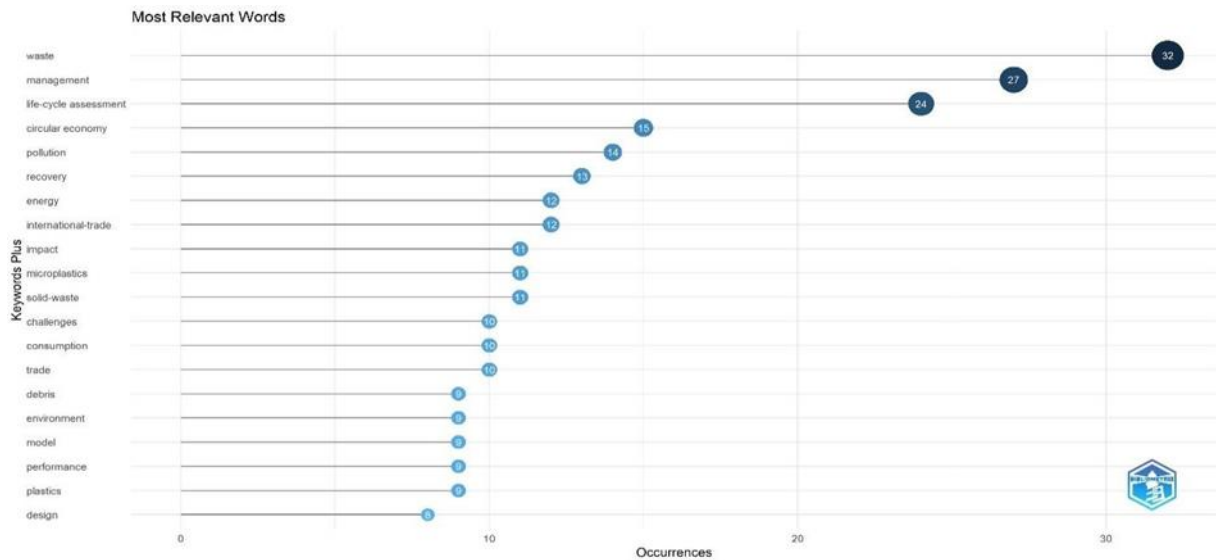

Figure. 8: Most Relevant Words

Source: Created by authors.

The initial scientific map that analyses global collaboration data pertaining to publications on plastic waste trade is the country collaboration map presented in Figure 9.
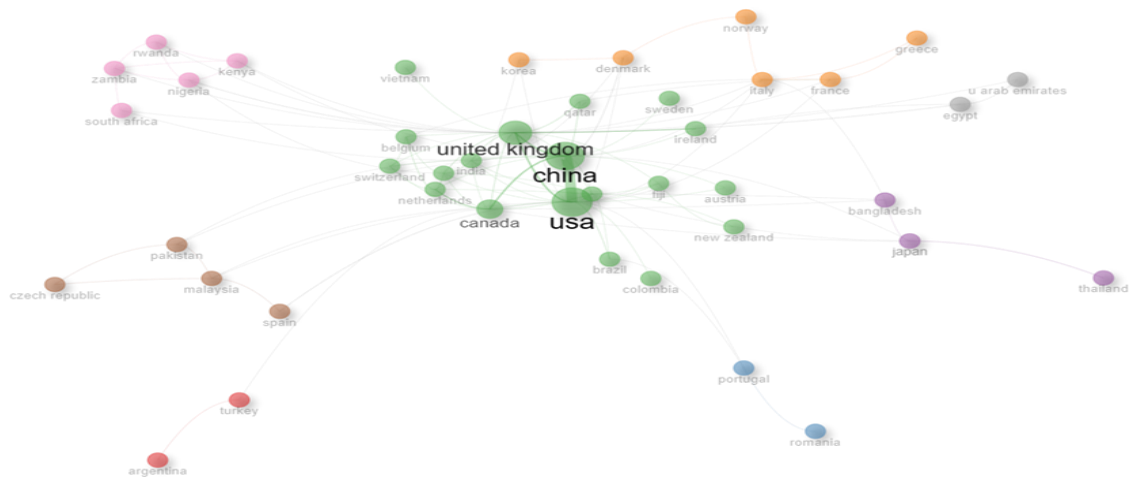

Figure 9: Collaboration Map of Countries

Source: Created by authors.

In the country collaboration map presented in Figure 9, the sizes of the circles correspond to the number of studies conducted, whereas the thickness of the lines reflects the degree of collaboration among the countries. The most substantial cooperation is observed between China and the United States, as indicated by a score of 9, followed by Canada and the United Kingdom, each with a score of 4. Additionally, the United States and the United Kingdom demonstrate a higher level of cooperation, with a score of 4, compared to other nations. These findings

are consistent with the data presented in Figure 5, which illustrates that China engages in the highest level of cooperation, as further depicted in Figure 9.

Another scientific map illustrating author collaborations is presented in Figure 10. This figure reveals a total of 11 distinct independent collaborations. The findings are consistent with those presented in Table 4, which indicates that Chen W.Q., who has the highest number of publications, is represented by the largest circle, thereby underscoring his position as the most collaborative author within his group.
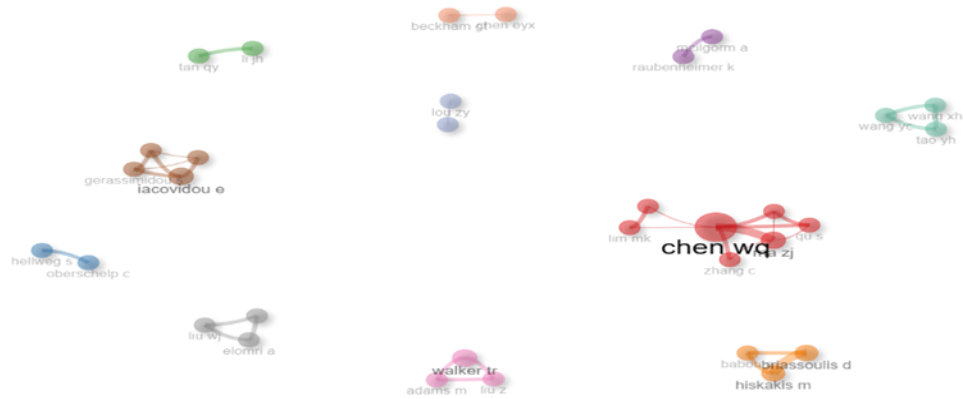
Figure 10: Author Collaboration

Source: Created by authors.
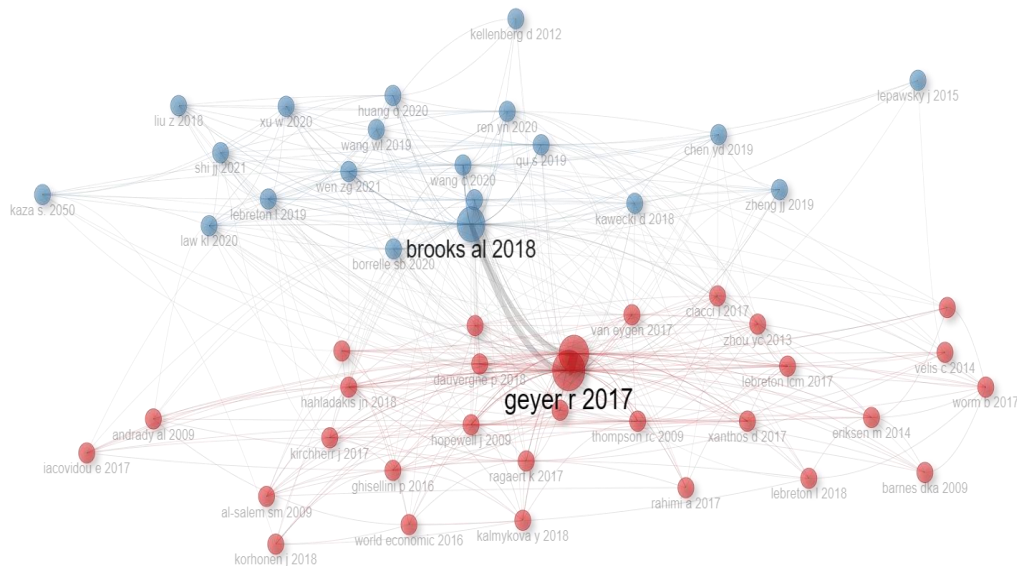
Figure 11: Citation Network Analysis between Publications

Source: Created by authors.

The citation network among publications represents another significant aspect of scientific mapping. As illustrated in Figure 11, two distinct clusters emerge from the citation analysis of these publications; however, there is a notable scarcity of citations between the clusters. Within the first cluster, the most frequently cited work is by Brooks et al. (2018), while the second cluster is predominantly represented by Geyer R.'s (2017) study titled

"Production, use, and fate of synthetic polymers". Geyer R. (2017) examines the global plastic sector, tracing its evolution from initial usage to waste management, and provides projections for the year 2050. When evaluating the citation analysis, it is evident that Geyer R.'s work serves as a crucial reference for other studies within its respective cluster.

Figure 12 presents three field plots that illustrate the interconnections among keywords, authors, and sources pertaining to the trade of plastic waste. The relationships among these three elements are depicted through gray linkages, which originate from the keywords-plus, connect to the authors, and subsequently link each author to the topics addressed in their publications. The size of each rectangle corresponds to the number of associated publications. Furthermore, the color intensity of the rectangles representing the units in the lists reflects their level of engagement with the subject matter. The width of the lines connecting the rectangles is indicative of the number of links. Notably, the author with the highest number of connections is Chen W.Q., who also leads in terms of publication volume. The most prevalent topics identified in the keywords-plus include circular economy, plastic waste, and recycling. Among the sources, Waste Management exhibits the most connections, followed by the Journal of Cleaner Production and Resources Conservation and Recycling.
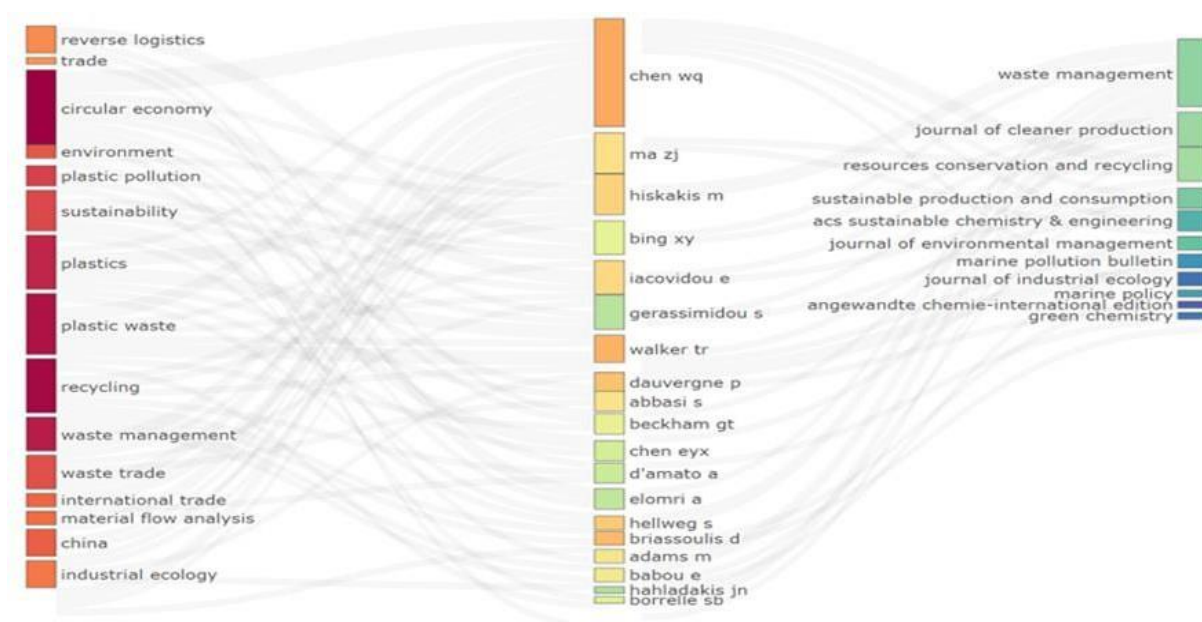

Figure 12: Three Field Plot

Source: Created by authors.

Biblioshiny provides a distinctive feature for the creation of thematic maps, which is not commonly available in other bibliometric software. Figure 13 illustrates the thematic map pertaining to publications on the trade of plastic waste.
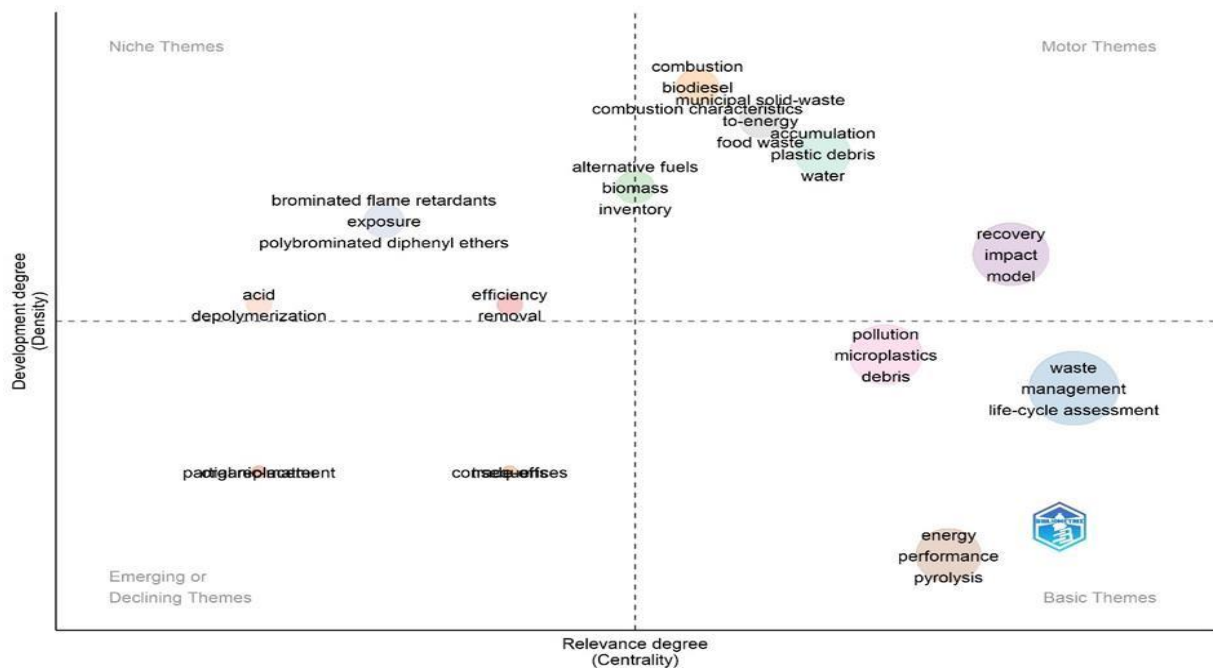
Figure 13: Thematic Map

Source: Created by authors.

