VOLUME: 9 / ISSUE: 2 OCTOBER • 2025
ISSN: 2636-8307

JOURNAL OF RESEARCH IN ECONOMICS

MARMARA ÜNİVERSİTESİ YAYINEVİ

Journal of Research in Economics
Volume: 9 / Issue: 2 / Ekim 2025
Biannual International Double-Blind Reviewed Academic Journal
ISSN: 2636-8307

Contact Details
Address: Marmara University, Faculty of Economics, Maltepe Campus, 34854, Istanbul, Türkiye
Phone: +90 (216) 777 30 00
E-mail: jore@marmara.edu.tr
URL 1: https://dergipark.org.tr/en/pub/jore
URL 2: https://ikf.marmara.edu.tr/en/research/about-jore

Marmara University Press
Address: Goztepe Campus, 34722, Istanbul, Türkiye
Phone: +90 (216) 777 14 00 • **Fax:** +90 (216) 777 14 01
E-mail: yayinevi@marmara.edu.tr

Journal of Research in Economics Journal of Research in Economics publishes research papers on applied econometrics and economic modeling. JORE accepts manuscripts in English and is published semi-annually (March and October). Manuscripts are subject to a double blind review process. JORE is indexed in ECONLIT and EBSCO and is in the monitoring process of several indexes. As a publication of Marmara University Press, JORE is a free journal from submission to publication and access.

İçindekiler • Contents

RESEARCH ARTICLES

Journal of Research in Economics • Volume: 9 / Issue 2 • October 2025 pp. 58-71
ISSN: 2636-8307 • DOI: http://dx.doi.org/10.29228/JORE.43

RESEARCH ARTICLE

A BIBLIOMETRIC EXPLORATION ON LABOUR MARKET OUTCOMES OF ADULT EDUCATION

Hande KUL GELAL*

Abstract

This study provides a comprehensive bibliometric analysis of the academic literature on adult education, post-school investment, and their labor market outcomes. Drawing on data from 541 peer-reviewed publications indexed in Scopus between 1986 and 2025, the analysis maps the evolution of scholarly activity, influential authors, leading countries, leading journals, country collaborations, and thematic clusters in the field. Results show a consistent upward trend in publication activity, with particularly rapid growth after 2012, reflecting rising interest in the role of lifelong learning and adult education in labor market outcomes. The most prominent keywords include "labor market", "employment", "training", and "returns to education", while recent trends highlight the emergence of themes related to "Covid-19", "working conditions", and "experimental study". Country-level analyses reveal that the USA is the dominant contributor, collaborating primarily with Central European countries, while smaller countries such as Denmark, Turkey, and Switzerland achieve high average citations per article. The findings underscore persistent research inequalities and highlight opportunities for greater international collaboration and thematic expansion. This paper contributes to the meta-knowledge of adult education by identifying the most influential journals, dominant paradigms, and potential collaborations to *guide future research agendas and policy discussions on adult education and labor market outcomes.*

Keywords: Bibliometric analysis, adult education, post-school investment, training, labor market outcomes, bibliometrix

JEL Classification: J01, I26, C88

1. Introduction

The theory of human capital provides a foundational perspective through which education—especially adult education and post-school investments—is viewed as a strategic investment for improving various labor market outcomes. As global economies adapt to rapid technological change, demographic aging, and evolving skill demands, adult education has emerged as a key policy instrument to enhance human capital, reduce inequality, and sustain employability throughout the life course. Rooted in human capital theory (Blaug, 1976; Becker, 1964; Mincer, 1974; Schultz, 1961), the idea that learning beyond initial formal schooling can generate measurable

* Piri Reis University, E-mail: hkul@pirireis.edu.tr, hande.kul@bilgi.edu.net, ORCID ID: 0000-0002-9492-4161

Submission Date: July 07, 20025
Revision Date: July 17, 2025
Acceptance Date: July 18, 2025

economic returns has spurred a growing body of empirical research. This literature examines not only wages and employment outcomes, but also broader indicators of job quality, promotions, mobility, and productivity associated with adult learning and post-school investments.

Despite the increasing volume of studies on the labor market outcomes of post-school investments, there remains a need to systematically map the development, structure, and thematic focus of this expanding field. Traditional systematic literature reviews often fall short of capturing the evolving dynamics and intellectual landscape of such a large and diverse body of work. In this context, bibliometric analysis offers a powerful methodological approach to visualize research trends, identify influential contributions, track citation networks, and detect emerging themes across time and disciplines.

Accordingly, this study undertakes a comprehensive bibliometric exploration of the academic literature on adult education, post-school investment, and their labor market outcomes. Using a dataset of peer-reviewed publications from the *Scopus* database, the study analyzes the evolution of research activity, leading authors, influential journals, prominent countries, citation patterns, international collaborations, and thematic clusters within the field. In doing so, it aims to provide an empirical foundation for understanding how the scholarly discourse on the labor market impacts of adult education has evolved, where research efforts are concentrated, and what gaps and opportunities remain for future inquiry.

Ultimately, this paper contributes to the meta-knowledge of adult education research and informs future inquiries by highlighting underexplored areas, dominant paradigms, and collaborative networks. It serves as a resource for scholars, practitioners, and policymakers seeking to navigate and strengthen the evidence base on the labor market implications of lifelong learning. In particular, this paper provides guidance for scholars who wish to publish high-quality and impactful research on adult education and its labor market returns.

The outline of the paper is as follows: Section 2 explains the difference between systematic literature reviews and bibliometric analysis. Section 3 summarizes the literature on adult education and labor market outcomes. Section 4 presents the data and describes the methodology of the analysis. Section 5 discusses the results descriptively. Section 6 offers concluding remarks.

2. Systematic Literature Review and Bibliometric Analysis: A Comparative Perspective

Systematic literature reviews (SLRs) and bibliometric analyses represent fundamentally distinct approaches to reviewing academic literature. While SLRs have been extensively applied for decades, bibliometric analysis has more recently emerged as a prominent method. Although both aim to advance knowledge within a given field, their methodologies, objectives, and outcomes differ substantially.

A systematic literature review is a qualitative research method that rigorously and transparently collects, evaluates, and synthesizes all relevant studies on a clearly defined research question. The ultimate

purpose of an SLR is to summarize, interpret, and critically appraise the content of the literature, thereby identifying theoretical frameworks, knowledge gaps, or evidence-based recommendations. The output of an SLR generally consists of a narrative synthesis, thematic categorizations, and detailed tables summarizing the characteristics and findings of the reviewed studies.

In contrast, bibliometric analysis is a quantitative approach that measures and maps patterns within scientific publications and citations. Rather than focusing on the substantive content of studies, bibliometric analysis examines publication and citation data to reveal the structural, developmental, and collaborative aspects of a research field. Common techniques include citation counts, co-authorship network analysis, keyword co-occurrence mapping, and co-citation analysis. Bibliometric studies typically rely on large-scale publication databases such as Scopus or Web of Science, enabling researchers to identify influential authors, core journals, emerging research themes, and patterns of international collaboration. The outputs of bibliometric studies are usually visualizations of networks, productivity trends, or other descriptive metrics that characterize the research landscape.

In summary, SLRs provide an in-depth, qualitative synthesis of the existing evidence to answer specific research questions, whereas bibliometric analyses quantitatively explore the structure, dynamics, and impact of scholarly communication. The most important comparative advantage of SLRs is that they help to identify research gaps and generate new research questions. On the other hand, bibliometric analysis can be conducted more rapidly nowadays, thanks to powerful software tools. These two methods are highly complementary: bibliometric analysis can help identify influential or high-impact studies, which can then be more deeply analyzed through a systematic literature review. Together, they offer a robust strategy for understanding both the content and the broader patterns of research within a field.

3. Bibliometric Insights into Adult Education and Post-Schooling Labor Market Dynamics

This section reviews bibliometric studies related to the labor market outcomes of adult education. While several bibliometric analyses have examined topics such as adult education, lifelong learning, and human capital development, only one study has specifically addressed labor market outcomes—and it focuses solely on employability. To date, no comprehensive bibliometric study has investigated the broader labor market outcomes of adult education.

Onopriienko et al. (2023) conducted a bibliometric study on how adult education and lifelong learning are conceptualized and connected to economic policy, particularly in the context of Sustainable Development Goal 4 (SDG 4). Using Scopus data and *VOSviewer* software, they analyze global research trends and identify key themes: adult education as a driver of economic development, a social phenomenon, and a source of innovation (Onopriienko et al., 2023, pp. 17-24). They outlined four research clusters, covering various roles of adult education (Onopriienko et al., 2023, p. 20). They found that adult education is underrepresented in SDG 4 research and

emphasize the need for economic policies that support lifelong learning while clarifying the distinction between adult education and lifelong learning (Onopriienko et al., 2023, p. 25).

Lajuni and Samsu (2011) made a bibliometric analysis of scientific literature on *human capital training and education*. Using data from the Scopus database and tools like *VOSviewer* and '*Publish or Perish*', they analyzed 1,218 relevant publications (mostly in English, starting from 1968), primarily in the fields of Business, Management, and Accounting (Lajuni & Samsu, 2011, pp. 1166-1167). Their analysis reveals growing academic interest in *human capital training* and education topics and identifies potential future research areas such as education, training, employment, and innovation in the context of human capital development (Lajuni & Samsu, 2011, p. 1174).

Fejes and Nylande (2014) investigate how the emerging global economy of publication and citations (EPC) influences adult education research using data from top three [1] adult education journals from 2005 to 2012. Their findings indicate that four Anglophone countries—USA, UK, Australia, and Canada—dominate both in terms of publication volume and citation impact (Fejes & Nylande, 2014, p. 13). Anglophone authors tend to publish in journals based in their own regions, suggesting a national rather than international orientation, which reflects an Anglophone dominance and the relative marginalization of non-Anglophone scholars in academic publishing (Fejes & Nylande, 2014, p. 13).

As a continuum of their previous study '*The Anglophone International(e): A Bibliometrical Analysis of three Adult Education Journals, 2005-2012*', (2014), Fejes and Nylander (2015) investigate the structure and diversity of the adult education research field by analyzing citation patterns using the same dataset. They found signs of homogeneity within the field in terms of dominant countries (USA, UK, Australia, Canada), English speaking authors, preferred qualitative methods, interview-based research studies, and common theoretical frameworks (e.g., socio-cultural theory, critical pedagogy, post-structuralism). However, there is also evidence of pluralism, especially in the diversity of authorship, including both early-career and established researchers and collaboration studies with authors from different disciplines (Fejes & Nylander, 2015, pp. 14-19). Moreover, being a professor, or of at least co-writer of a professor, or being located at a university in either US, UK, Canada, or Australia, or conducting a qualitative study increases the chance of being cited (Fejes & Nylander, 2015, p. 19). The authors argue that analyzing citation patterns can promote reflexivity in the field and guide emerging scholars.

On the other hand, Dinh et al. (2023) conducted bibliometric research on employability using Scopus data including the period 1972 to 2019. They found growing interest in employability and three main research themes: (1) employers' expectations and higher education's role, (2) factors influencing employability (antecedents), and (3) the impact of work-integrated learning (Dinh et al., 2023, p. 3). These trends imply that employability should be viewed not merely as a set

1 The top three journals representing different regions are: Adult Education Quarterly (AEQ) for the USA, International Journal of Lifelong Education (IJLE) for the UK, and Studies in Continuing Education (SICE) for Australia.

of graduate skills but as a dynamic process shaped by personal agency within specific contexts (Dinh et al., 2023, p. 14).

4. Data and Methodology

There are several bibliographic databases supplying meta-data for researchers such as *Clarivate Analytics Web of Science (WoS), Scopus, Google Scholar,* and *Science Direct*. Each of them has different facilities. Among them *Scopus* cover high-quality articles and has strong disambiguation tools, and robust citation analysis capabilities. For this reason, I retrieved the data from Scopus archive using the advanced search query;

> TITLE-ABS-KEY((adult PRE/0 education) OR (post?school PRE/0 investment) OR (*training OR (workplace PRE/1 education) OR formal OR informal OR mass OR seminar OR (distance PRE/0 learning) OR course) AND (labor PRE/0 market PRE/0 outcome))

I limited this selection to articles, books, and book chapters published in English within the subject areas of '*Social Sciences*', '*Economics, Econometrics and Finance*', and '*Business, Management and Accounting*'. I omitted documents containing 16 excluded keywords related to obesity, health, immigration, epidemiology, demography, and similar topics. After this filtering process, 541 Scopus-indexed publications from the period between 1986 and 2025 were ready for bibliometric analysis at exactly 2025, June 20.

The main characteristics of the sample are presented in Table 1. The dataset comprises 541 documents authored by 1,180 individuals and published across 321 different sources between 1986 and 2025. Among these documents, 491 are journal articles, 7 are books, and 43 are book chapters. The average number of citations per document is 18.76%. However, references for these documents are missing from the metadata. The average number of co-authors per document is 2.39, while 158 documents are single authored by 151 unique authors.

Table 1: Main Information About the Sample

Description	**Results**
MAIN INFORMATION ABOUT SAMPLE	
Time Period	1986-2025
#Sources (Journals, Books, etc.)	321
#Documents	541
Annual Growth Rate %	9,29
Average Age of the Documents	7,97
Average Citations Per Doc	18,76
#References	0
DOCUMENT CONTENTS	
#Keywords Plus (ID)	580

#Author's Keywords (DE)	1323
AUTHORS	
#Authors	1180
#Authors of single-authored docs	151
AUTHORS COLLABORATION	
#Single-authored docs	158
Co-Authors per Doc	2,39
International co-authorships %	30,13
DOCUMENT TYPES	
#Article	491
#Book	7
#Book Chapter	43

Source: Author's own calculations using Scopus data

After the data collection period, I analyzed the data by using the bibliometrix [2] package in R software. Bibliometrix is a comprehensive science mapping analysis to determine citation networks, measuring scientific productivity, calculating co-citation, country / author collaborations, co-occurrence networks, and analyzing keywords (Aria & Cuccurullo, 2017, p. 964). It also allows for visualizing all the descriptive statistics.

5. Results

This section illustrates and discusses the results of the bibliometric analysis.

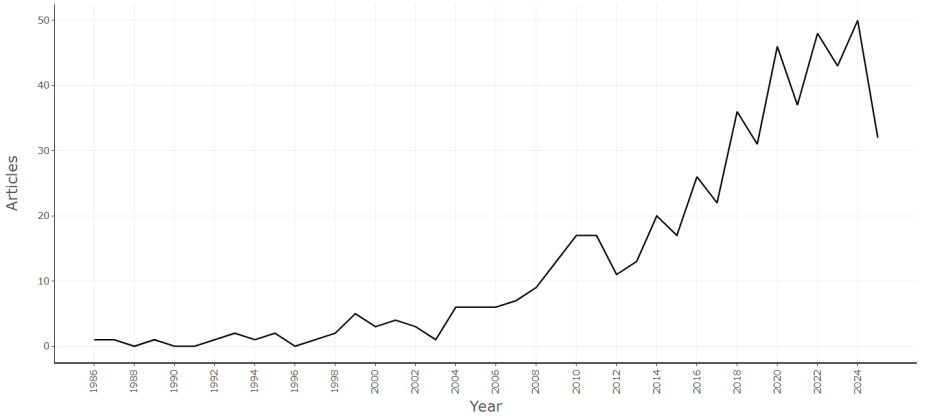


Figure 1: Annual Number of Publications

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

Figure 1 shows the number of documents published each year. Annual scientific production exhibits a generally increasing trend, with a compound annual growth rate of 9.1% since 1986,

2 An R package available at Bibliometrix: https://www.bibliometrix.org/home/index.php

despite some fluctuations. Especially after 2012, the growth pattern appears steeper compared to earlier periods. This suggests that the labor market outcomes of adult education or post-school investments have increasingly attracted scholarly interest in recent years.

Figure 2 illustrates the average citations per year for the documents in the sample. Overall, citation activity appears highly variable, with several pronounced peaks and troughs. Notably, there is a sharp spike around 2009, suggesting that some highly influential publications emerged prior to this period. A similar pattern of elevated average citations is observed around 2012 and 2017. In contrast, the average citation rate declines steadily after 2018, likely due to citation lag, as more recent publications have had less time to accumulate citations. This fluctuation reflects both the uneven distribution of influential works over time and the recency effect, whereby newer documents have not yet reached their full citation potential.

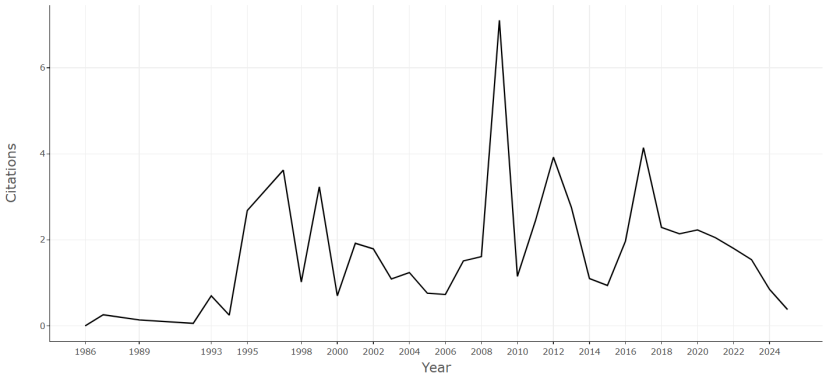


Figure 2: Average Citations per Year

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

A three-field diagram can effectively visualize how leading countries, key authors, and thematic priorities are interconnected in a scholarly domain, highlighting both dominant research clusters and potential areas for further exploration. In this respect, Figure 3 represents a three-field diagram linking the ten most prolific authors (on the center), their countries (l on the left), and their associated keywords (on the right). The USA and the United Kingdom emerge as dominant countries, demonstrating strong connections to multiple prolific authors such as *Novella Rafael, Flores-Lagunes Alfonso, Freund Richard, and Kluve Jochen*. Other countries, including Germany, Switzerland, and India, also contribute meaningfully, though with a narrower set of author affiliations. In contrast, the Netherlands, Italy, and China show relatively limited contributions, with the smallest number of author affiliations.

The prominent keywords driving this literature are "*labo(u)r market*," "*employment*," "*training,*" and "*labo(u)r market outcomes*," which appear recurrently across multiple authors. This suggests that

labour market impacts, particularly in relation to employment and training, are central concerns in adult education research. As a result, the links between countries, authors, and keywords illustrate collaborative and thematic networks. For example, USA-based authors display broader thematic engagement across "*employment*," "*training*," and "*labo(u)r market*," while European authors appear to focus more on specific areas such as "*unemployment*," "*labo(u)r market*," or "*educational attainment*."

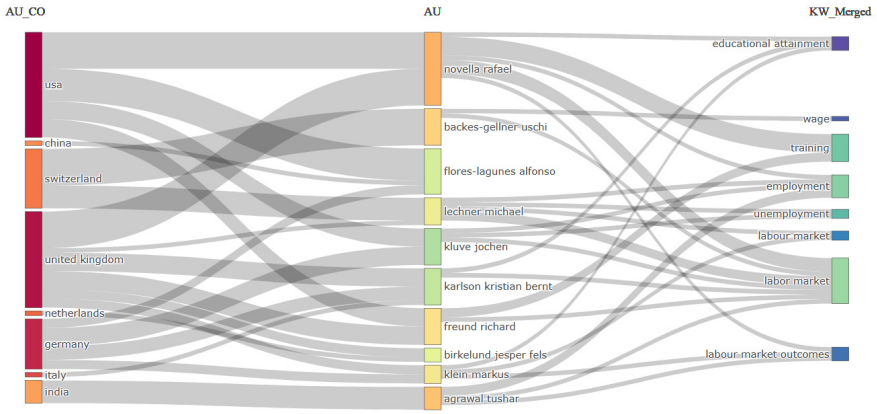


Figure 3: Three-Field Diagram of Author Countries, Authors, and Keywords

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

Figure 4 presents the ten most relevant sources related to the research theme. The figure indicates that the literature on labour market outcomes of adult education (or post-school investment) is highly concentrated in the *Labour Economics* journal, which has published 21 articles on this topic. It is followed by the *Economics of Education Review* and the *International Journal of Manpower*, each with 10 publications.

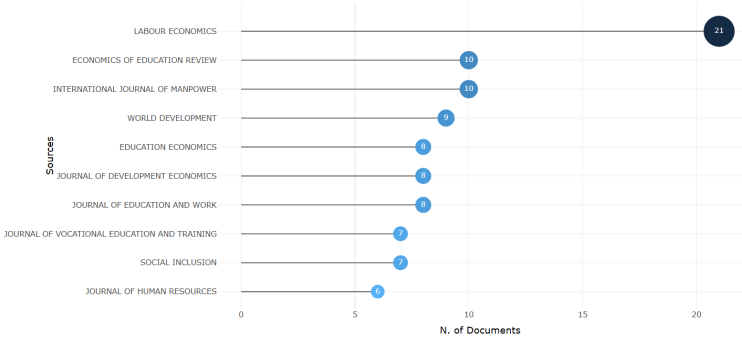


Figure 4: Most Frequently Publishing Journals Related to Labour Market Outcomes of Adult Education

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

Figure 5 illustrates the local impact of the ten most relevant journals publishing on the research theme, measured by their h-index values. A journal has an h-index of h if it has published h articles that have each been cited at least h times, reflecting both the journal's productivity (number of publications) and its scholarly impact (citation frequency). According to the figure, *Labour Economics* has the highest h-index, indicating that it is the most influential journal within this research area. *Economics of Education Review* follows with an h-index of 9, consistent with its ranking in Figure 4. In contrast, the *International Journal of Manpower* has a lower h-index despite being one of the most frequently publishing sources, suggesting relatively lower citation impact compared to the top two journals.

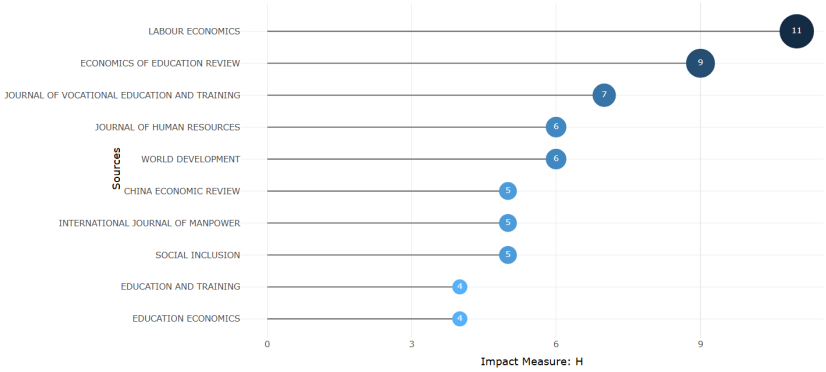


Figure 5: Local Impact of Relevant Sources in terms of h-Indexes

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

Figure 4 and Figure 5 together help scholars identify the most influential journals actively publishing in this research area, thereby informing their decisions on where to submit related work. Another three-fold diagram in Figure 6 links the ten most prolific sources (on the center), countries of their contributing authors (on the left), and their associated keywords (on the right).

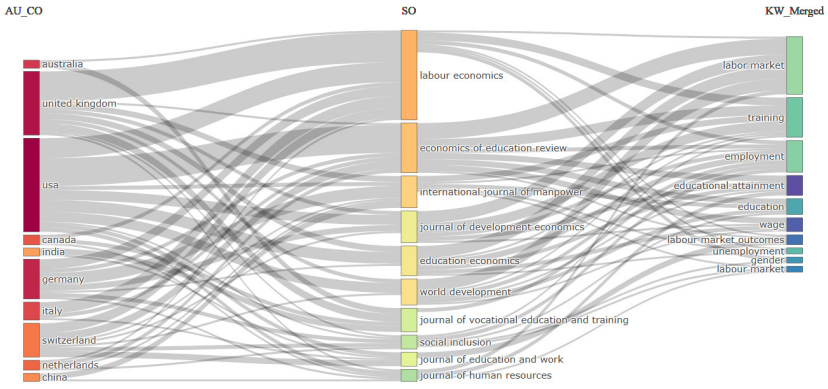


Figure 6: Three-Field Diagram of Author Countries, Sources, and Keywords

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

Figure 6 illustrates that Labour Economics, the most prolific journal in this domain, primarily features studies authored by scholars from the UK, USA, Germany, Italy, and Switzerland, focusing on keywords such as training, employment, labo(u)r market, and gender. Economics of Education Review, which also holds substantial influence, predominantly publishes work by scholars from the USA, Switzerland, Italy, and Germany, with associated keywords including "labo(u)r market", "training", "educational attainment", "education", "wages", and "employment". Meanwhile, the International Journal of Manpower largely features studies by scholars from Germany, UK, China, and USA, with a strong emphasis on keywords such as "training", "education", and "employment".

Figure 7 shows the total number of published articles by country over time. The United States dominates the research field with 294 published documents, followed by the United Kingdom and Germany with 113 and 105 documents, respectively. Most African and Arab countries, as well as many Small State, Balkan, Caucasus (SSBC) countries and some Asian countries like Iran, Afghanistan, and Mongolia have published no articles on this research theme, or they may not prefer to publish in Scopus-indexed sources.

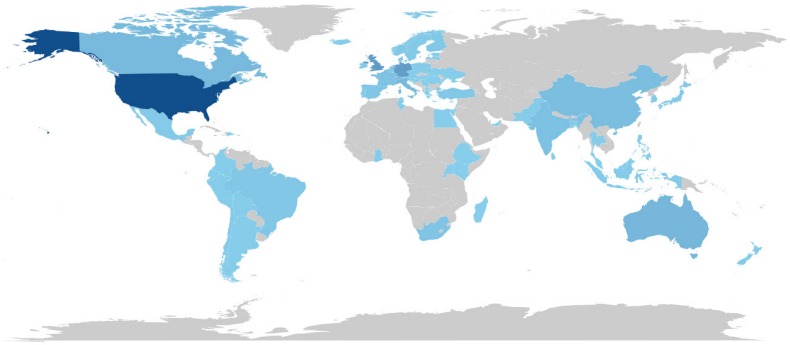


Figure 7: Countries Scientific Production

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

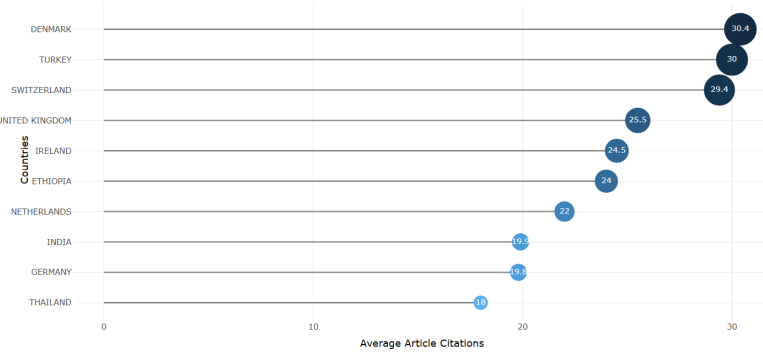


Figure 8: Countries by Average Article Citations

Source: Author's own calculations using Scopus data in the biblioshiny online software.

Figure 8 lists the top ten countries by average citations per article. Although the United States is the most prolific publishing country, it does not appear in Figure 8. Instead, Denmark (19 total publications), Turkey (14 total publications), and Switzerland (38 total publications) are the top three countries with the highest average citations per article, despite their relatively smaller publication counts. Notably, Turkey's average citation rate is substantial, at 30 citations per article, despite its lower total output.

Figure 9 depicts patterns of international collaboration among countries. The United States, identified as the most productive country, collaborates predominantly with Central European nations. In addition, some U.S.-based authors have co-authored publications with researchers from Canada and South Africa. There is also limited collaboration observed between the United States and countries in Latin America.

Figure 9: World Map of Countries Collaboration

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

Figure 10 shows that most of the keywords—such as "*training*", "*human capital*", "*employment*", and "*returns to education*"—are centered on the labour market. Additionally, keywords including "*adult*", "*female*", "*male*", "*earnings*", "*human*", "*income*", and "*life course*" form another important cluster.

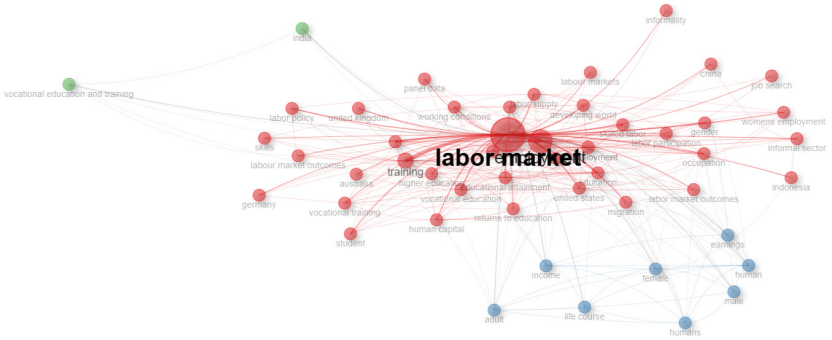


Figure 10: Co-occurrence Networks of the Keywords

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

Figure 11 presents the most popular keywords in recent years, along with their predominant periods and overall prevalence. Horizontal bars indicate the years during which these keywords were most frequently used; the size of each circle represents the number of documents containing the respective keyword, while the position of the circle denotes the year in which the keyword reached its peak usage. *"Covid-19", "working conditions", "job market", and "experimental study"* have emerged as the most popular keywords after 2022. "*Labo(u)r market"* remains the dominant keyword throughout the period 2015-2023, peaking in frequency in 2020, followed by *"employment"*, which reached its highest frequency in 2019. The keywords "*Canada*" and "*ethnicity*" exhibit longer persistence, spanning the periods 2001–2019 and 2002–2018, respectively.

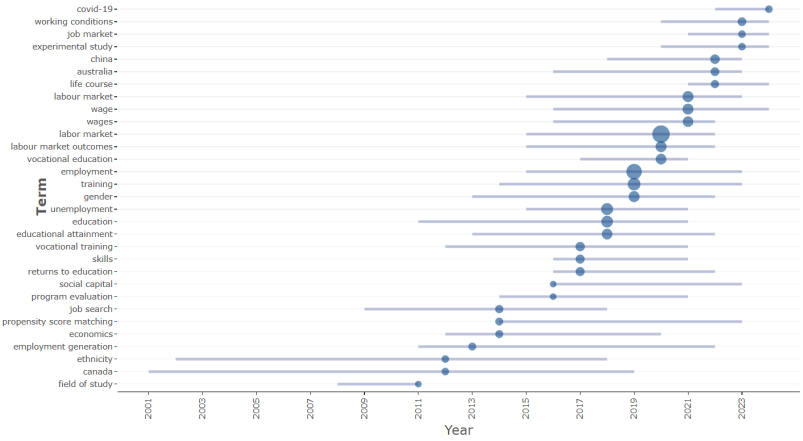


Figure 11: Trend Topics in Recent Years

Source: Author's own calculations using Scopus data in the Biblioshiny online software.

6. Conclusion

In summary, the bibliometric analysis presented through Figures 1–11 offers a comprehensive picture of the scholarly landscape on the labour market outcomes of adult education and post-school investment. The results reveal a consistent growth trajectory in annual scientific production, with a compound annual growth rate of 9.1% since 1986, and an even steeper increase in publication activity after 2012, reflecting rising academic interest in the topic. Despite some variability in citation rates over the years — largely due to citation lags and the emergence of influential publications in specific periods — the field demonstrates a strong and growing scholarly impact.

The analysis of publication sources highlights *Labour Economics* as the most prolific and impactful journal, followed by *Economics of Education Review* and *International Journal of Manpower*. These results provide valuable guidance for future authors seeking relevant, high-impact journals in which to publish on the labour market returns to adult education or post-school investment.

Country-level analyses confirm that while the United States dominates overall scientific output, other countries — such as Denmark, Turkey, and Switzerland — achieve high average citations per article, indicating the presence of influential scholarship even in regions with smaller publication volumes. The lack of contributions from many African, Arab, SSBC, and certain Asian countries underscores persistent global research inequalities and suggests opportunities for greater international collaboration. The United States, as the most productive country, primarily collaborates with Central Europe, with some additional co-authorship links to Canada, South Africa, and, to a lesser extent, Latin America.

Network visualizations, including the three-field diagrams, further illustrate how key authors, their countries, and core research themes are interconnected, with the United States and the United Kingdom emerging as dominant contributors.

Regarding keywords, recent years have seen an increased prominence of terms such as "*Covid-19*", "*working conditions*", "*job market*", and "*experimental study*" (especially after 2022). "*Labo(u)r market*" has remained the most dominant keyword from 2015 to 2023, peaking in 2020, while "*employment*" was most frequent in 2019. Keywords like "*Canada*" and "*ethnicity*" showed sustained relevance over longer periods, spanning 2001–2019 and 2002–2018, respectively. Keywords such as *"labo(u)r market"*, "*employment*", "*training*", and "*returns to education*" are consistently central, while complementary themes such as "*gender*", "*earnings*", and "*life course*" also form significant clusters, suggesting the multidimensional nature of adult education's labour market impacts.

Overall, this bibliometric evidence underscores the growing importance of labour market outcomes in adult education research and highlights both the dominant players and potential gaps in the field. These insights can inform future research agendas, support academic collaboration, and guide researchers in selecting appropriate publication venues.

References

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*, 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Becker, G. S. (1964). *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (1st ed.)*. NBER.

Blaug, M. (1976). The Empirical Status of Human Capital Theory: A Slightly Jaundiced Survey. *The Journal of Economic Literature, vol. 14, No. 3*, 827-855.

Dinh, N. T., Dinh Hai, L., & Pham, H.-H. (2023). A bibliometric review of research on employability: dataset from Scopus between 1972 and 2019. *Higher Education, Skills and Work-Based Learning, 13*(1), 1-21. https://doi.org/10.1108/HESWBL-02-2022-0031

Fejes, A., & Nylande, E. (2014). The Anglophone International(e): A Bibliometric Analysis of three Adult Education Journals, 2005-2012. *Adult Education Quarterly, 64*(3), 222-239. https://doi.org/0.1177/074.171.3614528025

Fejes, A., & Nylander, E. (2015). How pluralistic is the research field on adult education? Dominating bibliometrical trends, 2005-2012. *European journal for Research on the Education and Learning of Adults, 6*(2), 103-123. https://doi.org/10.25656/01:11450

Lajuni, N., & Samsu, S. (2011). Exploring Human Capital Training Trends Using Bibliometric Analysis. *International Journal of Academic Research in Business and Social Sciences, 12*(7), 1163 – 1176. https://doi.org/10.6007/IJARBSS/v12-i7/13030

Mincer, J. (1974). *Schooling, Experience, and Earnings.* New York and London: NBER. Retrieved from http://www.nber.org/books/minc74-1

Onopriienko, K., Lovciová, K., Mateášová, M., Kuznyetsova, A., & Vasylieva, T. (2023). Economic policy to support lifelong learning system development & SDG4 achievement: Bibliometric analysis. *Knowledge and Performance Management*, 15-28.

Schultz, T. W. (1961). Investment in Human Capital. *American Economic Review, 51*(1), 1-17. https://doi.org/https://www.jstor.org/stable/1818907

Journal of Research in Economics • Volume: 9 / Issue 2 • October 2025 pp. 72-89
ISSN: 2636-8307 • DOI: http://dx.doi.org/10.29228/JORE.44

RESEARCH ARTICLE

THE IMPACT OF GEOPOLITICAL RISK, TRADE OPENNESS, AND ENERGY CONSUMPTION ON CARBON EMISSIONS: THE CASE OF TURKEY

Zeliha Semra KILINÇ*

Abstract

This paper examines the key determinants of carbon emissions in Turkey using data from the period 1995–2023. The primary objective is to reveal the impacts of the geopolitical risk index, trade openness, energy consumption, and income levels on emissions. To jointly assess the short – and long-run relationships, the Autoregressive Distributed Lag (ARDL) approach is employed. The findings indicate that electricity consumption increases emissions in both the short and long run, while income contributes to emission growth, particularly in the long run. The trade Openness exhibits a complex relationship, showing both mitigating and aggravating effects in different periods. Geopolitical risk has a limited direct impact on emissions and does not play as pronounced a role as energy and trade channels. The results emphasize the importance of reducing the carbon intensity of energy production and consumption, implementing energy efficiency policies, and adopting low-carbon strategies in foreign trade to mitigate emissions. Furthermore, the design of energy security policies should take into account the potential influence of geopolitical uncertainties.

Keywords: Geopolitical Risk, Energy Consumption, Carbon Emissions, Trade Openness, ARDL Model
Jel Codes: F52, Q41, Q54, F18, C22

1. Introduction

The adverse consequences of climate change one of the most pressing environmental issues driven by global warming have been intensifying each day and often result in devastating outcomes. Since the Industrial Revolution, the detrimental effects of rising global temperatures have led numerous scholars to investigate the causes and propose mitigation strategies (IPCC 2023; Stern 2007). In this context, reducing greenhouse gas emissions, which contribute significantly to global warming, has become a central goal in environmental research and policymaking. Among all greenhouse gases, carbon dioxide (CO_2) stands out as the most harmful in terms of its impact on climate change, accounting for approximately 75% of total emissions. In particular, CO_2 resulting from fossil fuel consumption remains in the atmosphere for more than a century. Fossil

* Aydın Adnan Menderes University, Banking and Insurance Department, Aydın, Türkiye. Orcid: 0000-0001-9837-1587, E-mail: zeliha.semra@gmail.com, z.kilinc@adu.edu.tr

Submission Date: 15.08.2025
Revision Date: 26.09.2025
Acceptance Date: 26.09.2025

fuels, which are major sources of CO_2, are widely used in production processes and are especially prevalent in emerging economies such as Turkey, where economic growth objectives continue to drive emissions upward.

As a result of efforts spearheaded by the United Nations, the foundations of the Framework Convention on Climate Change were laid in 1991. Since then, a series of international agreements have been established to curb environmental degradation and reduce carbon emissions. However, many of these agreements have lacked binding enforcement mechanisms, thereby limiting their effectiveness in mitigating emissions. The most recent initiative, the European Green Deal (European Commission 2019), introduced more stringent measures aimed at emission reduction. Within this framework, the Carbon Border Adjustment Mechanism (CBAM) has been developed to impose regulatory instruments such as carbon tariffs on embedded emissions in international trade (European Commission 2021). The economic growth goals of countries, alongside increasing fossil fuel use, tend to move in tandem with rising emission levels. This paper presents Figure 1, which illustrates the trends in carbon emissions and gross domestic product (GDP) growth for Turkey over the 1990–2023 period, based on data obtained from the World Bank and compiled by the author.

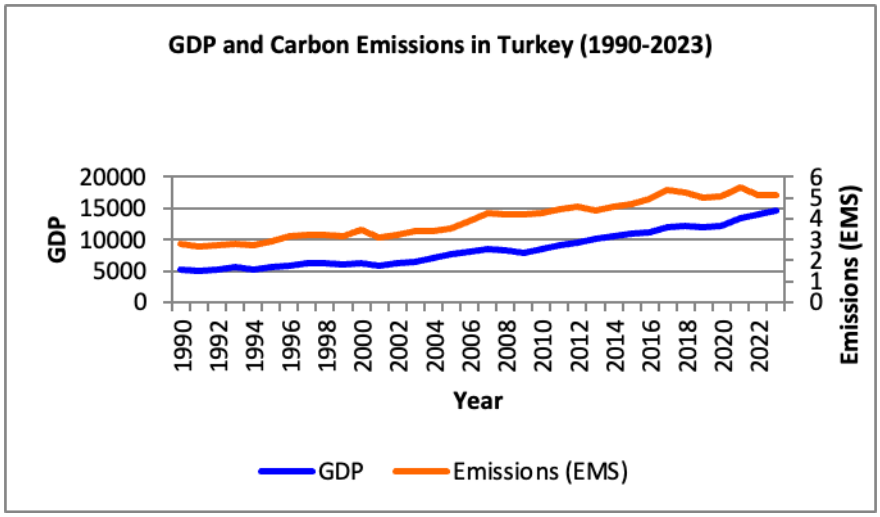


Figure 1. Economic Growth and Carbon Emissions in Turkey (1990–2023)
Source: Author's own elaboration based on data obtained from the World Bank

Figure 1 clearly shows that per capita GDP and per capita carbon emissions in Turkey moved in tandem over the 1990–2023 period. In the post - 2000 years, when economic growth accelerated, carbon emissions also rose markedly. Especially after 2010, the increase in GDP parallels the increase in emissions. This pattern indicates that environmental pressures intensify during periods of heightened economic activity and reveals that Turkey's economy largely rests on a fossil – fuel – based structure of production and consumption. The rise in fossil-fuel-related

emissions is also indirectly associated with international trade. In Turkey, the trade openness is driven to a considerable extent by energy demand, with coal, oil, and natural gas dominating imports. Fossil-fuel imports contribute both to the current-account Openness and to higher carbon emissions (Özokcu and Özdemir 2017).

As a primary energy source, fossil fuels are widely used in industrial production and substantially increase CO2 emissions. The sectors prioritized under the Carbon Border Adjustment Mechanism (cement, iron and steel, aluminum, fertilizer, and electricity) are among the most emission intensive precisely because of their high fossil-fuel use. Reducing fossil-fuel consumption and switching to renewable energy sources lowers carbon emissions (Mukhtarov et al. 2024).

A substantial body of research examines the determinants of carbon emissions. In recent years, particular attention has turned to the relationship between Geopolitical Risk Index (GPR) and emissions. (Caldara and Iacoviello 2022) define GPR to include ethnic conflicts, religious disputes, economic dependencies, political unrest, and other events that threaten national sovereignty, while Hu et al. (2023) also emphasize military interventions, armed threats, interventions by major powers, and terrorism developments that threaten national military security.

For Turkey, its prominent role in international trade and recurrent border related disputes place it among countries with relatively high geopolitical risk. The GPR index for Turkey constructed by (Caldara and Iacoviello 2022) is presented in Figure 2.

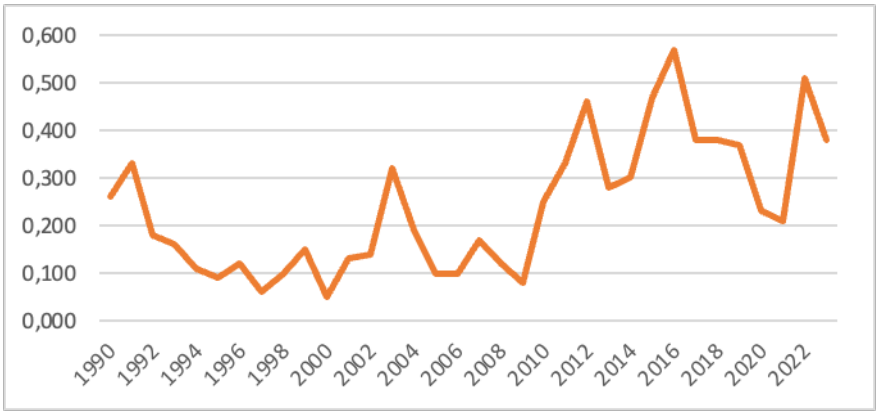


Figure 2. Geopolitical Risk Index for Turkey (1990–2023)
Source: Created by the author based on Caldara and Iacoviello (2022).

As illustrated in Figure 2, the Turkey Geopolitical Risk index for 1990–2023 exhibits pronounced fluctuations over time. After relatively high readings in the early 1990s, the GPR trended downward until the early 2000s, a pattern that can be linked to the relative stability of the post–Cold War period. Around 2003, the index displays a sharp spike, plausibly associated with the U.S. invasion of Iraq and heightened concerns over Turkey's border security. The post-2011 period is characterized by a marked rise in geopolitical risk; the Syrian civil war, terrorist attacks within

Turkey, the 2016 coup attempt, and cross-border military operations collectively drove the index sharply higher. The peak in 2016 likely reflects a moment when perceived internal and external threats reached a maximum. After 2018, the index shows a relative decline, though geopolitical uncertainties remain elevated. These swings make the GPR a critical indicator for understanding the implications of geopolitical conditions for Turkey's economy and security policies.

Given Turkey's strategic and geographic position, examining the relationship between GPR and carbon emissions is particularly salient. The literature evaluates the GPR–emissions nexus along two channels. First, higher GPR may dampen economic activity, reducing energy use and thereby lowering emissions. Second, rising GPR may discourage investment in technology and renewable energy, which negatively affects environmental outcomes by increasing emissions (Anser et al. 2021a).

The steadily rising volume of carbon emissions worldwide has become one of the major obstacles to achieving sustainable development goals. In this context, the increase in emissions accelerates climate change and compels a reshaping of environmental policies. Balancing economic growth targets with environmental sustainability has become even more complex for developing countries. For energy import dependent economies with persistent trade openness, such as Turkey, sustaining economic development without harming the environment is a priority for policymakers.

Within this framework, three factors stand out among the determinants of environmental performance: renewable energy use, the level of geopolitical risk, and the foreign trade balance. Substituting renewable energy sources for fossil fuels is widely regarded as an effective instrument for reducing carbon emissions. At the same time, geopolitical risks can indirectly affect emission levels by influencing energy supply security, investment decisions, and environmental priorities. Moreover, trade openness may intensify environmental burdens through their pressures on production and consumption; import-dependent consumption patterns tend to raise carbon emissions.

In this context, the study aims to analyze, within an econometric framework, the impact of energy consumption, the geopolitical risk index, per capita GDP, and the trade Openness on per capita carbon emissions in Turkey, using data from the 1990–2023 period. In the literature, studies that examine these variables collectively are limited; therefore, this paper offers an original contribution in this regard. The study is organized into four sections: the first section presents the theoretical framework in the introduction; the second section provides a review of the relevant literature; the third section outlines the analysis and findings; and the fourth section discusses the conclusions and implications.

2. Literature

A substantial body of research examines the adverse consequences of climate change driven by the rise in carbon dioxide (CO_2) emissions, which amplify global warming and environmental damage. As carbon emissions widely regarded as the principal cause of environmental pollution and global warming continue to increase, identifying their determinants and clarifying the nature of these relationships has become increasingly important. In this vein, the number of empirical papers analyzing the link between the Geopolitical Risk index developed by (Caldara and Iacoviello 2022) and carbon emissions has recently grown. In line with the focus of this paper, prior work addressing the relationships between carbon emissions and three key variables geopolitical risk, the foreign trade openness, and renewable energy consumption is reviewed under separate subsections.

2.1 Geopolitical Risk and Carbon Emissions

Luo and Sun (2024) examine the relationship between GPR and CO_2 for 27 countries using annual data for 1990–2020. Applying ordinary least squares, fixed and random-effects models, and panel quantile regression, the paper finds that GPR increases CO_2 emissions, with stronger effects among high-emitting countries. Using monthly data for China over 2000–2020, (Wang et al. 2022) analyze the causal linkage between GPR and CO_2. While full-sample tests do not detect Granger causality, sub-sample analyses reveal time varying, bidirectional effects: in some periods GPR raises CO_2, in others it lowers it; likewise, CO_2 influences GPR in a manner that shifts over time. Focusing on the BRICS, (Anser et al. 2021b) conduct panel analyses for 1985–2015. After accounting for cross-sectional dependence and slope heterogeneity and establishing cointegration via the Westerlund test, the paper estimates long-run coefficients using the Augmented Mean Group estimator and reports that geopolitical risk significantly increases CO_2 emissions in the long run. Also, for BRICS, (Zhao et al. 2021) employ ARDL and Nonlinear Autoregressive Distributed Lag models for 1985–2019 to study asymmetric effects. Their results indicate that positive changes in geopolitical risk reduce emissions in Russia and South Africa, whereas negative changes reduce emissions in China, India, and South Africa. (Riti et al. 2022) investigate the impact of geopolitical risk on environmental degradation measured by CO_2 emissions and ecological footprint in BRICS over 1990–2019. Using panel cointegration tests, the Pooled Mean Group (PMG) estimator, and panel causality tests, the paper finds that, at the panel level, geopolitical risk exacerbates environmental degradation, while country-specific results vary. (Chu et al. 2023) analyze E7 countries over 1995–2018, using panel cointegration and PMG-ARDL methods to assess the effects of GPR and economic policy uncertainty (EPU) on CO_2 emissions and ecological footprint. The findings suggest that GPR and EPU worsen environmental outcomes in the long run; in the short run, some adverse and some favorable effects emerge, and the role of economic complexity differs across countries. (Uddin et al. 2023) study BRICS (1990–2018) using CS-ARDL, FMOLS, and DOLS to evaluate how GPR, governance indicators, technological innovation, energy consumption, and foreign direct investment affect

CO_2 emissions. They report that GPR, corruption, political instability, and energy consumption increase emissions, whereas government effectiveness, regulatory quality, rule of law, FDI, and innovation reduce them.

In another China focused paper, (Wang et al. 2022) apply a bootstrap Granger rolling-window causality approach to 1985–2020 data and find pervasive bidirectional causality across sub-samples. The authors argue that GPR affects CO_2 through channels such as trade disputes, military activity, and risks to energy supply, while CO_2 levels can shape international cooperation and geopolitical configurations, thereby feeding back into GPR. For South Africa, (Lawal et al. 2023) use quarterly data for 1985–2018 and quantile Granger causality to assess the effects of GPR and globalization on CO_2 emissions. The results indicate especially strong bidirectional causality between GPR and CO_2, and between globalization and CO_2.

2.2 Geopolitical Risk and Energy Consumption

Adedoyin et al. (2020) analyze resource rich countries with high GPR over 1996–2017 using an ARDL model estimated via the Pooled Mean Group approach. Their results indicate that energy consumption and economic growth raise CO_2 emissions, economic policy uncertainty (EPU) is positively related to emissions in the long run, while geopolitical risk is associated with lower environmental impacts over the long horizon. The paper concludes that energy policies should incorporate risk factors such as EPU and GPR to support environmental sustainability. Hashmi et al. (2022) test the Environmental Kuznets Curve (EKC) for 17 advanced and emerging economies over 1997–2019 using a bootstrap ARDL framework that explicitly accounts for GPR. The findings confirm an inverted U relationship between environmental degradation and GDP per capita. They also show that GPR reduces emissions in the short run but increases them in the long run. For four Turkic republics Kazakhstan, Azerbaijan, Kyrgyzstan, and Uzbekistan Yesbolova et al. (2024) examine 2000–2020 panel data on renewable energy consumption, industrial production, and CO_2 emissions. The analysis shows that higher renewable energy consumption significantly lowers CO_2 emissions, whereas the effect of industrial production on CO_2 is statistically insignificant. Jiang and Khan (2023) study Belt and Road Initiative (BRI) countries for 1995–2019 using dynamic panel methods to assess the effects of renewable energy consumption and technological innovation on CO_2 emissions while controlling for economic growth, trade, foreign direct investment, urbanization, and industrialization. They find that technological innovation increases both renewable energy consumption and CO_2 emissions, whereas greater renewable energy consumption reduces CO_2. The EKC hypothesis is also supported. The results suggest promoting technological progress in energy systems alongside policies that incentivize renewables to improve environmental quality. Focusing on Turkey, Çoban (2015) employs annual data for 1990–2012 to investigate the impact of renewable energy consumption (REC) on per capita CO_2 emissions, using per capita GDP, per capita REC, and energy-sector per capita CO_2 as variables. Applying the ADF unit-root test, Johansen cointegration, Granger causality, and regression analysis, the paper reports a long-run cointegrating relationship and one-way causality from per

capita REC to per capita CO_2. Regression results indicate that renewable energy consumption reduces CO_2, while per capita GDP increases it. In a sample of countries with high renewable energy use over 2000–2015, Huang et al. (2021) apply the generalized method of moments (GMM) and find that renewable energy consumption leads to a statistically significant decline in CO_2 emissions.

2.3 Trade Openness and Carbon Emissions

Bhayana and Nag (2024) examine how manufacturing sectors' participation in global value chains (GVCs) affects carbon emissions in 16 emerging market economies over 1995–2018. Using panel data and feasible generalized least squares (FGLS), they find that deeper GVC participation is positively associated with emissions, both on the domestic and export sides. Derindag et al. (2023) analyze 20 Indian industrial subsectors for 2006–2021 with a threshold-regression framework, using industrial carbon-emission intensity as the threshold variable to assess the roles of foreign direct investment (FDI) and foreign trade openness (FTO). The results reveal triple threshold effects: the impact of FDI on emissions is negative in low-intensity sectors, strongest in medium-intensity sectors, and moderate in high-intensity sectors. Trade openness suppresses CO_2 in low-intensity sectors but raises emissions in high-intensity sectors. Kang (2021) studies the relationship between the portion of CO_2 emissions embodied in international trade and economic growth for OECD and non-OECD countries during 2005–2015. Extending the Environmental Kuznets Curve (EKC) by incorporating a net-exports-based measure of emissions, the paper employs panel regressions, unit-root and cointegration tests, and Granger causality analysis. The EKC is validated, and bidirectional Granger causality between CO_2 emissions and economic growth is documented. For India over 1985–2019, Adebayo et al. (2023) use quantile-on-quantile (QQR) regression to evaluate how geopolitical risk, trade openness, and economic growth affect CO_2 emissions. The findings show that GPR increases emissions at middle quantiles but reduces them at lower and upper quantiles. Moreover, GPR, growth, and trade openness exert adverse effects on environmental quality, with heterogeneous impacts that vary across the emissions distribution. The paper recommends that policymakers account for quantile-specific effects of GPR and openness when designing environmental strategies.

2.4 Energy Consumption – Carbon Emissions – Trade Openness

Using panel data for 30 Chinese provinces over 2003–2019, Cheng et al. (2023) analyze the effect of GPR on carbon emissions. Panel regression results indicate that GPR, economic growth, international trade, and fossil-energy consumption raise emissions, whereas technological progress, industrial restructuring, and marketization curb them. With a panel of the 50 most globalized countries for 2000–2019, Mirziyoyeva and Salahodjaev (2023) examine the nexus among economic growth, renewable energy consumption, and CO_2 emissions using a two-step system GMM estimator. They find that renewable energy consumption reduces CO_2 emissions by roughly 0.26 percent, globalization supports environmental quality, and per capita GDP

exhibits an inverted-U relationship with CO_2. Institutional indicators—such as the share of women in parliament—also have beneficial effects on emissions. For Azerbaijan over 1993–2019, Mukhtarov et al. (2023) apply DOLS to assess how per capita renewable energy consumption, per capita GDP, exports, and imports affect consumption-based CO_2 emissions. The evidence shows that renewable energy lowers CO_2, while per capita GDP and imports increase it; imports amplify emissions, whereas exports reduce them—patterns consistent with heterogeneous effects under greater trade openness.

For Turkey, papers directly linking GPR and emissions remain scarce. Using data for 1985–2019, Kızılkaya et al. (2024) implement Shin and Fourier-Shin cointegration tests and report that GPR and renewable energy consumption reduce CO_2 emissions in the long run, whereas economic growth and population increase them. In contrast, Aydın et al. (2024) employs the RALS-Fourier unit-root test, the Fourier-ADL cointegration model, and FMOLS to examine financial development, foreign direct investment (FDI), and GPR; their results indicate that GPR, financial development, and FDI each have positive and significant effects on emissions, suggesting that heightened geopolitical risk can raise energy demand and production pressure. Using ARDL cointegration for Turkey (1985–2019), Saadaoui, Doğan, and Omri (2023) find that GPR and renewable energy consumption exert negative and significant effects on CO_2 emissions, while economic growth and population increase emissions. Overall, the literature suggests that renewable energy consumption generally mitigates emissions, whereas the effects of GPR and greater trade openness are context-dependent, operating through channels such as energy demand, technology adoption, and the composition of trade. This study aims to contribute to the literature from a broad perspective by examining carbon emissions in relation to the geopolitical risk index, energy consumption, economic growth, and the trade Openness.

3. Methodology and Empirical Application

3.1 Method

In analyzing the relationships among economic variables, various econometric analysis techniques are employed. Particularly for examining short – and long-run associations, different cointegration methods such as those developed by Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990) are frequently utilized. However, in this paper, considering the stationarity levels of the variables, the Autoregressive Distributed Lag bounds testing approach is preferred. Unlike traditional cointegration methods that require all variables to be integrated at the same order, the ARDL method does not impose such a restriction; in other words, the presence of cointegration can be investigated when the variables are either I(0) or I(1) (Sharifi-Renani, 2007, p. 3). Nevertheless, for the method to be applicable, the dependent variable must be integrated of order one (I(1)), while the independent variables may be either I(0) or I(1) (Pesaran et al., 2001, p. 290).

Another advantage of the ARDL technique is its suitability for small sample sizes and its ability to provide more consistent and reliable results compared to conventional cointegration techniques (Engle & Granger, 1987; Johansen, 1988, 1995) (Narayan & Smyth, 2005, p. 103). Narayan and Smyth (2005) also emphasize that this method offers more robust results under small sample conditions.

In this study, the stationarity properties of the series used were investigated through the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. After determining the order of integration, the cointegration test was applied to identify both the short – and long-run relationships among the variables. Based on the empirical test results, both short-run and long-run coefficient interpretations were made. The model employed in the analysis is presented in Equation 1 below.

$$\text{logems}_t = \beta_0 + \beta_1 \text{logGPR}_t + \beta_2 \text{logNXM}_t + \beta_3 \text{logGDP}_t + \beta_4 \text{logEC} + \varepsilon_t \quad (1)$$

Pesaran et al. (2001) proposed a method by which the long-run relationship expressed in Equation 1 can be estimated using the bounds testing approach. This method relies on estimating the long-run association among the variables through an unrestricted error correction model. An ARDL model is presented in Equation 2 below.

$$\Delta Y_t = \mu + \rho_Y Y_{t-1} + \rho_X Z_{t-1} + \sum_{i=1}^{p-1} a_i \Delta Y_{t-i} + \sum_{i=0}^{q-i} \beta_i \Delta Z_{t-1} + \varepsilon_t \quad (2)$$

3.2 Data Set

The paper examines the relationship between per capita CO_2 emissions and geopolitical risk, trade openness, per capita income, and per capita energy consumption in Turkey. In other words, it investigates the impact of geopolitical risk, trade openness, per capita income, and per capita energy consumption on per capita carbon emissions. In this context, per capita CO_2 emissions serve as the dependent variable, while geopolitical risk, trade openness, and per capita energy consumption are the independent variables, and per capita income is included in the model as a control variable. The equation for the constructed model is as follows:

Per Capita Carbon Emissions = f (Geopolitical Risk, Trade Openness, Gross Domestic Product, Energy Consumption)

The variables used in the model and their data sources are presented in Table 1.

Table 1: Variables

Abbreviation	Description	Explanation
ems	CO_2 Emissions Per Capita	Tons
gpr	Geopolitical Risk Index	Historical GPR (Index: 1900:2019 = 100)
nxm	Trade Openness	Share of Net Trade in GDP (%)
gdp	Gross Domestic Product Per Capita	Constant 2015 US$
ec	Electric power consumption Per Capita	kWh

In this study, to investigate the determinants of carbon emissions, the geopolitical risk index, trade openness, per capita gross domestic product, and per capita energy consumption are used as independent variables, while per capita carbon emissions serve as the dependent variable. The limitation of the study period is due to the availability of the latest data for energy consumption in 2023. Accordingly, the variables cover the period 1990–2023, where (ems) denotes per capita carbon emissions, (gpr) represents the geopolitical risk index, (nxm) indicates the trade openness (measured as *net exports of goods and services (% of GDP)*, which reflects the balance of trade in relation to the size of the economy (negative values indicate a openness, while positive values indicate a surplus), (gdp) refers to per capita gross domestic product, and (ec) corresponds to energy consumption. Among the variables used in the analysis, the geopolitical risk index is obtained from the matteoiacoviello.com database, while per capita carbon emissions, trade openness, per capita energy consumption, and per capita gross domestic product are retrieved from the World Development Indicators (WDI) database of the World Bank.

Table 2: Descriptive Statistics of the Variables

Statistic	LEMS	LGDP	LGPR	LNXM	LEC
Mean	1.349	8.993	0.207	3.881	7.607
Median	1.397	8.979	0.182	3.887	7.702
Maximum	1.700	9.596	0.451	4.396	8.185
Minimum	0.984	8.537	0.0487	3.416	6.796
Std. Deviation	0.233	0.332	0.111	0.225	0.437
Skewness	-0.079	0.246	0.475	-0.203	-0.328
Kurtosis	1.599	1.717	2.135	3.183	1.830
Jarque-Bera	2.815	2.674	2.339	0.282	2.551
Probability	0.244	0.262	0.310	0.868	0.279

The descriptive statistics of the variables used in the study provide important insights into the distributions of the series. Table 2 summarizes these descriptive statistics. The mean and median values are close to each other, indicating a low influence of extreme observations. The standard deviations suggest relatively high fluctuations in the LEC variable. Skewness values are close to zero, indicating that the series are largely symmetric. The kurtosis values being less than 3 imply

that the series are flatter than the normal distribution. Since the probability values of the Jarque–Bera test are above 0.05, it can be inferred that none of the series reject the null hypothesis of normality.