As illustrated in Figure 13, the vertical axis of the thematic map represents the degree of development of the themes, commonly referred to as their intensity, while the horizontal axis indicates the degree of relevance to the subject, also known as the degree of centrality. The thematic map is divided into four quadrants based on the levels of centrality and intensity. The emerging or declining themes are in the lower left quadrant, while isolated and advanced (niche) themes are situated in the upper left quadrant. Basic or cyclical themes can be found in the lower right quadrant, and motor themes are positioned in the upper right quadrant.

As illustrated in Figure 13, the vertical axis of the thematic map represents the degree of development of the themes, commonly referred to as their intensity, while the horizontal axis indicates the degree of relevance to the subject, also known as the degree of centrality. The thematic map is divided into four quadrants based on the levels of centrality and intensity. The emerging or declining themes are located in the lower left quadrant, while isolated and advanced (niche) themes are situated in the upper left quadrant. Basic or cyclical themes can be found in the lower right quadrant, and motor themes are positioned in the upper right quadrant.

It can be asserted that the themes exhibiting the highest levels of centrality and intensity within these domains pertain to motor themes.

The map is divided into four quadrants: newly developing themes (lower left), isolated and developed themes (upper left), basic themes (lower right), and motor themes (upper right). Motor themes exhibit the highest centrality and intensity.

Motor themes identified in studies concerning the trade of plastic waste encompass 'incineration,' 'biodiesel,'

'municipal solid waste,' 'landfill,' 'food waste,' 'plastic debris,' 'recovery,' and 'mode of impact.'

The isolated and advanced themes (niche themes), which are less centralized but have a high intensity of development in the field, include 'brominated flame retardants', 'exposure', 'polybrominated diphenyl ethers', 'acid', 'depolymerization', 'efficiency', and 'removal', all of which are pertinent to plastic recycling and plastic separation.

The thematic map analysis indicates that 'alternative fuels,' 'biomass,' and 'inventory' are significant themes that are extensively researched within the field, forming a cluster that connects motor themes with isolated themes.

Conversely, two distinct clusters of emerging themes have been identified: the first cluster pertains to 'partial replacement,' while the second cluster relates to 'exchange.' These clusters indicate novel research topics of significance within the domains of plastic waste recycling and exchange.

Finaly, fundamental and circular themes characterized by high centrality yet low development within the field encompass 'pollution', 'microplastics', 'debris', 'waste', 'management', 'life-cycle assessment', 'energy', 'performance', and 'pyrolysis'.

The Biblioshiny program also generates outputs that assess the productivity of authors within the field. The graph illustrating Lokta's law, which depicts the productivity of authors in the context of plastic waste trade, is presented in Figure 13. According to Lotka's law (1926), it is anticipated that 60% of authors will contribute to the literature with one article, 15% will contribute with two articles, and 7% will contribute with three articles (Lotka, 1926, p.318).


Number of Publications	Number of Authors	Author Rate (%)
1	879	95,2
2	36	3,9
3	6	0,7
4	1	0,1
6	1	0,1
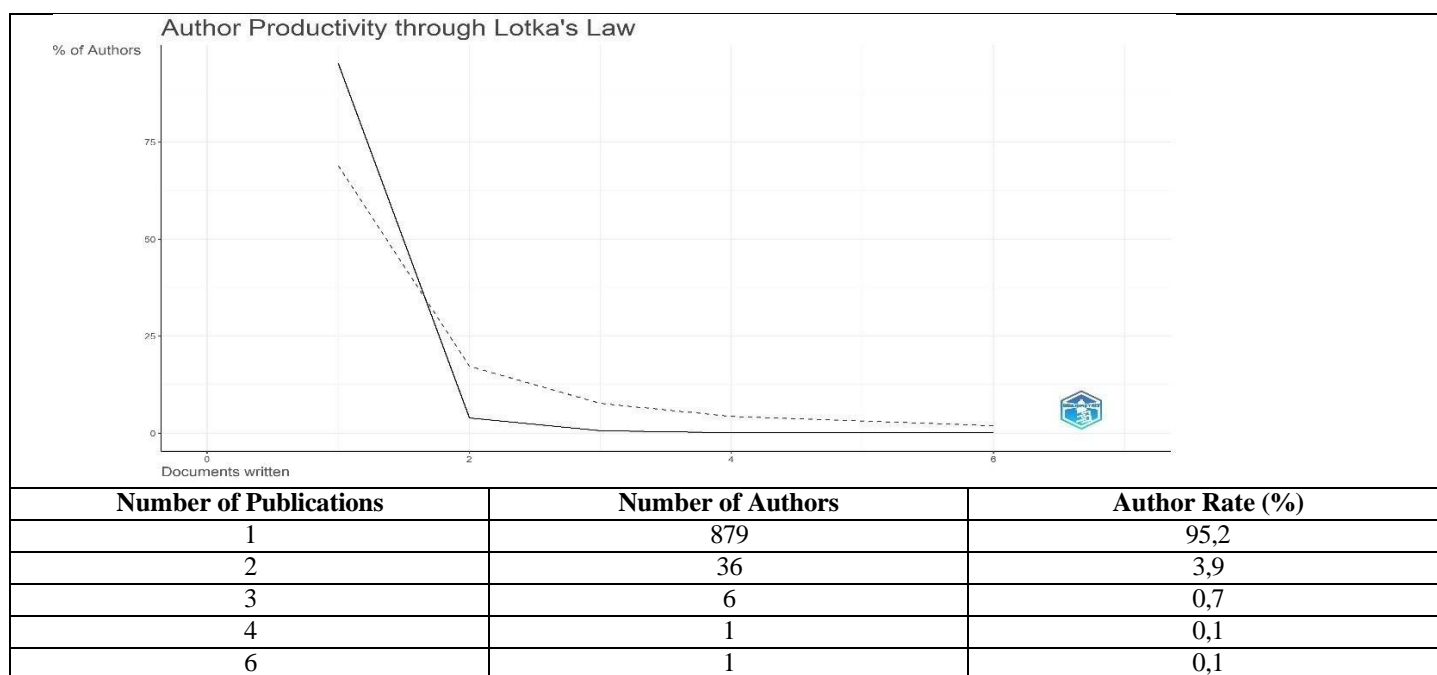
Figure 14: Author Productivities according to Lotka's Law

Source: Created by authors.

According to Figure 4, a total of 879 authors, representing 95.2% of the authors in the field, have published a single article on the topic of plastic waste trade. This finding suggests a lack of collaboration among authors in this area, indicating that those who publish once are unlikely to produce subsequent publications. Consequently, it can be inferred that the authors engaged in this field exhibit inefficiency, as evidenced by the results aligned with the principles of Lotka's Law.

CONCLUSION AND DISCUSSION

This study conducts a bibliometric analysis of publications related to the topic of "plastic waste trade" within the Web of Science (WoS) database, covering the period from 1996 to 2024. The analysis encompasses all fields, including titles, abstracts, keywords, and subject categories. The findings indicate that China emerged as the most productive and significant country in this domain, with Chen W.Q. identified as the most influential author. Additionally, the Chinese Academy of Sciences was recognized as the leading institution, with five of the top ten relevant institutions also located in China.

During the research period, 43.9% of the 257 publications accessed originated from China, while 33.1% were from the United States. China exhibited the highest volume of publications. An analysis of the publications revealed that China was the country with the greatest number of collaborative publications with other nations, and the United States was identified as the country with which China had the most collaborative publications.

It can be asserted that China, which consistently emerges as a prominent player across various categories in the research findings, exerts a significant influence on the trade of plastic waste as well as on academic research within this domain. This phenomenon can be elucidated by the emergence of a significant research topic within the literature, particularly following the imposition of a ban on the importation of plastic waste in 2017. The issue is addressed in discussions surrounding the trade of plastic waste, notably in the most frequently cited publication on the subject. This ban serves as the central theme of the work by Brooks A.L. et al. (2018), which has garnered considerable attention in academic discourse. This is the primary subject of the most cited publication in 2018 authored by Chen, W. Q., who is recognized as one of the leading authorities in the field of plastic waste trade, too. Additionally, another significant finding of the research is that the key concepts identified in the literature encompass the specific ban under consideration, the impact of this ban on the flow of plastic waste, as well as themes related to the environment and pollution, sustainability, the circular economy of plastics, secondary use, reuse, production, waste management, and international trade.

The keywords exhibiting the highest frequency in the discourse on plastic waste trade are "waste", "life-cycle economy" and "circular economy". It can be asserted that the principles of "circular plastics economy", which underscore the significance of cost-effective raw materials and resource efficiency and "life -cycle economy" which encompasses environmental protection and sustainability, constitute two pivotal frameworks for research

on plastic waste trade within the academic literature. The primary motivations for investigating the trade of plastic waste generally include environmental protection, sustainability, and the pursuit of affordable raw materials and resource efficiency. Addressing the challenges associated with plastic waste and its trade is imperative, particularly in the context of resource scarcity and environmental concerns. It can be anticipated that this issue will remain a central topic of discussion, especially concerning its environmental and economic implications.

In this context, international regulations and cooperation are pivotal in influencing policies regarding the trade of plastic waste. Specifically, the amendments to the Basel Convention enacted in 2019[7] seek to enhance the transparency and traceability of waste movements between countries, while also aiming to alleviate the environmental burden faced by developing nations. These regulations mandate that trade be conducted in a manner that is not only economically viable but also ethically sound and environmentally sustainable.

Nevertheless, disparities in capacity among nations, inequalities in recycling infrastructure, and deficiencies in technical expertise significantly diminish the efficacy of plastic waste management on a global level. This situation may result in the export of plastic waste from developed nations to developing countries, potentially leading to practices that pose significant risks to both environmental integrity and public health. In this context, the concept of "environmental justice" is also of great importance in terms of plastic waste trade. Consequently, the trade of plastic waste represents a complex phenomenon encompassing environmental, economic, and ethical dimensions. One of the primary approaches to reevaluating plastic waste pollution on a global scale in a more equitable and inclusive manner is through the lens of the Sustainable Development Goals, which emphasize the necessity of addressing this issue not solely as an environmental concern, but also as a matter of environmental justice (Stoll et al, 2020).

On the other hand, the research findings reveal that, over a period of 28 years, a total of 923 authors have published works pertaining to the trade of plastic waste, whereas 879 authors have contributed to only a single publication. This data suggests a low level of productivity within this field, as supported by Lotka's law. Nonetheless, it is crucial to recognize that there has been a significant increase in awareness regarding this issue, particularly in the aftermath of 2018.

According to Bradford's Law, which is a significant finding of the study that may assist new researchers interested in investigating the trade of plastic waste, the core sources of relevant literature include *Resource Conservation and Recycling*, * Journal of Clean Production*, and *Waste Management*. It can be asserted that these journals represent the primary resources for researchers seeking to investigate the trade of plastic waste.

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[7] https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/basel-convention-on-hazardous-wastes/
Access date: 15.06.2025

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APPENDIX-I

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
World	9.887,92	7.340,58	6.625,88	6.147,45	3.047,88	2.847,75	2.318,31	3.197,69	3.963,72	
China	6.034,667	4.183,374	3.694,425	3.259,988	39.036	508	180	0	0	
Netherlands	270,10	217,50	194,74	208,89	194,16	188,77	175,10	300,91	412,27	300,64
USA	287,33	234,81	233,79	244,17	268,86	246,98	232,96	367,81	378,05	306,75
Türkiye	44,40	35,64	49,58	76,24	116,43	113,12	139,82	195,10	296,94	202,93
Germany	234,94	195,64	187,79	168,55	158,90	167,79	141,93	212,56	290,59	179,40
Vietnam	52,19	51,48	43,57	70,82	108,09	150,16	141,53	205,79	199,62	
Taivan	88,30	83,51	71,46	80,26	193,02	181,30	133,34	156,70	186,15	143,98
Belgium	134,39	130,68	133,07	121,91	111,25	93,99	76,11	127,85	181,50	127,33
Malaysia	71,93	62,26	66,27	114,24	183,45	110,14	167,30	169,78	173,55	173,80
Spain	51,41	45,40	40,52	50,35	67,09	70,74	52,26	90,36	170,50	91,77
Italy	113,34	92,86	103,88	113,80	109,45	87,03	72,21	109,62	139,97	110,46
France	65,73	48,57	48,26	55,69	73,09	77,16	67,51	81,00	139,25	57,84
Austria	89,64	69,44	55,64	48,88	58,43	61,43	54,68	96,87	122,38	89,60
Canada	96,84	87,70	75,83	70,08	73,58	72,57	69,87	107,10	108,02	80,33
Indonesia	52,50	42,74	42,48	45,87	102,37	83,22	63,04	79,58	103,41	
Poland	38,15	41,14	49,58	59,69	78,95	68,68	54,77	75,42	102,57	81,28
United Kingdom	85,63	54,15	67,74	60,15	68,40	74,81	50,56	43,28	74,93	61,42
Portugal	26,68	22,26	22,53	28,12	33,32	28,24	18,86	37,12	59,76	35,47
Mexico	18,83	22,47	21,58	23,20	21,47	21,38	28,77	52,35	58,66	
Slovenia	33,17	30,06	28,61	24,22	25,62	32,42	23,12	41,50	54,96	35,13
India	162,76	93,40	79,74	71,89	69,14	53,84	704,00	28,71	49,18	
Thailand	21,04	11,35	14,18	27,26	72,77	46,16	25,11	40,76	47,46	57,09

Analysing Competitiveness with the Revealed Comparative Advantage Index: The Case of Türkiye and Finland[1]

Şüheda BARAN SATILMIŞ[2]

Abstract

Digitalisation has amplified the prominence of globalisation, making it a key topic across various fields, including economics, trade, culture, politics, and governance. International trade continues to evolve and transform rapidly, while technological progress has reshaped the nature of competition among countries, firms, and sectors. Exports are among the most significant factors in international competition. In this study, which aims to calculate the competitiveness of developed and developing countries, Finland, ranked high in the Global Competitiveness Index, is included as a developed country, and Türkiye, whose exports are increasing daily, is included as a developing country. To access the foreign trade data of countries, the databases of the Republic of Türkiye's Ministry of Trade and Trade Map were utilised, and the Harmonised System, accepted worldwide, was employed for product classification. Between 2018 and 2024, Türkiye's and Finland's RCA indices were calculated for 21 groups and 99 chapters, and their international competitiveness was analysed. As a result of the study, it was observed that Türkiye has a competitive advantage in more chapters. On the contrary, since Finland ranks among the top three in the Global Competitiveness Index and is classified as a developed country, the findings suggest that Türkiye should prioritise R&D investments aimed at producing high-value-added goods and should closely monitor and implement technological advancements to enhance its competitiveness.

Keywords: *Revealed Comparative Advantage Index, Exports, Competitiveness*

JEL Codes: *F10, F12, O57*

INTRODUCTION

Globalisation and rapid technological advancement have significantly reshaped the dynamics of international competition. In today's global economy, technology is no longer a complementary factor but a central determinant of economic performance and international competitiveness. As global markets become increasingly integrated, countries and firms are compelled to innovate, adapt, and position themselves strategically in order to sustain their competitive edge. In this context, the ability to produce and export high-value-added, technology-intensive products has emerged as a key indicator of competitiveness.

Technological capacity is particularly crucial for countries seeking to enhance their global trade position and advance up the value chain. Exporting firms play a vital role in this transformation, as they serve as the main

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actors in projecting national competitiveness onto the global stage. Accordingly, understanding the technological profiles of exporting sectors and their contribution to international competitiveness offers valuable insights for policymakers, industry stakeholders, and academics alike.

This study aims to evaluate and compare the competitiveness of a developed and a developing country—Finland and Türkiye, respectively—through the lens of technology-based export performance. Finland is selected as the representative of a developed economy due to its consistent top-ranking performance in the Global Competitiveness Index and its innovation-driven export structure. Türkiye, on the other hand, represents a developing economy with an increasingly dynamic export profile, showing significant potential for growth in technology-intensive sectors.

The main objective of the study is to conduct a comparative analysis using the Revealed Comparative Advantage (RCA) index to identify and classify competitive export groups in both countries. By analysing sectoral competitiveness, the study seeks to highlight the role of technology in enhancing national trade performance and to contribute to the literature by offering an empirical perspective on how different stages of economic development influence competitive capacity in the global market.

In the first part of the study, the relevant literature on technology and competitiveness will be reviewed, followed by an empirical analysis of sectoral competitiveness in Finland and Türkiye. The findings are expected to provide policy-relevant insights into how developing economies can enhance their competitive position through targeted investments in technology, research and development, and innovation.

Competitiveness

The concept of competition

The concept of competition is a term that is frequently used, but there is no consensus on its definition, and it carries different meanings depending on the situation and environment. Although it has different definitions in the literature, the concept of competition expresses the same phenomenon in every definition. According to the Law on Protection of Competition No. 4054, competition is defined as "competition among enterprises in the markets of goods and services that enables economic decisions to be made freely" (Law on Protection of Competition, 1994). On the other hand, the Turkish Language Association defines competition as "the rivalry, competition, or race between people who pursue the same goal" (Turkish Language Association, n.d.).

In other words, competition can also be defined as a behavior related to the orientation of pursuing human interests, organised around a specific market model, and is a concept inherent in human nature (Kılıçbay, 1985). The main purpose of competition is to ensure sustainability and maximise profit (Sarıdoğan, 2010). Competition is a topic of great importance and debate in the economics literature. Although this issue has been present in commercial life since ancient times, it was only after the Industrial Revolution that competition gained importance

in economics and became the primary topic of study. In economics, competition refers to the commercial competition between economic units that forms the basis of the market economy (Baltacı, Burgazoğlu, & Kılıç, 2012). In his book The Wealth of Nations, written in 1887, Adam Smith mentioned two roles of competition: the stabilising role of competition and the imbalance-creating role of competition. According to him, free competition supports the free movement of factors of production and balances supply and demand in the market (Smith, 1997). In this role, competition deals with a process of efficient resource allocation that leads the economy to equilibrium. Its other role, disequilibrium, is to make capital accumulation and sustained economic development available to owners of capital who have the objective of maximising profits. Competition increases the amount of capital and also provides incentives to explore new markets by discovering innovative production methods.

To summarise, according to Smith, competition is a process that creates both equilibrium and imbalance in economic terms (Tanyeri, 2000). According to classical economists, competition holds special importance in increasing individual and social welfare. In contrast, neo-classical economists have considered competition within the framework of market structure, with the most important factor determining competition being the number of firms. When there is only one firm in the market, a monopoly is formed, and there is no competition. If there are many firms in the market and no single firm dominates the market, we can discuss perfect competition (Kırankabeş, 2006). In classical economics, the equilibrium price occurs at the point where supply and demand are equal in a perfectly competitive market. This equilibrium is the ideal equilibrium. The market price may be below or above the equilibrium price, in which case it returns to the equilibrium point through the competition between buyers and sellers (Dinler, 2013). Although it is said that competition between buyers and sellers is an element that ensures equilibrium, competition between firms also includes issues such as product differentiation, product development, and innovation (Tokatlıoğlu, 1999). Today, it is noteworthy that the concept of competition is increasingly information- and technology-based, as well as innovation-oriented. With the changes brought about by globalisation and developments in the world economy, the concept of competition has gained more prominence in the literature. The concept of competition has been analysed in the literature at the firm, national and international levels. Based on the concept of comparison, competitiveness is defined as the advantage that firms, industries, or countries have over their competitors (Cockburn, Siggel, Coulibaly, & Vézina, 1999).

The concept of competitiveness

Just as with the concept of competition, numerous academic studies have been conducted to define the concept of competitiveness. This concept is defined in various ways depending on different fields and criteria, and a common definition that fully explains competitiveness has not been reached. According to the World Economic Forum (WEF), competitiveness is defined as the productivity level that encompasses all organisations and institutions capable of sustaining economic growth in a country, as well as the policies being implemented and

production factors that contribute to achieving sustainable economic growth (Ovalı, 2014). The Organisation for Economic Cooperation and Development (OECD) defines competitiveness as the ability of a country to produce goods and services that can withstand foreign competition in free market conditions while increasing its real gross domestic product (Reinert, 1995). According to the International Institute for Management Development (IMD), "competitiveness is the ability of a country to create an environment that can continuously increase value-added" (Hounie, Pittaluga, Porcile, & Scatolin, 1999).

Competitiveness is about providing superior services and, most importantly, being perceived as superior to high-quality and differentiated products from competitors or other organisations in the market (Bal & Erkan, 2019). According to Landau, competitiveness is defined as achieving a high standard of living and an acceptable growth rate in the country by reaching the level of full employment or close to full employment without reducing the living standards of future generations or compromising the country's growth potential (Landau, 1992).

The concept of competitiveness can be analysed on a country, sector, and firm basis and can also be examined in both micro and macro dimensions. In the micro dimension, the competition among firms within the country and the effects of this competition in the national or international market are discussed. In contrast, from a macro perspective, the country's position in international competition is emphasised (Scott & Lodge, 1985, p. 20). According to Krugman (1994), competitiveness is a concept that should be handled at the enterprise level. However, when analysed at the country level, it is synonymous with productivity and, therefore, not very meaningful. When firms compete with each other, one firm loses and the other gains.

In contrast, countries can benefit from each other due to the law of comparative advantage. Therefore, Krugman (1994) argues that the concept of competitiveness means different things for firms and countries (Krugman, 1994). In academic studies, competitiveness has been analysed at micro and macro levels. In this study, competitiveness will be analysed at the micro, firm, and industrial levels, as well as the macro and country levels.

Competitiveness at the Micro Level

Micro-level competitiveness studies focus on research that aims to identify the competitiveness of individual firms and sectors composed of those firms. Cockburn et al. (1988) define the competitiveness of a firm at the micro-level as the ability to produce and sell its products and services at a price equal to or lower than that of its competitors. In other words, micro-level competitiveness refers to a firm's ability to achieve a competitive advantage over its domestic or foreign competitors in terms of non-price factors such as product quality, delivery time, or after-sales service (Kibritçioğlu, 1996). To achieve high competitiveness in the market, a firm must satisfy its customers in both terms of product and service quality, as well as operational excellence. It is crucial to satisfy customers not only before but also during and after the sales process. If a firm can achieve customer satisfaction, it can maintain its market continuity.

Another approach to the concept of competitiveness is Porter's approach. Porter (1991) examines this concept from the perspective of improving society's living standards, defining competitiveness as the ability to increase productivity through the possibility of competition. Competitiveness depends on factors such as research and development activities, sector performance, countries' net exports, the use of highly developed services or products created with high technology, and the use of qualified human resources. The primary aspects focused on to increase productivity and production, which are associated with competitiveness, include enhancing product and service quality, introducing new qualities that differentiate the product, increasing efficiency in the production stage, and achieving high levels of automation (Porter, 1991).

Industrial competitiveness, on the other hand, is measured by the competitiveness of firms within a specific industry. Markusen (1992) defines industrial competitiveness as the ability of an industry to surpass its competitors with high levels of productivity, sustain that level of productivity, and produce and sell at a lower cost than its competitors (Markusen, 1992).

According to the OECD (1994), international competitiveness is defined as a country's ability to produce goods and services under transparent and free market conditions and to maintain and increase economic welfare. Competition is a race to bring out the best in individuals. While striving to achieve competitive power or competitiveness, participants aim to be the best in this race. To increase their competitiveness, businesses will reevaluate their technology, cost, and differentiation competencies, develop innovations based on these competencies, or create differences compared to their competitors (Bal & Erkan, 2019, p. 628).

Competitiveness, which is managed at various levels, is defined as the ability of firms to offer high-quality products or services at a low cost. It is stated that the determinants of a firm's competitiveness are organisational structure, innovation capability, management structure, firm standards, and productivity, which affect cost, quality, and price (Kırankabeş, 2006, p. 236). The source of competitiveness can be different. It can be caused by price and cost, or by other factors such as quality and after-sales services (Arık, 2019).

Competitiveness at the macro level

At the macro level, competitiveness has been defined by the World Economic Forum, an international organisation that measures competitiveness among countries since 1979, as "a set of institutions, policies, and factors that determine the level of productivity of a country." Macro-level competitiveness refers to international competitiveness, which is defined as a country's ability to produce goods and services demanded in the global market, increase real income, and raise the welfare level of its citizens (Haque, 1995).

A country's main economic goal is to increase the standard of living of its citizens and ensure they have a secure future. The key to achieving this goal is to produce efficiently and use resources effectively. The majority of research at this level takes David Ricardo's Theory of Comparative Advantage as a reference point. It is stated

that increasing international competitiveness or gaining a competitive advantage over rival countries depends on research and development activities, natural resources and capital, technological change flexibility, education level, and macroeconomic impacts (Arık, 2019). Countries also attach great importance to the issue of balance of trade to increase their international competitiveness. An increase in total productivity, an improvement in living conditions and standards, and a rise in gross national income could be indicators that a country is at the top of the competitiveness rankings. A country's level of welfare can also provide insight into its competitiveness (Karaaslan & Tuncer, 2010).

Factors affecting international competitiveness

The concept of international competition has been defined in various ways in the literature. The concept of international competitiveness, which has been defined in various ways over time, has become a key goal in the efforts of national economies to achieve high levels of performance. The international competitiveness of a country is related to the international competitiveness of its businesses (Herciu, 2013). What makes competition global is to think globally and to create and develop a permanent situation at the firm, regional, or national level by harmonising the domestic potentials of the step to be taken (Dulupçu, 2001).

The determinants of competition can be classified in various ways. These determinants can be analysed at the country, industry, and firm levels, as well as in terms of price and non-price factors (Atik, 2005, pp. 56-60). Porter (1990) summarised the factors affecting competition in four headings: the structure, strategy, and competition of the firm, factor conditions, demand conditions, and related and supporting industries (Porter, 1990, p. 78). In Porter's Diamond Model, in addition to four internal factors, two external factors are mentioned: government and chance.

Indices used in measuring competitiveness

Factors determining competitiveness and studies related to these factors have been a topic of discussion in the literature for many years. The first of these studies was Balassa's (1965, as cited in Seyoum, 2007) attempt to measure the competitiveness of countries using the concept of revealed comparative advantage. The approach put forward by Balassa was a method that incorporated non-price factors, as well as production activities, in the analysis. In the relevant analysis, exports are linked to domestic production, while imports are associated with domestic consumption. In practice, the explained comparative advantage approach is used to determine the role of factor returns or factor intensities (Altay, 2006).

Relative export advantage index

Vollrath (1991) criticised Balassa's Revealed Comparative Advantage Index theory as insufficient because it only considered exports for the calculation. Instead, he proposed three alternative indices as an alternative to the RCA. The first index is the Relative Export Advantage Index.

Relative import advantage index

Another index developed by Vollrath (1991) is the Relative Import Advantage Index. The RMA index is the ratio of the share of imports of a particular product or sector in the country's total imports to the share of worldwide imports of that product or sector in the total world imports.

Relative trade advantage index

Relative Trade Advantage (RTA) is equal to the difference between the Relative Export Advantage Index (RXA) and the Relative Import Advantage Index (RMA) (Vollrath, 1991). If the index value is greater than zero, it indicates that the country has a competitive advantage in the relevant sector or product. Conversely, a value less than zero signifies a competitive disadvantage in the same sector or product.

Revealed comparative advantages index

The concept of revealed comparative advantage is based on the specialisation in international trade, and new studies have continued to be conducted by adding different factors to this approach. Theories that argue the accumulation of factors in a country determines its competitive power in international trade have proven inadequate in explaining economic events in daily life, leading to the development of new theories (Cho & Olsen, 1998).

Revised competitive advantage index

The Revised Competitiveness Index (RC) is calculated by taking the logarithms of the Relative Export Power Index and the Relative Import Power Index and then calculating their differences. In his 1991 study, Vollrath stated that the RC Index is a more preferable measurement method than lnRXA and RTA because it reflects the balance between supply and demand more accurately. He also states that it would be more appropriate to use RCA and lnRXA instead of RC and RTA in case of distortions caused by import policies. Vollrath (1991) emphasises that various alternatives can also be applied in policy making.

The Revised Competitiveness Index encompasses both supply and demand balances. If there is bilateral trade between two countries, the Revised Competitiveness Index serves as the benchmark. If the value is greater than zero, it indicates that the country has a competitive advantage in the relevant product or sector. Conversely, if the value is less than zero, it means that the country does not have a competitive advantage in that sector or product. Since this index is calculated using both export and import values of countries, the results are more applicable.

COMPETITION AND EXPORT RELATIONSHIP

The fundamental common characteristics of companies that gain an advantage in competition against their competitors in the market include creating value for their customers, possessing unique skills, and producing

goods and services at a low cost. These characteristics enable them to have a dominant and advantageous position in the market compared to their competitors.

Suppose economic growth is considered to stem from exports. In that case, an industrialisation strategy based on exports is essential for more effective growth, as it opens up products used in the industry to international markets and shifts towards global trade.

In an industrialisation policy based on exports, the primary aim is to create a more competitive economy by utilising global input prices, enhancing quality standards to produce higher-quality products and services, increasing workforce productivity, and reducing production costs. To make unused capacity more efficient in industrialisation, it is necessary to be economically integrated with price and cost elements. Opening up to international markets and achieving economic integration is the means to compete. Export is one of the most efficient and fundamental tools for gaining a competitive advantage in the market.

In his study examining the relationship between exports and competitiveness, Kahveci (2013) refers to Kaleka (2002), stating that "export competitive advantage means that firms achieve a more competitive position by combining cost, service, and production elements in the international market." The cost advantage in exports is related to the cost of the product produced per unit, the cost of raw materials, the selling price to customers in foreign markets, and the total cost of all products sold. Product advantages are related to the quality standards of the exported product being above average, proper packaging, the product and brand image in the market, and product design (Piercy et al., 1998; Morgan et al., 2004; Kaleka, 2002). In this context, the competitive advantage in exports refers to the position a company achieves against its competitors in a specific international market by combining elements such as product, service, and cost (Louter et al., 1991).