3.3 Empirical Findings

Table 3. Results of ADF and PP Unit Root Tests

		Variable	ADF	PP
Level	Intercept	DLEMS	-0.816(0)	-0.735(5)
		DLGPR	– 2.226(0)	-2.202(1)
		DLNXM	0.457(6)	-1.677(10)
		DLGDP	0.665(0)	1.970(8)
		DLEC	-2.696(2)***	-4.728(18)*
	Trend+Intercept	DLEMS	-2.963(0)	-2.963(0)
		DLGPR	-3.399(0)***	-3.236(5)***
		DLNXM	-3.194(2)	-2.736(7)
		DLGDP	-2.556(2)	-2.472(4)
		DLEC	-0.353(2)	0.125(11)
First Difference	Intercept	DLEMS	-6.435(0)*	-7.154(6)*
		DLGPR	-5.662(1)*	-7.840(11)*
		DLNXM	-5.387(1)*	-5.608(14)*
		DLGDP	-5.736(0)*	-6.501(7)*
		DLEC	-4.385(1)*	-4.335(4)*
	Trend+Intercept	DLEMS	-6.396(0)*	-8.039(8)*
		DLGPR	-5.620(1)*	-8.643(12)*
		DLNXM	-5.312(1)*	-5.435(14)*
		DLGDP	-4.324(5)**	-7.635(10)*
		DLEC	-5.518(1)*	-9.521(31)*

*, **, and *** indicate that the series are stationary at the 1%, 5%, and 10% significance levels, respectively. The values in parentheses denote that, in the ADF test, the lag length is determined according to the Akaike Information Criterion, while in the PP test, it is determined using the Bartlett Kernel Newey–West Bandwidth method.

The ADF and PP unit root test results indicate that the LEC variable is stationary at level, while all other variables are non-stationary at level but become stationary at the 1% significance level after first differencing. These findings reveal that the series exhibit a mixed order of integration at I (0) and I (1), thereby confirming the applicability of the ARDL approach.

Table 4: Results of ARDL Bounds Test and Diagnostic Tests

	F Statistic	**Critical Value**	
K	4	**Lower Bound**	**Upper Bound**
F-Statistic	17.378	2.52	3.56
Diagnostic Test			
	Test Statistic	**Probability Value**	
Breusch Pagan Godfrey	0.519	0.861	
Ramsey Reset	0.385	0.578	
Breusch Godfrey	0.519	0.861	
Jarque-Bera Normallik Testi	1.008	0.604	
R^2	0.996		
Adjusted R^2	0.987		

Note: *k refers to the number of independent variables. Critical values are taken from Table CI(iii) in Pesaran et al. (2001:300). The critical values correspond to the 1% significance level.

The ARDL bounds testing procedure yielded an F-statistic value of 17.37808, which is well above the upper bound critical value of 3.56 at the 1% significance level. This result indicates the presence of a long-run cointegration relationship between the dependent and independent variables in the model. According to the results of the ARDL (4,4,4,4,4) model, estimated with differenced series, the short-run effects on DLEMS reveal that the DLEC variable and some of its lags are statistically significant; this finding suggests that changes in energy consumption have a strong and positive impact on changes in emissions. Most of the coefficients of DLNXM are negative, and some are statistically significant, implying that changes in trade may reduce emission growth in the short term. The coefficients of DLGDP display mixed signs, with some positive and significant lags, indicating that increases in economic growth rates may contribute to higher emissions. The lag length structure was determined by setting the maximum lag to four, given the annual frequency of the data, and selecting the optimal specification based on the Akaike Information Criterion (AIC) and supporting diagnostic tests. Alternative lag orders were evaluated, but the ARDL (4,4,4,4,4) model provided the most consistent results across variables and satisfied the key econometric assumptions.

Diagnostic tests performed to evaluate the validity of the model produced satisfactory results. The Breusch–Pagan–Godfrey test ($p = 0.861447$) shows no evidence of heteroskedasticity in the model. The Ramsey RESET test ($p = 0.57876$) confirms the correct functional form specification. The Breusch–Godfrey LM test ($p = 0.8614$) indicates that the model is free from autocorrelation. Furthermore, the Jarque–Bera normality test ($p = 0.604096$) verifies that the residuals follow a normal distribution. The explanatory power of the model is remarkably high; with $R^2 = 0.996096$ and adjusted $R^2 = 0.987855$, a large proportion of the variation in the dependent variable is explained by the independent variables. Overall, these findings demonstrate that the estimated ARDL model is both statistically significant and econometrically reliable.

The long-run coefficient estimates, as presented in Table 5, reveal that the LGDP and LEC variables have positive effects at the 1% significance level, indicating that economic growth and energy consumption significantly increase carbon emissions in the long term. The LNXM variable is significant at the 10% level, and its positive coefficient suggests that the trade openness contributes to emission growth over the long run. In contrast, the LGPR variable is not statistically significant in the long term, while the constant term is estimated to be negative and significant; this implies the presence of a structural downward component in the emission level when other factors are held constant.

Table 5: Long and Short Run ARDL Estimation Results

LONG RUN TEST				
Variable	**Coefficent**	**Standard Error**	**t-statistic**	**Probability**
DLGDP	0.705	0.116	6.053	0.003
DLGPR	-0.061	0.072	-0.853	0.441
DLNXM	0.173	0.074	-2.338	0.079
DLEC	0.647	0.083	7.741	0.001
C	-0.021961	0.006068	-3.618882	0.0224
SHORT RUN TEST				
D(DLEMS(-1))	0.826	0.128	6.404	0.003
D(DLGDP)	0.671	0.125	5.360	0.005
D(DLGDP(-1))	-1.236	0.094	-13.104	0.000
D(DLGDP(-2))	-1.737	0.154	-11.266	0.000
D(DLGDP(-3))	-1.404	0.169	-8.296	0.001
D(DLGPR(-2))	0.131	0.039	3.360	0.028
D(DLNXM)	-0.308	0.040	-7.692	0.001
D(DLNXM(-1))	0.249	0.031	7.791	0.001
D(DLEC)	0.799	0.125	6.391	0.003
D(DLEC(-2))	1.162	0.179	6.474	0.002

The short-run estimation results, as presented in Table 5, indicate that economic growth (DLGDP) and energy consumption (DLEC) have positive and significant effects on emissions, although the lagged values of growth display negative and highly significant coefficients, suggesting that growth shocks undergo a corrective process over time that reduces emissions. The DLGPR variable is found to be positive and significant at the second lag, implying that geopolitical risk can increase emissions in certain periods. The trade deficit (DLNXM) exhibits both negative and positive coefficients in the short run, indicating a fluctuating impact pattern. This can be explained by the fact that widening trade deficits may initially reduce domestic emissions by outsourcing carbon-intensive production abroad through increased imports, whereas in subsequent periods the recovery of domestic demand and production tends to offset this effect, leading to higher emissions. This cyclical behavior highlights the dual role of trade deficits in shaping short-run emission dynamics. Although GPR is insignificant in the long run, this outcome may be attributed

to the fact that Turkey's energy supply and emission trajectory are primarily shaped by long-term contracts and domestic demand, thereby offsetting the direct impact of geopolitical shocks. The CointEq(-1) coefficient is – 2.48, which is large in magnitude and statistically significant, indicating that the system returns rapidly to its long-run equilibrium.

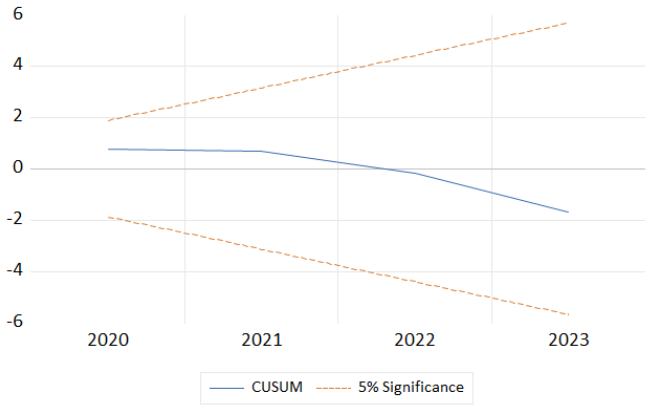


Figure 3: CUSUM Test

As shown in Figure 3, the CUSUM test graph is used to assess the stability of the model and the consistency of its parameters over time. An examination of the graph reveals that the cumulative residual series (blue line) remains within the critical bounds (dashed orange lines) representing the 5% significance level. This indicates that the model's parameters are stable over time and that the model does not contain any structural breaks. Therefore, it can be stated that the model is statistically consistent in terms of reliability and forecasting performance.

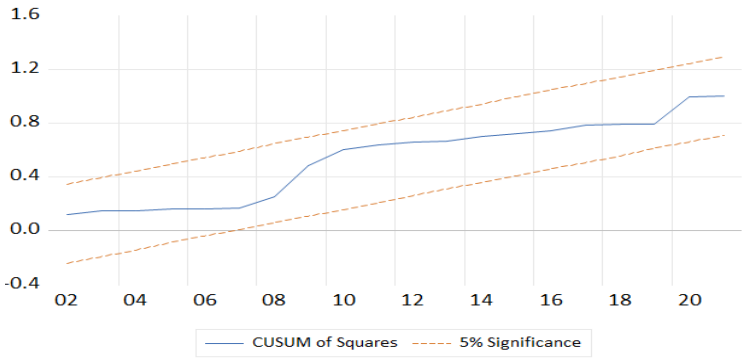


Figure 4: CUSUM of Squares Test

As shown in Figure 4, the CUSUM of Squares test graph is applied to detect potential structural breaks or changes in variance in the model parameters over time. An examination of the graph shows that the CUSUMSQ curve remains within the critical bounds representing the 5% significance level. This indicates that the model's parameters are stable over time and that there are no structural breaks or variance changes in the model. Consequently, the reliability and validity of the estimated ARDL model are diagnostically confirmed.

4. Conclusion and Implications

This study examines the relationship between carbon emissions and economic growth, geopolitical risk, trade openness, and energy consumption in Turkey over the period 1990–2023 using the ARDL approach, and identifies the existence of a long-run equilibrium relationship among the variables. The long-run estimates indicate that economic growth and energy consumption have a significant and positive impact on emissions, while the trade openness also contributes to emission increases in the long term, and geopolitical risk is not statistically significant in the long run. In the short run, the emission-increasing effects of growth and energy consumption are confirmed, while growth shocks tend to balance out over time, and the trade openness exhibits a fluctuating impact pattern. These findings are partly consistent and partly divergent from the existing literature: unlike Kızılkaya et al. (2024) and Saadaoui et al. (2023), the results do not reveal a mitigating long-run impact of geopolitical risk on emissions in Turkey, which may be explained by the dominant role of domestic demand and long-term energy contracts in shaping emission dynamics. Conversely, the evidence on the positive role of energy consumption is strongly in line with many previous studies (e.g., Mukhtarov et al., 2023; Hashmi et al., 2022; Adebayo et al., 2023), confirming that energy use remains the most critical driver of emissions. The findings underscore the critical importance of reducing the carbon intensity of electricity generation and consumption in emission mitigation; they support policy recommendations such as the gradual phase-out of coal-based electricity generation, expansion of renewable energy capacity, dissemination of energy efficiency standards, promotion of electrification and low-carbon fuels in transportation, increasing the share of rail and maritime transport in logistics, mandatory emission reporting for export-oriented sectors, phased implementation of a national ETS, and enhancement of energy source diversification to mitigate geopolitical risks.

References

Adebayo, T. S., Saint Akadiri, S., Riti, J. S., & Odu, A. T. (2023). Interaction among geopolitical risk, trade openness, economic growth, carbon emissions and its implication on climate change in India. *Energy & Environment, 34*(5), 1305–1326. https://doi.org/10.1177/0958305X221083236

Adedoyin, F. F., Adams, S., Olaniran, E., & Bekun, F. V. (2020). Energy consumption, economic policy uncertainty and carbon emissions: Causality evidence from resource rich economies. *Economic Analysis and Policy, 68*, 179–190. https://doi.org/10.1016/j.eap.2020.09.012

Anser, M. K., Syed, Q. R., Lean, H. H., Alola, A. A., & Ahmad, M. (2021a). Do economic policy uncertainty and geopolitical risk lead to environmental degradation? Evidence from emerging economies. *Sustainability, 13*(11), 5866. https://doi.org/10.3390/su13115866

Anser, M. K., Yousaf, Z., Khan, M. A., Zaman, K., & Nassani, A. A. (2021b). Does geopolitical risk escalate CO_2 emissions? Evidence from the BRICS countries. *Environmental Science and Pollution Research, 28*(35), 48011–48021. https://doi.org/10.1007/s11356.021.14032-z

Aydın, Ş., Öztutuş, F., & Polat, İ. H. (2024). The impact of financial development, foreign direct investment and geopolitical risk on CO_2 emissions: Evidence from Turkey. *Fiscaoeconomia*, *8*(1), 1–24. https://doi.org/10.25295/fsecon.1377785

Bhayana, S., & Nag, B. (2024). Global value chain linkages and carbon emissions embodied in trade: Evidence from emerging economies: Uncovering connections. *arXiv preprint*, arXiv:2411.02963. https://doi.org/10.48550/arXiv.2411.02963

Caldara, D., & Iacoviello, M. (2022). Measuring geopolitical risk. *American Economic Review, 112*(4), 1194–1225. https://doi.org/10.1257/aer.20191823

Cheng, P., Xingang, H., & Choi, B. (2023). The effect of geopolitical risk on carbon emissions: Influence mechanisms and heterogeneity analyzed using evidence from China. *Environmental Science and Pollution Research, 30*(48), 105220–105230. https://doi.org/10.1007/s11356.023.29829-3

Chu, L. K., Doğan, B., Abakah, E. J. A., Ghosh, S., & Albeni, M. (2023). Impact of economic policy uncertainty, geopolitical risk, and economic complexity on carbon emissions and ecological footprint: an investigation of the E7 countries. Environmental Science and Pollution Research, 30(12), 34406–34427. https://doi.org/10.1007/s11356.022.24682-2

Çoban, O. (2015). Yenilenebilir enerji tüketimi ve karbon emisyonu ilişkisi: Turkey örneği. *Erciyes Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *1*(38), 195–208.

Derindag, O. F., Maydybura, A., Kalra, A., Wong, W. K., & Chang, B. H. (2023). Carbon emissions and the rising effect of trade openness and foreign direct investment: Evidence from a threshold regression model. *Heliyon, 9*(7), e17448. https://doi.org/10.1016/j.heliyon.2023.e17448

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica, 55*(2), 251–276. https://doi.org/10.2307/1913236

European Commission. (2019). *The European Green Deal*. Brussels: European Commission.

European Commission. (2021). *Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism (CBAM)*. Brussels: European Commission.

Hashmi, S. M., Bhowmik, R., Inglesi-Lotz, R., & Syed, Q. R. (2022). *Investigating the Environmental Kuznets Curve hypothesis amidst geopolitical risk: Global evidence using bootstrap ARDL approach*. Environmental Science and Pollution Research, 29(16), 24049–24062. https://doi.org/10.1007/s11356.021.17488-1

Hu, W., Shan, Y., Deng, Y., Fu, N., Duan, J., Jiang, H., & Zhang, J. (2023). *Geopolitical Risk Evolution and Obstacle Factors of Countries along the Belt and Road and Its Types Classification*. International Journal of Environmental Research and Public Health, 20, 1618. https://doi.org/10.3390/ijerph20021618

Huang, Y., Kuldasheva, Z., & Salahodjaev, R. (2021). Renewable energy and CO_2 emissions: empirical evidence from major energy-consuming countries. *Energies, 14*(22), 7504. https://doi.org/10.3390/en14227504

Intergovernmental Panel on Climate Change (IPCC). (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC.

Jiang, Y., & Khan, H. (2023). The relationship between renewable energy consumption, technological innovations, and carbon dioxide emission: Evidence from two-step system GMM. *Environmental Science and Pollution Research, 30*(2), 4187–4202. https://doi.org/10.1007/s11356.022.22391-4

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control, 12*(2–3), 231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration – with applications to the demand for money. *Oxford Bulletin of Economics and Statistics, 52*(2), 169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Kang, H. (2021). CO_2 emissions embodied in international trade and economic growth: Empirical evidence for OECD and non-OECD countries. *Sustainability, 13*(21), 12114. https://doi.org/10.3390/su132112114

Kızılkaya, F., Kızılkaya, O., & Mike, F. (2024). Does geopolitical risk escalate environmental degradation in Turkey? Evidence from a Fourier approach. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668.024.05258-1

Lawal, G. O., Aladenika, B., Akadiri, A., Fatigun, A. S., & Olanrewaju, V. O. (2023). Geopolitical risk, globalization and environmental degradation in South Africa: Evidence from advanced quantiles approach. *Problemy Ekorozwoju, 18*(1), 207–215. https://doi.org/10.35784/pe.2023.1.22

Luo, H., & Sun, Y. (2024). Effects of geopolitical risk on environmental sustainability and the moderating role of environmental policy stringency. *Scientific Reports, 14*(1), 10747. https://doi.org/10.1038/s41598.024.47166-7

Mirziyoyeva, Z., & Salahodjaev, R. (2023). Renewable energy, GDP and CO_2 emissions in high-globalized countries. *Frontiers in Energy Research, 11*, Article 1123269. https://doi.org/10.3389/fenrg.2023.112.3269

Mukhtarov, S., Aliyev, F., Aliyev, J., & Ajayi, R. (2023). Renewable energy consumption and carbon emissions: Evidence from an oil-rich economy. *Sustainability, 15*(1), 134. https://doi.org/10.3390/su15010134

Narayan, P. K., & Smyth, R. (2005). Trade liberalization and economic growth in Fiji: An empirical assessment using the ARDL approach. *Journal of the Asia Pacific Economy, 10*(1), 96–115. https://doi.org/10.1080/135.478.6042000309092

Özokcu, S., & Özdemir, Ö. (2017). Economic growth, energy, and environmental Kuznets curve. *Renewable and Sustainable Energy Reviews, 72*, 639–647. https://doi.org/10.1016/j.rser.2017.01.059

Pesaran, M. H., Shin, Y., ve Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326.

Riti, J. S., Shu, Y., & Riti, M. K. J. (2022). Geopolitical risk and environmental degradation in BRICS: Aggregation bias and policy inference. Energy Policy, 166, 113010. https://doi.org/10.1016/j.enpol.2022.113010

Saadaoui, Z., Doğan, E., & Omri, A. (2023). Does geopolitical risk affect CO_2 emissions in Turkey? ARDL and spectral causality analysis. *Environmental Science and Pollution Research, 30*, 36975–36988. https://doi.org/10.1007/s11356.023.36975-36988

Sharifi-Renani, H. (2007). Demand for money in Iran: An ARDL approach. *MPRA*, 1-9

Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.

Uddin, I., Usman, M., Saqib, N., & Makhdum, M. S. A. (2023). The impact of geopolitical risk, governance, technological innovations, energy use, and foreign direct investment on CO_2 emissions in the BRICS

region. *Environmental Science and Pollution Research, 30*, 73714–73729. https://doi.org/10.1007/s11356.023.27466-4

Yesbolova, A. Y., Abdulova, T., Nurgabylov, M., Yessenbekova, S., Turalina, S., Baytaeva, G., & Myrzabekkyzy, K. (2024). Analysis of the effect of renewable energy consumption and industrial production on CO_2 emissions in Turkic Republics by panel data analysis method. *International Journal of Energy Economics and Policy, 14*(1), 480–487. https://doi.org/10.32479/ijeep.15261

Zhao, W., et al. (2021). Nonlinear effects of geopolitical risk on carbon emissions: New evidence from BRICS countries. *Environmental Science and Pollution Research, 28*(29), 39668–39679. https://doi.org/10.1007/s11356.021.13505-5

Wang, K. H., Kan, J. M., Jiang, C. F., & Su, C. W. (2022). Is geopolitical risk powerful enough to affect carbon dioxide emissions? Evidence from China. *Sustainability, 14*(13), 7867. https://doi.org/10.3390/su14137867

World Bank. (2024). *Trade (net exports of goods and services % of GDP) – Turkey*. Retrieved July 2025, from https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?locations=TR

World Bank. (2024). *Renewable energy consumption (% of total final energy consumption) – Turkey*. Retrieved July 2025, from https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS?locations=TR

World Bank. (2024). *GDP (constant 2015 US$) – Turkey*. Retrieved July 2025, from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=TR

Journal of Research in Economics • Volume: 9 / Issue 2 • October 2025 pp. 90-103
ISSN: 2636-8307 • DOI: http://dx.doi.org/10.29228/JORE.45

RESEARCH ARTICLE

DOES ENVIRONMENTAL, SOCIAL, GOVERNANCE (ESG) INVESTMENTS INFLUENCE BANK PERFORMANCE? CROSS-COUNTRY EVIDENCE FROM EMERGING MARKETS

Mehtap ÖNER[*]
Aslı AYBARS[**]
Murat ÇİNKO[***]
Emre ZEHİR[****]

Abstract

This study aims to provide a comprehensive analysis of how Environmental, Social, and Governance (ESG) practices of banks influence their financial and market performance, which are proxied by return on assets (ROA) and Tobin's Q, respectively. The sample comprises 35 banks from 11 emerging market countries over the period from 2017 to 2022. To assess this relationship, two distinct models are estimated for each performance indicator, examining both contemporaneous and lagged effects. The results reveal a negative association between ESG scores and financial performance, consistent with the predictions of the Trade-off Hypothesis in that costs associated with ESG investments may outweigh their financial benefits. This negative relationship remains robust when considering the lagged effects. However, no significant impact is found between ESG practices and market performance, as proxied by Tobin's Q, across the models tested. The findings of this study offer important insights into the role of ESG practices within the banking industry, especially in emerging economies where the adoption and implementation of these practices may be in the early phases and differ considerably among institutions.
Keywords: ESG, Banking sector, Emerging countries, Financial performance, Market performance, Panel data analysis
JEL Classification Codes: G20, G21, G30, C33, O50

1. Introduction

In the recent decades, companies' tendency towards acting in a socially responsible manner and pursuing sustainable investment practices have increased due to fast changing economic environment. As a result, both financial performance and non-financial performance – often captured through Environmental, Social, and Governance (ESG) pillars – have become essential

* Marmara Üniversitesi İşletme Fakültesi, mehtap.oner@marmara.edu.tr, https://orcid.org/0000-0001-7527-5875
** Marmara Üniversitesi İşletme Fakültesi, asli.aybars@marmara.edu.tr, https://orcid.org/0000-0002-7899-2367
*** Marmara Üniversitesi İşletme Fakültesi, mcinko@marmara.edu.tr, https://orcid.org/0000-0001-8560-7482
**** JCR-ER Rating İstanbul, emre.zehir@jcrer.com.tr, https://orcid.org/0000-0002-0262-1826

Submission Date: May 24, 2025
Revision Date: July 13, 2025
Acceptance Date: July 14, 2025

concerns for economic actors. ESG score, reflecting a company's ESG performance based on publicly reported information, is derived from a combination of 10 grouped categories making up the three pillars. The environmental pillar focuses on a firm's activities related with emissions, resource usage, and environmental product innovation. The social pillar encompasses actions as to workforce, human rights, community engagement, and product responsibility. Lastly, the governance pillar is related with management, shareholders, and corporate social responsibility strategy (London Stock Exchange Group (LSEG) Methodology, 2024). In recent decades, ESG scores have gained concern and attention from investors, policy makers, and all other stakeholders alike since they demonstrate the manner companies conduct their businesses with a perspective on being socially responsible and corporate governance issues.

Banks, as key financial intermediaries, play a vital role in channeling funds from those with excess capital to those with capital shortage and good investment prospects. Thereby, they facilitate the flow of capital in the most efficient manner. As one of the most fundamental institutions in the economy, banks' attitude towards the implementation of ESG activities cannot be ignored and how banks integrate ESG practices into their financial activities is a paramount concern of investors. The ESG pillars stated above carry distinct and significant implications for the banking sector. For example, Environmental practices may shape banks' exposure to climate-related financial risks, particularly through lending to carbon-intensive industries. Social considerations**,** such as employee relations, customer treatment, and community engagement, play a vital role in building stakeholder trust and long-term client relationships. Finally, governance practices are central to ensuring effective risk management, enhancing transparency, and maintaining regulatory compliance that are important in a sector fundamentally based on credibility.

Accordingly, this study investigates the impact of ESG activities on both the financial and market performance of banks in emerging markets. As banks are relatively more heavily regulated, investments in ESG can prove to be an important factor to attain competitive advantage. Especially in developing countries, this situation may be more strongly pronounced and add more value to the banks due to the relatively low regulatory restrictions in these markets (Azmi et al., 2021). Furthermore, since regulations, corporate governance and transparency are weaker in emerging markets, providing a perspective from the banking sector in a cross-country setting from these markets is essential as potentially more value can be generated with ESG practices. However, as further will be detailed in the section devoted to the theoretical background, this relationship between ESG practices and performance can turn out to be negative if resources for these investments are used inefficiently.

While ESG has gained significant attention globally, there remains a limited understanding of its implications within the banking sector of developing economies. In particular, existing studies often focus on developed countries or single-country analyses, leaving a research gap regarding cross-country evidence from emerging markets where ESG adoption is still evolving. Thus, this study aims to fill this gap by examining whether ESG practices enhance or hinder bank performance in a cross-national sample of 11 emerging economies.

The layout of the study is organized as follows. Theoretical background and hypotheses formulation are presented in the next section. Literature review is provided in Section 3 followed by research design and methodology. The findings of the models utilized are displayed and evaluated in Section 5; lastly followed by concluding remarks.

2. Theoretical Review and Hypothesis Formulation

This section focuses on theories with respect to the link between ESG investments and firm performance. Preston and O'Bannon (1997) present two key opposing theories, known as the Trade-off and Social Impact hypotheses, regarding the nature of the connection between corporate social and financial performance. The Trade-off Hypothesis is a reflection of the ideas of Friedman (1970, 2007) and argues that ESG practices result in resources being inefficiently used. Being a major proponent of neoclassical theory, Friedman argues that investments in ESG activities increase costs, put firms into a competitive disadvantage, and reduce corporate performance. Thus, rather than concentrating on ESG practices, he proposes that firms should prioritize maximizing profits and wealth for shareholders. Accordingly, the predicted relationship is negative. In contrast, the relationship is expected to be positive in Social Impact Hypothesis. According to the Stakeholder Hypothesis, which supports a positive connection, the success of a business' goods and services relies on fulfilling the interests of its stakeholders. Therefore, firms are expected to enhance their performance and value when stakeholders' needs are satisfied. Moreover, it is regarded to be the managers' responsibility to enhance value for and communicate with all interested parties (Freeman, 1984; Freeman et al. 2010). Additionally, as stated by Velte (2017), if the trust of stakeholders increases, both financial and nonfinancial circumstances will be improved.

Contrarily, according to the Agency Theory; when principles (owners) delegate decision making process to an agent (manager) and make them act on their behalf, the agents' actions may not align with the interests of the principle; thus, interest discrepancies may arise (Jensen and Meckling, 1976). The costs that arise due to this misalignment of interest will be detrimental to corporate performance. Based on the fundamentals of agency theory, ESG practices can be undertaken by managers to pursue their own interests, specifically when the managers are not correctly incentivized. Thus, when resources are diverted away from shareholders, it may lead to reduction in value. In opposition, the Resource-Based View proposes that both tangible and intangible assets, which are considered key strategic resources, contribute to improved performance and a competitive advantage (Wernerfelt, 1984). According to Buallay et al. (2020), revealing both financial and non-financial resources helps firms attain superior performance. With the help of these resources, firms' capabilities and competence are improved; thus, competitive advantage can be attained. Furthermore, Azmi et al. (2021) views investments in ESG practices as strategic investments.

As stated above, contrasting predictions have been offered by theories with respect to the relationship between ESG activities of banks and their performance. Whereas a negative association is expected by the Trade-off Hypothesis and Agency Theory; Social Impact Hypotheses, Stakeholder Theory and Resource-Based View anticipate a positive relationship. As theoretical predictions are divergent, an empirical question still remains on the relationship between ESG scores and performance—particularly in the context of emerging markets where institutional structures, stakeholder expectations, and ESG maturity differ significantly from developed economies. Building on these contradictory theoretical predictions, this study aims to explore the nature of the ESG–performance relationship across both financial and market performance indicators based on a dataset of emerging market banks. Consequently, two hypotheses are formulated as follows:

H1a. There is a significant relationship between the ESG Scores and bank financial performance.

H1b. There is a significant relationship between the ESG Scores and bank market performance.

3. Literature Review

Within the scope of this array of literature; while some researchers have observed that investments in ESG related activities improve performance (Brogi and Lagasio, 2018; Alam, et al. 2022; Sain and Kashiramka, 2024), others have demonstrated the negative impact of these investments upon performance (Buallay et al. 2020; Menicucci and Paolucci, 2023; Yuen et al. 2022). Furthermore, no significant association between ESG and firm performance have been documented (Alghafes et al., 2024). Additionally, the researches that investigate this relationship for the ESG components have come up with conflicting results with respect to these individual components. A comprehensive overview of about 2,200 academic researches performed by Friede et al. (2015) reveals that around 90% of the studies document positive results as to ESG and firm performance relationship. The number of studies conducted within this array of literature for developing economies are relatively limited with respect to developed ones due to fact that the companies that disclose data as to ESG activities are limited in number and confronted with difficulties as to the quantification of ESG practices. Furthermore, within the scope of developing ones, single country studies are less in number so researchers focus mostly on multi-country and regional studies rather than single country ones due to data availability issues.

A study conducted by Brogi and Lagasio (2018) with respect to a developed market, U.S., evaluates influence of ESG investments on ROA of listed firms. The sample is divided into three sub-categories made up of banks, insurance, and industrial companies. The overall evidence reveals that ESG score contributes to financial performance of selected firms. This finding is pronounced to be stronger for the case of banks in comparison to the industrial companies. Moreover, significant differences have been documented as to industrial companies and financial institutions. Additionally, the analysis as to the components of ESG score also reveals environmental dimension to be strongly associated with bank profitability. Another study

based on the U.S. explores how ESG practices affect banks' market value and shows an inverted U-shaped association between the associated variables (Ersoy et al., 2022). One other developed country study, performed on a dataset of Italian banks, explores the impact of ESG activities and its pillars on banks' financial, operational, and market performance. ESG is found to negatively influence operational and market performance. However, analysis as to dimensions under selected pillars reveals that waste reductions and emissions improve banks' performance (Menicucci and Paolucci, 2023). Furthermore, the evidence based on developing countries have been found to be positive and significant for India and Turkey in the studies of Sain and Kashiramka (2024), Çetenak et al. (2022), and Korkmaz and Nur (2023).

A comprehensive regional study by Khoury et al. (2023), which includes data belonging to the Middle East and North Africa regions, conducted on a dataset of 46 banks evaluates the direction of the association between ESG and financial performance. The evidence shows a concave relationship in that whereas investments in ESG are found to add value to the firm at lower investment levels, the opposite is true for higher levels of investments.