In exports, it is much more important for the survival of the enterprise to export products that it produces and develops within its own organisation, rather than marketing products produced by other enterprises. To increase competitiveness, it is necessary to enhance production by utilising the same amount of inputs more efficiently and to produce products that meet or exceed quality standards. Instead of importing, producing products that can appeal to customers by arousing their interest will help companies better control their costs and increase their profit margins. Companies that control every stage of production and sales will be able to manage them effectively. With this, their competitiveness against competitors in the market will increase, and they will be able to maintain their presence in the market more strongly with the exported products they sell (Dilber, 2015).

Technology leads to the formation of new methods in the business field, and this formation causes some innovations in competition structures. Firms strive to achieve a more advantageous position through differentiation policies and cost leadership, aiming to gain a competitive edge over their competitors in the market. To achieve this, they must be open to innovative ideas and meet the needs of buyers by utilising

technology effectively and efficiently and launching products that differentiate them from their competitors. In the face of this situation, which prompts businesses to adopt innovative technological developments and apply them in their work, companies, suppliers, and competitors that keep pace with technological change have had to undergo significant changes. From this perspective, just as businesses, countries have also been significantly impacted by technological changes, innovations, and shifts in competitive conditions. When countries fail to keep pace with technological developments and innovation, and instead focus on more traditional trade, trade opportunities become scarce. In particular, by closely following all developments in the field of technology and increasing their support for R&D, they gain an advantage over rival countries in competition in international markets. While on the one hand, firms strive to update and improve their technology base in order to increase their competitive advantage due to the rapid diffusion of new technologies, on the other hand, they may face significant problems in accepting the innovations that come with these new technologies within the firm (Zhou & Li, 2007).

Another effect of technological changes on the competitiveness of firms is the reduction in capital costs. In periods when technological developments were not yet in place, firms were required to hold stocks of semi-finished goods, finished goods, and raw materials. As the working capital requirements of firms holding large amounts of stock increased, so did their costs during periods of rising interest rates. Technological developments, which can be significantly enhanced through the application of scientific studies with R&D organisations, have always had a profound impact on enterprises active in the production of goods and services, first through mechanisation and then through automation, following the Industrial Revolution (Şimşek & Akın, 2003).

Generally, radical changes in the economy are mainly dependent on the pace of technological progress. Technological advancements serve as the focal point for companies to focus on globalisation and reach economies of scale. Global companies need to leverage technological innovations to enhance their operations in every sense and ensure that this growth is sustainable. This situation means that technology both promotes globalisation and develops as a result of it (Şimşek & Akın, 2003). The effects of this close connection between globalisation and technology on the industry can be summarised as follows: Technological innovations and developments, considered the most fundamental elements of growth and competition, offer significant opportunities for Türkiye. Technological advancements are considered a key element for both countries and firms to be proactive and competitive in international markets. To take advantage of these opportunities in the best possible way, we must objectively evaluate our deficiencies, strengths, the level of technology we have, and our needs to build our policy on realistic foundations and determine a strategy accordingly (Çetindamar & Gürsel, 2009). There are various methods used to assess a country's competitive power in international markets. These methods are generally classified into two main categories: price-based and non-price-based factors (Kibritçioğlu, 1996). Price-based factors include elements such as unit labour costs, exchange rates, and the price levels of exported goods, which

directly affect a country's cost competitiveness. Non-price-based factors, on the other hand, refer to qualitative and structural components such as technological capacity, R&D activities, innovation performance, brand value, institutional quality, human capital, and logistics infrastructure. Among these, technology and R&D activities stand out as crucial drivers of sustainable competitive advantage, especially in high-value-added sectors (Porter, 1990; OECD, 2024)

Since competitiveness and R&D activities are mutually supportive, the R&D environment cannot be improved without an improvement in market competitiveness, and consequently, R&D investments will not increase. It is clear that if investments are not at the required levels, competitiveness will not increase (Konya Chamber of Commerce, 2006). Keesing (1965) and Kenen (1965), Grossman and Helpman (1989), Vernon (1966), Porter (1990), Krugman (1979), and Posner (1961) suggest that, besides increasing the competitiveness of R&D organisations in international markets, it is also one of the crucial factors in industry and business competitiveness.

According to Posner (1990), who believes that the level of technological development can explain competitiveness, the factors that determine superiority in the competition are a positive attitude towards technological innovations and the ability to adapt and utilise these innovations. There are cost differences in production among countries, and comparing these cost differences makes trade possible during the time lag between technological innovations that occur in any country and the time when other countries can imitate them. Companies that produce new products and services often obtain monopoly profits as a result of their investments in research and development (R&D). Producers of low-quality goods tend to be weaker than companies that produce advanced products. Therefore, innovation enhances efficiency within the company, and growth follows suit. Countries and companies that design future technologies, make R&D investments, attach importance to technology development, determine a strategy for technology development, and draw a roadmap have an advantageous position in their competition with rivals in global markets.

There are three different relationships between international competitiveness and technological innovation. Firstly, innovations in the process further increase competitiveness by reducing production costs. Secondly, secondary product innovations make their products more attractive in both the domestic and foreign markets by surpassing quality standards. Thirdly, innovations in products support the retention of these products in the market for a limited period, providing monopoly profits (Archibugi & Michie, 1998). The benefits of technological innovations in businesses and countries that prioritise innovation support a more balanced structure of foreign trade by reducing the need for imports and, consequently, lowering foreign currency expenditures in the short term. In the long term, it appears that developing skills in foreign trade and specialising in markets with very high returns is the key.

ANALYSING COMPETITIVENESS WITH THE REVEALED COMPARATIVE ADVANTAGE MODEL: THE CASE OF FINLAND AND TÜRKİYE

In this part of the study, a general overview of the trade between Finland and Türkiye will be provided. Then, RCA indices will be calculated and analysed for 21 product groups between the relevant countries. At the end of the analysis, the chapters in the groups with a competitive advantage will be examined separately to determine the extent of competitiveness.

The Ottoman Empire recognised the independence of Finland in February 1918, which was declared on December 6, 1917. Political relations between the Republic of Türkiye and Finland were established with the signing of the Treaty of Friendship in 1924 (Republic of Türkiye Ministry of Foreign Affairs, n.d.). In 2010, Türkiye and Finland spearheaded the "Mediation for Peace" initiative to enhance the effectiveness and capacity of the UN in peacemaking. They established the Mediation Friends Group (ADG), the only forum on this issue within the UN framework. The ADG has 61 members, comprising 53 countries and eight international or regional organisations, including the UN.

- Main products exported: motor vehicles, garments, electrical equipment and appliances, textiles, and iron and steel products.
- Main imported products Include Paper and cardboard products, pulp, industrial machinery, electrical appliances, iron and steel, and plastic raw materials (Republic of Türkiye Ministry of Foreign Affairs, n.d.).

Direct investments from Türkiye to Finland between 2002 and 2023 totalled USD 67 million, while direct investments from Finland to Türkiye during the same period amounted to USD 447 million. Upon examining the relevant data, it is observed that Türkiye and Finland have complementary industrial structures (Ministry of Trade of Türkiye, 2022). On the other hand, considering Türkiye's strength in manufacturing and its competitiveness in traditional export markets, there is great potential for development in economic relations with Finland.

Table 1: Türkiye's Trade with Finland
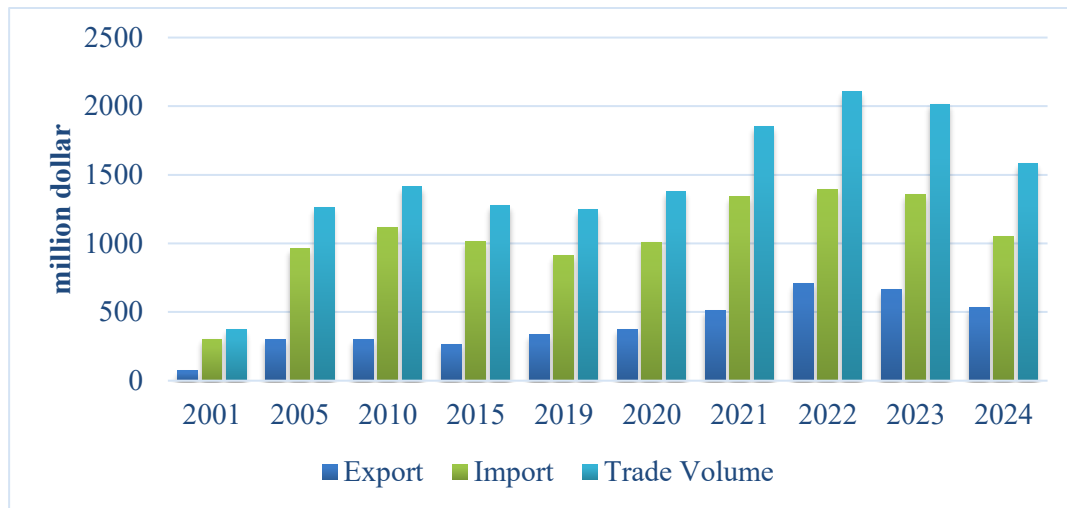
Source: Trademap (Graph prepared by the author based on data)

The graph above shows the trade data between Türkiye and Finland. It displays data on four variables: exports, imports, total trade volume, and trade balance. The graph covers the period between 2001 and 2023 and visualises the change in trade over the years. Türkiye's exports to Finland have generally been on an upward trend since 2001, with a significant increase, especially after 2020. Imports, on the other hand, follow a similar trend, with periods of decline and recovery in certain years. Around 2010, imports were significantly higher than exports, and Türkiye had a foreign trade deficit with Finland. There has been an increase in imports and exports in the last 3 years. Although there were improvements in the trade balance from 2010 to 2015, the trend reversed in 2019, resulting in a negative increase. The deficit in the trade balance indicates that imports from Finland exceed Türkiye's exports. Under the infrastructure provided by the EU Customs Union, Finland can obtain some consumer and industrial products from Türkiye at competitive prices. Regarding investments in Türkiye, new markets can emerge in Central Asia and Africa, primarily for the domestic market. This can provide a competitive advantage over Finland, which has high labor costs.

Table 2: Türkiye and Finland's Exports to the World
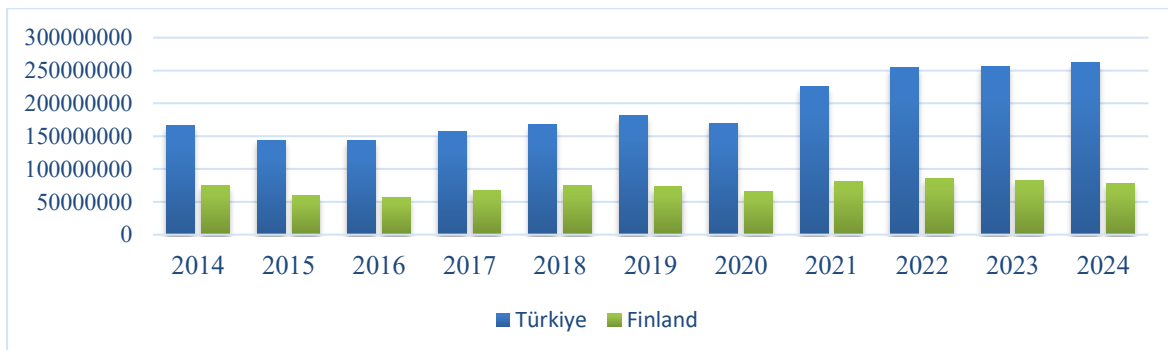
Source: Trademap (Graph prepared by the author based on data)

The above table shows the values of goods exports between 2014 and 2024. Upon examining the table, it can be seen that Türkiye's exports exceed those of Finland. Türkiye's exports, which followed a fluctuating course

between 2014 and 2016, entered a sharp upward trend, especially after 2020. Between 2021 and 2024, they reached record levels and stabilised at 25 million units. Finland, on the other hand, has maintained a more stable but limited export level in the same period. Despite the decline observed in 2015 and 2016, there has been a gradual recovery towards 2021, but the overall export volume remains well below Türkiye's. Additionally, there is a noticeable decline in exports for both countries when transitioning from 2019 to 2020, which is attributed to the COVID-19 pandemic. With most sectors disrupted by the pandemic, production has ceased, and exports have decreased.

Table 3: Türkiye-Finland-World Export

	2018	2019	2020	2021	2022	2023	2024
Türkiye	167.923.862	180.870.841	169.657.940	225.264.314	254.171.899	255.412.194	261.801.501
Finland	75.258.290	72.839.176	65.606.976	81.500.265	86.228.240	82.567.753	78.154.637
World	19.328.891.567	18.762.111.637	17.494.364.089	22.148.212.524	24.718.768.68	23.651.975.102	23.879.911.094

Source: Trademap (Graph prepared by the author based on data)

Table 3 presents the values of goods exports from 2018 to 2024. Upon examining the table, it can be seen that Türkiye's exports exceed those of Finland. When examining export data for the 2018–2024 period, a remarkable increase in Türkiye's exports is observed after 2020. Despite the pandemic's impact on global supply chains, especially in 2021, Türkiye increased its exports by approximately 33% and continued this upward trend until 2023. This shows that Türkiye has strengthened its position as an alternative producer country in supply chains. Finland, on the other hand, has followed a more stable course; despite reaching its highest export value in 2022, it has experienced a slight decline in 2024. This situation reflects the high-tech, yet more limited-volume, sector specialisation in Finland's export structure. Following the sharp decline observed in 2020, a strong recovery was experienced in 2021; however, a slight contraction was observed again in 2022. In this context, Türkiye's export growth, which exceeds global trends, highlights the structural elements driving the increase in competitiveness. Additionally, there is a noticeable decline in exports for both countries when transitioning from 2019 to 2020, which is attributed to the COVID-19 pandemic. With most sectors disrupted by the pandemic, production has ceased, and exports have decreased.

DATA AND METHOD

In this study, the competitiveness of countries will be analysed by calculating the index of revealed comparative advantages.

Index of Revealed Comparative Advantage:

$$RCA = \frac{\dfrac{\mathrm{Xug}}{\mathrm{Xut}}}{\dfrac{Xnu}{Xnt}}$$

In this equation, X_{ug} represents the exports of country u in product g, while X_{ut} denotes the total exports of country u across all products t. Similarly, X_{ng} stands for the total world exports of product g, and X_{nt} represents total world exports of all products t. If the RCA value is greater than 1, the country is considered to have a revealed comparative advantage in that product; if it is less than 1, it indicates a comparative disadvantage. This index helps determine a country's relative export performance in specific product groups compared to the world average. The approach aims to determine the relative export performance of countries in the identified products.

RCA index analysis:

$0 \leq RCA \leq 1$: No comparative advantage exists

$1 < RCA \leq 2$: Low level of comparative advantage

$2 < RCA < 3$: Moderate level of comparative advantage

$3 < RCA$: High level of comparative advantage (Peker, 2016).

The concept of revealed comparative advantage is based on the specialisation in international trade, and new studies have continued to be conducted by adding different factors to this approach. Theories that argue the accumulation of factors in a country determines its competitive power in international trade have proven inadequate in explaining economic events in daily life, leading to the development of new theories (Çivi et al., 2008).