With a cross-country dataset, Buallay (2019) concentrates on a total of 235 European banks and documents a significant and positive influence of ESG score on selected performance indicators. However, analysis of ESG components demonstrates varying evidence. Environmental score positively influences ROA and Tobin's Q and governance score is detected to positively affect only Tobin's Q. In contrast, the evidence with respect to social score is in opposition with its influence being negative and significant for all three performance indicators. Furthermore, governance score is also detected to negatively influence ROA and return on equity (ROE). A more extensive analysis, involving a dataset of 882 banks across 80 countries, provide evidence for a negative and significant effect of ESG on all selected performance measures as in the aforementioned study (Buallay et al., 2020). This negative relationship is further corroborated by a subsequent paper by Buallay et al. (2023) examining the banking and finance industry across seven regions and 60 countries.

Shakil et al. (2019) perform a comprehensive study on 93 emerging markets to evaluate how ESG and bank performance are related. Their findings highlight a positive and significant impact of the environmental and social dimensions on ROE, while no significant effect of governance pillar has been detected. Furthermore, none of the ESG pillars were found to have a significant influence on operational performance, as indicated by ROA. Another study conducted on 44 emerging countries documents a non-linear association between firm value and ESG. While low levels of ESG practices are found to positively influence firm value measured by Tobin's Q, high levels are observed to display diminishing returns to scale. Additionally, the evidence reveals that among the ESG components, environmental activities are found to be the most influential one on bank value (Azmi et al., 2021). Furthermore, the study of Yuen et al. (2022) takes into account the potential influence of COVID-19 on the global banking system with a focus on both developed and developing economies. The study is performed on a dataset of 487 banks compiled from 51 countries with the result that ESG activities exert a negative impact on bank profitability due to

increasing costs associated with these investments. Furthermore, a U-shaped relationship has been identified, suggesting that, over the long term, ESG activities may be positively influencing bank performance. Lastly, banks that are better in terms ESG activities are found to demonstrate superior performance during the pandemic period.

A cross-country study based on both developing and developed economies with a perspective on Islamic finance investigates how the Islamic Finance Development Indicator (IFDI) relates with ESG practices. The findings point to a positive relation between the scores of IFDI and ESG specifically for the social component (Paltrinieri et al. 2020). Another study comparing conventional and Islamic banks in the MENA region, investigating the impact of ESG practices on efficiency, finds a positive effect for both types of banks when considering the overall dataset. However, when the research question is analyzed separately on the basis of bank type, the impact is found to be insignificant for Islamic banks. While further component analysis reveals no significant impact of governance practices neither on conventional or Islamic banks, a positive influence is found for both types in the case of environmental practices. Additionally, social activities are found to contribute only to conventional bank efficiency (Alam, et al. 2022). A more recent paper conducted on 29 Islamic banks in Gulf Cooperation Council countries finds no significant influence of ESG on bank performance proxied by ROE, ROA, and Tobin's Q. However, when component analysis is applied, it is seen that each component contributes positively to only one or two of the selected performance measures (Alghafes et al., 2024).

Based on the review of literature, the direction and significance of the relationship differs as to the country, market, and the region for which the analysis is being conducted and the period under question. Even though the array of literature on ESG and firm performance is growing, gaps still exist. Since the concept of ESG is relatively more established and data is more available in developed countries, most of the studies focus on these economies. Although emerging markets have a vital and growing role in global finance with a significant potential for ESG practices, they receive relatively limited attention from researchers. Additionally, cross-country studies in the banking industry are relatively limited due to the fact that greater portion of existing literate focus on individual countries or specific sectors. Moreover, the studies evaluating the impact of ESG activities on both financial and market performance together with the potential lagged effects are also few in number. Accordingly, this study aims to fill these gaps in literature by providing a cross-country analysis in banking industry, evaluating both immediate and lagged impacts of ESG practices on banks' financial and market performance.

4. Research Design and Methodology

This section presents the sample, variables, methodology, and models employed in the study. To probe how ESG influences financial and market performance of the selected banks, panel data analysis is applied. This method is advantageous as it integrates both time series and cross-sectional data, thereby enhancing degrees of freedom, richness of the data, and its variability.

Furthermore, the method mitigates the presence of multi-collinearity and also handles with heterogeneity (Baltagi, 2001; Wooldridge, 2002).

4.1. Data Set and Variables

This study uses a population of 91 banks from 15 countries covering the years between 2017-2022. The sample is restricted to banks with the availability of ESG data in Refinitiv ESG Database formerly known as Thomson Reuters. Furthermore, the selected countries are the ones that are defined as emerging markets by the chosen database. Data for the bank-specific explanatory and control variables are obtained from Thomson Reuters. As the final sample is being constructed, the idea is to generate the largest and most recent firm-year observations as possible so that the analyses are conducted for 35 banks from 11 countries. The breakdown of the data as to countries with respect to the number of banks is provided in Table 1 below;

Table 1: The Country Breakdown of the Data

Country	Number of Banks
Brazil	2
Chile	1
Colombia	2
Indonesia	3
South Korea	4
Malaysia	6
Mexico	2
Philippines	1
Poland	5
Thailand	5
Turkey	4
Total	**35**

To assess the effect of ESG practices on bank performance, this study uses two key dependent variables: ROA and Tobin's Q. These metrics are employed to represent financial performance and market valuation, respectively (Bătae et al., 2021; Buallay et al., 2021; Menicucci and Paolucci, 2023; Khoury et al., 2023). ROA is computed as the ratio of net income to total assets, while Tobin's Q is derived by dividing the sum of the market value of equity and the book value of liabilities by the total book value of assets. Moreover, the explanatory variable of the study is chosen to be the combined ESG score, which comprises environmental, social, and governance pillars. Additionally, to investigate the potential lagged effects of ESG practices on performance, the ESG score is included in the model with a one-year lag.

In order to choose control variables, previous theoretical and empirical studies have been screened to identify bank specific factors that have a potential to influence financial and market performance other than ESG. Thus, control variables such as size, capital adequacy, leverage, loan to customer deposits, and cost to income are embedded into the models. Consistent with the works

of Paltrinieri et al. (2020), Menicucci and Paolucci (2023), and Lamanda and Tamásné Vőneki (2024), size is measured as natural logarithm of total assets to reveal the potential advantages of being larger due to economies of scale and market share. To control for the degree to which banks comply with capital requirement regulations, capital adequacy ratio is included in the models, calculated as total capital divided by total risk-weighted assets (Bătae et al., 2021; Menicucci and Paolucci, 2023; Lamanda and Tamásné Vőneki, 2024). To control for financial risk of the banks and degree of reliance on external financing that can influence bank risk-return profile, the ratio of total liabilities to total equity is utilized in all models as an indicator of leverage (Esteban-Sanchez et al., 2017; Ungphakorn, 2024). This control variable can be regarded as an indicator for the investment strategies of the banks as it shows the degree of using external financing for value creation (Bătae et al., 2021). Bank liquidity is captured in the models by the ratio of total loans to customer deposits to reflect liquidity risk in line with the studies of Wu and Shen (2013); Terraza (2015), Bătae et al. (2021); and Serino et al. (2024). Finally, cost to income ratio is utilized as an indicator of bank operating efficiency and is computed as the ratio of operating expenses divided by operating income (Gupta and Kashiramka, 2020; Khoury et al, 2023; Sain and Kashiramka, 2024). The variables with their abbreviations and definitions are displayed in Table 2 below.

Table 2: The Variables and Their Abbreviations

Variable	Abbreviation	Definition
Dependent Variables		
Return on Assets	ROA*it*	Net income/Total assets for firm *i* at year *t*
Tobin's Q	TOBINSQ*it*	(Total market value of equity + total book value of liabilities)/Total book value of assets for firm *i* at year *t*
Explanatory Variables		
ESG	ESG*it*	Overall company score based on the self-reported information in the Environmental, Social, and Corporate Governance pillars for firm *i* at year *t*
ESGLAG	ESGLAG*it*	Overall company score based on the self-reported information in the Environmental, Social, and Corporate Governance pillars for firm *i* at year *t-1*
Control Variables		
Firm Size	SIZE*it*	Natural logarithm of total assets for firm *i* at year *t*
Capital Adequecy Ratio	CAPADQ*it*	The ratio of total capital to total risk-weighted assets for firm *i* at year *t*
Financial Risk	RISK*it*	Total liabilities/Total equtiy for firm *i* at year *t*
Liquidity	LIQ*it*	Indicates the proportion of loans that are funded by customer deposits and is computed as net loans divided by total deposits for firm *i* at year *t*
Cost to Income Ratio	*CIit*	Operating expenses/operating income for firm *i* at year *t*

4.2. The Models Utilized

To evaluate the effect of ESG on financial and market performance of the selected banks with respect to the hypothesis generated, the models in Table 3 are developed. As can be seen by the mathematical representations, model (1) and model (2) are generated to find the link between ESG and bank financial performance, namely ROA. Whereas model (1) evaluates this relationship by using the ESG scores, the second model takes into account the lagged effect to find out how investments in ESG issues influence financial performance of the following year. Additionally, models (3) and (4) are generated in the same manner in that they evaluate the impact of ESG on Tobin's Q as an indicator of bank market performance.

Table 3: Models in Their Functional Forms

Models	Functional Representations	Equation No
ROA = *f* (ESG, SIZE, CAPADQ, RISK, LIQ, CI)	$ROA_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 CAPADQ_{it} + \beta_3 RISK_{it} + \beta_3 LIQ_{it} + \beta_3 CI_{it} + \epsilon_{it}$	(1)
ROA = *f* (ESGLAG, SIZE, CAPADQ, RISK, LIQ, CI)	$ROA_{it} = \beta_0 + \beta_1 ESGLAG_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 CAPADQ_{it} + \beta_3 RISK_{it} + \beta_3 LIQ_{it} + \beta_3 CI_{it} + \epsilon_{it}$	(2)
TOBINSQ = *f* (ESG, SIZE, CAPADQ, RISK, LIQ, CI)	$TOBINSQ_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 CAPADQ_{it} + \beta_3 RISK_{it} + \beta_3 LIQ_{it} + \beta_3 CI_{it} + \epsilon_{it}$	(3)
TOBINSQ = *f* (ESGLAG, SIZE, CAPADQ, RISK, LIQ, CI)	$TOBINSQ_{it} = \beta_0 + \beta_1 ESGLAG_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 CAPADQ_{it} + \beta_3 RISK_{it} + \beta_3 LIQ_{it} + \beta_3 CI_{it} + \epsilon_{it}$	(4)

In order to select the appropriate estimator for the models, Likelihood-ratio (LR) test is performed to assess the existence of unit and/or time effects. The findings demonstrate that all models except model (4) have both unit and time affects, making them two-way models. In contrast, model (4), which explores the impact of lagged ESG scores on market-based bank performance, only shows a unit effect. The determination of whether the models should use fixed or random effects is determined based on the Hausman test results. Accordingly, while models (1) and (2) have fixed affects, the other two models are found to demonstrate random effects. Furthermore, regarding associated test results, all models are found to have heteroskedasticity, autocorrelation, and cross-sectional independence. Consequently, Driscoll-Kraay standard errors are applied in the regression analysis of all four models (Tatoğlu, 2020, p. 338-339).

5. Empirical Findings

The results for models (1) through (4), which examine the relationship between bank performance and ESG practices, are presented in Table 4. Models (1) and (2) focus on financial performance, while models (3) and (4) use market performance as the dependent variable. Furthermore, the lagged relationship as to the main variables of interest, namely; performance and ESG scores is taken into account in Models (2) and (4).

Based on the findings of model (1), ESG scores are found to be negatively and significantly influencing financial performance in line with the results of Yuen et al. (2022) and Buallay et al. (2023). Regarding the control variables, only bank leverage, which is used as a measure of financial risk, and cost to income ratio that controls for banks' operating efficiency are found to demonstrate significant and negative impact on financial performance. These findings imply that while higher financial risk deteriorates ROA, a lower ratio of operating efficiency contributes to financial performance. When investigating the potential lagged effect of ESG investments on future financial performance in model (2), a similar negative and significant relationship is still observed, though with a higher coefficient. In addition to the control variables that are significant in Model (1), bank size and capital adequacy are also found to have a significant and positive effect on the selected measure of bank performance.

From a theoretical standpoint, the findings of the study for the models using ROA are parallel to the predictions of Trade-off Hypothesis. This theory suggests that investments in ESG practices incur additional costs, which can negatively impact bank performance. Thus, a negative relationship between ESG scores and financial performance is predicted consistent with the building blocks of this theory.

In contrast, with regard to the influence of ESG scores on the market performance of the banks, no significant evidence is found in Model (3). When the lagged relationship is further embedded into Model (4), it is observed that the association is still insignificant. The only significant control variable that is influential on market performance is capital adequacy, though at 10% significance level, in Model (3). Furthermore, this variable turns out to be insignificant in Model (4) with none of the variables being significant in this last model.

Table 4: The Results of the Models (1) – (4)

Method	**Fixed Effects**	**Fixed Effects**	**Random Effects**	**Random Effects**
Dependent Variable	**ROA**	**ROA**	**TOBINSQ**	**TOBINSQ**
Variables	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**
ESG	-.01998***		-.00108	
	(.00440)		(.00067)	
ESGLAG		-.02958***		-.00026
		(.00219)		(.00036)
SIZE	.96723	1.50148*	-.00306	-.00241
	(.52222)	(.55264)	(.00312)	(.00338)
CAPADQ	.03947	.04959*	-.00271*	-.00173
	(.02138)	(.01907)	(.00131)	(.00102)
RISK	-.51259**	-.66316**	-.00621	-.00472
	(.19703)	(.18193)	(.00739)	(.00773)
LIQ	.00000	.00000	.00000	.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
CI	-.03317***	-.02850***	-.00037	-.00014
	(.00545)	(.00543)	(.00032)	(.00022)
constant	-25.07347	-39.8663*	1.22277***	1.12101***
	(-14.7999)	-1.601.219	(.06096)	(.06096)
Number of observations	210	175	210	175
Number of groups	35	35	35	35
F	573.90	10479.07		
Prob>F	0.0000	0.0000		
Wald chi2			187.82	55.55
Prob > Chi2			0.0000	0.0000
Within R-squared	0.2571	0.3379		
Overall R-squared			0.0157	0.0131
legend	** p<0.10;*	*** p<0.05;*	****p<0.01*	
All models are regressed with Driscoll-Kraay standard errors				

6. Conclusion

This study adds to the expanding body of literature that investigates the connection between ESG scores and bank performance; namely, financial and market, with a particular focus on emerging markets. This relationship is explored on a sample of 210 bank-year observations spanning from 2017 to 2022. To test the influence of ESG scores on performance, two distinct models are estimated for each dependent variable, ROA and Tobin's Q, both with and without a lag for each performance proxy.

The study reveals that ESG scores negatively affect banks' financial performance. When the lagged effect is also taken into account, this negative relationship is still observed with a higher coefficient. This result is parallel to predictions of Trade-off Hypothesis suggesting that additional costs associated with ESG activities contribute to a deterioration in performance. In other words, the hypothesis posits that costs associated with ESG investments may outweigh their financial benefits. However, the relationship turns out to be insignificant when Tobin's Q is utilized as a measure of market performance in both of the models. These may suggest that while ESG practices influence financial outcomes, their impact on market performance may be less pronounced, or perhaps influenced by other factors not captured in this study. The results of this study provide valuable insights into the role of ESG practices within the banking sector, particularly in emerging economies, where the adoption and implementation of ESG practices may still be in the early stages and vary significantly across institutions.

From a cross-country perspective, this study adds to the literature regarding the influence of ESG practices on banking sector's performance. However, the study has some limitations. The major limitation is that the sample is relatively small, which is made up of 35 emerging market banks. This limited sample size may affect the generalizability of the results. Since the aim is to construct a balanced panel data set that is uninterrupted in terms of ESG scores to make up the largest and most recent bank-year dataset possible, the data set turns out to be limited. The main reason rests upon the fact that ESG data in Refinitive ESG Database does not have a very long and consecutive history for the emerging market case. Therefore, the lack of long-term and consistent ESG data for the banks presents a challenge, as ESG scores in emerging economies are often less comprehensive and may not fully reflect the impact of ESG activities. This fact also results in a selection bias since the banks with ESG scores may already be the ones that are larger, better governed, more performance oriented than their non-ESG-disclosing counterparts. Additionally, banks with better performance may have more resources and motivation to invest more in ESG activities, which may result in an endogeneity problem. While control variables are utilized in the models to reduce some of these problems, the same issue of endogeneity is common for most of the cross-country studies. Thus, further research could address this issue with additional analyses.

Future studies could also enhance the understanding of ESG's impact by expanding the sample to include a wider range of banks from diverse regions, as well as by examining the potential long-term effects of ESG investments on performance. Moreover, the role of specific ESG dimensions

can be individually investigated in shaping financial outcomes. The findings of this study show that ESG investments do not always result in improved financial performance for banks in emerging markets. Thus, before encouraging banks to adopt ESG practices, policymakers should deeply consider the cost–benefit balance involved. Ultimately, understanding the broader implications of ESG investments in banking could provide valuable guidance for both practitioners and policymakers aiming to address the growing importance of sustainable and responsible banking practices. Additionally, improving the standardization and transparency of ESG reporting can help ensure that such practices are more effective and comparable across institutions. Lastly, results within this array of literature will contribute to a more comprehensive understanding of how ESG activities can influence the financial outcomes of banks, particularly in regions where the adoption of ESG practices may still be evolving.

References

Alam, A. W., Banna, H., & Hassan, M. K. (2022). ESG activities and bank efficiency: Are Islamic Banks Better? *Journal of Islamic Monetary Economics and Finance*, 8 (1): 65-88.

Alghafes, R., Karim, S., Aliani, K., Qureishi, N., & Alkayed, L. (2024). Influence of key ESG factors on Islamic banks' financial performance: Evidence from GCC countries. *International Review of Economics & Finance*. 96 (Part A): 103629. https://doi.org/10.1016/j.iref.2024.103629.

Azmi, W., Hassan, M. K., Houston, R., & Karim, M. S. (2021). ESG activities and banking performance: International evidence from emerging economies. *Journal of International Financial Markets, Institutions and Money*, 70: 101277. https://doi.org/10.1016/j.intfin.2020.101277

Baltagi, B. H. (2001). *Econometric analysis of panel data*. (2nd ed.). United Kingdom: John Wiley&Sons, Ltd.

Bătae, O. M., Dragomir, V. D., & Feleagă, L. (2021). The relationship between environmental, social, and financial performance in the banking sector: A European study. *Journal of Cleaner Production*, 290: 125791. https://doi.org/10.1016/j.jclepro.2021.125791.

Brogi, M., & Lagasio, V. (2018). Environmental, social, and governance and company profitability: Are financial intermediaries different? *Corporate Social Responsibility and Environmental Management*, 26: 576-587. Doi: 10.1002/csr.1704

Buallay, A. (2019). Is sustainability reporting (ESG) associated with performance? Evidence from the European banking sector. *Management of Environmental Quality: An International Journal*, 30(1): 98-115. Doi: 10.1108/MEQ-12-2017-0149

Buallay, A., Fadel, S. M., Al-Ajmi, J. Y., & Saudagaran, S. (2020). Sustainability reporting and performance of MENA banks: Is there a trade-off? *Measuring Business Excellence*, 24(2): 197-221.

Buallay, A., Fadel, S. M., Alajmi, J., & Saudagaran, S. (2021). Sustainability reporting and bank performance after financial crisis: Evidence from developed and developing countries. *Competitiveness Review*, 31(4): 747-770. Doi: 10.1108/CR-04-2019-0040

Buallay, A. M., Marri, M. A., Nasrallah, N., Hamdan, A., Barone, E., & Zureigat, Q. (2023). Sustainability reporting in banking and financial services sector: A regional analysis. *Journal of Sustainable Finance & Investment*, 13(1): 776-801. Doi: 10.1080/20430.795.2021.1978919

Çetenak, E. H., Ersoy, E., & Işık, Ö. (2022). The effect of ESG (environmental, social and governance) scores on firm Performance: Evidence from Turkish banking industry. *Erciyes Üniversitesi İİBF Dergisi*, 63: 75-82. Doi: 10.18070/erciyesiibd.1212587

Ersoy, E., Swiecka, B., Grima, S., Özen, E., & Romanova, I. (2022). The impact of ESG scores on bank market value? Evidence from the U.S. banking industry. *Sustainability*, 14: 9527. https://doi.org/10.3390/su14159527

Esteban-Sanchez, P., de la Cuesta-Gonzalez, M., & Paredes-Gazquez, J.D. (2017). Corporate social performance and its relation with corporate financial performance: International evidence in the banking industry. *Journal of Cleaner Production*. 162: 1102e1110. https://doi.org/10.1016/j.jclepro.2017.06.127.

Freeman, R.E. (1984), *Strategic management: A stakeholder approach*, Boston, MA.

Freeman, R. E., Harrison, J. S., Wicks, A. C., Parmar, B. L., & De Colle, S. (2010). Stakeholder theory: The state of the art.

Friede, G., Busch, T., & Bassen, A., (2015). ESG and financial performance: Aggregated evidence from more than 2000 empirical studies. *Journal of Sustainable Finance & Investment.* 5: 210e233. https://doi.org/10.1080/20430.795.2015.1118917.

Friedman, M., (1970). The social responsibility is to increase its profits. *The New York Times Magazine*, September 13: 32-3.

Friedman, M. (2007). The social responsibility of business is to increase its profits. In Corporate Ethics and Corporate Governance, edited by W. C. Zimmerli, M. Holzinger, and K. Richter, 173– 178. New York, Springer.

Gupta. J, & Kashiramka, S. (2020). Financial stability of banks in India: Does liquidity creation matter? *Pacific-Basin Finance Journal*, 64: 101439. doi.org/10.1016/j.pacfin.2020.101439.

Jensen, M.C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3 (4): 305–360.

Khoury, R. E., Nasrallah, & Alareeni, B. (2023), ESG and financial performance of banks in the MENAT region: Concavity–convexity patterns. *Journal of Sustainable Finance & Investment*, 13(1): 406–430. https://doi.org/10.1080/20430.795.2021.1929807

Korkmaz, T. & Nur, T. (2023). The effect of ESG sustainability on firm performance: A view under size and age on BIST bank index firms. *Journal of Research in Economics, Politics and Finance*, 8(2): 208-223. Doi: 10.30784/epfad.1278491

Lamanda, G. & Tamásné Vőneki, Z. (2024), Is ESG disclosure associated with bank performance? Evidence from the Visegrad four countries. *Management of Environmental Quality,* 35 (1): 201-219. https://doi.org/10.1108/MEQ-02-2023-0064

LSEG Data & Analytics (2024). Environmental, Social and Governance scores from LSEG, 1-33. https://www.lseg.com/content/dam/data-analytics/en_us/documents/methodology/lseg-esg-scores-methodology.pdf

Menicucci, E., & Paolucci, G. (2023). ESG dimensions and bank performance: An empirical investigation in Italy. *Corporate Governance*, 23(3): 563-586. Doi: 10.1108/CG-03-2022-0094

Paltrinieri, A., Dreassi, A., Migliavacca, M., & Stefano Piserà, S. (2020). Islamic finance development and banking ESG scores: Evidence from a cross-country analysis. *Research in International Business and Finance*, 51: 101100. https://doi.org/10.1016/j.ribaf.2019.101100

Preston, L. E., & O'Bannon, D. P. (1997), The corporate social-financial performance relationship: A typology and analysis. *Business and Society*, 36(4): 419-429.

Sain, A. & Kashiramka, S. (2024), Do corporate governance mechanisms and ESG disclosures improve bank performance and stability in an emerging economy? *Journal of Advances in Management Research*, 21(4): 530-555. https://doi.org/10.1108/JAMR-12-2022-0253

Serino, L., Spignese, A., & Campanella, F. (2024). Are ESG scores driven by financial information? Evidence from European banks. *Journal of Risk Management in Financial Institutions*, 17(4): 409-425.

Shakil, M. H., Mahmood, N., Tasnia, M. & Munim, Z. H. (2019). Do environmental, social and governance performance affect the financial performance of banks? A cross-country study of emerging market banks. *Management of Environmental Quality*, 30(6): 1331-1344. https://doi.org/10.1108/MEQ-08-2018-0155

Tatoğlu, F. Y. (2020). *Panel veri ekonometrisi stata uygulamalı* (5th ed.). Istanbul: Beta Yayınları.

Terraza, V. (2015) The effect of bank size on risk ratios: Implications of banks' performance. *Procedia Economics and Finance*, 30: 903–9.

Ungphakorn, T. (2024). Effects of country and firm specific factors on ESG performance: A cross – country analysis for emerging markets. *Journal of Electrical Systems*, 20(4s): 1705-1714.

Velte, P. (2017). Does ESG performance have an impact on financial performance? Evidence from Germany. *Journal of Global Responsibility*, 80(2): 169-178.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, 5(2): 171–180. http://www.jstor.org/stable/2486175

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. London: The MIT Press.

Wu, M. W., & Shen, C. H. (2013). Corporate social responsibility in the banking industry: Motives and financial performance. *Journal of Banking & Finance*, 37(9): 3529-3547. https://doi.org/10.1016/j.jbankfin.2013.04.023.

Yuen, M. K.., Ngo, T., Le, T. D. Q. & Ho, T. H. (2022). The environment, social and governance (ESG) activities and profitability under COVID-19: Evidence from the global banking sector, *Journal of Economics and Development*, 24 (4): 345-364. https://doi.org/10.1108/JED-08-2022-0136.

Journal of Research in Economics • Volume: 9 / Issue 2 • October 2025 pp. 104-119
ISSN: 2636-8307 • DOI: http://dx.doi.org/10.29228/JORE.46

RESEARCH ARTICLE

ENERGY CONSUMPTION FORECAST FROM A SUSTAINABLE DEVELOPMENT PERSPECTIVE: 2035 PROJECTION WITH MACROECONOMIC INDICATORS

Yaşar TURNA*

Abstract

Predicting the future course of energy consumption in line with sustainable development goals plays a critical role in long-term planning processes in terms of resource management, environmental sustainability, and economic stability. Therefore, in this study, Turkey's energy consumption until 2035 was estimated using the Random Forest machine learning model developed based on macroeconomic indicators. In the modeling process, energy consumption, economic growth, inflation, industrial carbon dioxide emissions and population growth data between 1965 and 2024 were used. These data were obtained from the World Development Indicators (WDI, 2025) and World Energy Statistics (WES, 2025) databases. In the analysis, the Random Forest model, a machine learning method, was preferred. In the established model, energy consumption was estimated to account for the nonlinear and complex interactions of economic growth, inflation, industrial carbon dioxide emissions and population growth variables. The estimation results obtained with the Random Forest model show that Turkey's energy consumption in the 2025-2034 period will follow a fluctuating but generally upward trend. Non-linear transitions have been observed in the forecasts, especially in some years, where there have been sudden jumps and fixations.

Keywords: Energy Consumption, Sustainable Energy, Sustainable Development, Machine Learning
JEL Classification: Q41, Q56, O44

1. Introduction

The process of energy dependency worldwide, which started with the Industrial Revolution, continued throughout the industrialization period. However, towards the end of the 20th century, this energy dependence and usage process changed the agenda of all developed and developing countries owing to reasons such as global warming, climate change, and environmental pollution (IPCC, 2014:4-16; Stern, 2007:15-17). Environmental pollution, especially due to the use of fossil fuels, has become an important topic of discussion for sustainable living and the environment (Sorrell, 2010: 1794-1802; Çetin and Sezen, 2018:137). In particular, in the 20th century, the negative effects of carbon dioxide emissions on global warming and climate change have caused

* PhD., Pamukkale University, Çivril Atasay Kamer Vocational School, Department of Finance-Banking and Insurance, e-mail: yturna@pau.edu.tr, Orcid: 0000-0002-3972-9099

Submission Date: 20.08.2025
Revision Date: 04.10.2025
Acceptance Date: 05.10.2025

policymakers to focus on energy consumption (Shahbaz et al., 2012: 2948–2951). Therefore, to realize the ecological growth and development process, transformation policies have been implemented in the energy sector. In addition, with the 1973 Oil Crisis in the past, countries started to take measures against the consequences of their energy dependency (Hamilton, 1983: 228–240). In addition, the global warming process has caused countries to change their energy policies. Therefore, renewable energy consumption, other than fossil fuels, has started to be encouraged in industrial production and residential consumption. Simultaneously, apart from the initial investment cost of renewable energy, the long-term cost advantage has made the use of these energy resources important (Pata and Yurtkuran, 2018:304). In parallel, the Kyoto Protocol was signed in 1997 in Kyoto, Japan, in accordance with the United Nations Convention on Climate Change and the Environment. Kyoto Protocol: It is an international agreement that contains binding legal provisions for industrialized countries to reduce greenhouse gas emissions to combat global warming and climate change. In this context, the Kyoto Protocol, as a solution to climate change and increasing energy consumption and demand, emphasizes the use of alternative energy sources, that is, the use of renewable energy sources (Çetin and Sezen, 2018:137).

Energy has strategic importance in achieving sustainable development and development goals of developed, underdeveloped, and developing countries worldwide. Especially in the world, energy consumption and energy need are increasing day by day due to reasons such as industrialization, population growth, economic growth, development and welfare increase. Recently, the increase in energy consumption due to population growth continues with economic growth (Es, 2020:772). Therefore, energy appears as an indicator of social development as a requirement of modern life, and energy consumption per capita is considered an indicator of development (Smil, 2018: 1–30). Accordingly, it can be said that energy consumption significantly affects people's quality of life and welfare levels. Simultaneously, the development levels of countries with energy sources in today's world are high. However, the main problem here is that instability in the countries that hold energy resources endangers the security of the energy supply and causes the production costs of other energy-dependent economies to increase (Sadorsky, 2011: 741–743). This situation causes companies in the domestic market to lose their competitive advantages, disrupt long-term production plans, and delay investments in the energy sector. In addition, increases in energy costs cause macroeconomic stability to deteriorate due to high current account and foreign trade deficits (Apergis and Payne, 2010: 652–654). For this reason, determining and planning energy needs is of great importance in ensuring a sustainable energy management in an economy (Çeltek, 2024: 706-707).