The list used in the study is the classification of goods according to the Harmonised System, managed and updated by the World Customs Organisation. The export data for Türkiye, Finland, and the world used in the Revealed Comparative Advantage index was obtained from TradeMap.

Table 4: Commodity Group Classification List according to the Harmonised System

No	Description of Goods	No	Description of Goods
01-05	Live Animals; Animal Products	64-67	Footwear, Headgear, Umbrellas, Sun Umbrellas, Walking Sticks, Seat sticks, Whips, Riding Crops and Parts Thereof; Prepared Feathers and Articles Made therewith; Artificial flowers; Articles of Human Hair
06-14	Vegetable Products	68-70	Articles Of Stone, Plaster, Cement, Asbestos, Mica or Similar Materials; Ceramic Products; Glass and Glassware
15-15	Animal, Vegetable or Microbial Fats and Oils and Their Cleavage Products; Prepared Edible Fats; Animal or Vegetable Waxes	71-71	Natural Or Cultured Pearls, Precious Or Semiprecious Stones, Precious Metals, Metals Clad With Precious Metal, And Articles Thereof; Imitation Jewellery; Coin
16-24	Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco and Manufactured Tobacco Substitutes; Products, Whether or Not Containing Nicotine, Intended For Inhalation Without Combustion; Other Nicotine-Containing Products Intended For The Intake Of Nicotine Into The Human Body	72-83	Base Metals and Articles of Base Metal
25-27	Mineral Products	84-85	Machinery And Mechanical Appliances; Electrical Equipment; Parts Thereof; Sound Recorders and Reproducers, Television Image and Sound Recorders and Reproducers, and Parts and Accessories of Such Articles
28-38	Products of the Chemical or Allied Industries	86-89	Vehicles, Aircraft, Vessels and Associated Transport Equipment
39-40	Plastics and Articles Thereof; Rubber and Articles Thereof	90-92	Optical, Photographic, Cinematographic, Measuring, Checking, Precision, Medical or Surgical Instruments and Apparatus; Clocks and Watches; Musical Instruments; Parts and Accessories Thereof
41-43	Raw Hides and Skins, Leather, Furskins and Articles Thereof; Saddlery and Harness; Travel Goods, Hand Bags And Similar Containers; Articles of Animal Gut (Other Than Silk-Worm Gut)	93-93	Arms and Ammunition; Parts and Accessories Thereof
44-46	Wood and Articles of Wood; Wood Charcoal; Cork and Articles Of Cork; Manufacturers of Straw, of Esparto or other Plaiting Materials; Basketware and Wickerwork	94-96	Miscellaneous Manufactured Articles
47-49	Pulp of Wood or of other Fibrous Cellulosic Material; Recovered (Waste and Scrap) Paper or Paperboard; Paper and Paperboard and Articles Thereof Of	97-99	Works of Art, Collectors' Pieces and Antiques
50-63	Textile and Textile Articles		

Source: UNCTAD, 2022

Findings

In this section, the Revealed Comparative Advantage index was used to analyse the competitiveness of Türkiye and Finland in 21 groups for 6 years, and the results were presented in tabular form. The Comparative Advantage model has been used mathematically to analyse the competitiveness of the products exported by Finland and Türkiye in order to determine their position in the world. The analysis findings were visualised on a graph.

Table 5: Türkiye's RCA Index in 21 Groups

Product Group	2018	2019	2020	2021	2022	2023	2024
Live Animals; Animal Products	0,70	0,66	0,65	0,73	0,82	0,73	0,72
Vegetable Products	1,58	1,70	1,62	1,55	1,52	1,66	1,69
Animal, Vegetable or Microbial Fats and Oils and Their Cleavage Products; Prepared Edible Fats; Animal or Vegetable Waxes	1,21	1,17	1,40	1,34	1,94	1,74	1,75
Prepared Foodstuffs; Beverages, Spirit and Vinegar; Tobacco and Manufactured Tobacco Substitutes; Products, Whether or Not Containing Nicotine, Intended for Inhalation without Combustion; other	1,36	1,33	1,39	1,33	1,47	1,47	1,41
Mineral Products	0,34	0,54	0,47	0,47	0,49	0,52	0,59
Products of the Chemical or Allied Industries	0,46	0,46	0,50	0,45	0,54	0,53	0,53
Plastics and Articles Thereof; Rubber and Articles Thereof	1,20	1,24	1,26	1,27	1,41	1,40	1,38
Raw Hides and Skins, Leather, Furskins and Articles Thereof; Saddlery and Harness; Travel Goods, Handbags and Similar Containers; Articles of Animal Gut (Other Than Silk-Worm Gut)	0,69	0,66	0,61	0,70	0,73	0,59	0,61
Wood and Articles of Wood; Wood Charcoal; Cork and Articles of Cork; Manufacturers of Straw, of Esparto or Other Plaiting Materials; Basket ware and Wickerwork	0,62	0,65	0,72	0,74	0,93	1,02	1,01
Pulp Of Wood or other Fibrous Cellulosic Material; Recovered (Waste and Scrap) Paper or Paperboard; Paper and Paperboard and Articles There of	0,78	0,80	0,84	0,83	1,00	0,98	0,99
Textile and Textile Articles	3,85	3,61	3,60	3,77	3,58	3,28	3,25
Footwear, Headgear, Umbrellas, Sun Umbrellas, Walking- Sticks, Seat sticks, Whips, Riding-Crops and Parts Thereof; Prepared Feathers and Articles Made therewith; Artificial flowers; Articles of Human Hair	0,64	0,60	0,60	0,60	0,66	0,59	0,57
Articles Of Stone, Plaster, Cement, Asbestos, Mica or Similar Materials; Ceramic Products; Glass and Glassware	2,00	1,99	2,10	2,13	2,29	2,03	2,15
Natural Or Cultured Pearls, Precious or Semiprecious Stones, Precious Metals, Metals Clad with Precious Metal, and Articles Thereof; Imitation Jewellery; Coin	1,27	1,16	0,96	1,28	1,07	1,27	1,25

Base Metals and Articles of Base Metal	2,11	1,93	1,95	2,15	2,05	1,73	1,77
Machinery and Mechanical Appliances; Electrical Equipment; Parts Thereof; Sound Recorders and Reproducers, Television Image and Sound Recorders and Reproducers, and Parts and Accessories of Such Articles	0,56	0,57	0,55	0,54	0,58	0,62	0,59
Vehicles, Aircraft, Vessels and Associated Transport Equipment	1,61	1,53	1,55	1,46	1,45	1,43	1,44
Optical, Photographic, Cinematographic, Measuring, Checking, Precision, Medical or Surgical Instruments and Apparatus; Clocks and Watches; Musical Instruments; Parts and Accessories Thereof	0,15	0,19	0,21	0,19	0,22	0,24	0,24
Arms and Ammunition; Parts and Accessories Thereof	2,31	2,38	4,17	5,43	5,07	9,49	7,56
Miscellaneous Manufactured Articles	1,11	1,17	1,13	1,04	1,17	1,12	1,10
Works of Art, Collectors' Pieces and Antiques	0,08	0,05	0,13	0,08	0,08	0,08	0,08

Source: Calculated by the author with data from TradeMap.

In Table 5, the competitiveness values of Türkiye, as determined by the RCA index, are presented. As shown in Table 5, out of the 21 product groups for which calculations were made, 11 sectors exhibit competitiveness. As a result of the findings, a more detailed examination was conducted regarding the groups with a competitive advantage. The degree of comparative advantage was measured by examining the RCA indices of the relevant chapters within each group.

Table 7: Finland's RCA Index in 21 Groups

	2018	2019	2020	2021	2022	2023	2024
Live Animals; Animal Products	0,52	0,55	0,64	0,57	0,67	0,62	0,66
Vegetable Products	0,13	0,15	0,16	0,13	0,15	0,14	0,18
Animal, Vegetable or Microbial Fats and Oils and Their Cleavage Products; Prepared Edible Fats; Animal or Vegetable Waxes	0,08	0,07	0,06	0,06	0,078	0,08	0,08
Prepard Foodstuffs; Beverages, Spirit and Vinegar; Tobacco and Manufactured Tobacco Substitutes; Products, Whether or Not Containing Nicotine, Intended for Inhalation Without Combustion; Other Nicotine Containing Products Intended For The Intake of Nicotine Into The Human Body	0,29	0,32	0,31	0,32	0,34	0,33	0,35
Mineral Products	0,66	0,790	0,74	0,64	0,65	0,66	0,66
Products of the Chemical or Allied Industries	0,74	0,69	0,75	0,75	0,80	0,78	0,87
Plastics and Articles Thereof; Rubber and Articles Thereof	0,95	0,92	0,92	0,99	1,03	0,93	0,97
Raw Hides and Skins, Leather, Furskins and Articles Thereof; Saddlery and Harness; Travel Goods, Handbags and Similar Containers; Articles of Animal Gut (Other Than Silk-Worm Gut)	1,01	0,89	0,72	1,18	0,76	0,97	1,03

Wood and Articles of Wood; Wood Charcoal; Cork and Articles of Cork; Manufacturers of Straw, of Esparto or of Other Plaiting Materials; Basket ware and Wickerwork	5,69	5,60	5,38	6,24	6,45	6,00
						6,48
Pulp of Wood or of Other Fibrous Cellulosic Material; Recovered (Waste and Scrap) Paper or Paperboard; Paper and Paperboard and Articles There Of	11,61	11,08	10,30	10,65	10,27	10,10
						10,64
Textile and Textile Articles	0,20	0,19	0,20	0,19	0,21	0,21
						0,22
Footwear, Headgear, Umbrellas, Sun Umbrellas, Walking-Sticks, Seatsticks, Whıps, Riding-Crops And Parts Thereof; Prepared Feathers And Articles Made therewith; Artificialflowers; Articles of Human Hair	0,22	0,22	0,21	0,20	0,22	0,21
						0,20
Articles of Stone, Plaster, Cement, Asbestos, Mica or Similar Materials; Ceramic Products; Glass and Glassware	0,88	0,80	0,80	0,83	0,83	0,90
						0,97
Natural or Cultured Pearls, Precious or Semiprecious Stones, Precious Metals, Metals Clad with Precious Metal, and Articles Thereof; Imitation Jewellery; Coin	0,23	0,26	0,35	0,36	0,38	0,44
						0,47
Base Metals and Articles of Base Metal	2,18	2,22	2,21	2,14	2,36	2,31
						2,31
Machinery and Mechanical Appliances; Electrical Equipment; Parts Thereof; Sound Recorders and Reproducers, Television Image and Sound Recorders and Reproducers, and Parts and Accessories of Such Articles	0,80	0,79	0,80	0,76	0,83	0,93
						0,88
Vehicles, Aircraft, Vessels and Associated Transport Equipment	0,88	1,03	1,07	1,14	0,97	0,85
						0,73
Optical, Photographic, Cinematographic, Measuring, Checking, Precision, Medical or Surgical Instruments and Apparatus; Clocks and Watches; Musical Instruments; Parts and Accessories Thereof	1,30	1,33	1,35	1,27	1,44	1,40
						1,41
Arms and Ammunition; Parts and Accessories Thereof	1,59	1,58	1,75	1,98	2,00	2,01
						1,56
Miscellaneous Manufactured Articles	0,40	0,40	0,38	0,39	0,45	0,43
						0,43
Works of Art, Collectors' Pieces and Antiques	1,03	0,61	1,21	0,95	0,30	0,88
						0,80

Source: Calculated by the author with data from TradeMap

Table 7 shows the competitiveness values according to the RCA index for Finland. As seen in Table 7, out of the 21 product groups analysed, eight sectors have competitiveness. Unlike Türkiye, Finland has fewer groups in which it has competitiveness. A more detailed examination has also been conducted for Finland regarding the groups with comparative advantage identified at the end of the analysis.

When the RCA values of the chapters were analysed, the products with the highest value were determined as Furs and Imitation Furs Products. Pulp of Wood or Other Fibrous Cellulosic Materials, Paper, and cardboard were also among the products with a high level of competition. Exports of nickel, zinc and articles made from these raw materials have also been found to be highly competitive. The table shows that Finland's largest export items are paper and cardboard products. In addition, the country is also known to have a high level of technology in shipbuilding, and the RCA index value in this chapter is also high. Examining the RCA values of the product

groups, the products with the highest value are determined to be Furs and Imitation Furs. Wood or Other Fibrous Cellulosic Pulp, paper, cardboard, and similar products are also among the products with a high level of competitiveness. The RCA values of exports of goods made of nickel, zinc, and other raw materials are also relatively high, indicating a strong level of competition. Looking at the table, we can see that paper and cardboard products make up Finland's largest export items. Additionally, we can see that the country's RCA index value in the shipbuilding sector, which is known for its high level of technology, is also high in this chapter.

Table 8: Türkiye-Finlandiya Comparison Table (Summary)

	Türkiye	**Finland**
Agriculture & Food	Strong	Weak
Industrial Raw Materials (Metal, Plastic, Etc.)	Moderately Successful	Strong
High Technology (90-92)	Too Weak	Strong
Fashion & Textile	Strong	Weak
Forest & Paper	Too Weak	Serious Expertise

Source: Created by author.

Türkiye's differences in sectors such as agriculture and food, fashion and textile can be explained by various variables and economic factors. First of all, Türkiye's suitable climate conditions and diverse agreements support the production of a wide range of products, which contributes to the country's strong performance in food product production (OECD, 2024). In addition, Türkiye's proximity to key markets, such as those in Europe, the Middle East, and Central Asia, increases its competitiveness, especially in perishable products, due to lower transportation costs (World Bank, 2023).

In the fashion and textile sector, Turkey stands out with its long-standing industrial infrastructure, experienced workforce and flexible production structure. The high level of integration with the EU market, thanks to the Customs Union agreement in force with the European Union, also supports the sector's development (European Commission, 2023). Additionally, companies can gain a competitive advantage in the market by adapting to global "fast fashion" trends and meeting short delivery times (Erdil & Yetkiner, 2022).

On the other hand, Turkey's weak performance in high technology (especially in products within the scope of SITC 90–92 codes) can be associated with relatively low research and development expenditures, limited university-industry collaborations, and structural problems in the commercialisation of innovations (TÜBİTAK, 2024; OECD, 2024). While Turkey's share of high-technology product exports in total exports is currently below 3%, this rate is above 15% in developed countries (UNCTAD, 2023).

Finland's strong performance in sectors such as high technology, forestry and paper is based on its high R&D

expenditures relative to GDP (approximately 2.9%), an effective national innovation system and public-private cooperation (European Innovation Scoreboard, 2024; OECD, 2024). Finland stands out as one of the leading countries in Europe, especially in the fields of information and communication technologies, engineering and environmental technologies (Agora Energiewende, 2021).

These structural differences indicate that Turkey needs to diversify its export base, invest more in technology-intensive sectors, and develop policies that encourage high-value-added production. Sustainably increasing competitiveness will be possible not only by preserving existing advantages but also by adopting a growth strategy focused on innovation and digital transformation (Kirchherr et al., 2018; Lall & Weiss, 2020).