The use of energy in society from the early ages of human history to the present day has made significant contributions to economic and social development. Simultaneously, it is important for ensuring and increasing the continuity of economic growth. Energy is considered the basic input of industrial production and one of the main factors that meet human needs. Therefore, there are important relationships between the amount of energy consumed in an economy and its economic performance. As the rate of economic growth increases, the amount of energy consumption also increases (Akbaş and Lebe, 2015:197). In particular, it is important to maintain uninterrupted

energy consumption and supply to ensure the continuity of industrial production and continue its activities without interruption. In this way, the raw material processing capacities of the economies that ensure continuity increase; In parallel with the increases in export rates, foreign trade deficits are closing and foreign exchange reserves are increasing (Halmuratov et al., 2025: 23-26). However, high energy consumption increases environmental carbon dioxide emissions and environmental pollution. In the growth process, energy consumption also increases depending on the increasing production level. Simultaneously, the fact that the energy composition used in production consists of fossil fuels causes environmental pollution to increase even more (Pata and Yurtkuran, 2018:304). In recent years, due to increasing environmental problems, climate change, and environmental degradation in the world and Turkey, the amount of energy consumption of countries and the energy components they use have been examined. The world population is increasing day by day with economic growth, which causes the need for energy to increase. The consumption needs of the growing population are increasing; the increasing amount of consumption leads to an increase in the production of industrial and agricultural products. Because the main input of production is energy, increasing energy consumption further increases environmental degradation and pollution. Increased energy consumption and the high rate of fossil fuel use, which is the primary energy source, further increase carbon dioxide emissions. Therefore, the amount of investment in energy transformation has increased in all production industries worldwide. Environmental pollution can be reduced and environmental sustainability ensured, especially by increasing renewable energy investments (Efeoğlu, 2022:2104).

Uninterrupted energy access and energy supply security are essential for economic development and socio-economic progress. In the current global economy, the strong relationship between energy consumption and key macroeconomic indicators such as gross domestic product has become increasingly prominent (Apergis and Payne, 2010: 650-651). However, this relationship presents a complex dilemma at the heart of the United Nations' 2030 Agenda for Sustainable Development. On one hand, meeting energy demand to support economic growth and prosperity is a prerequisite for SDG 8 (Decent Work and Economic Growth); on the other hand, current energy consumption patterns based on fossil fuels pose a serious threat to SDG 13 (Climate Action), which aims to address climate change. At this juncture, SDG 7 (Affordable and Clean Energy), which ensures the security and accessibility of energy supply while promoting the transition to clean energy sources, plays a crucial role. Therefore, predicting future energy consumption trends based on macroeconomic variables is not only an economic forecasting exercise but also an indispensable tool for designing strategic policies to achieve a sustainable balance between these three key SDGs (IEA, 2023:61-82). This study aims to address this critical gap and provide a scientific basis for policymakers.

In terms of the Turkish economy, the decisions made on January 24, 1980, were an important turning point. These decisions ensured the integration of the country into the globalization trend, and the import substitution industrialization strategy was abandoned and an export-oriented strategy was adopted in its place. This process has initiated intense internal migration from rural areas to cities, resulting in an increase in the urban population. The per capita income and welfare

levels of individuals who find job opportunities in cities have increased. The increasing level of welfare has increased the amount of energy consumed throughout the country by increasing individual consumption. From the post-1980 period to the present, Turkey's energy consumption has increased by 223%. The fact that most of the energy consumed consists of fossil fuels poses a major problem in terms of environmental and economic sustainability (Kardaşlar, 2022:386).

For these reasons, countries that are aware of their energy dependencies and engage in strategic energy planning will enable them to become resistant to possible energy crises. The use of alternative and renewable energy sources can reduce environmental pollution by reducing production costs, ensuring sustainable production performance, and enabling a strong political stance by reducing foreign dependency. In this context, this study aims to provide a perspective on the country's energy path by estimating energy consumption for the next 10 years in Turkey. In this direction, based on macroeconomic indicators, Turkey's energy consumption forecast for the next 10 years was realized using the machine learning method, and alternative solutions were offered. The use of machine learning, a new-generation estimation method, in the analysis reveals the original aspect of this study.

In line with these explanations, in the following sections of the study, first, a literature review on energy demand and consumption estimation will be presented, then the data used will be introduced, and the established model and descriptive statistics will be included. Finally, methodological explanations of machine learning analyses are presented, and the findings are discussed in the conclusion section.

2. Literature

When similar studies in the literature on this study, in which Turkey's energy demand in the next decade is estimated by a machine learning method based on the data of energy consumption, economic growth, inflation, carbon dioxide emissions, and population growth in Turkey between 1965-2024, it is seen that causality relationships, cointegration, or simpler regression models are generally used. However, machine learning models can provide more stable and reliable predictions with the ability to capture complex, nonlinear relationships between variables. Stern (1993), one of the prominent studies in this field, analyzed the causality relationship between GDP, energy use, capital, and employment in the USA between 1947-1990 and concluded that there is a causality relationship between energy consumption and GDP. Bekhet and Othman (2011) analyzed the causality relationship between electricity consumption, GDP, CPI, and foreign direct investment in the Malaysian economy between 1971 and 2009 using the vector error correction model (VECM) and concluded that there is a one-way causality relationship from electricity consumption to GDP, FDI, and inflation. Belke et al. (2011) analyzed the long-run relationship between energy consumption, real GDP, and energy prices in 25 OECD countries in the period 1981-2007 with panel cointegration and VECM methods. They concluded that there is a bidirectional causality relationship between energy consumption and economic

growth. Shafiei and Salim (2014) analyzed the determinants of carbon dioxide emissions in OECD countries between 1980 and 2011 using the STIRPAT model and concluded that non-renewable energy consumption increases carbon dioxide emissions, whereas renewable energy consumption decreases carbon dioxide emissions. Begum et al. (2015) analyzed the dynamic effects of GDP, energy consumption and population growth on CO2 emissions in Malaysia between 1970 and 2009 using ARDL, DOLS and SLM U-test methods, and concluded that energy and its consumption and GDP have an effect on carbon dioxide emissions, but population growth does not have any effect on carbon emissions. Bozkurt and Okumuş (2015) analyzed the relationship between carbon dioxide emissions, economic growth, energy consumption, trade openness, and population density in Turkey between 1966 and 2011 using the Hatemi-J cointegration test and concluded that there is a cointegration relationship between the variables. Büyükyılmaz and Mert (2015) analyzed the relationship between carbon dioxide emissions, renewable energy consumption per capita and GDP per capita in Turkey between 1960-2010 with the multivariate Markov regime change model (MS-VAR), and concluded that the relationship between the variables in the analysis is not linear, varies according to the regimes, and there is a bidirectional causality relationship between them. Ekinci (2019) found that the ANFIS model predicts electricity consumption more accurately than the ANN model in his study, in which he comparatively analyzed artificial neural networks (ANN) and adaptive network-based fuzzy logic inference system (ANFIS) models in energy demand estimation based on electrical energy data in Turkey between 1970-2015. Yücesan et al. (2019) analyzed the effect of economic growth and energy consumption on carbon dioxide emissions based on 1988-2014 data for 8 middle-income countries (including Turkey) with panel data method, and concluded that there is a bidirectional causality relationship between energy consumption and economic growth and between carbon dioxide emissions and economic growth. Tong et al. (2020) analyzed the relationship between economic growth, energy consumption and carbon dioxide emissions in E7 countries (including Turkey) between 1990-2014 with the bootstrap ARDL bounds test method. They concluded that there is a causality relationship from energy consumption to carbon dioxide emissions in all E7 countries except Indonesia. Ülkü and Yalpır (2021) concluded that the artificial neural network method provides more effective results in electricity estimation. In their study, they estimated the electrical energy demand for 2030 with artificial neural networks and multiple regression analysis methods, based on the energy consumption data between 2009-2018 in Turkey. Özdemir (2021) concluded that the artificial neural network method has high predictive power and can be used in medium-term predictions in his study in which he made medium-term electricity consumption estimation with the artificial neural network method between 2011-2020 in the Iskenderun region of Turkey. Kazanasmaz et al. (2023) analyzed the relationship between economic growth, electricity consumption and carbon emissions in Turkey between 1967-2017 with vector error correction model (VECM), Granger causality and Johansen cointegration tests, and concluded that electricity consumption positively affects economic growth in the long run, while carbon dioxide emissions affect negatively in the long run. Özekenci (2023) concluded that there is a statistically significant and positive relationship between carbon dioxide emissions and foreign direct investments, and energy consumption in their study, in which they analyzed the effect of

exports, energy consumption, foreign direct investments (FDI), and economic growth on CO2 emissions in Turkey between 1990-2015 using the ARDL limit test and VECM methods. Gök and Yıldız (2024) analyzed the relationship between economic growth, energy consumption, carbon dioxide emissions, and urbanization in MIST (Mexico, Indonesia, South Korea, and Turkey) countries between 1971-2014 using Durbin-Hausman and LM cointegration tests and concluded that there is a cointegration relationship between the variables.

When the existing studies in the literature are examined, it is seen that the relationships between economic growth, energy consumption, and carbon dioxide emissions have been analyzed retrospectively by econometric methods such as causality and cointegration (Bekhet and Bt Othman, 2011; Belke et al., 2011; Kazanasmaz et al., 2023) or future demand forecasts are made with models such as artificial neural networks (Ekinci, 2019; Ülkü and Yalpır, 2021). In this study, contrary to the studies conducted in the literature, an energy consumption forecast until 2035 is made within the framework of sustainable development goals by combining basic macroeconomic indicators such as economic growth, energy, and population with a sectoral environmental pollutant and price stability indicator, rather than only determining the retrospective causality relationship between variables or estimating with a specific methodology. Therefore, while this multidimensional approach offers a more holistic perspective on energy planning, it differs from other studies in the literature in that it makes more robust and realistic predictions by evaluating economic, environmental, and social factors together. Thus, this study differs from other studies in that it not only predicts energy demand but also provides a policy-oriented and forward-looking roadmap on how this demand can be aligned with sustainable growth goals, filling the gap in the existing literature.

3. Dataset and Model

In this study, Turkey's future energy consumption is estimated within the scope of sustainable development goals, and the effects of economic growth, inflation, industrial carbon dioxide emissions, and population growth on energy consumption are examined using data from to 1965-2024. In the analysis, the Random Forest method, which is a machine learning method, was used. This method can be used to model nonlinear and complex relationships between input variables (economic growth, inflation, industrial carbon dioxide emissions, and population growth) and output variables (energy consumption). The data used in this study were obtained from the World Development Indicators (WDI, 2025) and World Energy Statistics (WES, 2025) databases. In this study, a linear model, which is frequently used in the literature, was chosen to analyse the basic macroeconomic factors that determine energy consumption. The estimated model is expressed as follows:

$$Energy_t = \beta_0 + \beta_1 GDP + \beta_2 Inf + \beta_3 Indust\_CO_2 + \beta_4 \mathrm{Pop} + \varepsilon_t$$

In the model, energy consumption (Energy) is the dependent variable. The energy variable refers to the total primary energy consumption (Energy). The data are in Mtoe (million tonnes of oil equivalent) and adjusted for constant prices. Energy types are not separated in the series; renewable and non-renewable resources are included together in the total energy consumption. This choice was made to ensure that the macro-level effects of energy use were evaluated holistically in the analysis. The variable in question is directly related to SDG 7 (Affordable and Clean Energy). The GDP variable is the growth rate of the Real Gross Domestic Product (GDP). It has been included to assess the environmental impacts of economic growth and ensure the integration of SDG 8 (Decent Work and Economic Growth) and the model. The Inf variable is the annual inflation rate, based on the consumer price index. It is included in the model as an indicator of the macroeconomic stability. Internal interactions are controlled by considering the effects of inflation on both growth and energy demand. $Indust\_CO_2$, Represents CO_2 emissions from industrial sources. This variable is considered a key indicator directly linked to SDG 13 (Climate Action) and represents the environmental costs of energy consumption. As industrial emissions constitute a significant subset of energy-related emissions, they hold a critical place in the environmental sustainability framework that the study focuses on. Pop, this variable shows the proportional change in the total population. It is included in the model to reflect the long-term pressure on energy demand and emissions. There are also aspects that overlap with SDG 11 (Sustainable Cities and Communities) and SDG 3 (Health and Wellbeing). Within the framework, the function defined based on the obtained data is expressed as follows:

Energy Consumption = f (Economic Growth, Inflation, Industrial Carbon Dioxide Emission, Population Growth)

Here, the function "f" represents the complex relationship between the input and output variables. By learning this function, the Random Forest model analyzes in depth how each variable, alone and in combination with other variables, affects energy consumption. In this context, the descriptive statistics of the variables used in the analysis are presented in the table below:

Table 1: Descriptive Statistics on Variables

Variables	Energy Consumption	GDP	CO_2 Emissions	Inflation	Population
Average	708.3643	4.7249	22.6189	34.2865	1.6623
Median	579.2473	5.0395	20.8623	21.4148	1.6707
Maximum	1667.24327	11.4393	54.2197	105.2149	2.5965
Minimum	84.6708	-5.7500	5.3762	1.1196	0.1608
Std. Error	496.9684	3.9304	16.2971	28.7002	0.5763
Skewness	0.5273	-0.7033	0.5093	0.7215	-0.414
Kurtosis	1.9566	3.3650	2.0480	2.2381	2.7965
Jarque-Bera	5.5023	5.2808	4.8601	6.6580	1.8211
Probability	0.0638	0.0713	0.0880	0.0358	0.4022

When the descriptive statistics of the dataset in the table and defined in the function are examined, significant differences in the distribution characteristics of the variables are observed. The variables of energy consumption and carbon dioxide emissions exhibited a right-skewed distribution, with limited differences between the mean and median values and positive skewness coefficients. In contrast, the GDP variable has a left-skewed structure with a negative skewness coefficient. The inflation variable, on the other hand, shows both high variance and positive skewness, and according to the result of the Jarque-Bera test, the normal distribution assumption cannot be rejected. Simultaneously, the assumption of normality in the variables of energy consumption, GDP, carbon dioxide emissions and population could not be rejected. When kurtosis values were examined, it was found that the variables of energy consumption and carbon dioxide emission were flattened; It was determined that the GDP variable showed a sharp distribution.

4. Random Forest Model

The Random Forest method has been proposed as a method that can work as a classification and regression algorithm that creates a tree structure by using random vectors sampled based on the input vector developed by Ho in 1998 and Breiman in 2001 (Orhan and Sağlam, 2023:178). The Random Forest method is based on a decision tree-based machine learning algorithm. It is considered one of the approaches that provides the most stable results among the machine learning methods. This method is created by generating more than one decision tree structure and is therefore called a "forest." In the Random Forest model, the number of trees (N) and the number of variables to be randomly selected in each tree (m) are determined exogenously. Each tree structure is created through variables randomly selected from the training data and is therefore defined by the expression "random" (Sevgen and Aliefendioğlu, 2020:304).

In the Random Forest method, each randomly generated decision tree structure is considered to be of equal importance. In this respect, Random Forest, which is among the supervised machine learning algorithms, is based on a set of randomly generated decision trees. Based on the averages of the created random decision trees, reliable and stable results can be produced (Orhan and Sağlam, 2023:178). The Random Forest algorithm is a fast-running model that produces stable and consistent results for both small and large sample groups. In this context, the Random Forest algorithm produces effective and consistent results for both regression and classification problems (Sungur and Bakır, 2024:50). In this model, obtaining effective and consistent results in solving classification and regression problems, which form the basis of other supervised and unsupervised machine learning methods, is considered one of the biggest advantages of the model. Another advantage of the Random Forest model is that it eliminates the problem of memorizing data because decisions are made based on the averages of the randomly generated decision tree regression (Arslankaya and Toprak, 2021:182). Therefore, the stochastic decision tree structures created using the Random Forest method can be created in the form of both a classification tree

and a regression tree. For this reason, the nodes in the created decision tools are segmented based on an optimization logic within themselves (Kumral et al., 2022:1318).

In the Random Forest method, multiple randomly generated decision trees are built for the same dependent variable, and the final decision is made with an optimization based on majority selection. In this direction, the decision tree structure created is the estimation of the nth random tree obtained from the set of N different regression trees;

$$\hat{C}_{rf}^{N}=\frac{1}{N}\{\hat{C}_{N}(X)\}_{1}^{N}$$

It is expressed as. In this context, Random Forest regression is expressed as a learning algorithm created by taking regression averages for each randomly generated dataset. Therefore, there are two important variables in the regression algorithm, namely the parameter and the number of trees (Akay et al., 2019:8-9).

5. Empirical Applications

The Random Forest method, which is a machine learning model, can directly learn the intrinsic trends and seasonal patterns in the data structure. Therefore, the unit root test, that is, whether the data used in the analysis are stationary or not, is not a mandatory prerequisite for predictions made with such models. Therefore, based on the previous year's data in the analysis function, an estimate of the direct energy consumption can be made. The results of the energy consumption estimation within this framework are presented in table below.

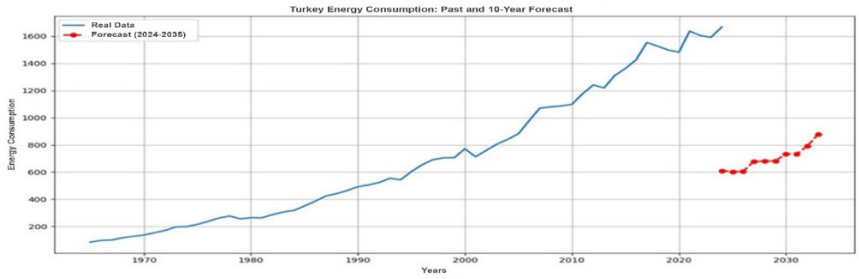
Table 2: Energy Consumption Estimation Results

Duration	Years	Estimated Energy Consumption
Year	2025	609.882019
Year	2026	602.453446
Year	2027	604.564837
Year	2028	678.888830
Year	2029	679.590310
Year	2030	682.320063
Year	2031	732.639448
Year	2032	732.639448
Year	2033	791.953484
Year	2034	876.833310

The table shows the estimated energy consumption values obtained from the Random Forest regression model between 2025 and 2034 in Turkey. The established Random Forest model made predictions for the next decade based on the data of the past year and predicted that energy consumption would generally fluctuate but follow an upward trend. Although the estimated energy consumption in 2025 is 609.88 units, this value is predicted to increase to 876.83 units in 2034. However, the estimated results show nonlinear transitions between years. In particular, there is a

significant jump in 2028, and a relatively flat course is observed in the following years (for example, the same consumption value is repeated in 2031 and 2032). This shows the sensitivity of the model to fluctuations in the input variables and that energy can increase unsteadily over the years.

Chart 1: Turkey's Energy Consumption Estimation Graph



In the graph, the years are on the horizontal axis and the energy consumption amounts are on the vertical axis. The historical data shown by the blue line indicate a generally stable and ever-increasing trend in energy consumption since 1965. The forecast values shown by the red dots represent the energy consumption levels predicted by the model for the post-2024 period. According to the estimation results obtained from the study, energy consumption in Turkey has fluctuated over the years and is expected to increase towards 2034. This shows that the model is highly sensitive to annual changes in input data, such as inflation, GDP, carbon emissions, and population growth. The rise observed, especially after 2028, shows that the model responds to the acceleration in economic growth or demographic factors. In this context, the heat map showing the Pearson correlation coefficients between the variables used in the energy consumption estimation with a color scale is shown in figure below.

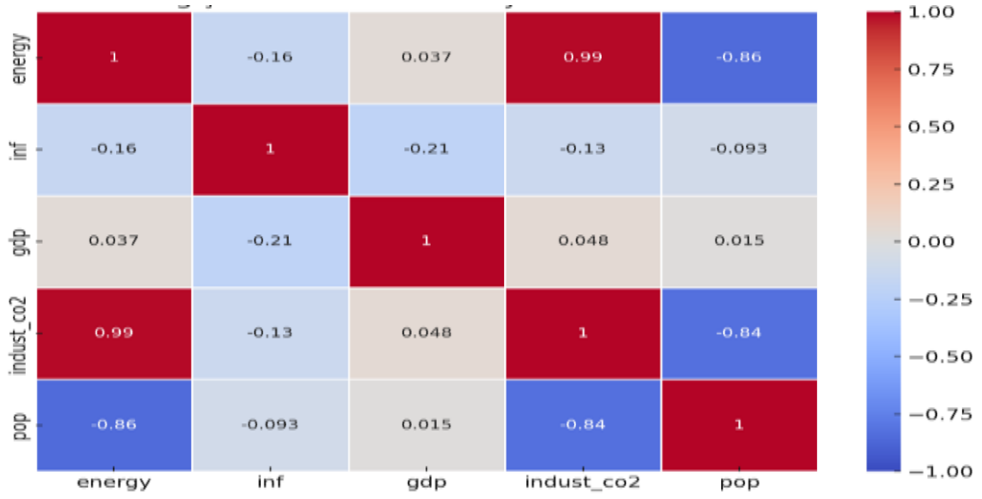
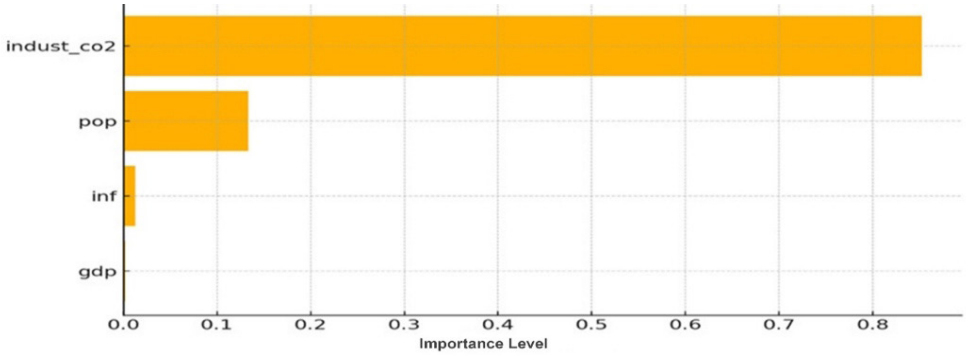


Figure 1: Inter-Variable Correlation Heatmap

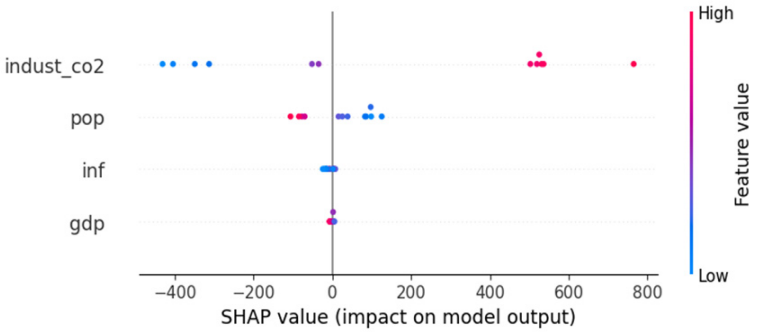
According to the Pearson correlation coefficients in the figure, the most striking relationship between the variables was observed between energy consumption and industrial carbon emissions ($r \approx 0.99$), indicating that industrial activities are directly related to energy demand. There is also a strong negative relationship between energy consumption and population ($r \approx -0.86$). This situation can be evaluated as a decrease in energy use per capita despite the increasing population or that population growth is balanced by factors that increase energy efficiency. However, the correlation between energy consumption and GDP appears to be quite low ($r \approx 0.04$), which can be considered a direct and strong effect of economic growth on energy consumption in the model. The inflation variable, on the other hand, exhibits weak relationships with all other variables. As a matter of fact, the graph showing the level of importance of the variables in the analysis is given below.

Chart 2: Importance Level Graph for Variables



The relative importance of the independent variables on energy consumption was presented according to the Random Forest regression model. The variable to which the model attributes the most weight is industrial carbon dioxide emissions (indust_co2), and the importance coefficient of this variable was calculated as 0.852. This high rate clearly shows that the most direct determinant of energy consumption is the emissions from industrial activities. The population (pop) variable ranked second in the model and contributed 0.133. This indicates that demographic factors are important determinants of energy consumption. In contrast, the variables inflation (inf) and GDP (GDP) have very low significance values (0.0128 and 0.0020). This shows that the model could not detect the decisive effect of these economic indicators on energy consumption during the learning process. In particular, the low effect of GDP coincides with the weak correlation ($r \approx 0.04$) obtained in the correlation analysis. In general, the model considers environmental (emission) and demographic (population) variables to be more deterministic.

Chart 3: SHAP (SHapley Additive exPlanations) Value Summary Chart



The figure presents a SHAP (SHapley Additive exPlanations) summary that visualizes the relative effects of the four key independent variables used in the model on energy consumption. This graph describes not only the order of importance of variables, but also the direction and magnitude of the effect of variable values on the model output. The horizontal axis shows the contribution (positive or negative SHAP value) of the variable on the energy consumption estimate for each observation; The color scale indicates whether the value of the variable in question is low (blue) or high (red).

According to the findings in the graph, the industrial carbon dioxide emission variable stands out as the most dominant determinant in the model. High industrial CO_2 emission values (red) strongly increase the estimated energy consumption; Low emission values (blue) have a reducing effect on consumption. This situation reveals that there is a positive and strong relationship between energy consumption and the environmental reflection of industrial activities. In addition, this finding is consistent with previous variable significance analyses. The population variable, which ranks second, produced both positive and negative SHAP values in the model's estimates. This shows that the effect of population growth on energy consumption varies, that is, it does not have a one-way effect. Under certain conditions, the model considered population growth as an energy consumption enhancer, while in some cases it attributed limiting or neutral effects.

In contrast, inflation and gross domestic product variables have a lower impact on the model. The SHAP values of both variables are largely concentrated in the center of the horizontal axis, and their effects on energy consumption are limited. In particular, the fact that the SHAP values of the gross domestic product variable are almost zero shows that this variable does not make a significant contribution to the model output and is not directly related to energy consumption.

6. Result and Conclusion

In this study, Turkey's energy consumption projection was considered from a sustainable development perspective and modeled using the Random Forest algorithm based on

macroeconomic indicators. Estimates up to 2035 were obtained based on key indicators such as energy consumption, economic growth, inflation, industrial carbon dioxide emissions and population growth for the period 1965–2024. The findings reveal that energy policies should be restructured not only on the axis of economic indicators, but also in a way that takes into account environmental and demographic dynamics.

According to the estimates made with the Random Forest model, Turkey's energy consumption generally follows an upward trend in the 2025-2034 period. However, this increase does not exhibit a linear structure, but reveals a fluctuating appearance with periodic jumps and stagnation. Especially in 2028, a significant jump is observed; In the following years, consumption values are fixed from time to time. This shows that the model is sensitive to annual changes in the variables it uses as inputs; thus, changes in economic, environmental, and demographic conditions can cause significant fluctuations in energy demand. Correlation analysis and SHAP value analyses allow us to understand the inner workings of the model in more depth. According to the Pearson correlation coefficients, there is a very strong positive relationship between energy consumption and industrial carbon dioxide emissions ($r \approx 0.99$). This finding clearly establishes the dominant role of industrial activities in energy demand. On the other hand, a strong negative relationship ($r \approx -0.86$) was found between energy consumption and population. This situation can be evaluated as a decrease in energy use per capita, especially despite the recent population growth, or that the increasing population is balanced by more efficient energy systems. Traditional economic indicators such as gross domestic product (GDP) and inflation, on the other hand, do not show a significant relationship with energy consumption. In particular, the correlation value of GDP and the contribution of SHAP have been close to zero. This result can be expressed as the effect of economic growth on energy consumption in Turkey is limited or indirect. According to SHAP analysis, the variable with the greatest impact on energy consumption is carbon emissions from industry. The model considered this variable as the most important determinant. The population variable is in second place, but its effect varies in positive and negative directions. This shows that the impact of the population on energy consumption can vary depending on certain conditions. Inflation and GDP variables, on the other hand, have a limited impact on the model in terms of both their importance and contribution.

These findings point to several key points in guiding energy policies. First, the fact that emissions from the industrial sector are the strongest determinant of energy consumption shows that the industry should be at the center of environmentally oriented policies and energy efficiency strategies. Promoting low-carbon technologies for industry, increasing investments that provide energy efficiency in production processes, and gradually implementing environmental regulations such as carbon taxes can both reduce energy demand and contribute significantly to environmental sustainability. Secondly, the variability of population growth reveals that energy planning should be differentiated at local and regional levels. In large cities, it is important to increase the capacity of the energy infrastructure depending on the population density and to manage the energy demand sustainably. Energy-efficient housing projects, smart city applications, and regional energy policies are among the priorities in this area. Third, traditional economic

indicators, such as GDP and inflation, have a limited impact on energy consumption, suggesting that energy policies may not be directly aligned with economic growth targets.

In general, the findings of this study show that environmental and demographic factors are key determinants of Turkey's future energy consumption, emphasizing that energy policies should be reshaped from a sustainable development perspective. Achieving the balance between energy supply security, reducing environmental impacts and meeting societal needs may be the main strategic goal of energy management in the 2035 and beyond period.

References

Akay, E. Ç., Topal, K. H., Kizilarslan, S., & Bulbul, H. (2019). Forecasting of Turkish housing price index: ARIMA, random forest, ARIMA-random forest. *Pressacademia*, 10(10), 7-11.

Akbaş, Y. E., & Lebe, F. (2015). Türkiye'de sanayileşme, finansal gelişme, ekonomik büyüme ve kentleşmenin enerji tüketimi üzerindeki etkisi: Çoklu yapısal kırılmalı bir araştırma. *Ege Academic Review*, 15(2), 197-206.

Apergis, N., & Payne, J. E. (2010). The emissions, energy consumption, and growth nexus: evidence from the commonwealth of independent states. *Energy policy*, 38(1), 650-655.

Arslankaya, S., & Toprak, Ş. (2021). Makine öğrenmesi ve derin öğrenme algoritmalarını kullanarak hisse senedi fiyat tahmini. *International Journal of Engineering Research and Development*, 13(1), 178-192.

Begum, R. A., Sohag, K., Abdullah, S. M. S., & Jaafar, M. (2015). CO2 emissions, energy consumption, economic and population growth in Malaysia. *Renewable and Sustainable Energy Reviews*, 41, 594-601.

Bekhet, H. A., & Bt Othman, N. S. (2011). Causality analysis among electricity consumption, consumer expenditure, gross domestic product (GDP) and foreign direct investment (FDI): Case study of Malaysia. *Journal of economics and international finance*, 3(4), 228.

Belke, A., Dobnik, F., & Dreger, C. (2011). Energy consumption and economic growth: New insights into the cointegration relationship. *Energy Economics*, 33(5), 782-789.

Bozkurt, C., & Okumuş, İ. (2015). Türkiye'de ekonomik büyüme, enerji tüketimi, ticari serbestleşme ve nüfus yoğunluğunun CO2 emisyonu üzerindeki etkileri: yapisal kirilmali eşbütünleşme analizi. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 12(32), 23-35.

Büyükyılmaz, A., & Mert, M. (2015). CO2 Emisyonu, Yenilenebilir Enerji Tüketimi ve Ekonomik Büyüme Arasındaki İlişkinin MS-VAR Yaklaşımı ile Modellenmesi: Türkiye Örneği. *Zeitschrift Für Die Welt Der Türken*, 7(3).

Çeltek, S. A. (2024). Türkiye'nin enerji talebi tahmin probleminin çözümünde regresyon yöntemlerine dayalı yaklaşımlar. *Fırat Üniversitesi Mühendislik Bilimleri Dergisi*, 36(2), 705-715.

Çetin, M., & Sezen, S. (2018). Türkiye'de yenilenebilir ve yenilenemeyen enerji tüketimi, ekonomik büyüme ve karbondioksit salinimi arasindaki ilişki: Bir svar (yapisal var) analizi. *Journal of Management and Economics Research*, 16(1), 136-157.

Efeoğlu, R. (2022). Çevresel Kuznets eğrisi çerçevesinde sanayileşme, yenilenebilir enerji, enerji tüketimi ve finansal gelişmenin CO2 salınımı üzerindeki etkisi. *Alanya Akademik Bakış*, 6(2), 2103-2115.

Ekinci, F. (2019). YSA ve ANFIS tekniklerine dayalı enerji tüketim tahmin yöntemlerinin karşılaştırılması. *Duzce University Journal of Science and Technology*, 7(3), 1029-1044.

Energy Institute Statistical Review of World Energy (2025). https://www.energyinst.org/ statistical-review. (Access Date: 19.07.2025).

Es, H. A. (2020). Gri tahmin modelleri ile toplam enerji talep tahmini: Türkiye örneği. *Gümüşhane Üniversitesi Fen Bilimleri Dergisi*, 10(3), 771-782.

Gök, A., & Yıldız, Ş. (2024). İktisadi Büyüme, Enerji Tüketimi ve CO2 Emisyonu Arasındaki İlişki: MIST Ülkeleri Üzerine Bir Değerlendirme. *Süleyman Demirel Üniversitesi Vizyoner Dergisi*, 15(43), 1031-1045.

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. *Journal of political economy*, 91(2), 228-248.

Halmuratov, G., Madraximov, Q., Zakirova, G., Xolmuratov, X., Djumabayeva, S., Yaqubova, Y., & Xolmurotov, F. (2025). The impact of energy consumption and trade openness on economic growth in uzbekistan: a vecm approach. *International Journal of Energy Economics and Policy*, 15(2), 23.

IEA (2023). World energy outlook 2023. Paris, France: International Energy Agency (IEA).

Intergovernmental Panel on Climate Change (2014). Climate Change 2014 Synthesis Report. IPCC: Geneva, Szwitzerland.

Kardaşlar, A. (2022). Ekonomik büyüme, enerji tüketimi ve küreselleşme sürecinin ekolojik ayak izi üzerindeki etkisi: Türkiye örneği. *Business and Economics Research Journal*, 13(3), 385-401.

Kazanasmaz, E., Demirel, B. L., Karatepe, S., & Hızarcı, A. E. (2023). Ekonomik büyüme, elektrik tüketimi ve karbon emisyonu ilişkisi: Türkiye örneği. *Muhasebe ve Finans İncelemeleri Dergisi*, 6(2), 248-265.

Kumral, C. D., Topal, A., Ersoy, M., Çolak, R., & Yiğit, T. (2022). Random forest algoritmasının FPGA üzerinde gerçekleştirilerek performans analizinin yapılması. *El-Cezeri*, 9(4), 1315-1327.

Orhan, A., & Sağlam, N. (2023). Financial Forecast in Business and an Application Proposal: The Case of Random Forest Technique. *Journal of Accounting & Finance/Muhasebe ve Finansman Dergisi*, (99).

Özdemir, M. E. (2021). Yapay Sinir Ağları Kullanılarak Orta Dönem Elektrik Enerjisi Tüketim Tahmini: İskenderun Örneği. *Avrupa Bilim ve Teknoloji Dergisi*, (28), 489-492.

Özekenci, E. K. (2023). Karbondioksit Emisyonu (CO2) ile İhracat, Enerji, Doğrudan Yabancı Yatırımlar ve Ekonomik Büyüme Arasındaki İlişki: Türkiye Örneği. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, (40), 83-98.

Pata, U. K., & Yurtkuran, S. (2018). Yenilenebilir enerji tüketimi, nüfus yoğunluğu ve finansal gelişmenin CO2 salimina etkisi: Türkiye Örneği. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, 303-318.

Sadorsky, P. (2011). Trade and energy consumption in the Middle East. Energy Economics, 33(5), 739-749.

Sevgen, S. C., & Aliefendioğlu, Y. (2020). Mass apprasial with a machine learning algorithm: random forest regression. *Bilişim Teknolojileri Dergisi*, 13(3), 301-311.

Shafiei, S., & Salim, R. A. (2014). Non-renewable and renewable energy consumption and CO2 emissions in OECD countries: a comparative analysis. *Energy policy*, 66, 547-556.

Shahbaz, M., Lean, H. H., & Shabbir, M. S. (2012). Environmental Kuznets curve hypothesis in Pakistan: cointegration and Granger causality. *Renewable and Sustainable Energy Reviews*, 16(5), 2947-2953.

Smil, V. (2018). Energy and civilization: a history. MIT press.

Sorrell, S. (2010). Energy, economic growth and environmental sustainability: Five propositions. Sustainability, 2(6), 1784-1809.

Stern, D. I. (1993). Energy and economic growth in the USA: a multivariate approach. *Energy economics*, 15(2), 137-150.

Stern, N. H. (2007). The economics of climate change: the Stern review. *Cambridge University press*.

Sungur, F., & Bakır, H. (2024). Hiperparametre ayarlama ve veri dengelemenin kalp hastalığı tahmini için kullanılan makine öğrenimi algoritmaları üzerindeki etkilerinin incelenmesi. *Bilişim Teknolojileri Dergisi*, 17(1), 45-58.

Tong, T., Ortiz, J., Xu, C., & Li, F. (2020). Economic growth, energy consumption, and carbon dioxide emissions in the E7 countries: a bootstrap ARDL bound test. *Energy, Sustainability and Society*, 10(1), 1-17.

Ülkü, H., & Yalpır, Ş. (2021). Enerji talep tahmini için metodoloji geliştirme: 2030 yılı Türkiye örneği. *Niğde Ömer Halisdemir Üniversitesi Mühendislik Bilimleri Dergisi*, 10(1), 188-201.

Yücesan, M., Yağış, O., & Torun, M. (2019). Ekonomik büyüme ve enerji tüketiminin CO2 emisyonu üzerindeki etkileri: Seçilmiş MENA ülkeleri için panel veri analizi. *Journal of Management and Economics Research*, 17(4), 351-368.

World Bank (2025). World Development İndicator. https://databank.worldbank.org /source/world – development – indicators (Erişim tarihi; 19.07.2025).

Journal of Research in Economics • Volume: 9 / Issue 2 • October 2025 pp. 120-139
ISSN: 2636-8307 • DOI: http://dx.doi.org/10.29228/JORE.47

RESEARCH ARTICLE

EFFECT OF FINANCIAL ACCESS AND INSTITUTIONAL QUALITY ON POVERTY: EMPIRICAL EVIDENCE FROM SUB-SAHARAN AFRICA

Shehu Bijimi UMARU[*]
Martins IYOBOYI[**]
Abdulsalam S. ADEMOLA[***]

Abstract

Financial access and poverty nexus has received extensive investigation. However, the moderating role of institutional quality in the financial access-poverty nexus, especially in the context of sub-Saharan Africa, has not been vigorously explored. Implementing the two-step system GMM technique, this study uncovers the moderating role that institutional quality has regarding the impact of financial access on poverty. The study covers a panel of 32 countries in sub-Saharan Africa from 2000 to 2023 and uses combined data of number of Automated Teller Machines (ATMs) per 100,000 adults and number of bank branches per 1000 adults to measure financial access. The empirical results show that financial access has reduced poverty in sub-Saharan Africa under the period of investigation. Additionally, the effects of the interaction of financial access and institutional quality (proxied by Control of Corruption, and Rule of Law) are negative, implying a reduction in poverty. The study recommends improved financial access through the establishment of more bank branches and Automated Teller Machines especially to remote areas, including enhanced institutions through intensifying the fight on corruption in sub-Saharan Africa.

Keywords: Financial access; Institutional quality; Poverty; System GMM technique
JEL Classification: C33, I30, P48, O55

1. Introduction

The incidence of poverty is a major concern across the world. Different approaches to tackling poverty over the years have been designed both at country, regional and global levels. This is evident in the efforts by the United Nations under the SDGs, which makes poverty eradication a

* Department of Economics, Kaduna State College of Education, Gidan Waya, Kafanchan, Kaduna State, Nigeria. E-mail: jimiluv20@gmail.com. ORCID: 0009-0001-5138-1064
** Corresponding Author: Department of Economics and Development Studies, Federal University, Dutsin-Ma, Katsina State, Nigeria. E-mail: miyoboyi@fudutsinma.edu.ng. ORCID: 0000-0002-4781-1252
*** Department of Economics and Development Studies, Federal University, Dutsin-Ma, Katsina State, Nigeria. E-mail: sabdulsalam@fudutsinma.edu.ng. ORCID: 0009-0000-3361-500X

Submission Date: 1-Jan-25
Revision Date: 10-Mar-2025, 24-Jun-2025, 31-Jul-2025
Acceptance Date: 6-Aug-25

major target (Babafemi, 2020). In this context, improving financial access has been demonstrated as one of the ways to address poverty. Generally, the effect of finance on poverty has gained considerable attention from economists in recent decades. The direct effect of finance on poverty can occur through the lowering of credit and transaction costs, information costs, promoting investment in human capital, expanding access to credit and improving micro-financing for the poor and vulnerable population (Wang, 2020). Costs induced by market imperfections constrain economic development, decelerate improvements in the standard of living and trigger poverty (Cihak et al., 2012). Financial access and development, including the rise of varieties of financial markets, contracts and other financial intermediaries are factors contributing to reduce these costs and market imperfections (Wang, 2020).

Sub-Saharan Africa (SSA subsequently) has experienced an improvement in its financial sector in recent decades while many of its countries have embraced financial liberalization (Fashina, 2022). SSA has recorded successes in financial sector development in the financial institutions and markets, although banking sectors in most of the countries are stronger than the financial markets. For instance, pension funds contribute significantly to the system assets within the nonbank financial sector, while stock exchanges are typically underdeveloped and cashless in less than 60% of the countries (International Monetary Fund, 2016). Additionally, only about 13% of individuals in SSA have mobile money accounts, while 45% rely only on mobile phones for conventional banking services (Asuming, Osei-Agyei and Mohammed, 2018). Moreover, although the usage of mobile banking has increased significantly in SSA, it is still considerably less in comparison to other regions (Siano et al., 2020). Adedokun and Aga (2023) have shown that despite the improvement in financial access in SSA, only 23% of the adult population has financial inclusion, in contrast to other emerging countries where the figure is 41%. In Africa, mobile money provides greater options for financial inclusion of the poor, youths, rural dwellers, and small businesses (Anarfor et al., 2019). World Bank (2018) reports that accounts ownership, digital payments, mobile money, credit, and savings are 42.5%, 34.4%, 20.9%, 8.4%, and 14.9% in SSA, compared to 69.6%, 27.8%, 4.2%, 7.8%, and 17.2% respectively in Asia. This suggests that, although the degree of financial access in SSA has increased, it is still comparatively low.

On a general note, the financial sector in SSA has evolved over time, having experienced major reforms such as financial liberalization, banking recapitalisation, mergers and acquisition, e-banking, cashless policies, financing small and medium scale businesses, market liberalization, among others. According to Bello and Oladunjoye (2020), although financial access in SSA compared with other developing countries is low, it has improved in recent times. Consequently, despite the advancements in financial access and the institutional setup in SSA, poverty has remained a major challenge. In 2018, about 40 percent of the people in SSA still lived in extreme poverty, with 18 of the 20 poorest countries in the world are situated in SSA (World Bank, 2020). Based on the global poverty line of $1.90 per day per person, Nwani and Osuji (2020) maintain that SSA surpassed Asia in 2019 as the region with the greatest concentration of the poor.

Connected to the effect of financial access on poverty reduction is the role of institutions. In recent times, particularly in the last two decades, the role of institutions has taken a center stage among scholars in the economic development discourse. To ensure order and minimise uncertainties in exchange, institutions have been designed by human authorities throughout history (North, 1991). The impact that institutional quality has on economic outcomes is documented in the literature. While some studies link institutions to reduced poverty (e.g., Singh, 2021; Akobeng, 2016; Dhrifi, 2013; Tebaldi and Mohan, 2010), others have reported the converse (e.g., Perera and Lee, 2013).

Against this background, this paper aims at examining the effect of financial access on poverty in SSA, with particular emphasis on the moderating role of institutional quality. The study thus extends the empirical investigation of the finance-poverty nexus and the moderating role of institutions in that context. The study is novel in a major respect. Whereas the effect of financial access (in all its dimensions) on poverty has been widely examined (e.g., Saha and Qin, 2022; Dogan and Guler, 2021; Koomson, Villano and Hadley, 2020; Bakari et al., 2019; Demirguc-Kunt et al., 2018; Ampah et al., 2017; Park and Mercado, 2015), the moderating role of institutional quality has been largely unexplored. In addition, by examining both financial access and institutional quality, this study differs from previous investigations which used either financial access or institutional quality. Importantly, the study takes a more holistic view by not only combining the two dimensions, but also exploring the role of their interactions on poverty, thus improving the understanding of how poverty can be curtailed. In the extant literature, only one study, Aracil et al. (2022) investigated the interaction of financial inclusion and institutional quality on poverty, applying the quantile regression technique. This study thus extends the literature by using the System GMM, a technique that is superior and robust in dealing with the problem of endogeneity, variable omission and autocorrelation in panel data. Finally, this study combines data on number of ATMs and bank branches, instead of single indicators used in several studies.

The remaining parts of this paper are structured as follows: section two is on the review of literature; section three is the methodology used; section four contains the empirical results and discussion; and section five is the conclusion.

2. Literature Review

2.1 Conceptual Literature and Theoretical Framework

Three main concepts are critical to this study. These are financial access, institutional quality and poverty. Financial access is conceptualized as the extent to which financial intermediaries are available and accessible by the populace. Access to financial services can be categorized into availability and usage. Access connotes the presence of functional, reliable and affordable financial services, while usage is the actual consumption of the financial services (Awunyo-Vitor,

2018). Asongu and Odhaimbo (2018) considered financial access as non-encumbrance to finance with regards to price and non-price impediments. Abraham (2018) viewed financial access as occurring when quality financial services are available at reasonable costs. Financial access is thus the extent to which individuals and firms can access and use financial services. On the part of institutions, they are defined as a society's systems of rules that shape its interactions, including norms, conventions and legal rules (Hodgson, 2015). According to North (1990), institutions are the limitations that humans have created to influence how people interact. In light of this, institutional quality is viewed as a society's ability to carry out civil and public functions (Lehne, Mo and Plekhanov, 2014). Consequently, the presence of effective and functional institutions can be referred to as institutional quality. The multidimensional nature of poverty makes it difficult to define. Due to countries or regional peculiarities, what is seen as poverty in one country or region might be different in another country or region. In the context of this paper, poverty is defined as population having $1.90 a day or lower, based on 2011 purchasing power parity.

This study is underpinned by two theories, complemented to explain the relationships among the variables of interest. The first is the McKinnon's hypothesis (McKinnon, 1973), referred to as the "capital conduit effect", which considers an economy where sources of external financing are difficult and individual/firms resort to self-financing. Since individuals/firms do not have enough funds to invest, they save until they have enough to invest in physical capital. This suggests that actual returns on investments increase, encouraging poor people to hold money and resulting in a sizeable fraction of investments that are self-financing. This illustrates how money is thought of as a "capital conduit" (Boukhatem, 2016). In McKinnon's usage, real interests on deposits may serve as a channel for capital formation. In this regard, deposits and capital become complementary. When deposits are available and are characterized by positive real rates of return, saving and capital accumulation is enhanced.

In summary, according to McKinnon (1973), liberalisation is related with higher real interest rates and has the potential to promote increased savings. The theory's major postulation is that savings are attentive to real interest rates. Greater saving rates would fund more investment, resulting in stronger economic growth. Eliminating interest rate ceilings and other types of regulation is a way of reforming a repressed financial sector which encourages higher real interest rates on deposits, enticing savers, thereby broadening financial intermediation and development.

The second theory is the "legal theory of finance" advanced by La Porta et al. (1997), which maintains that differences in financial development across countries could be explained by the differences in how the law protects investors and creditors, including the quality of legal enforcement. According to La Porta et al. (1997), the rights of the private property owners are protected by the common law against the state. The exchangeable financial contracts have worth and credibility because of these legal underpinnings. The main contribution of the literature on law and finance was to introduce systematic empirical analysis into the study of law and economics, and to demonstrate that investor rights are the main ways in which the law affects finance. Financial systems tend to be more advanced under legal regimes that better protect these

rights (Pistor, 2013). The law establishes and safeguards these contractual rights, thus bringing the study of financial access within the ambit of the institutional framework.

Overall, drawing from the theoretical construct of the capital conduit effect, financial intermediation such as availability of bank branches and ATM will help in channeling resources to the poor. Improvement in institutional setup (control of corruption and the rule of law) will facilitate financial intermediation and reduce poverty. Human capital development and a stable macroeconomy are essential conditions for development and poverty reduction.

2.2 Empirical Literature

2.2.1. Financial Access and Poverty

Several studies support the role of financial access on poverty reduction (e.g., Sahaand Qin, 2022; Dogan and Guler, 2021; Koomson et al., 2020; Opeyemi and Oladunjoye, 2020; Bakari et al., 2019; Abraham, 2018; Ampah et al., 2017; Bae, Han and Sohn, 2012). Some studies have considered the interaction effects of financial access on various other dimensions (e.g., Aracilet al., 2022; Asongu et al., 2020; Hussaini and Chibuzo, 2018).

Dogan and Guler (2021) examined the impact of financial inclusion on income inequality in Turkey, Colombia, Mexico, Indonesia and South Africa for the period 2005 to 2018, using the Dumistrescu and Hurlin panel Granger causality test. It was found that financial inclusion reduced income inequality in the study area over the period of investigation. Ampah et al. (2017) investigated the effect of financial access on poverty in central region of China. Using the multi-regression analysis, it was found that access to credit and financial resources reduced poverty. Similarly, Koomson et al. (2020) assessed the effect of financial inclusion and vulnerability on poverty in Ghana. Using the instrumental variable probit technique, the findings showed that financial inclusion reduced poverty over the period of study. Likewise, Opeyemi and Oladunjoye (2020) examined the effect of financial access on poverty in SSA using panel data from 2004 to 2018. Results from the panel OLS show that access to finance significantly reduced poverty. Similarly, Bakari et al. (2019) investigated the impact of financial inclusion on poverty in SSA from 1980 to 2017. Using the pooled OLS, it was revealed that access to finance reduced poverty.

Furthermore, Abraham (2018) assessed the effect of financial access on poverty in northern Nigeria. Result from the logit technique shows that financial access significantly reduced poverty. Likewise, Hussaini and Chibuzo (2018) examined the effect of financial inclusion on poverty in Nigeria. Using the partial least squares regression, it was found that financial inclusion reduced poverty. Additionally, Khaki and Sangmi (2017) studied the effect that financial access has on poverty in Kashmir region of India. It was found that access to finance reduced poverty. Nevertheless, Bae, Han and Sohn (2014) assessed the relationship between financial access, income inequality and poverty in the United States of America. Result from the fixed effects technique revealed that access to finance reduced both poverty and income inequality.

Asongu and Odhaimbo (2018) examined the effect of gender inclusion, ICT and financial access in the formal economic sector in Africa, using a sample of 48 countries from 2004 to 2014. Based on the GMM results, it was found that the interaction of ICT and financial access enhanced female formal economic sector participation. Tchamyou (2019) investigated the moderating role of information on the effect of financial access on inequality using a panel of 48 countries in SSA. The results revealed that the interaction of information sharing and financial access reduced inequality. In addition, Aracilet al. (2022) investigated the institutional quality, financial inclusion and poverty nexus in 75 developing countries from 2004 to 2017. Results from the quantile regression show that financial inclusion and quality institutions are complimentary in reducing poverty. Additionally, Saha and Qin (2022) empirically examined the relationship between financial inclusion and poverty alleviation in 156 countries comprising different income groups. Results from the GMM estimation show that in developing countries, financial inclusion has a negative and significant relationship with poverty.

2.2.2. Institutional Quality and Poverty

Making use of household and provincial levels data in Vietnam, Loi et al. (2022) examined the impact of institutions on multidimensional poverty reduction. Data was obtained from two sources, namely the Public Administration Performance Index and the Vietnam Household Living Standards Survey. Results from the probit model revealed that the likelihood of poor localities benefiting from institutional improvement is higher compared to rich localities. In a similar study, Zhao (2020) investigated the impact of tourism and institutions on poverty, using a panel of 29 provinces in China from 1999 to 2014. Results from the system GMM suggest that institutional quality positively and significantly influenced poverty reduction.

Dwumfour (2020) evaluated the impact of corporate regulations, policies, and institutions on poverty in SSA. The results of the GMM approach demonstrate how institutional quality raises well-being and lowers poverty. Saddique et al. (2016) studied the impact of governance and institutions on education and poverty alleviation in a panel of South Asian Association for Regional Cooperation economies. Using the Principal Component Analysis, it was found that quality institutions reduced poverty.

Cuestas and Intartaglia (2016) examined the impact of institutions on poverty in 69 countries over the period of 1984-2013. The system GMM was employed and the results show that institutional quality reduced poverty in the long-run. Akobeng (2016) assessed the relationship between institutions, gross capital formation and poverty in SSA using a panel data set of 41 countries from 1981-2010. Results from the two-step system GMM revealed that institutional quality interacted with fixed capital formation to reduce poverty.

Perera and Lee (2013) studied the impact of economic growth and institutional quality on poverty and inequality in Asia from 1998-2010. Using the GMM technique, the results show on one hand, that improvement in government stability and law and order reduced poverty. On the other hand, improvement in the fight against corruption, democratic accountability and bureaucratic quality tend to worsen poverty. Tebaldi and Mohan (2010) assessed the relationship between institutions

and poverty, using a panel of 53 countries. The instrumental variable method was used and the results show that control of corruption, government effectiveness, and a political system that is stable, promote economic growth, minimize conflicts in income distribution and lessen poverty.

3. Data and Methodology

The data used in the study encompasses a time dimension ('T' = 24) over larger number of cross-sections ('N' = 32), which is appropriate for the system GMM. The use of system-GMM is underscored on its strength to address the problem of weak instruments, which is typically brought on by system regressors in the case of differenced GMM. It considers country-specific effects and controls for endogeneity through the inclusion of the lagged dependent variables, measurement errors and missing or omitted variables. In implementing the system GMM, the standard practice is to treat endogenous variables, by using 2 lags and more lags for the transformed equation, while for the levels equation, 1 lag is used. The number of instruments should not be higher than the number of groups. A good way to achieve this is to instrument endogenous variables with fewer lags. A major problem encountered in the empirical research is proliferation of instruments, including weak tests. Roodman (2009) suggested that, to overcome this, the set of instruments could be restricted to certain lags, collapsed or the two approaches could be combined. In this study, the set of instruments was restricted to 2 lags and collapsed. The estimations were accomplished via the xtabond2 syntax in STATA 17. The description of the dataset is presented in Table 1.

Table 1: Variable Description and Measurement

Variable	Measurement	Source
Poverty (Pov)	Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	World Bank (2023)
Financial Access (FA)	Financial Access, combines data on number of ATMs per 100,000 adults and number of bank branches per 1000 adults	IMF (2023)
Institutional quality (IQ)	Control of Corruption (CoC). It is a composite indicator, which measures corruption on a scale of – 2.5 to +2.5 with higher scores indicating less corruption.	World Bank (2023)
	Rule of Law (RL), a composite indicator that measures rule of law on a scale of – 2.5 to +2.5 with higher scores indicating high rule of law.	World Bank (2023)
Human Capital (HC)	Percentage of the gross primary school completion rate	World Bank (2023)
Population (pop)	Natural logarithm of total number of people	World Bank (2023)
Inflation (Infl)	Consumer Price Index (2015), PPP	World Bank (2023)
GDP per capita (GDP)	Natural logarithm of GDP at constant prices or GDP in volume based on 2015, PPP	World Bank (2023)
Instability (Inst)	Standard Deviation of Real GDP	World Bank (2023)
Openness (Open)	Total trade (i.e., sum of exports and Imports) as proportion of GDP	World Bank (2023)

Source: Authors' compilation

To examine the effect of financial access on poverty, a baseline model is specified as follows:

$$Pov_{i,t} = \beta_1 Pov_{i,t-1} + \beta_2 FA_{i,t-1} + X_{i,t}\delta + \lambda_{i_t} + \eta_{i_t} + \varepsilon_{i,t} (1)$$

where Pov represents poverty, FA represents Financial Access, X is a vector of control variables including human capital (HC), population (pop), inflation (Infl), GDP per capita (GDP), economic instability (Inst) and trade openness (Open); δ r epresents the vector of unknown parameters; λ represents time specific-effects; η are unobserved country-specific effects, ε is the observation-specific error, where *i* is the individual dimension of the panel (country) and *t* is the time dimension. To account for the dynamic process, the response variable is lagged ($Pov_{i,t-1}$) and included as an independent variable in the model. The study uses combined data of number of ATMs per 100,000 adults and number of bank branches per 1000 adults, as a proxy of Financial Access. Studies such as Fashina (2022) and Bello and Oladunjoye (2020) used the number of bank branches and ATM per 100,000 adults.

The use of the selected control variables is not without theoretical and empirical justification. First, human capital theory (see for example, Becker, 1967) postulates that human capital via education raises workers' productivity and efficiency, leading to increased incomes and thus a decline in poverty. On the empirical front, several studies including Arias, Gimenez and Sanchez (2016), and Ali and Hamad (2013) infer that human capital reduces poverty. Additionally, rising population can have direct impact on poverty as shown in previous studies including Ritonga and Wulantika (2020), Sari (2021), Putra et al. (2021) and Hilmi et al. (2022). Furthermore, for inflation, poverty is aggravated when prices of goods and services increase, and as argued in the literature, inflation increases poverty by reducing disposable real income, and that real wages fall when nominal wages rise less than the rise in the price of goods and services. Ultimately, high inflation negatively impacts the poor (Artuc et al., 2022; de Haan, Pleninger and Sturm, 2021; Zhang and Ben Naceur, 2019; Sehrawat and Giri, 2018; Inoue, 2018). However, some studies considered inflation as a stimulant of investment, which brings about more employment opportunities and income for the poor (Olaniyi and Odhiambo, 2023; Easterly and Fischer, 2001).

GDP growth (implying rising income) is thought to lead to poverty reduction as it trickles down to the poor (deHaan et al., 2021; Seven and Coskun, 2016; Jalilianand Kirkpatrick, 2002), and evidences from the developed countries indicate that higher income is associated with lower poverty (de Haan et al., 2021; Rashid and Intartaglia, 2017). Economic instability such as those resulting from adverse economic conditions brings about income inequality (de Haan and Sturm, 2017), which, in turn, may be detrimental to the poor (Jeanneney and Kpodar, 2011). Finally, trade openness can lead to higher wages and consequently poverty reduction (Friedman, 2001; Le Goff and Singh, 2014). Other studies including Coulibaly and Yogo (2016) however reported that openness significantly increases poverty. Dollar and Kraay (2004) found that, keeping the growth effect constant, the poverty reduction impact of openness is negligible.

To examine if the effect of financial access on poverty changes in the presence of institutional quality, equation (2) is specified:

$$Pov_{i,t} = \beta_1 Pov_{i,t-1} + \beta_2 FA_{i,t-1} + \beta_3 CoC_{i,t-1} + \beta_4 RL_{i,t-1} + X_{i,t}\delta + \lambda_{i,_t} + \eta_{i,_t} + \varepsilon_{i,t} (2)$$

The proxies of institutional quality used in the study are control of corruption (CoC) and Rule of law (RL).Corruption, being a major feature of bureaucracy (Justesen and Bjørnskov, 2014), benefits the elite at the expense of others (Gupta et al., 2002), and for developing countries, it disproportionately affects low-income earners (Nwabuzor, 2005). Thus, by adequately controlling corruption, a country is able to direct scarce resources for development and improve its economic outcomes and thus reduce the level of poverty of its people. In addition, rule of law is critical in a manner that ensures the right of citizens regarding access to justice and property right protection, including the enforcement and performance of contracts, while facilitating the creation and access to markets for the poor and marginalized sections of the population, all of which promote economic development and therefore leads to poverty reduction (see Hallward-Driemeyer and Hasan, 2012; Haggard and Tiede, 2011; UNDP, 2008).

To account for the interaction effects of financial access and institutional quality on poverty, the following is specified:

$$Pov_{i,t} = \beta_1 Pov_{i,t-1} + \beta_2 FA_{i,t-1} + \beta_3 CoC_{i,t-1} + \beta_4 RL_{i,t-1} + \beta_5 (FA * CoC)_{i,t-1} + \beta_6 (FA * RL)_{i,t-1} + X_{i,t}\delta + \lambda_{i,_t} + \eta_{i,_t} + \varepsilon_{i,t} (3)$$

The specification in equation (3) is consistent with the empirical trend in the moderating role of a variable in the relationship between two variables. On *a priori* grounds, it is expected that $\beta_1 > 0$ and β_2-$\beta_4 < 0$. If the coefficient of the interaction term is less than zero, it implies that financial development and quality institutions are pro-poor and complementary. Conversely, if it is larger than zero, this suggests that financial access and quality institutions are substitutes.

4. Results and Discussions

The summary statistics of the variables used in the study are presented in Table A1 of the Appendix. From Panel B of Table A1, it is observed that all the variables, with the exception of inflation (Infl), economic instability (Inst) and population (Pop) are negatively correlated with poverty (Pov). A rise in financial access (FA), improvement in the control of corruption (CoC) and the rule of law (RL), increase in economic growth (GDP), quality and affordable education (HC), and favourable trade (Open) reduce poverty, although the negative correlation between poverty and rule of law and between poverty and openness is not statistically significant. As expected, large population that is not productive, high economic volatility (Inst) and high inflation rates (Infl) worsen poverty. The correlation among the variables ranges from low to moderate, the highest

being 0.72 between AF and GDP. As noted in Gujarati (2004), multicollinearity is serious if the correlation coefficient is 0.8 (or 80%) and higher.

The structure of the data used in the study satisfies the requirements for the implementation of the GMM estimator, i.e., small 'T' (24) and large 'N' (32). To explore the nature of the data, the test for endogeneity (see Table A2 of the appendix) shows that the probability values of the Durbin and Wu-Hausman are low and significant, thus rejecting the null hypothesis of exogenous variables, implying that there is a problem of endogeneity.