Examining product groups, Türkiye exhibits a comparative advantage in a greater number of sectors. However, an analysis of overall economic data shows that Finland has higher levels of welfare, stronger economic indicators and higher per capita income. What could be the reason(s) for this?

How is Finland considered a developed country despite having less exports than Türkiye?

Finland has reached world standards today thanks to its technological development. Although it is one of the youngest industrialised countries in Western Europe, its share in Gross Domestic Product has exceeded that of agriculture and forestry in the early 1960s. Today, Finland ranks among the top performers in digitalisation, R&D investment, and education-based competitiveness (World Bank, 2023; European Commission, 2023; WIPO, 2024).

Finland continues to maintain its global leadership in the forest-based bioeconomy and is internationally recognised for its advanced papermaking and shipbuilding technologies. A strong transition toward digital technologies, cleantech, and sustainable innovation has complemented the country's long-standing expertise in heavy industrial engineering. This success can be attributed to Finland's coherent science, technology, and innovation policies that emphasise R&D investment, public-private collaboration, and education-based innovation capacity (European Commission, 2023; Business Finland, 2024; OECD, 2024). As a result, the country has become a nation with a high standard of living, advanced educational opportunities, and a robust economy, ranking among the world's technological leaders.

Science and technology play a central role in shaping economic productivity and global competitiveness. In Finland, strategic investments in research and innovation have substantially contributed to the country's high-tech capabilities and economic resilience. This has not only expanded the national technological base but also enhanced Finland's ability to collaborate in international research and development initiatives. The country consistently ranks among the top in global innovation indices, reflecting the strength of its science and technology policies (European Commission, 2023; OECD, 2024; WIPO, 2024).

Finland lays the groundwork for technological development through R&D studies. The science and technology

policies implemented in the country are based on these studies. Therefore, they have been pursuing important policies regarding R&D investments from the past to the present. Since Finland is not a country rich in natural resources, it attaches importance to these studies in order to continue production and maintain its welfare as a country with a high level of prosperity. The idea that their economic assets will increase and multiply thanks to the technical knowledge gained as an information society is adopted (CORDIS, 2020). This system comprises various centres and academies throughout the country. The most important of these are the Technology Development Centre, the Academy of Finland, and the Technical Research Centre of Finland. These institutions and organisations play a major role in ensuring international cooperation by providing services and financing for R&D studies.

Finland is considered a developed country despite having lower exports than Türkiye, primarily due to its high-tech and value-added products in the sectors where it concentrates its exports. Finland is a world leader in high-tech products, particularly in telecommunications, information technology, medical devices, forest products, machinery, and equipment, as well as the chemical industry, with significant export figures in these sectors. Additionally, Finland's exports are primarily directed towards other developed countries, especially those in the European Union (Bank of Finland Bulletin, 2024). These factors explain why Finland is considered a developed country despite having lower exports than Türkiye.

Importance of Technology in Exports

There is a tight connection between technology and commerce. This connection varies among countries due to differences in their approaches towards technology. It is predicted that an innovative country will export its innovations until other countries make a technological innovation or change based on that innovation, and this will continue until other countries make a similar innovation (Seyidoğlu, 2003, pp. 82-84).

The importance of technological developments, which have been increasing rapidly in recent years, and the classification of manufacturing according to the intensity of the technology used have been significant indicators of the formation and structure of foreign trade. Achieving competitiveness at the international level depends on producing products and services that exceed global standards in terms of technology and exporting these products and services (Özmen, 2014).

For export-oriented strategies to be successful, the ability to enter the markets of developed and developing countries is as important as the policy arrangements in underdeveloped countries. Countries with insufficient levels of foreign exchange earnings try to increase their income by exporting raw materials in industrial products. The possibility of exporting from the resources currently used in production is becoming increasingly complex due to the ever-increasing global competition (Robertson, 1982).

Çavuşgil (1984) stated that there is a positive and significant relationship between the technology orientation of

the enterprise and its developed export potential. Chetty and Hamilton (1993) found in their study that the technology level of the enterprise has a positive impact on export performance. On the other hand, Anıl (2020) found a positive and significant relationship between the technology intensity of firms and their export performance. Sökmen and Danışman (2007), in their analysis of exporting firms in Türkiye, concluded that there is a positive relationship between the export performance of firms and the technologies used by firms. Beamish et al. (1993), in their study based on exporting firms in Canada, found a strong and significant positive relationship between export intensity and product technologies. Namiki (1994), in a study on exporting firms, concluded that firms with technological advantages and innovations will have high export performance. In addition to the researchers who find a positive relationship between technology and exports, some conclude that a negative relationship exists.

International trade triggers and even necessitates technology orientation. The fact that world trade is increasingly composed of products produced with advanced technology is an indication of this. In addition to the use of technology in production, companies have also taken technological steps to facilitate easier exports. The Ministry of Trade of the Republic of Türkiye has introduced online platforms utilising technology to support exports.

Kaynak and Kuan (1993) find a negative relationship between a firm's technology intensity and its export sales, whereas Axinn (1988) concludes that there is no significant relationship between a firm's technology and export performance. Supporting the export sector is often seen as a key component of the manufacturing sector. Obtaining products above quality standards in production is made possible by the use of such supports. Export subsidies are used for financial purposes such as improving the balance of payments and increasing exports. Subsidies offer firms a range of export incentives and support, including tax refunds, export credits, and exemptions on specific payments (Robertson, 1982). The liberalisation of trade based on a free economy has increased the traffic of exports in Türkiye. With the 1996 Customs Union, export transactions between countries have become much easier. While a certificate of export capability was previously required for exporting, the fact that anyone with merchant status can now export has made international trade much easier today. Rather than these legal developments, the export demands arising from companies' desire to increase profits have increased the tendency to turn to foreign markets (Dölek, 2006).

DISCUSSION

International trade is a multifaceted economic activity that involves the exchange of goods and services between countries. With the acceleration of the globalisation process, international trade has become not only the main engine of economic growth but also one of the most important means of technological transfer, specialisation and welfare increase between countries (Krugman, Obstfeld & Melitz, 2018).

In the classical theory of comparative advantage, countries' specialisation in goods and services in which they are

relatively efficient with respect to factors of production allows them to maximise total welfare through international trade (Ricardo, 2004). This situation is of strategic importance, especially for developing countries, as foreign trade enables these countries to complement their limited capital and technological accumulation with external resources, diversify their production structures, and strengthen macroeconomic stability by providing a foreign exchange inflow (World Bank, 2020).

In the competitive advantage analysis of goods in international trade, the RCA (Revealed Comparative Advantage) index, which measures comparative advantages on a product group basis, reveals the relative competitive power of a country in specific goods or services. However, the high number of products with high RCA values may not always be directly proportional to the level of macroeconomic development. A country may have relative competitive advantage in many sectors; however, the nature of these advantages, the level of added value and their weight in the economic structure are the main elements that determine the country's position in the global income hierarchy. In this context, it is necessary to discuss a development understanding that is shaped not by product diversity but by the technological level of the production structure, productivity capacity, financial depth, and the quality of human capital. When RCA analysis is conducted by looking at product groups, it is concluded that Türkiye has a comparative advantage in more sectors. Türkiye has a relative competitive advantage in many product groups (e.g. food, textiles, leather, plastic products, ready-made clothing, etc.). These sectors, in which Türkiye demonstrates a competitive advantage, are largely labor-intensive and have a medium-low technology production structure. These sectors play a crucial role, particularly in terms of employment creation and domestic demand balance, but are subject to low-margin and high-volume competition within global value chains (UNIDO, 2020). This situation clearly reveals that Türkiye's export structure must evolve into high-value-added production.

On the other hand, although Finland shows a competitive advantage in fewer product groups in the RCA analysis, these advantages are mostly based on high technology, natural resource efficiency, and R&D-intensive sectors. Finland has specialised in areas such as optical and medical devices, precision measuring instruments, paper and cellulose products and base metals and has advanced its efficiency in these areas (OECD, 2021). This provides superiority in a limited number of product groups. However, it has a significant impact on the country's economy because these advantages are concentrated in strategic and high-yield sectors.

This structural difference is clearly observed in the productivity levels of the countries. While Finland prioritises automation, digitalisation, and process efficiency in its production, Türkiye is more dominated by labour-intensive production models. As a natural result of this, per capita export data also show striking differences. As of 2023, Türkiye's per capita exports remain at approximately \$3,000, while Finland's will reach \$14,900, almost five times this value (World Bank, 2023). This situation highlights the structural differences between the two

countries, not only in terms of foreign trade volume but also in terms of economic efficiency and resource utilisation efficiency. Similarly, there are striking differences in the composition of GDP between the two countries. While the Finnish economy is based mainly on structures in the service sector, advanced technology, and a knowledge economy, agriculture and the low-tech manufacturing industry still dominate the Turkish economy (IMF, 2022). This increases Türkiye's vulnerabilities while reinforcing Finland's economic resilience.

In addition, Finland has a more developed institutional structure, including enhanced capacity, educational infrastructure, R&D activities, and an innovation culture. Finland's share of R&D expenditures in GDP is considerably higher than Türkiye's; the country exceeds the European average in terms of patent applications, innovation outputs, and global brand creation capacity. Companies such as Nokia, Kone and Wärtsilä symbolise Finland's global competitive power not only economically but also in terms of technological identity (Acemoğlu & Robinson, 2012). In summary, although Türkiye has a declared comparative advantage in more sectors, the low value-added structure of these sectors, the lack of technological intensity and low productivity levels have a limited impact on economic development and welfare. Finland, on the other hand, has achieved a more sustainable, resilient and inclusive economic welfare structure thanks to the strategic nature and high technology level of these sectors, despite showing a competitive advantage in fewer sectors.

In this age where information circulation is also effortless, countries must keep pace with technological developments step by step, make significant investments in R&D studies, and try to make their presence felt in the field by supporting various innovations, to not fall behind in the competition race and to gain an advantage in the competition against their rival countries. Countries should strive to be in a more advantageous position in terms of differentiation policies and cost leadership to gain a competitive edge in the development race against their competitors. Türkiye's export target for 2023 has been set at $ 226.6 billion (TİM, 2019). One of the foundations on which this target is based is competitiveness. The most important factors that will ensure a country's presence in the competitive arena are the exporting companies.

Companies should be integrated into a structure that combines Türkiye Trade Centres, distribution, and storage channels to maximise their competitiveness, leveraging the fast supply advantage. Especially companies that want to maintain their continuity in the international market should be open to innovative ideas and utilise technology in the most efficient way by launching a variety of products that meet the needs of buyers, thereby differentiating themselves from their competitors. The concepts of technology and innovation are important not only in product exports but also in service exports. Companies that provide services to their customers can gain a competitive advantage over their competitors by enhancing the quality of their services with innovative solutions and becoming more preferred companies in their respective markets. Businesses should keep pace with technological changes in today's environment, which drives them to implement innovative developments in the technology field.

The structural transformations experienced in the global economy over recent years have enabled developing countries to gain not only a competitive advantage but also redefine their development through high-value-added production and innovation capacity. In this context, Türkiye is making significant progress towards achieving the status of a developed country through sectoral transformation in its economic structure, technological breakthroughs, and an increase in domestic production capacity.

Especially in the last decade, Türkiye's high-tech industrial policies have prioritised not only moving away from traditional production but also R&D-based economic structuring. In this context, advances in areas such as the defence industry, automotive technologies, the software sector, civil aviation, satellite, and space technologies demonstrate that Türkiye has risen to a more strategic position in global value chains (SSB, 2023; TUBITAK, 2022). The defense industry, in particular, is one of the main examples symbolising Türkiye's rising technology capacity. National companies such as TUSAŞ, ASELSAN, ROKETSAN and BAYKAR have not only reduced external dependency with the products they have developed in the fields of unmanned aerial vehicles (UAV and SIHA), electronic warfare systems, rocket technologies and radar solutions, but have also increased high-tech exports by exporting these products (OECD, 2023). UAV platforms, such as Bayraktar TB2 and AKINCI, have entered the defence inventories of many countries, elevating Türkiye to the position of a technology exporter in this field. Similarly, TOGG, Türkiye's domestic and national automobile project, is not only a production initiative; it is also a visionary project that incorporates advanced technologies in terms of digitalisation, sustainability, and the mobility ecosystem. The fact that many high-value-added components, such as battery technologies, autonomous driving infrastructure, software integrations, and digital platform solutions, are included in the development of TOGG demonstrates Türkiye's active participation in Industry 4.0 processes (Ministry of Industry and Technology, 2023).

Türkiye also stands out in the field of information technologies with its start-up ecosystem, fintech initiatives and developments in information infrastructure. The increase in the number of unicorns, the expansion of technology clusters, and the rise in the number of technoparks demonstrate that the country has become open to global competition, not only in terms of production but also in terms of creativity and innovation (StartupBlink, 2023). In addition to these, state-supported incentive systems, investment programs for strategic sectors, and initiatives to increase university-industry cooperation within the scope of the National Technology Move, implemented in recent years, have accelerated Türkiye's transition to a high-value-added production structure. This transformation is also reflected in export data: In addition to the weight in traditional sectors, the share of software, electronics, machinery equipment, medical devices and aviation products in exports is increasing (TİM, 2023).

Therefore, Türkiye is becoming an economy that approaches the criteria of developed countries, not only in terms

of product diversity but also in its increasing technological competence, production quality, and innovation capacity. If current development strategies are continued, it seems possible for Türkiye to achieve the status of a high-income country within the next decade and to establish a competitive and sustainable economic structure based on the knowledge economy. Countries, like companies, should benefit from these technological changes and innovations and be aware of the shifts in competitive conditions to adapt to the new age. Countries that fail to keep pace with technological developments and do not increase their R&D activities to produce high-value-added products may be doomed to decline in the international trade arena through traditional trade.

CONCLUSION

This study has revealed that while Türkiye shows a comparative advantage in a broader range of sectors, these sectors are mostly labour-intensive and characterised by low to medium technological intensity. On the other hand, Finland demonstrates comparative advantage in fewer but strategically important and high-tech sectors, resulting in higher economic efficiency and export value per capita. The RCA analysis, combined with macroeconomic indicators, emphasises that the structure and value-added content of a country's export portfolio are more critical than mere sectoral diversity in achieving sustainable development and global competitiveness.

In light of these findings, it becomes evident that Türkiye must shift its export strategy toward innovation-driven, technology-intensive production. Increasing R&D investments, enhancing institutional capacity, and improving the quality of human capital are essential steps toward this transformation. By aligning export policies with high-value-added sectors and adopting long-term innovation strategies, Türkiye can enhance its position in global value chains and move closer to achieving high-income country status.

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Ecological Footprint Convergence in Emerging Market Economies: Panel Data Analysis[1]

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Abstract

In the fast-growing global landscape, environmental degradation has commenced to be recognized as an outcome of industrialization and globalization. Several indicators associated with environmental degradation are studied in the literature. One of these indicators is the ecological footprint. This indicator is considered an assessment that signifies the biological area utilized to generate the resources necessary for individuals to sustain their existence and assimilate waste. Accordingly, acknowledging the significance of current environmental policies, it is shown as an exceptionally comprehensive indicator. In this article, utilizing the 1990-2022 dataset for selected emerging market economies, the existence of ecological convergence was examined through panel unit root tests. This study found that the ecological footprint in emerging market economies was stable. This finding indicates that there is convergence within these economies to achieve global sustainability.