To avoid the risk of spurious regression which can arise when a non-stationary series or variable is regressed on a set of other non-stationary variables, the test of unit root was considered necessary. In this study, unit root was examined using the Pesaran (2007) approach. This test is suitable for heterogeneous panels with cross-section dependence. The results are shown in Table A3 of the appendix. As observed in Table A3, the null hypothesis of non-stationarity is rejected in each case. In particular, the hypothesis is rejected at 1% for Povhc, FA, CoC, Pop, Infl, Inst and Open, while in the case of RL, HC and GDP, the rejection is at 5% level. Thus, all the variables are integrated of order zero (i.e., I/0) or are stationary.

Each of the three models is estimated using OLS and GMM. The estimated results are presented in Table 2.

Table 2: Estimated Results

	OLS			**System GMM**		
Variable	**(1) Baseline model**	**(2) With IQ**	**(3) With Interaction term**	**(4) Baseline model**	**(5) With IQ**	**(6) With Interaction term**
Pov (-1)	0.9063***	0.9063***	0.9013***	0.9294***	0.9558***	0.9167***
	(0.0074)	(0.0074)	(0.0076)	(0.0499)	(0.0521)	(0.0508)
FA	–0.2417**	–0.2380**	0.0022	–0.1053*	–0.0308	–0.0718*(0.0425)
	(0.1105)	(0.1111)	(0.0278)	(0.0575)	(0.0623)	
CoC		–0.0286	0.1718		–0.1165**	0.3972**
		(0.0690)	(0.1223)		(0.0515)	(0.1609)
RL		0.1329	0.0460		–1.1556*	–0.7477
		(0.2351)	(0.2783)		(0.6470)	(1.2365)
FA*CoC			–0.0462*			–0.0984*
			(0.0276)			(0.0559)
FA*RL			0.0101			–0.2376
			(0.0430)			(0.2325)
HC	0.0014	0.0013	0.0393	-0.0283**	0.0398***	0.0206
	(0.0050)	(0.0050)	(0.2749)	(0.0112)	(0.0147)	(0.0213)
Pop	0.5427*	0.5458*	0.2313	0.8305**	0.3529	0.0136
	(0.3998)	(0.3005)	(0.2937)	(0.3813)	(0.3589)	(0.2943)
Infl	–0.0113*	–0.0112*	–0.0086	0.0021	–0.0007	0.0033
	(0.0058)	(0.0058)	(0.0059)	(0.0084)	(0.0066)	(0.0246)
GDP	–0.4839***	–0.4924***	–0.6387***	–0.6304	–0.3491	–0.6469
	(0.1610)	(0.1720)	(0.1744)	(0.6172)	(0.7032)	(0.6768)
Inst	–0.0019	–0.0624	–0.1227	–0.0014	0.1299	0.4192
	(0.0048)	(0.1130)	(0.1127)	(0.0104)	(0.3779)	(0.4228)

Open			−0.8702***			−0.4790
			(0.2173)			(0.7846)
Constant	−1.7706	−1.5525	8.1531	−8.0265**	−5.4039	6.0389
	(4.6286)	(4.6775)	(4.6053)	(3.4459)	(3.9751)	(7.8428)
R^2	0.97	0.97	0.97			
F-stat.	0.000	0.000	0.000			
Instruments				16	22	18
Hansen P.val				0.46	0.71	0.58
AR(1) P-val				0.00	0.00	0.00
AR(2) P-val				0.41	0.55	0.57
Observations	704	704	704	704	704	704
Group	32	32	32	32	32	32

Source: Authors' computation

Note: *,** and*** denote significance at 10%, 5% and 1% levels respectively; Values in parentheses are standard errors.

An examination of the diagnostic statistics indicates that the instruments used are valid. The Hansen p-values signify that the instruments are not correlated with the residuals, given that the null hypothesis that there is no correlation between the instruments and the error term is not rejected. Consequently, the instruments satisfy the orthogonality requirements. This result is complemented by the Arellano and Bond second-order AR (2) serial correlation test, which indicates absence of serial correlation with regard to the non-significant p-values across all the specifications.

Columns 1–3 of Table 2 present the OLS estimates while columns 4–6 are from the system GMM. However, due to the shortcomings of OLS when applied on panel data, the GMM results are the focus of the study. The baseline model is presented in column 4. In column 5, control of corruption (CoC) and rule of law (RL) (the institutional quality indicators) are added, while in column 6, the interaction terms are included.

First, we examine the effect of past levels of poverty on its current state. As seen in Table 2, results across all six columns show a positive and significant effect of the present poverty level and its1-lagged (previous) period, an indication that poverty is persistent in the SSA context. Financial access (FA) in columns 4 – 6 has a negative effect on poverty. The effect is significant when we consider the baseline model (column 4) and when we control for institutional quality and the interaction terms (column 6). For instance, a unit increase in financial access brings about 0.11 (column 4) and 0.07 (column 6) percentage point decreases respectively in poverty and it is significant at 10%.

When the institutional variables are considered (column 5), control of corruption (CoC) has a negative effect on poverty, and it is significant at 5%. A unit increase in control of corruption is associated with a fall in poverty by about 0.12 percentage point. The same is true with rule of law (RL) which has a significant negative effect on poverty. Consequently, an increase in the rule of law reduces poverty. The implication of these results is that by improving control of corruption and the rule of law, poverty reduction can be ensured. It needs to be noted however, that poverty reduction occurs even when the institutional variables are not interacted with financial access

(column 5). With the interaction terms (column 6), it can be seen that the effect of the interaction between financial access and control of corruption (FA*CoC) is negative and significant at 10%, while control of corruption in itself raises poverty as seen by the CoC coefficient of 0.3972. This result is important, in that it suggests that control of corruption reduces poverty through financial access. However, the interaction between financial access and the rule of law, has a negative but not a significant effect on poverty, whether in itself (from the coefficient of RL in column 6) or when it is interacted with financial access (FA*RL). In essence, it is instructive to note that the interactions of financial access (FA) and the institutional quality indicators each has a negative effect on poverty, with the former having a significant effect at 10%. In this context, a rise in financial access and improvement in institutional quality will reduce poverty. To sum it, an increase in financial access and control of corruption (FA*CoC) on one hand, and financial access and rule of law (FA*RL) on the other hand are complementary in poverty reduction in SSA. This is consistent with the earlier finding of Fashina (2022). On the whole, the interaction effect of financial access and institutional quality are also in line with earlier findings (Fashina, 2022; Aracil, Gomez-Begoechea and Moreno-de-Tejada (2022).

The result of the effect of human capital on poverty is illuminating. Considering column 4, human capital has a negative and significant effect on poverty. A 1 percentage point rise in primary school completion rate (proxy of human capital) brings down the level of poverty by about 0.03 percentage point. This effect changes when we control for institutional quality (columns 5 and 6), in which case, the coefficients are positive. This is an indication that institutional quality can alter the negative effect of human capital on poverty. Furthermore, population has a positive and significant (at 5% level) effect on poverty, as shown in column 4. 1% increase in population is linked to 0.83 percentage point rise in poverty. When the institutional variables are brought to bear (columns 5 and 6), it is observed that while the effect of population is positive, it is not significant. The implication of this is that if corruption and rule of law are effectively controlled, it can mitigate the impact of higher population on poverty.

Other variables such as inflation (Infl), real income (GDP), instability (Inst) and openness (Open) are not significant factors affecting poverty in SSA, as seen in columns 4 – 6, in both the baseline and extended models. However, they follow *a priori* expectations. For instance, in column 6, it is observed that the effect of inflation is positive, an indication that poverty worsens poverty, consistent with the prior findings of Inoue (2018), and Artuc et al. (2022). Moreover, real income (GDP) is inversely related to poverty, which supports earlier findings (e.g., Rashid and Intartaglia, 2017; de Haan et al., 2021), while economic instability raises poverty, in line with the literature linking adverse economic conditions to deteriorating life of the poor (Jeanneney and Kpodar, 2011). Finally, openness has a negative but not a significant effect on poverty. Given that the model controls for real income (or economic growth), this result echoes previous empirical findings by Dollar and Kraay (2004), which showed that the impact that openness exerts on poverty is insignificant when the growth effect has been accounted for.

5. Conclusion

Sub-Saharan African has experienced persistent poverty for several years, including poor financial development and institutional environment. The effect of financial access on poverty, and the moderating role of institutional quality in that regard, was tested in this study, using a sample of 32 countries in SSA from 2000 to 2023. As proxy of financial access, the study used combined data of number of Automated Teller Machines and number of bank branches, while poverty headcount was deployed to capture poverty. *Control of Corruption* and *Rule of Law* were used as indicators of institutional quality. The study also controlled for human capital, population, inflation, real GDP per capita, economic instability and openness.

Poverty was found to be persistent in the SSA context. Financial access was shown to exert a negative effect on poverty, in both the baseline model and when the institutional quality and the interaction terms were considered. Without controlling for institutional quality, human capital has a negative and significant relationship with poverty. This relationship changes when we control for institutional quality, which raises poverty, an indication that weak institutions can alter the negative effect of human capital on poverty. When the institutional variables are considered, control of corruption was found to have a negative effect on poverty and it is significant. The same is true about rule of law which has a significant negative effect on poverty. It needs to be noted however, that the poverty reduction impact of the institutional variables occurs without the interaction variables, an indication that the institutional quality in itself are critical towards poverty reduction. Other variables such as inflation, GDP per capita, instability and openness were found not to be significant factors affecting poverty in SSA within the period of investigation.

Two major policy implications arise from the findings. First, the need to prioritize financial access in SSA cannot be overemphasized if the objective is to address persistent poverty. Second, effectual policies that strengthen the institutional environment to address poverty should guide public policymakers.

Findings in this study call for actionable recommendations. Improvements in financial access, depth and efficiency are required. Based on the findings, it is recommended that policies that encourage financial access be made and implemented such as the provision of more ATMs to remote areas by monetary authorities, including promoting cashless transactions through increased use of mobile banking in SSA. There is also the need to improve financial depth in terms of liquidity and size of the financial sector, through increased domestic private credit to the real sector by deposit money banks in SSA. Furthermore, enhancing financial efficiency is recommended in order to reduce the cost of financial services through policies that lower bank lending interest rates.It is equally recommended that strong institutions, including fighting corruption and strengthening the rule of law should be intensified by the government in order to significantly reduce poverty in SSA. Overall, efforts at tacking poverty must combine financial

access with institutional strengthening, if the persistent poverty experienced in SSA is to be curtailed.

References

Abraham, T.W. (2018). Estimating the effects of financial access on poor farmers in rural northern Nigeria. *Financial Innovation,* 4(25). doi.org/10.1186/s40854.018.0112-2.

Adedokun, M.W. & Aga, M. (2023). Financial inclusion: A pathway to economic growth in sub-Sahara African economies. *International Journal of Finance & Economics,* 28(3), 2712-2728.

Akobeng, E. (2016). Gross capita formation, institutions and poverty in sub-Saharan Africa. *Journal of Economics Policy Reform,* 20(2), 1-29.

Ali, S., and Hamad, N. (2013). Human capital and poverty in Pakistan: Evidence from the Punjab province. *European Journal of Science and Public Policy,* 11, 36-41.

Ampah, S.N., Ambrose, J.O., Omagwa, J.O., and Frimpong, S. (2017). Effect of access to credit and financial services on poverty in central region of Ghana. *International Journal of Business and Social Sciences,* 8(8), 49-60.

Anarfor, E.B., Abor, J.Y., Osei, K.A., and Gyeke-Dako, A. (2019). Financial inclusion and financial development in sub-Saharan Africa: A panel VAR approach. *International Journal of Managerial Finance,* 19(3), 24-38. https://doi.org/10.1108/IJMF-07-2018-0205

Aracil, E., Gomez-Bengoechea, E., and Moreno-de-Tejada, O. (2022). Institutional quality and the financial inclusion-poverty alleviation link: Empirical evidence across countries. *BorsaInstanbul Review*, 22(1), 179-188.

Arias, R., Gimenez, G., and Sanchez, L. (2016). Impact of education on poverty and health: Evidence from Indonesia. *Economic Development Analysis Journal,* 9(1), 87-96.

Artuc, E., Falcone, G., Port, G., and Rijkers, B. (2022). War-induced food price inflation imperils the poor. *Supply Chains and Sustainability*, 16,155-162.

Asongu, S.A., and Odhaimbo, N.M. (2018). ICT, financial access and gender inclusion in the formal economic sector: Evidence from Africa. African Governance and Development Institute Working Paper Number 58.

Asongu, S.A., Nnanna, J., and Acha-Anyi, P.N. (2020). Inclusive education for inclusive economic participation: The financial access channel. MPRA Paper No. 103151. https://mpra.ub.uni-muenchen.de/103151/1/MPRA_paper_103151.pdf

Asuming, P.O., Osei-Agyei, L.G., and Mohammed J.I. (2018). Financial inclusion in sub-Saharan Africa: Recent trends and determinants. *Journal of African Business,* 20(1), 112-134.

Awunyo-Vitor, D. (2018). Theoretical and conceptual framework access to financial services by in emerging economies: implication for empirical analysis. *Journal of Economics and Business,* 6(18), 43-59.

Babafemi, I.D. (2020). Financial development and poverty reduction nexus: Evidence from Nigeria. *European Journal of Accounting and Finance Research,* 8(3), 1-12.

Bae, K., Han, D., and Sohn, H. (2012). Importance of access to finance in reducing income inequality and poverty level. *International Review of Public Administration*, 17(1), 55-77. DOI.org/10.1080/12264.431.2012.10805217.

Bakari, I.H., Donga, M., Idi, A., Hedima, J.E., Wilson, K., Bahago, H., and Ibrahim, Y. (2019). An examination of the impact of financial inclusion on poverty reduction: An empirical evidence from sub-Saharan Africa. *International Journal of Scientific Research Publications,* 9(1), 239-252.

Becker, G.S. (1967). *Human capital: A theoretical and empirical analysis with special Reference to Education.*2nded. National Bureau of Economic Research, United States of America.

Bello, T.W., and Oladunjoye, O.N. (2020). Access to finance and rate of poverty in sub-Saharan Africa. Ilorin Journal of Economic Policy, 7(1), 67-82.

Boukhatem, J. (2016). Assessing the direct effect of financial development on poverty reduction in a panel of low and middle income countries. *Research in International Business and Finance*, 37(C), 214-230. http://dx.doi.org/10.1016/j.ribaf.2015.11.0088.

Cihak, M., Demirguc-Kunt, A., Feyen, E., and Levine, R. (2012). Benchmarking financial systems around the world. Policy Research Working Paper Series 6175. The World Bank.

Coulibaly, A., and Yogo, U.T. (2016). Access to financial services and working poverty in developing countries. http://cerdi.org/production/show/id/1833/type_production_id/1.

Cuestas, J.C., and Intartaglia, M. (2016). Do institutions alleviate poverty? New empirical evidence. *Economics Bulletin,* 36(1), 145-154.

de Haan, J., and Sturm, J.-E. (2017). Finance and income inequality: A review and new evidence. *European Journal of Political Economy*, 50, 171-195. https://doi.org/10.1016/j.ejpoleco.2017.04.007

de Haan, J., Pleninger, R., and Sturm, J.-E. (2021). Does Financial Development Reduce the Poverty Gap? *Social Indicators Research*. https://doi.org/10.1007/s11205.021.02705-8

Demirguc-Kunt. A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2018). The global findex database 2017: Measuring financial inclusion and the fintech revolution. Washington, DC: World Bank.

Dhrifi, A. (2013). A revisit of the growth-inequality-poverty relationship: The role of institutional quality. *International Journal of Advances in Management and Economics,* 2(1), 94-102.

Dogan, E., and Guler, C. (2021). An analysis of the impacts of financial inclusion on income inequality in fragile five countries. DOI:10.14780/muiibd.960047

Dollar, D., and Kraay, A. (2004). Trade, growth and poverty. *The Economic Journal*, 114, 22-49.

Dwumfour, R.A. (2020). Poverty in sub-Saharan Africa: The role of business regulations, policies and institutions. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement*, 149(3), 861-890.

Easterly, W., and Fischer, S. (2001). Inflation and the Poor. *Journal of Money, Credit and Banking*, 33(2), 160-178.

Fashina, O. (2022). Financial development, institutions and poverty reduction: An empirical evidence from sub-Saharan Africa. Published Master's Thesis Submitted to Linnaeus University Sweden.

Friedman, J. (2001). Differential impacts of trade liberalization on Indonesia's poor and non-poor. Paper Prepared for the Conference "Poverty and the International Economy", Stockholm, 20-21, 2000, Organized by the World Bank and the Swedish Parliamentary Commission on Global Development.

Gujarati, D.N. (2004). Basic econometrics (4th ed). Sidney: McGraw-Hill

Gupta, S., Davoodi, H., and Alonso-Terme, R. (2002). Does corruption affect income inequality and poverty? Economics of Governance, 3(1), 23-45.

Haggard, S. and Tiede, L. (2011). The Rule of Law and Economic Growth: Where are We? *World Development*. 39(5), 673-685.

Hallward-Driemeyer, M. and Hasan, T. (2012). *Empowering Women: Legal Rights and Economic Opportunities in Africa*. Washington, D.C.: World Bank.

Hilmi, M., Dg, N.H., Ramlawati, M., and Peuru, C.D. (2022). The effect of population and unemployment on poverty rate in Tolitoli Regency. *Scientific Journal of Development Economics*, 1(1), 20-27.

Hodgson, G.M. (2015). On defining institutions: rules versus equilibria. *Journal of Institutional Economics,* 11(3), 497-505. https://doi.org/10.1017/s174.413.7415000028

Hussaini, U., and Chibuzo, I.C. (2018). The effects of financial inclusion on poverty reduction: The moderating effect of microfinance. *International Journal of Multidisciplinary Research and Development*, 5(12), 188-198.

Inoue, T. (2018). Financial development, remittances, and poverty reduction: Empirical evidence from a macroeconomic viewpoint. *Journal of Economics and Business*, 96, 59-68. https://doi.org/10.1016/j.jeconbus.2017.12.001

International Monetary Fund (IMF, 2016). Financial development in sub-Saharan Africa: Promoting inclusive and sustainable growth. https://www.imf.org/external/pubs/ft/dp/2016/afr1605.pdf

International Monetary Fund [IMF] (2023). Financial access survey. https://data.imf.org/?sk=388DFA60-1D26-4ADE-B505-A05A558D9A42&sId=147.932.9132316

Jalilian, H., and Kirkpatrick, C. (2002). Financial development and poverty reduction in developing countries. *International Journal of Finance & Economics*, 7(2), 97-108. https://doi.org/10.1002/ijfe.179

Jeanneney, S. G., and Kpodar, K. (2011). Financial development and poverty reduction: Can there be a benefit without a cost? *The Journal of Development Studies*, 47(1), 143-163. https://doi.org/10.1080/00220.388.2010.506918

Justesen, M.K., and Bjørnskov, C. (2014). Exploiting the poor: Bureaucratic corruption and poverty in Africa. *World Development,* 58, 106-115.

Khaki, A.R., and Sangmi, M. (2017). Does access to finance alleviate poverty? A case study of SGSY beneficiaries in Kashmir valley. *International Journal of Social Economics,* 44(8), 1032-1045. DOI.org/10.1108/IJSE-10-2015-0277.

Koomson, I., Villano, R.A., and Hadley, D. (2020). Effect of financial inclusion on poverty and vulnerability of poverty: Evidence using a multidimensional measure of financial inclusion. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement*, 149(2), 613-639.

La Porta, R., Lopez-de-Silances, F., Shleifer, A., and Vishny, R.W. (1997). Legal determination of external finance. Journal of Finance, 52, 1311-1155.

Le Goff, M., and Singh, R.J. (2014). Does trade reduce poverty? A view of Africa. *Journal of African Trade*, 1, 5-14. doi: 10.1016/j.joat.2014.06.001.

Lehne, J., Mo, J., and Plekhanov, A. (2014). What determines the quality of economic institutions? Cross-country evidence. European Bank for Reconstruction and Development Working Paper No. 171.

Loi, N.T., Huang, V.T., Duc, D.A., Dung, N.Q., and Van, V.Q. (2022). The impact of institutions on multidimensional poverty in Vietnam. *Journal of Social Economics Research,* 9(2), 111-120.

Mckinnon, R.I. (1973). *Money and capital development*. Brookings Institute. Washington.

North, D.C. (1990). *Institutions, institutional change and economic performance.* Cambridge University Press.

North, D.C. (1991). Institutions. *The Journal of Economics Perspectives,* 5(1), 97-112.

Nwabuzor, A. (2005). Corruption and development: New initiatives in economic openness and strengthened rule of law. *Journal of Business Ethics*, 59,121-138.

Nwani, S.E., and Osuji, E. (2020). Poverty in sub-Saharan Africa: The dynamics of population, energy consumption and misery index. *International Journal of Management, Economics and Social Sciences,* 9(4), 247-270.http://dx.doi.org/10.32327/IJMESS/9.4.2020.13

Olaniyi, C.O., and Odhiambo, N.M. (2023). Does institutional quality matter in the financial Development-Economic complexity Nexus? Empirical insights from Africa. *Research in Globalization,* 7. doi: 10.1016/j.resglo.2023.100173.

Opeyemi, T.W., and Oladunjoye, O.N. (2020). Access to finance and rate of poverty in sub-Saharan Africa. *Ilorin Journal of Economic Policy*, 7(1), 67-82.

Park, C. Y., and Mercado, R. (2015). Financial inclusion, poverty, and income inequality in developing Asia. Asian Development Bank EconomicsWorking. Paper Series 426.

Perera, L.D.H., and Lee, G.H.Y. (2013). Have economic growth and institutional quality contributed to poverty and inequality reduction in Asia? *Journal of Asian Economics,* 27(4), 71-86.

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross-section dependence. Journal of Applied Economics, 22, 265-312.

Pistor, K. (2013). A legal theory of finance. *Journal of Comparative Economics,* 41(2), 315-330.

Putra, H.P., Diaudin, M., Fahrudin, R., and Suwanan, A.F. (2021). The effect of population growth rate, Gini ratio and GDP growth per capita on poverty rate in Blitar City in 2011-2020. *Journal of Economics and Education*, 18(2), 152-161.

Rashid, A., and Intartaglia, M. (2017). Financial development – does it lessen poverty? *Journal of Economic Studies*, 44(1), 69-86. https://doi.org/10.1108/JES-06-2015-0111

Ritonga, M., and Wulantika, T. (2020). The effect of GRDP and population on poverty rate in Coal District of North Sumatra (2010-2018). *Diversita Journal*, 6(1), 95-102. https://doi.org/10.31289/diversita.v6i1.3135

Roodman, D. (2009). A note on the theme of too many instruments, *Oxford Bulletin of Economics and Statistics*, 71(1), 135-158.

Saddique, H.M.A., Shehzadi, I., Shaheen, A., and Manzoor, M.R. (2016). The impact of governance and institutions on education and poverty alleviation: a panel of SAARC economies. Working Paper No. 71248.

Saha, S.K., and Qin, J. (2022). Financial inclusion and poverty alleviation: An empirical examination. *Journal of Economic Change and Reconstruction*, 56(X), 409-440.

Sari, Y.A. (2021). The effect of minimum wage, open unemployment rate and population on poverty in Central Java Province. *Equilibrium: Scientific Journal of Economics, Management and Accounting*, 10(2), 121-130. https://doi.org/10.35906/je001.v10i2.785

Sehrawat, M., and Giri, A.K. (2018). The impact of financial development, economic growth, income inequality on poverty: evidence from India. *Empirical Economics*, 55(4), 1585-1602. doi: 10.1007/s00181.017.1321-7.

Seven, U., and Coskun, Y. (2016). Does financial development reduce income inequality and poverty? Evidence from emerging countries. *Emerging Markets Review*, 26, 34-63. https://doi.org/10.1016/j.ememar.2016.02.002

Siano, A., Raimi, L., Palazzo, M., and Panait, M.C. (2020). Mobile banking: An innovative solution for increasing financial inclusion in sub-Sahara African countries: Evidence from Nigeria. *Sustainability, MDPI*, 12(23), 1-24.

Singh, B.P. (2021). Institutional quality and poverty reduction in BRICS. *Poverty and Public Policy,* 13(4), 335-350. https://doi.org/10.1002/POP4.327

Tchamyou, V.T. (2019). The role of information sharing in modulating the effect of financial access on inequality. *Journal of African Business*, 20(3), 317-338.

Tebaldi, E., and Mohan, R. (2010). Institutions and poverty. *Journal of Development Studies,* 4(6), 1047-1066.

UNDP (2008). *Making the Law Work for Everyone: Volume 1.* Commission on Legal Empowerment of the Poor. New York: UNDP.

Wang, R. (2020). Financial development and poverty alleviation in developing and emerging economies. Unpublished Doctoral Thesis, University College London.

World Bank (2018). Universal financial access by 2020, (UFA2020) overview: Available at https://www.worldbank.org/en/topic/financialinclusion/brief/achieving-universal-financial-access-by-2020

World Bank (2020). Poverty and shared prosperity 2020: Reversals of fortune. Doi:10.1596/978-1-4648-1602-4.

World Bank (2023). World development indicators. https://databank.worldbank.org/source/world-development-indicators

Zhang, R., and Ben Naceur, S. (2019). Financial development, inequality, and poverty: Some international evidence. *International Review of Economics & Finance*, 61, 1-16. https://doi.org/10.1016/j.iref.2018.12.015

Zhao, L. (2020). Tourism, institutions, and poverty alleviation: empirical evidence from China. *Journal of Travel Research,* 1-23. https://doi.org/10.1177/00472.875.2094779

APPENDIX

Table A1: Summary Statistics

Panel A: Descriptive Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
Pov	736	39.24218	21.06327	.2	86.2
FA	736	.1084783	.1234465	0	.72
CoC	736	–.1581656	2.015426	–1.597468	13
RL	736	–.5096483	.5782564	–1.802306	1.07713
HC	736	68.32237	19.43321	16.56425	112.522
Pop	736	15.87491	1.543371	13.03517	19.20249
Infl	736	7.642968	15.36026	–9.616154	324.9969
GDP	736	1948.87	2215.695	110.4609	11643.46
Inst	736	20.34196	10.13721	3.234466	85.80166
Open	736	67.86863	28.52574	23.98087	175.798

Panel B: Correlation Matrix

Variable	Pov	FA	CoC	RL	Infl	GDP	Inst	Open	HC	Pop
Pov	1.00									
FA	–0.61*	1.00								
CoC	–0.01**	0.09	1.00							
RL	–0.46	0.66**	0.23*	1.00						
Infl	0.05***	–0.01	–0.09	–0.16	1.00					
GDP	–0.65**	0.72	0.05	0.52**	–0.09***	1.00				
Inst	0.12*	0.03	–0.05**	0.03	–0.06	–0.07**	1.00			
Open	–0.30	0.41	–0.01	0.27	0.08*	7	–0.05*	1.00		
HC	–0.45*	0.59	0.20	0.54*	–0.20	0.49*	0.04	0.35*	1.00	
Pop	0.15	–0.09	–0.13	–0.18	0.20*	–0.09	0.12	–0.05	0.004*	1.00

Source: Authors' computation

Note: The variables in the summary statistics are in their raw form. *, ** and *** denote significance at 10%, 5% and 1% levels respectively

Table A2: Test of Endogeneity

H0: Variables are exogenous

Test	Statistic	Probability Value
Durbin (score) chi2(2)	727.14	0.0000
Wu-Hausman F(2,724)	29709.6	0.0000

Source: Authors' computation

Table A3: Unit Root Test Results

Variable	t-Bar	Z[t-bar]	p-value
Povhc	-2.223	-2.701	0.003
FA	-2.430	-3.910	0.000
CoR	-2.449	-4.815	0.000
RL	-2.043	-1.649	0.050
HC	-2.108	-2.030	0.021
Pop	-3.039	-7.462	0.000
Infl	-2.460	-4.080	0.000
GDP	-2.217	-2.049	0.012
Inst	-2.799	-6.058	0.000
Open	-2.610	3.872	0.002

Source: Authors' computation

Note: Intercept is included in the test. The critical values are –2.04 (for 10%), –2.11 (for 5%) and –2.23 (for 1%) respectively.

Journal of Research in Economics • Volume: 9 / Issue 2 • October 2025 pp. 140-171
ISSN: 2636-8307 • DOI: http://dx.doi.org/10.29228/JORE.48

RESEARCH ARTICLE

MATHEMATICAL ANALYSIS OF THE EFFECTS OF THE OTTOMAN APPROACH TO ANIMALS ON ANIMAL DIVERSITY IN ANATOLIA

Mehmet Emin YARDIMCI[*]
Ümran GÜMÜŞ[**]
Şevket Alper KOÇ [***]

A wide variety of animals live in Anatolian lands. The number of animal species living in Anatolia is on average 1.5 times higher than that living in Europe. Anatolia is an important stopping point for intercontinental bird migrations. The main research question of this study is whether the institutions that shaped the approach of Ottomans to animals had an impact on the diversity of animal species living in Anatolian lands. In line with the main aim of the study "the Crime Rate Model", "Intergenerational Transfer Model" and "Bargaining Model Under the Infinite Horizon" are constructed. Additionally, historical documents supporting the findings are presented. Transferring the awareness of protecting nature from generation to generation has a significant impact on shaping social mentality in the Ottoman context. The two most important factors that shaped the approach of Ottomans to animals were the Islamic belief, which mandated animals to be treated compassionately and traditions-customs. The Ottomans treated not only domesticated animals but also wild animals compassionately and tried to protect them. The Ottoman legal system, foresees optimal punishment of those who harm animals. The findings show that the institutions that shaped the approach of Ottomans to animals had a significant impact on the diversity of animal species living in Anatolian lands. However, it is understood that the effects of the two World Wars that took place in the 20th century are also an important point that should be evaluated in this framework. In this structure and process, it is evident that the World Wars caused the richness of Anatolia to decrease. This situation also affected the diversity of animal species living in Anatolian lands.