Keywords: *Ecological Footprint, Environmental Pollution, Emerging Market Economy*

JEL Codes*: E00, Q56, Q57*

INTRODUCTION

It is stressed that ecological degradation has influenced the earth due to influences such as industrialization growth, technological developments, demographic expansion, and urbanization level (Erden Özsoy and Dinç, 2016, p.36). All of these challenges extend the demand for natural resources and, consequently, negatively impact environmental quality.

With the deterioration of environmental quality and its perception as an important problem for countries, national and international conferences, workshops, research and meetings have been organized in recent years on environmental problems, climate changes and global warming. The first international conference on this subject was the United Nations Environment Conference held in Stockholm in 1972. In this conference, it was

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emphasized that there is a need for a partnership on a global scale in order to protect and develop the human environment and to improve environmental problems (Güçlü, 2007, p.68). Another global measure on this issue is the Bruntland Report in 1987. In this report, the concept of sustainable development has been officially brought to the agenda. In addition, issues such as global partnerships for the prevention of poverty, ensuring the control of the population growth rate, and the creation of environmentally sensitive technologies were emphasized (Turan, 2014, p.61). Other global measures and conferences on environmental problems are the Rio Conference (1992), the Istanbul Habitat II Conference (1996), the Kyoto Conference (1997), the Johannesburg Summit (2002), the Rio+ 20 UN Sustainable Development Conference (2012) and the Paris Climate Agreement (2015).

In order to achieve convergence towards reducing the ecological footprint, a multidimensional strategy is needed, including education-based, positive changes in individual and social behavior, technological advances and legal regulations. Policies that encourage waste minimization, sustainable agricultural practices, renewable energy use and energy conservation play a critical role. Advances in technology are expected to make significant contributions to reducing the ecological footprint by making resource use more efficient and generating new solutions for environmental sustainability. In addition, raising awareness of sustainable living through educational activities and awareness activities that can be passed on to future generations can facilitate the adoption of environmentally friendly behaviors (Tillaguango et al., 2021, p1-13).

Among these global measures, the Kyoto Protocol, which was adopted in Kyoto, Japan, in 1997, is known as a step to combat climate change and the environmental problems caused by it. It entered into force in 2005. In this protocol, to which Turkey became a party in 2009, many countries have committed to reducing greenhouse gas emissions (Pata, 2020, p.52).

Throughout the studies on environmental pollution, carbon dioxide emissions have been focused on as a variable. (Salaluddin et al., 2015; Wang et al., 2016; Pata, 2018). However, the increasing environmental problems and the fight against climate crises have made other indicators gain importance. One of these indicators is the ecological footprint indicator (Bucak, 2021, p.2). This indicator was first introduced by Rees (1992) and then considered as a methodological framework through Wackernagel and Rees (1996). This criterion, which has been developed for ecological measurements, is calculated in global hectares. It also shows the biologically fertile water areas and lands needed to eliminate the resulting waste, as well as the production of all the resources consumed with resource management and current technology. The fertile water areas and lands mentioned here are an indicator of the biological capacity required to meet the requirements (Wackenagel et al., 2005, p.4). Biocapacity, on the other hand, is expressed as an indicator that measures a bio-productive supply in a certain area (Forest, Pasture, Arable Land, etc.). An increase in a country's ecological deficit means a decrease in the biological capacity of that country. (Schaefer, et al, 2006, p.5-11). In other words, in a sense, the existence of an ecological deficit and the rise of this deficit shows that our people are unconsciously destroying the environment and that this is

unsustainable.

In the literature on environmental economics, the number of studies dealing with the ecological consequences of individuals' activities towards the environment has recently started to attract attention and research. However, in general, most of the studies dealing with environmental degradation have focused on issues such as the Environmental Kuznet Hypothesis and the Pollution Shelter Hypothesis. In the economic literature, convergence is stated as an approach that suggests that the gap between low-income countries and high-income countries in neoclassical growth theory will close over time (Barro and Salai Martin, 1992, p.225), and it is stated that the issue of convergence has gained importance as a research area that has not been applied to the field of environmental convergence in determining environmental climate change strategies over time (Strazicich and List, 2003, p.265).

The course and convergence trends of pollutant emissions are of great importance for predicting the future of environmental degradation and developing effective climate policies in both developed and developing countries. As a matter of fact, long-term climate change scenarios and most of the international environmental obligations are based on the assumption that pollutant emissions will converge over time. In this context, analyzing whether countries' environmental performances are converging or not can contribute to the formulation of more effective and targeted environmental policies against global warming (Belloc and Molina, 2022:2).

In today's world, environmental problems are increasing in certain countries and country groups. In particular, factors such as industrialization, rapid population growth, and urbanization cause environmental destruction. Since the focus is on rapid economic growth and industrialization process in developing countries, this situation leads to an increase in the ecological footprint indicator. In this study, which is considered in line with this perspective, ecological footprint convergence was investigated for selected emerging market economies, and the data for the period 1990-2022 were examined using the panel unit root test.

When the studies in the literature are examined from a holistic perspective, it is seen that carbon emission convergence has become the focus rather than ecological convergence. In addition, determining whether ecological footprint convergence exists in emerging market economies, which have an important position in global trade with their high production capacity and rapid growth rates, is of critical importance in terms of environmental and economic policies to be developed. It is thought that the study will fill the gap in the literature both on a variable basis and on a country basis. This study is based on four main sections. In the first part, the introduction and the second part include studies (literature) that test ecological footprint stability. The third chapter presents the theoretical background of the study. In the fourth part, the data set and methodology were introduced, and the study was terminated by making comments and suggestions in the light of econometric findings.

LITERATURE REVIEW

It can be noted that scholarly and scientific investigations referring to environmental economics have gathered considerable attention in recent years as the significance of the environment and ecological conditions has increased. In many empirical analyses within the reviewed articles of environmental economics literature, it has been concluded that carbon emissions are largely utilized. Notwithstanding this, it has been noted that studies employing the ecological footprint variable to determine stationarity and convergence among nations are limited. Thus, it is suggested that this study attempts to riches the literature in this regard.

It can be found that the first analysis evaluating the stationarity of carbon emissions within the academic was published by Strazicich and List (2003). It examined the 1960-1997 temporal data gathering for 21 industrialized economies utilizing the panel data methodology. In the results, it was suggested that carbon emissions displayed stability. One of the earlier analyses studying the stationarity of carbon emissions was analyzed by Lee and Chang (2008). In the research, in which the data gathering for the period 1960-2000 was employed for 21 OECD countries, convergence was noted in 7 countries and deviation in 14 nations was observed. In scholarly works such as Romero and Asilla (2008), Westerlund ve Basher (2008), Lee and Chang(2009), Panopoulou & Pantelidis (2009) Yavuz and Yılancı (2013), Christidou vd.,(2013), Solarin (2014), Wang, vd.(2016), Burnet (2016),Tiwari et al.(2016), Apergis and Payne (2017), Yu vd., (2018), Emir vd.(2019), Churchill et al.(2020), Apergis and Payne(2020), Topalli (2021), Payne and Apergis(2021), Apeaning and Labaran (2024) the convergence of carbon dioxide emissions was evaluated employing diverse cross-country groups and econometric methodologies

On the other side, upon reviewing studies that utilize ecological footprint, the first study was conducted by Ulucak and Lin (2017), which analyzed the stability of the ecological footprint of the United States during the period of 1961-2012. In their conclusions, they highlighted that the ecological footprint is not static. Additional studies that evaluating ecological footprint convergence are summarized in the following table (Table 1).

Table 1: Literature Review on Ecological Footprint Convergence

Author(s)- Year	Period/Country(s)	Method	Finding
Bilgili ve Ulucak(2018)	1961-2014/G-20 countries	Panel KPSS Unit Root Test	There is convergence
Bilgili-Ulucak(2019)	1961-2014/60 Countries	Panel KPSS Unit Root Test	There is deviation in Africa-America-Europe.
Solarin (2019)	1961-2013/27 OECD Country	RALS-LM Unit Root Corporal	While there was convergence in 13 countries, deviation was found in 12 countries.
Solarin vd. (2019)	1961-2014-92 countries	Panel Unit Root Test	There is convergence
Haider – Akram (2019)	1961-2014/77 countries	Phillps and Sul method	Findings supporting the club convergence hypothesis have been obtained.
Özcan et al. (2019)	1961-2013/Low-Middle-High income countries	Panel CSR Unit Root Testing	It has been found that there is ecological footprint convergence.
Pata (2020)	191-2016/N-11 Countries	Hadri-Kurozumi (2012) and Lee and Tieslau (2019) panel unit root tests	It shows that the ecological footprint per capita in N11 countries is converging
Yılancı and Pata(2020)	ASEAN 5-Countries/1961-2016	TAR Unit Root Test	The convergence hypothesis is found to be valid.
Tillaguango (2021)	1990-2016/16 Latin American Country	Logistics Regression Analysis	Findings supporting the existence of club convergence have been obtained.
Işık et al.(2021)	1961-2016/USMCA Countries	TAR Unit Root Test	It has been found that there is ecological footprint convergence.
Belloc and Morina (2022)	African Countries/1970-2018	Panel Club Convergence Test	There is not findings were obtained to support the existence of convergence
Yılancı vd.(2022)	G-7 /1961-2016	Panel Fourier Threshold Unıt root test	It has been determined that there is convergence in ecological footprint and carbon footprint.
Cabaş (2023)	1961-2018/Newly Industrialized Countries	Panel Fourier Unit Root Test	On the basis of countries, China, India, Thailand, Malaysia and Turkey, the per capita ecological footprint is unit-rooted, It has been stationary for Brazil, Mexico, Argentina, the Philippines and South Africa
Bayraktar et al.(2023)	1992-2017/BRICS-T	Panel Fourier Unit Root Test	When we look at the countries individually, it was obtained that the ecological footprint converged in Russia and Turkey according to the ADF test, in China and Russia according to the Fourier ADF test, and in Brazil and China according to the Fractional Fourier Frequency test.
Çelik et al.(2023)	ECCAS ve ECOVAS Countries/1961-2017	Panel Unit Root Test	As a result of unit root analysis, it was determined that the convergence was valid
Aragundade vd.(2023)	189 Countries/1990-2017	Panel Club Convergence Test	It has been determined that convergence is valid in the findings obtained.
Gomez and Rodrigez (2024)	ABD Countries/1990-2022	Panel Club Convergence Test	There is findings were obtained to support the existence of convergence

Source: Created by the authors.

When the literature on convergence analyses is examined, it is noteworthy that the vast majority of studies focus on carbon emissions. However, in some studies, ecological footprint, certain greenhouse gases or various combinations of these gases are also included in the scope of the analysis. It is seen that different countries and country groups have been studied. There is no complete consensus on the convergence of ecological footprint

findings. It can be said that the use of different methods, variables and countries has an effect on this.

THEORETICAL FRAMEWORK

Ecological deterioration is considered one of the factors that significantly affect the quality of an individual's life and the sustainability of economic growth. Recently, the large accumulation of greenhouse gas emissions in the atmosphere elevates ecological degradation to a high level of concern in both developed and developing countries. It is notable that the industrialization process, which occurs through the utilization of non-renewable energy in the majority of countries, harms ecological degradation in these countries and negatively impacts economic progress (Solarin, 2019, p.6167).

Convergence theory is dependent on the convergence analysis of growth dynamics, which Solow (1956) evaluated within the context of the Neo-Classical Growth Model. This theory proposes that developing countries can catch up with developed nations (Bayraktar et al., 2023, p.325). This theoretical framework, which supposes that low-income countries will achieve accelerated growth compared to high-income countries, additionally suggests that the growth rate of any country is inversely correlated with the initial per capita income level in this country. It is also highlighted that low-income countries will grow more than high-income countries over the long term and that investments in physical capital will yield significant efficacy (Üzümcü & Ayyıldız, 2022, p.29; Abdioğlu and Uysal, 2013, p.85).

By reviewing literature, convergence is categorized into beta (β) and sigma (σ) convergences. As a comprehensive definition, β convergence is examined to discover whether the relatively low-income country will grow at a rate higher than the growth rate of high-income countries and whether it can catch up with the countries with high-income levels. σ convergence, conversely, focuses on the distribution of income among countries. In addition to these classifications of convergence, it is emphasized that there exist various forms of convergence including micro and macro convergence, conditional and unconditional convergence, stochastic and deterministic convergence, convergence in growth rates and convergence in income levels, conditional convergence, and club convergence (for climate club's countries) (Ceylan, 2010, p.53).

From an economic perspective, convergence analyses are typically studied within the framework of income convergence. Nevertheless, recently, convergence analyses have been conducted concerning various economic and social indicators. One such indicator is environmental convergence. Therefore, based on the abovementioned convergence classifications, it is argued that environmental convergence is examined in a manner affiliated to economic convergence. In other words, the assumption that the actual environmental quality of countries will align over time is defined as "environmental convergence" (Brock & Taylor 2003, p.2).

For a studied country, the convergence in this context is outlined as the per capita carbon dioxide emissions equalizing over time. Besides, the concept of divergence is recognized as the increasing disparity of carbon

dioxide emissions among countries over time. Consequently, the phenomenon of convergence or divergence regarding such emissions has been explained in the literature accordingly. The significant consideration here is the reality that countries may be moved towards a specific stationary state due to economic and geographical factors or the accumulation of energy resources (Herrerias, 2013, p.1141). Furthermore, when econometric research studies convergence, convergence is observed in some countries while divergence is observed in others. This process gives insights regarding the feasibility of implementing environmental policies.

On the other hand, in order to achieve sustainable development goals, the theory of convergence has started to be discussed in the literature as environmental convergence. Environmental convergence is characterized as a theory based on examining whether environmental policies progressively become similar over time. For the first time, Strazicich and List (2003) tested the convergence analysis of carbon dioxide emissions for 21 industrialized countries. Over time, the ecological footprint indicator began to be included in the convergence analysis. Because the ecological footprint is expressed as one of the main indicators of environmental pollution, which represents sustainability. Compared to other indicators of environmental pollution, the ecological footprint indicator is a more comprehensive indicator. The ecological footprint is considered as an indicator that deals with total production and consumption instead of consumption and production activities that only cause carbon dioxide emissions. It is stated that environmental pollution indicators, especially ecological footprint convergence, may affect international climate agreements (Bayraktar et al., 2023, p.63026).

The ecological footprint indicator calculates the biological capacity required for the production of goods and services consumed by individuals living in a country, as well as the capacity required for nature to absorb pollutants resulting from these activities. In this respect, the Ecological Footprint (EFP) index assesses human-induced environmental damage in a broader framework and reflects environmental impacts in a more holistic manner compared to indicators that focus only on CO_2 emissions. Ecological footprint convergence is based on the fact that global consumption and waste generation patterns are not sustainable and that the world's natural resources are limited. Since high-income countries generally have a larger ecological footprint, they adopt more sustainability-oriented practices, increase efficiency by reducing resource use, and contribute to legal and institutional initiatives in this field by supporting environmental regulations. On the other hand, although low-income countries have a smaller ecological footprint, it is observed that they tend to increase their resource consumption in order to increase their living standards (Apaydın et al., 2021, p.53379-53393; Kazemzadeh vd., 2022, p.1-5).

In conclusion, it is suggested that the ecological footprint convergence will result in the existing environmental pollution discrepancy among countries to reduce over time. In other words, it is underscored that there will be a convergence among countries over time. In this process, it is emphasized that it is essential to study the stationary

characteristics of the ecological footprint utilizing diverse methodologies for various countries groups (Yılancı & Pata, 2020, p.106178).

EMPIRICAL FINDINGS

Data Set

In this article, the stationarity of the ecological footprint convergence for selected emerging market economies (Argentina, Brazil, China, India, Indonesia, Chile, Thailand, Mexico, South Africa, Turkey) was examined utilizing a panel unit root test for the period of 1990-2022. The ecological footprint variable was obtained from the Global Footprint Network repository.

Methodology and Findings

Methodology

- **Cross-Section Dependency Tests**

In the context of panel data analysis, the assessment of cross-sectional dependence and the evaluation of homogeneity among the units constituting the variables are crucial for determining the appropriate tests to be employed in both the estimation methodology and the stationarity examination. This is due to the fact that in scenarios characterized by cross-sectional dependency, it is necessary to apply second-generation panel unit root tests, whereas in the absence of cross-sectional dependency, first-generation panel unit root tests are utilized.

In this article, prior to the execution of the unit root analysis, an examination of cross-sectional dependence and homogeneity conditions was conducted, leading to the determination of the most suitable unit root test. A multitude of cross-sectional dependency tests are employed within the realm of panel data analysis. Among these, the Breusch-Pagan (1980) LM test, alongside the CD and CD_{LM} tests formulated by Pesaran (2004), as well as the LMadj test established by Pesaran et al., is noteworthy. The mathematical equations of these tests are delineated in equations (1), (2), (3) and (4) as follows:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}^2 \qquad \sim X^2 N \ (N\text{-}1)/2 \tag{1}$$

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}i^2 j - 1) \qquad \sim N(0,1) \tag{2}$$

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{P}_{ij} \right. \tag{3}$$

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{(T-k)\rho^2 ij - \upsilon_{Tij}}{\sqrt{v 2_{Tij}}} \qquad \sim N \ (0,1) \tag{4}$$

In all three of these tests, T represents the time dimension in the panel and N represents the unit dimension. Here,

k is the number of regressors, μ_{Tij} and v^2_{ij} are the mean and variance of (T-k) $\rho^2{}_{ij}$, respectively (Pesaran et al., 2008: 108).It is stated that in cases where cross-sectional dependence is not taken into account, erroneous parameters may be revealed with estimates tested with traditional panel estimators (Chudik and Pesaran, 2013, p.2). In order to eliminate this situation, the above tests should be applied. In this context, it is essential to determine the cross-sectional dependence for variables and the model. The zero hypothesis of the cross-sectional dependence test is established as "H_0: There is no intersectional dependence". When the H_0 hypothesis is accepted, the first-generation panel unit root tests should be preferred, and when it is rejected, the second-generation panel unit root tests should be preferred (Baltagi, 2008, p.284).

- **Homogeneity Tests**

The homogeneity test is recognized as an additional primary test that takes consideration after the assessment of horizontal cross-sectional dependence. According to Swamy (1970), this homogeneity test for slopes is estimated upon the distribution of individual slope estimations obtained from a suitable pooled estimator. It has been suggested that Swamy's test, affiliated with the F test, was formulated for panel data where the number of cross-sectional N values is less than the value of T (Akçacı and Yılmaz, 2021, p.390). The hypotheses associated with the Swamy test are as follows:

H_0: Slope coefficients are homogeneous.

H_1: Slope coefficients are heterogeneous.

- **Unit Root Test**

Prior to applying an econometric estimation, it is essential to determine whether the series intended for utilization possess stationary characteristics through the application of unit root tests; this is crucial for preemptively addressing the issue of spurious regression and for deriving economically significant econometric findings (Tarı, 2015, p.544). Given the presence of cross-sectional dependence, as identified in the following section of this article, the stationarity of the series, which fulfils the T>N condition and aligns with the structure of the panel data framework, was evaluated using the MADF unit root test, a recognized second-generation panel unit root testing method. The MADF unit root test is classified as a second-generation panel unit root testing methodology and is recognized as a test formulated by Taylor and Sarro (1998), based on the ADF test. The calculation of the MADF unit root test is conducted as follows (Yerdelen Tatoğlu, 2020, p.80):

$$\text{MADF} = \frac{(t - \Psi\hat{\beta})\Psi\left[Z'(\wedge^{-1} \otimes I_{T_j})^{-1}\right]\Psi(t - \Psi\hat{\beta})N(T - k - 1)}{(Y - Z\hat{\beta})'(\hat{\wedge}^{-1} \otimes I_T)(Y - Z\hat{\beta})} \tag{5}$$

Here $\hat{\beta}$ and $\hat{\wedge}$, according to the equation, $\hat{\beta}$ and $\hat{\wedge}$ are expressed as consistent estimators, and the MADF unit root test shows that it has a distribution of X^2 squares with N degrees of freedom (Yerdelen Tatoğlu, 2020, p.81). In

this study, MADF unit root test and Pesaran (2007) CADF-CIPS unit root test was used because it satisfies the T>N condition and has a cross-sectional dependency.

The Cross-sectional Augmented Dickey-Fuller (CADF) unit root test, developed by Paseran (2007) while considering cross-sectional dependencies among units, suggested the formulation of an enhanced test by integrating the lagged values of unit means alongside the first differences of units within the framework of the Augmented Dickey-Fuller (ADF) test. This methodology has been labeled as the Cross-sectional Augmented Dickey-Fuller (CADF) test (Yerdelen Tatoğlu, 2020, p.84). In standing out from established panel unit root tests that rely on simple averages of CADF statistics, this test is predicated upon the t-bar statistic introduced by Im, Pesaran, and Shin (2003) for the individual CADF statistics. Consequently, different asymptotic results are obtained for both individual CADF statistics and the mean test represented as the Cross-sectional Im, Pesaran, and Shin (CIPS) test (Pesaran, 2007: 266). While the CADF test is enhanced to determine stationarity at the unit level, the CIPS test is aimed to examining the stationarity of the panel (Gençoğlu et al., 2020, p.1289). Simply, the CADF test can be presented as follows:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + c \ \bar{y}_{t-1} + d_i \Delta \bar{y}_t + e_{it} \tag{6}$$

As mentioned above, determining the stationarity of the values for each cross-section utilizing the CADF test presents considerable challenges. Thus, CIPS statistics are considered for each individual section. Initially, the CADF test is conducted, then, the validity of the null hypothesis can be evaluated through the application of CIPS statistics across the entire panel.

$$CIPS = N^{-1} \sum_{i=1}^{N} CADF_i \tag{7}$$

The data presented in the figure relating to the CIPS statistics is a result of calculating the average values of the t-statistics related to the lagged variables (Pesaran, 2007, p.265-312).

Findings

- **Cross-Section Dependency Results**

In this article, the LM test developed by Breusch-Pagan (1980), which gives effective results for T>N, and the Pesaran (2004) CD test, which gives more effective results in both T>N and T<N situations, were preferred as the cross-sectional dependency test. The cross-sectional dependency test results are shown in Table 2 in the following:

Table 2: Cross-Section Dependency Test Results

Test	Breusch- Pagan LM	Pesaran CD$_{LM}$
Statistic Value	452.96	43.003

| Probability Value | 0.000 | 0.000 |

Source: Created by the authors.

The validity of the cross-sectional dependency assumption illustrates that an economic shock in one country significantly influences the economies of other countries (Bayrakdar and Soyyiğit, 2020, p.53). Analyzing the findings presented in Table 2, it was found that a cross-sectional dependency exists regarding the ecological footprint within emerging market economies, as evidenced by both sets of test results. The implementation of cross-sectional dependency confirms that the first condition is appropriate for the implementation of the second-generation panel unit root test.

- **Homogeneity Test Results**

The findings of the Swamy S test conducted in this article are summarized in Table 3. The assumption of heterogeneity indicates that countries maintain their unique characteristics.

Table 3: Swamy S Homogeneity Test Result

Swamy S Testi	Chi-Square Test Statistic Value	Probability Value
	4144.75	0.000

Source: Created by the authors.

According to the results of the Swamy S test as presented in Table 3, the Chi-Square probability value falls below the significance level set at 0.05, and the null hypothesis positing "the parameters exhibit homogeneity" is consequently dismissed, thus leading to the acceptance of the alternative hypothesis. This indicates a heterogeneous distribution within the dataset. Hence, the identified heterogeneity confirms that the required condition is fulfilled for the implementation of the second-generation panel unit root analysis.

- **Unit Root Test**

Based on the findings obtained from the cross-sectional dependency and homogeneity tests within Emerging Market Economies, it was found that the second-generation panel unit root test should be implemented. The outcomes relating to the stationarity evaluation of ecological footprint convergence across Emerging Market Economies are presented in Table 4. and Tablo 5.

Table 4.:MADF Unit Root Test Result

Ecological Footprint Variable (LFOOT) at the Level			
Obs	Lags	MADF	About 5%
32	1	82.913	25.898

Source: Created by the authors.

Table 4 Upon presenting the results of the MADF unit root analysis, it is evident that the delay length has been

established as 1. According to the MADF unit root test results, the MADF test statistic is greater than the given 5% critical value. Consequently, at the 95% confidence level, the null hypothesis H_0 was rejected, leading to the conclusion that our series exhibits stationarity. This scenario explains that it is feasible to forecast future values predicated on the historical values of the ecological footprint observed in each country and that shocks affecting the relevant variable prompt a temporary impact.

Table 5: Pesaran (2007) CIPS Unit Root Test Results

	CIPS Statistics
Variable	Level Values
Ecological Footprint Variable (LFOOT) at the Level	-5.716
	Critical Values
%1	-2.55
%5	-2.33
%10	-2.21

Source: Created by the authors.

If the statistical value resulting from the CIPS unit root test exceeds any of the thresholds established at the 10%, 5%, and 1% significance levels in absolute values, this indicates a rejection of the null hypothesis, thereby considering the series as stationary. Therefore, given that the absolute value of the CIPS test statistic for the LFOOT variable exceeds the critical values at the 10%, 5%, and 1% confidence levels, it can be concluded that the variable exhibits stationarity at the specified level

In conclusion, the results from both the MADF unit root test and the CIPS unit root test confirm the findings relating to convergence. Also, the results yielded by both unit root tests support the convergence of the ecological footprint within the Emerging Market Economies during the studied period.

CONCLUSION AND EVALUATION

The economic development aims that countries attempt to achieve growth to enhance welfare standards, resulting in a constant escalation in fossil fuel consumption. Consequently, this phenomenon engenders the challenges associated with climate change and global warming, thereby exacerbating environmental pollution. A principal metric of environmental pollution is identified as carbon emissions.

Carbon dioxide emissions are commonly employed in numerous searches relating to environmental pollution. Nevertheless, this singular variable is deemed not enough for a thorough analysis of environmental pollution. It has been stated that petroleum reserves, mineral extraction, and land utilization also contribute negatively to ecological well-being (Tatar, 2022, p.1027). Consequently, current studies increasingly analyze the ecological footprint indicator, which offers a more holistic approach to identifying environmental pollution.

One of the main issues in the domain of economic development is the convergence hypothesis. The convergence

hypothesis constitutes one of the fundamental assumptions of the Solow growth model. Although this hypothesis was originally characterized as a framework to illustrate income inequalities between countries with high-income levels and those with low-income levels, it has progressively become a hypothesis that explains environmental challenges over time. Environmental convergence illustrates this evolution. In this context, the validity of ecological footprint convergence, which is considered a comprehensive indicator of environmental degradation, is examined in this article utilizing a panel unit root test. The analysis, which employed a dataset covering the period from 1990 to 2022, was employed to discover the existence of ecological footprint convergence among selected emerging market economies. In the study where the MADF unit root test was used, according to the unit root test results, the critical value of the MADF test statistic at the level was greater than 5%. Consequently, at the 95% confidence level, the null hypothesis (H_0) was rejected, leading to the conclusion that the data series exhibits stationarity. In addition, considering that the absolute value of the CIPS test statistic for the LFOOT variable exceeded the critical values at the 10%, 5% and 1% confidence levels, it was determined by this test statistic that the variable was stationary at the level. In other words, it has been concluded that ecological footprint convergence exists within the aforementioned countries.

The findings reveal that the ecological footprint is stable in the countries examined, and therefore, in the long run, these countries converge in their environmental sustainability levels. This result suggests that ecological indicators have converged over time and that these countries have responded similarly to similar environmental policies or external environmental pressures. These findings, which are in line with the studies by Bilgili and Ulucak (2018), Solarin et al. (2019), Özcan et al. (2019) and Yılancı and Pata (2019) in the literature, support that emerging market economies have a certain convergence trend in terms of ecological indicators. These studies also revealed that emerging market economies show a convergence trend in ecological footprint, carbon emissions or environmental sustainability

Minimizing the gap in ecological footprints represents a significant concern for both developing and developed countries. In this regard, it is necessary to mitigate carbon emissions within emerging market economies to avoid environmental degradation. In these countries, it is essential to prioritize the increased utilization of renewable energy sources alongside the implementation of technology-driven policies that facilitate the effective deployment of these resources. Accordingly, it is suggested that environmentally sustainable energy practices be initiated instantly. It is worth mentioning that the reduction of environmental pollution and the establishment of sustainability can only be realized through the adoption of clean energy alternatives. To this end, it is crucial for governments to enhance both the production and consumption of electric vehicles, while simultaneously promoting the utilization of solar and wind energy. Achieving ecological equilibrium for a habitable planet can solely be accomplished through mindful consumption and production practices.

In the light of these findings, emerging market countries are exposed to similar environmental pressures and may experience common sustainability problems in the development process. Therefore, regional cooperation platforms can be established in order to ensure coordination in environmental regulations and practices, increase information sharing and facilitate green technology transfer. In order for countries to maintain ecological balance in sustainable development processes, it may be recommended to adopt sustainable production and consumption models that limit resource use, minimize waste generation and support circular economy. As a matter of fact, policies can be developed to increase resource efficiency especially in transport, industry and agriculture sectors. In sectors with high ecological footprint, environmental taxes should be applied to discourage environmentally damaging activities, while low-carbon production enterprises should be encouraged. Moreover, market-based mechanisms such as carbon markets and emission trading systems should be gradually implemented in this group of countries. Since the ecological footprint is directly related to individual and institutional behavior, educational policies can be implemented to increase environmental awareness and raise awareness for sustainable environmental awareness.

Ultimately, in future research, it is suggested that the ecological footprint convergence may be analyzed through the comparative analysis of individual countries and groups of countries. Within this framework, it becomes feasible to suggest policy recommendations for these countries and country groups, thereby enriching the literature accordingly.

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