Keywords: Animal Rights Law, Animal Welfare Policy, Assessment of Environmental Impacts, intergenerational Transmission, Game Theory
Jel Codes: K38, S18, S51, D64, C70

* Kocaeli University, Faculty of Political Sciences, Department of Economics, Kocaeli, Email: emin.yardimci@kocaeli.edu.tr, Orcid: 0000-0002-2896-8342
** Independent Researcher, Beyoğlu, İstanbul, Email:umrangumus47300@gmail.com, Orcid: 0000-0001-7538-6970
*** Kocaeli University, Faculty of Political Sciences, Department of Economics, Kocaeli, Email: alperkoc@kocaeli.edu.tr, Orcid: 0000-0002-0824-7054

Submission Date: 13.05.2025
Revision Date: 18.09.2025
Acceptance Date: 25.09.2025

1. Introduction

Anatolia, which has gone through geological and climatic changes many times throughout history, is the homeland of many plant and animal species, thanks to its character as a continent of high biological importance. Anatolia, significantly affects the living composition on earth due to its geographical location and topographic conditions. The number of animal species living in Anatolia is on average 1.5 times higher than those living in Europe. However, if the diversity of species depending on topographic conditions is taken into account it becomes clear that further studies are needed to understand the ecological impact. It should not be forgotten that Anatolia is one of the bridges most used by intercontinental migrating birds. With the influence of this whole structure and process, Anatolian people can substantially benefit from animals. The livestock sector plays an important role in meeting the nutritional needs of the increasing population in Anatolia. It creates employment opportunities in basic economic activities such as feed, leather-textile, animal husbandry equipment, veterinary medicine and chemical pharmaceutical manufacturing. Significant benefits are provided in agricultural production. camels and horses are especially used in transportation services. The benefits of dogs in ensuring security are substantial Hence it is no coincidence that a high number of animal species live in Anatolia. There is a high probability that this wealth is part of cultural heritage. The main research question of this study is whether the animal protection policies of the Ottoman Empire were effective in the diversity of animal species living in Anatolian lands. Analysis of the effects of intergenerational transmission of nature conservation awareness forms the basis of the research process. The attitudes and behaviors of the Ottomans towards the protection of animals, the animal protection policies implemented by the state and the penalties imposed on those who harm animals are effective in clarifying this research question (Siddiq and Şanlı, 2020; Gündem, 2024; Özyaşar and Nacar, 2024).

The main aim of this study is to investigate the effects of the institutions that shaped the approach of Ottomans to animals on the high level of animal species living in Anatolian lands. For this aim, the next part of this study is designed to consist of three parts. The first part consists of a literature review on animal protection. The second is the empirical part. This section is divided into two parts. The first part contains data and methodology information. In the second, the model is presented and the analysis is carried out. The third section is the conclusion section.

2. Literature Review

Studies on animal protection are of great importance clarifying the connections and contributions of this study to the literature (Metcalfe, 2008; Mehak et al., 2025). Johnson (2017) proves that the social mentality phenomenon, shaped by homo-economicus behaviors driven solely by capitalist motives, creates significant difficulties in protecting animal health. Hawkins et al. (2019) evaluate the effects of technological developments and game-based learning on the protection of animal

rights. Choi and Han (2023) analyze the statements of companies that produce with animal raw materials regarding the protection of animal rights (Table 1).

Table 1: Literature Review

STUDY	SAMPLE	PERIOD	METHOD	FINDINGS
Johnson (2017)	-	-	Game Theory	It states that the effective demand patient who decides to seek animal medical care, faces the interaction between clinics, pharmaceutical firms, government, health insurers, and regulators. It shows that as a result of this systematical interaction, the process related to the quality of health services, medicine innovation, treatment decisions and medicine approval is shaped. The most important reason for this situation is that the basis of game theory analysis lies in the desire to examine the behavior of homo-economicus.
Mehak et al. (2025)	Pakistan	13 November 2023-9 February 2024	Questionnaire	It reveals that there are economic risks, management risks and occupational risks that can affect the protection and sustainability of the fisheries sector in Pakistan.
Hawkins et al. (2019)	Scotland United Kingdom		Questionnaire	It shows how technology and game-based learning impact ensuring animal rights and reducing harm to animals
Choi & Han (2023)	Especially in USA and Canada	-	Game Theory	This study aims to determine the optimal solution to the dilemma between the animal-friendly values of a vegan fashion brand and the situation caused by its materials. It shows that Pareto efficiency is more rational and preferable than Nash equilibrium in this structure of the process.
Metcalfe (2008)	Huntington England	1997	Game Theory	It evaluates the protests of animal rights activists against the European animal testing company named "Huntingdon Life Science" in 1997. Solutions are offered where the interaction between protesters and life scientists can lead to agreement based on protecting animal rights.

3. Data and Methodology

Game theory is an analysis method that uses mathematics based on the assumption of rationality in order to examine the interaction between at least two players. Not needing statistical data

for analysis, is effective in helping the development of game theory reach its full potential. At this point, it is understood that game theory analysis is applied in almost every field of social sciences. As Yardımcı et al. (2023) states that, one of the most important benefits of game theory to economic history is related to the long – term analysis adopted by historical development process and therefore the support that can be provided to continuous historical structures. The main aim of this study is to analyze the effects of the institutions that shaped the approach of Ottomans to animals on the high level of animal species living in Anatolian lands by "the Crime Rate Model", "Intergenerational Transfer Model" and "Bargaining Model Under the Infinite Horizon". The Bargaining Model Under the Infinite Horizon can be constructed to carry out a long-term analysis based on the assumption that the players agree at a certain point in the bargaining process. There is the desire to examine a long-term process on the basis of the Intergenerational Transfer Model and the Crime Rate Model. The Crime Rate Model is designed to evaluate the reduction of the effects of the activities of those who harm animals on the level of social welfare. An index is developed using game theoretical tools to determine the optimal level of harm to animals for the aim of increasing social welfare. The Ottoman punishment system for those who harm animals is also being evaluated in this framework. For these aims, the avarage cost of animal harm on social welfare is determined based on the per capita share of those who harm animals. There isn't an aim regarding the definition of an utility function in the target path of the model. Can't these functions be defined in the model? These functions can be described by including some new variables. However this process falls outside the main aim of this study. The main aim of constructing the Intergenerational Transfer Model is to examine the positive effects of intergenerational transfer of nature conservation awareness on the level of social utility functions. By the Bargaining Model Under the Infinite Horizon, analysis is carried out on the basis of the damage caused by humans to nature and attitudes and behaviors of humans regarding the protection of nature. Players have complete information. This means that everybody is aware of everything (Ougolnitsky and Korolev, 2025; Gkekas et al., 2025; Biella et al., 2025).

The data used to construct the models of this study are limited to the Ottoman Period. The level of importance each society gives to the protection of nature, the approach regarding this perspective, and the policies followed in this framework are different (Li, 2024; Lavelle et al., 2024; Weir et al., 2025). The scope of investigation this study is limited to the analysis of the effects of the institutions that shaped the approach of Ottomans to animals. For academics who want to study in this field, it is recommended to evaluate the policies and social mentality of different societies towards the protection of nature in this context

4. Model and Analyses

4.1. Human Interaction with Nature

Mankind is in constant interaction with nature. It gains either benefit or suffers harm from nature depending on whether it harms or protects nature. In fact, it is a constant negotiation between

nature and humans. One of the most important features of this bargain is that every action of man is in balance in a way that causes the counter-movement of nature. In the long run, bargaining ends with an agreement, with positive or negative consequences. The level of benefit from nature is determined as a result of bargaining. The effect of unconscious behavior towards nature results in a significant time cost. It is more costly to secure the agreement in a future period than in the previous period. In the discipline of mathematics, time cost is shown by the discount rate. Humans and nature negotiate over time with offers and counter-offers for the level of benefit to be obtained from nature.

The sum of all possible benefits that can be obtained from nature constitutes the complete benefit of fully protecting nature In the *t* period, people obtain up to $x_{t,H}$ part of the benefit of protecting the nature with 100% efficiency in return for the damage to the nature and the benefits it provides to the nature. Nature does not provide $x_{t,N}$ part of this benefit to human in period *t*. Nature offers its benefits by restraining its resources, aligning with a motive of restraint. In fact, nature is damaged due to the unintended actions of human beings. The opposite is also true. However, nature can gain additional benefits through mechanisms that negatively impact people. In the model, it is assumed that human behavior towards nature is fixed. Therefore, it is assumed that the harms and benefits nature experiences gets from these behaviors are also fixed.

The maximum benefit level that human beings can achieve is equal to the level of benefit that can be achieved by protecting nature in the most effective way (100%). Human beings' benefit levels depend on provided and potential benefits level that will be achieved by protecting nature in the most effective way (100%). Under these conditions, the level of utility of human beings is realized as follows:

$$u_{HUMAN}(x_{t,H}, x_{t,N}) = x_{t,H} \qquad (1)$$

Similarly, the maximum damage level that nature can achieve is equal to the level of benefit that can be achieved by protecting nature in the most effective way (100%). The benefit level of nature depends on the actualized and potential parts of the benefit that can be achieved by protecting nature in the most effective way (100%). Under these conditions, the utility level of nature is as follows:

$$u_{NATURE}(x_{t,H}, x_{t,N}) = x_{t,N} \qquad (2)$$

The game begins with the man proposing to provide $x_{t,H}$ part of the benefit of protecting nature with 100% efficiency in the first period. Nature will either accept or reject this offer. Provided that nature accepts the proposal, $x_{1,H}$ part of the benefit of protecting nature with 100% efficiency rate will be provided and $x_{t,N} = 1 - x_{1,H}$ part will not be provided. If the offer is rejected, the game will go into the second period. In the second period, nature proposes not to provide $x_{2,N}$ of the benefit of protecting nature with 100% effectiveness. If the proposal is accepted, $x_{2,H} = 1 - x_{2,N}$ part of the benefit of protecting the nature with 100% efficiency rate will be provided and $x_{2,N}$ part will not be provided. If the offer is rejected, the game will go into the third period. This

will continue until an agreement is reached between the players. The model is in the form of a dynamic game with perfect information. For two main reasons, the backward induction method is used to determine the perfect Nash equilibrium of the model. The first is that the information is perfect. Second, the time structure of the game is dynamic. The game ends in the period agreed upon by the players.

It is assumed that the players agree in the n^{th} period. The number of periods of the game determines the type of the game. If n is odd, the model becomes the Rubinstein – Stahl Bargaining Model. However, if n is even, the model becomes the ultimatum bargaining model. The Rubinstein – Stahl Bargaining Model and the ultimatum bargaining model are usually constructed so that two players make offers in a sequential manner. If the players do not reach an agreement at the end of the bargaining process, both players receive zero utility. However, in the ultimatum bargaining model, the player who makes the first offer obtains approximately all of the surplus, whereas in the Rubinstein – Stahl Bargaining Model, the player who makes the second offer also obtains approximately all of the surplus. In the "Human Interaction with Nature: Infinite Horizon Bargaining Game" model, which is one of the models on which this study is based, the study obtains acceptable findings for both the Rubinstein – Stahl Bargaining Model and the Ultimatum Bargaining model. Therefore, Rubinstein (1982) presents the general structure of the "Human lnteraction with Nature: Infinite Horizon Bargaining Game" model, which is one of the models on which this study is based. Since the game starts with the person offering, person offers in the n^{th} period. The equilibrium condition for the agreement to be reached in the n^{th} period is as follows:

$$\delta_{NATURE}^{n-1}\left(1 - x_{n,HUMAN}\right) \geq \delta_{NATURE}^{n-1}(1 - x) \tag{3}$$

In the n^{th} period, if the offer to be made by humans to nature is accepted, $\delta_{HUMAN}^{n-1}x$ part of the benefit of protecting nature with 100% efficiency rate will be provided and $\delta_{NATIURE}^{n-1}(1 - x)$ part will not be provided. Therefore, person has to offer $x_{n,HUMAN}^{*} = x$ at the beginning of the n^{th} period. From this point of view, nature's proposal in the $(n-1)^{th}$ period must meet the following condition:

$$\delta_{HUMAN}^{n-2}x_{n-1,HUMAN} \geq \delta_{HUMAN}^{n-1}x \tag{4}$$

In the $(n-1)^{th}$ period, nature offers $1 - x_{n-1,NATURE} = x_{n-1,HUMAN}$ for the acceptance of the proposal. In this case, $\delta_{HUMAN}^{n-2}x$ part of the benefit of protecting nature with 100% efficiency rate will be provided, and $\delta_{NATURE}^{n-2}(1 - \delta_{HUMAN}^{n-2}x)$ will not be provided. Perfectly well-informed players who know that the process is going this way will also adjust their offers that way. It is rational for person to propose in the first period of the game as follows:

$$1 - x_{1,HUMAN} \geq \delta_{NATURE}(1 - \delta_{HUMAN}x) \tag{5}$$

Therefore, in the first period, a person has to submit an offer in the form of $x^*_{1,HUMAN} = 1 - \delta_{NATURE}(1 - \delta_{HUMAN}x)$. In this case, $1 - \delta_{NATURE}(1 - \delta_{HUMAN}x)$ part of the benefit of protecting nature with 100% efficiency rate will be provided and $\delta_{NATURE}(1 - \delta_{HUMAN}x)$ part will be not. So the perfect Nash equilibrium of the game is:

$$(x^*, 1 - x^*) = \left(\frac{1-\delta_{NATURE}}{1-\delta_{NATURE}\delta_{HUMAN}}, \frac{\delta_{NATURE}(1-\delta_{HUMAN})}{1-\delta_{NATURE}\delta_{HUMAN}}\right) \quad (6)$$

The equilibrium of this bargaining game depends on the patience levels of the players. This is due to nature reaching a critical threshold. Some global events in the 2020s reveal that unintended consequences of human behaviors should be prevented. The persistence of climate problems shows that the level of resilience of nature has decreased, and sustainability has become fragile.

It is understood that a unique mentality flourished widely throughout the Ottoman Empire, as a result of the mixture of cultural values coming from Central Asia with the Islamic faith, which commands to treating nature with tolerance and compassion. It can be said that the model formed by the mixture of Turkish Culture and lslamic belief lies at the basis of the compassionate attitudes of Ottomans towards animals. The Ottomans exhibited a determined and systematic attitude towards animals' rights. In the Ottoman Classical Era Kanunnames [1] and fıqh [2] studies, compensation is foreseen for the killing of owned and trained dogs. Ebussuud states that the person who killed the guard dog should pay compensation to its owner in his Fatwa [3]. English tourist Julia Pardoe, known for her writtings about Ottoman lstanbul, talks about a sanction imposed on those who kill dogs. She states that the dead dog was hanged by its tail with its nose touching the ground and the person who killed it covered it with maize. The person who killed the dog was punished with compensation equivalent to approximately one thousand kuruş [4]. She says that this money was given to the poor. In the Ottoman Empire, legal regulations were made to protect animals. For example, "The Vilayat Municipality Law of 1877", included the act of beating animals among the acts that should be prohibited by the municipality. Animal rights have been protected by applying various provisions through different regulations (Aykanat, 2024). Regulations were made on issues related to not overloading products to animals and working hours by fermans [5]. In the Ferman dated 1587, it can be determined that porters carried heavy loads on weak animals and used saddles that were damaged, which harmed them. In the Ferman dated 1722, it was determined that the porters don't pay attention to the warnings and work while leaving the animals hungry and thirsty in order to increase their earnings due to greed. It was decided that the managers of porters should be warned to exert stricter control, and the animals of those who didn't comply with the law would be branded and taken away from them. The

1 Kanunname is a decree of Sultan in the Ottoman Period, that generally set forth legal provisions regarding a certain theme.

2 Fiqh is the awareness of a human of its rights, powers and responsibilities. The science of fiqh examines interhuman relationships in the basis of the obligations of worship towards God.

3 Fatwa is the answer given by religious authorities explaining the solution of a problem related to Islamic law according to religious legal rules.

4 Kuruş is standard currency of the Ottomans.

5 Ferman is written order of the Sultan in the Ottoman Empire.

Ferman dated 1813 addressed the problems in previous fermans, reminding that a decision was taken not to let animals work on Fridays (Gürler and Osmanağaoğlu, 2009).

Western tourists who came to visit the Ottoman Empire were impressed by the attitude and behavior of the Ottomans towards stray animals. Starting from the 16th century, travelogues admiringly wrote that the Ottomans kept not only domesticated stray animals but also wild animals. Stating, that Turks cannot tolerate cruelty to animals, Thévenot declares that Turkish philanthropy covers all animals. Thévenot, talks about the foundations established to feed cats or dogs and the rich people who leave money to bakeries as well as butchers to feed animals. Thévenot, makes statements that he enjoys observing the hands of men full of meat who are shouting while feeding cats or dogs every day (Thévenot, 2018). Pharmacist Lubenau, who was in King Second Rudolf's delegation, observed that the Ottoman society attached a high level of importance to the protection of animals during his stay in Istanbul from 1587 to 1589. Lubenau witnessed a pregnant dog lying on the ground, being taken care of, with dry grass spread under it. Observing that the manca makers were interested in cats and dogs, Lubenau also experienced the tradition of buying and freeing birds. He states, that under the influence of the Islamic faith, the Ottoman society had a strong affection for cats. He makes assessments about the punishment given to those who violate animal rights in the Ottoman Empire. He also conveys his observations about the reaction and punishment applied to the criminals who nailed a bat to their door and hung an owl on the wall of the house (Lubenau, 1995). During the historical development process of the Ottoman Empire, the number of manca sellers increased considerably, particularly near the Fatih Mosque in İstanbul. Hans Jacob Breuning, like many tourists, observed this situation. Breuning (2020) states that in the Ottoman society, near the Fatih Mosque, meat was distributed to feed the cats, fish were fed with pieces of bread thrown into the sea, and birds were bought for the purpose of emancipation. In 1591, Baron W. Wratislav, who came to Istanbul on the orders of Rudolf II, conveys his experiences with the manca makers in Wratislaw (1996). He observed that when the manca makers, who put pieces of meat on the skewers, were walking on the streets with a herd of dogs, the cats were waiting on high buildings to catch any meat that might be dropped. When the locals bought these pieces of meat, the manca makers would feed the cats, dogs, and birds. In addition, Wratislaw (1996) states that under the influence of the Islamic belief, Ottoman society gave special importance to new recruits. He says that when Hz. Muhammad built a mosque in Mecca, camels were considered sacred because they were believed to carry materials such as water, lime, sand and stone. Walsh (2021) evaluates attitudes and behaviors of the Ottoman society toward the protection of animals. Walsh (2021) provides information about a thick and soft bread specifically produced for the feeding of dogs in Ottoman bakeries. He states that the Ottomans forbade the hunting of dolphins, despite the possibility of earning a high level of income from the usage of dolphin oil for lighting purposes. Olivier (2016) is one of the studies that reveal the effect of birdhouses on the Ottoman architectural structure. Olivier (2016) reports his observations of the birds that feed in flocks in the vicinity of Tophane. The ornate nests made by the Ottoman people for birds, along with the conservation efforts for bird eggs and nests, drew the attention of Olivier (2016). He observed that the manca makers, who were walking

around with pieces of meat in their hands, fed the animals in the region in return for the money they received from the people. Lady Montagu, the wife of the British ambassador of Istanbul, wrote letters to her relatives stating that storks were given a special value under the influence of the Islamic faith. She says that storks roam freely in the streets and build their nests on the low structures of buildings. She also states that if storks make their nests close to a house, the owner of that house believes they will be protected from accident and trouble (Montagu, 1994).

Cleanliness is crucial for the protection of nature and the health of the living. The garbage problem in terms of cleanliness, is remarkable. During the Classical Era, the highest level personnel responsible for cleaning in Ottoman cities were kadı [6]. In İstanbul, the grand vizier managed the Çarşamba Divanı, where the important needs of İstanbul were discussed. In order to carry out cleaning activities regularly, kadı assigned duties especially to city subaşı [7]. Janissaries were responsible for cleaning the squares and streets in general. Those who didn't pay attention to cleanliness were punished. Arayıcı esnafı, would collect garbage subaşı for a certain fee by bidding. They collected garbage and also gained money from recyclable garbage (Açıkel, 2023; Nasıroğlu, 2012; Özcoşar, 2018).

Diseases such as cholera and plague, which left their mark on the 19th century, forced medical authorities and governments to seek a solution. The need for healthy population as workforce, taxpayers and soldiers has had significant effects on the institutionalization of public health. Towards the end of the century, "the germ theory", which is based on the Pasteurist style of defining the disease and the idea that the disease can be combated by identifying its location has begun to gain strength. During this process a telegram was sent to Pasteur by the Ottoman sultan and Chantemesse came to İstanbul as a preventive doctor. Chantemesse recommended that the Hıfzıssıhha Commission, which was established to combat cholera in Ottoman Empire, be made permanent. During the historical development process studies were carried out to affiliate this institution with Şehremaneti [8] (Bingöl, 2021; Altan, 2019; Çağman, 2017).

During 1892-93 the factors that prevented the elimination of garbage were identified by the committee formed under the chairmanship of Charles Bonkowski Pasha to investigate in detail the problems that threatened the protection of public health and the risks related to the protection of drinking water were analyzed. Şehremaneti has made a significant effort in solving these problems with its meticulous activities and thus successful results have been achieved. After the establishment of Şehremaneti, İntizam – ı Şehir Komisyonu [9], a significant portion of whose members were non – Muslims, realized regulations to solve many municipal problems, especially

6 Kadı is the name given to the presidents of the courts that handled all kinds of cases in the Ottoman Empire until the Tanzimat Period and only marriage, divorce, alimony and inheritance cases between the Tanzimat Period and the first years of the Turkish Republic.

7 Subaşı was guard in Ottoman cities.

8 Şehremaneti is the local management that fulfills the duty of municipal police in the Ottoman Empire and is responsible for the cleaning of the city.

9 İntizam – ı Şehir Komisyonu was a commission authorized to prepare regulations on municipal issues. It makes decisions on municipal issues and offers suggestions to the government.

the lighting and cleaning problems of İstanbul. The Sixth Arrondissement was established in 1858 in Beyoğlu, which was selected as a specific area to develop and implement a municipal system during this process. This institution which acts primarily in line with the aim of solving the garbage problem, has implemented active policies in this regard by undertaking the responsibility of garbage collection. As a result of granting this institution the right to impose taxes in areas such as lighting, garbage collection and real estate transfer contracts, the field of activity of this institution has expanded (Akbulut, 2023; Küçükuğurlu, 2023; Obuz, 2022).

In 1858 "the Ottoman Penal Code" was also put into effect to punish those who pollute the environment. In this structure and process it is envisaged that the garbage collection task will be transferred to a subcontractor. This practice was legalized with "the Regulation on Streets" in 1859. In addition for this application streets were classified, working hours were determined and working seasons were separated. Thus, these activities have been systematized. In 1868, street cleaning vehicles was purchased for municipalities. At the same time officers have been assigned to destroy garbage. Cleaning activieties in municipalities began to be organized on the basis of the inspectorate system. During this period, cleaning taxes started to be collected in municipalities. In 1889, it was decided to collect cleaning taxes on a monthly basis. During the historical development process, the mechanism for cleaning work had been realized more effectively and efforts had been made to increase the level of social welfare. Although the responsibility for garbage collection was planned on the basis of the municipal service area, in Ottoman İstanbul in the 19th century there were of garbage collectors, a significant portion of whom belonged to the low-income group who migrated and tried to earn their living from garbage (Aktürkoğlu, 2022; Onaran, 2022; Kolay, 2023).

There are various historical events regarding the implementation of policies for the protection of nature during the development of the Ottoman Empire. The ban on animal grazing and agriculture in the river basins, intended to prevent the streams from filling the Golden Horn with mud during, the reign of Sultan Mehmet II in the mid – 15th century, is related to the decisions taken in this context. For this purpose, couch grass was planted on steep slopes to ensure that the soil remained stable. It has great importance at this point that the decision to prevent the cutting of trees in the Sapanca mountains was taken by the Divan [10] in 1559. Similarly, the intervention in illegal tree cutting in İstanbul in 1727 and the stopping of the construction of baths in 1767, considering the water and wood shortage, are important historical events that should be evaluated in this context (Aydın, 2024; Vadas and Baráth, 2024; Akgündüz and Öztürk, 2011; Tamtam, 2022). Households were requested to dispose of garbage regularly their designated area. This was the reason why the garbage thrown at the Unkapanı pier was requested to be thrown into the garbage dump near the Ayazma pier in 1779. However especially after the Tanzimat Period important developments regarding the environment and the emergence of non – governmental organizations were effective in reaching the peak level of importance given to the protection of nature. In the 19th century, activities related to the drying of swamps were carried out intensively

10 Divan was the parliament formed by the sultan, grand vizier and some high – ranking state officials during the Ottoman Empire.

in order to increase environmental sustainability and achieve agricultural production. The activities related to the draining of 60 thousand zira [11] of swamp in Çanakkale on 25 July 1886, should be evaluated in this context (Yeşil, 2016; Öztürk, 2025; Kurt, 2021).

Recycling also has significant importance in the field of human interaction with nature. Recycling garbage has great importance in terms of reducing the damage caused by human activities to nature and thus promoting the sustainability of nature. In 1902, two Armenian merchants requested the right to burn the garbage brought by municipal vehicles to a factory to be opened outside Yedikule in İstanbul, in exchange for 200 Ottoman gold coins per year. However, this request was met with a negative response because accumulating all the garbage in the same area poses a risk for public health. Cemil Topuzlu Pasha played an important role in the implementation of the modern municipal system in order to ensure institutional economic efficiency in the Ottoman Empire. For this aim, reports from travelers were requested to obtain information about modern municipal systems implemented in European cities. These reports contain detailed information on how recycling opportunities were utilized due to methods applied in garbage disposal processes in European cities (Ortaylı, 2024). It is stated that in some European cities' garbage in some European cities was spread on empty lands and then turned into fertilizer through rain-induced fermentation. It is also said that high profits are gained from these functions. It is reported that garbage thrown into the sea comes back to the shores due to the wind. After a certain period, it rots and emits a smell in the surroundings. For this aim, it is recommended that the decision on how to evaluate garbage in İstanbul should be made thoughtfully. In fact, it should be noted that the factories required for recycling garbage involve high costs to establish. In a document dated 17 December 1916, it is indicated that profit can be gained by utilizing certain parts of animal carcasses. Cemil Topuzlu Pasha examined the reports and decided to put the garbage collection task out to tender. Panayot and Yorgiyadi, who responded to the advertisement he opened for this purpose in 1913, requested a forty-year privilege. This application was rejected due to the excessive duration (Tamgörgü, 2020; Topuzlu, 2002).

There are various historical documents in the Prime Ministry Ottoman Archives regarding the development of environmental awareness in Ottoman social life. There is a lot of evidence that research on nature was supported. High-level support was provided to scientists who came to the country to conduct scientific research (BOA, 1262). The achievements of scientists serving public health were rewarded (BOA, 1282). Historical documents describing the policies regarding the cultivation of different types of plants during the Ottoman Period are remarkable (BOA, 1311). The primary aim of the Ottoman Empire's policies aimed at protecting and developing nature was to ensure public health. For this reason, the import of plants posing a threat to public health was prevented (BOA, 1297) and the cultivation of plants disrupting environmental order was prohibited (BOA, 1309). During this process, information was exchanged with international organizations for the development of the disciplines of botany and zoology (BOA, 1899). In addition, financial aid was provided to support international scientific

11 Zira is a measure of length used before the metric system was adopted. It is the part between the elbow and the tip of the middle finger.

activities (BOA, 1275). There are studies on the establishment of institutional infrastructure for scientific activities to be carried out in the country (BOA, 1918). There are documents indicating that laws have been enacted to prevent damage to agricultural production (BOA, 1332) and that support has been provided to farmers for this purpose (BOA, 1336). There is a document indicating that foundation land was allocated for the exhibition of plants and animals in Şişli, İstanbul (BOA, 1309). Historical documents regarding the support for the desire to utilize plants have great importance in nature and human interaction (BOA, 1317). There is a historical document within the scope of the research indicating that information was collected from the provinces for the Rami plant, which was intended to be newly cultivated (BOA, 1310). The historical document regarding the prescription of herbal treatment for tuberculosis should also be evaluated in this framework (BOA, 1326). Thanks to the support of the Ottoman Administration for scientific activities, letters of appreciation were received from international organizations (BOA, 1859).

4.2. Transmission of Nature Conservation Awareness

As the number of families conscious of nature conservation increases in society, more effective steps can be taken to protect nature. The awareness of the need to protect nature is a phenomenon that is transmitted between generations. This situation increases the importance of the state's policies to create awareness of nature conservation in society.

The ratio of married men and women who mutually instill the awareness of protecting nature in each other in the t+1period (π_{t+1})depends on the followings:

- Ratio of families in which the awareness of protecting nature is instilled in period t (π_t)
- The probability of instilling the consciousness of nature protection in his own marriage of the man who grew up in the family where the consciousness of nature protection is instilled (R_E)
- The probability of instilling the consciousness of nature protection in his own marriage for the man who grew up in the family where the consciousness of nature protection is not instilled (R_H)
- The probability of instilling the awareness of nature conservation in her own marriage of the woman who grew up in the family where the consciousness of nature protection is instilled (Z_E)
- The probability of instilling the consciousness of nature conservation in her own marriage of the woman who did not grow up in the family where the consciousness of nature protection was instilled (Z_H)

- In terms of instilling the consciousness of protecting nature, the probability of marriage of those coming from the same type of family (Q)

There are three basic assumptions of the model. The first states that divorce occurs only between the end of the previous period and the beginning of the next period. During this period, the divorced get married again before the beginning of the next period. It is also assumed that divorces are ineffective in instilling awareness of nature conservation in families (Based on the ecofeminism discussions as, instilling the awareness of nature conservation is evaluated separately in terms of male and female individuals and analysis is carried out) (Çetin, 2005).

The second assumption is that individuals raised in a conservation-conscious family are more likely to instill this awareness in their own marriage than those who did not grow up in such a family: $R_E > R_H$ and $Z_E > Z_H$. The third assumption shows that, in terms of nature conservation awareness, men and women with similar family backgrounds are more likely to marry each other: $Q>0.5$

The rate of marriages in period $t+1$ among individuals who grew up in families where the awareness of nature conservation was instilled is $Q\pi_t$. The probability of mutually instilling the consciousness of protecting nature in their marriage is $Q\pi_t R_E Z_E$.

The rate of marriages in period $t+1$ among individuals who grew up in families where the awareness of nature conservation is not instilled is $Q(1-\pi_t)$. The probability of these individuals to mutually instill the consciousness of protecting nature in their marriage is $Q(1-\pi_t)R_H Z_H$.

In terms of instilling the awareness of protecting nature, the rate of marriages between those who grew up in different families in period $t+1$ is $1-Q$. The probability of these individuals to mutually instill the awareness of protecting nature in their marriage,
$(1-Q)\,[\pi^2 R_E Z_E \;+\; \pi_t(1-\pi_t)R_E Z_H + \pi_t(1-\pi_t)R_H Z_E + (1-\pi_t)^2 R_H Z_H]$.

The ratio of married men and women mutually instilling the awareness of protecting nature in each other in period $t+1$:

$$\pi_{t+1} = (1-Q)[\pi_t^2 R_E Z_E + \pi_t(1-\pi_t)R_E Z_H + \pi_t(1-\pi_t)Z_E R_H + (1-\pi_t)^2 R_H Z_H] + Q\pi_t R_E Z_E + Q(1-\pi_t)R_H Z_H \quad (7)$$

At steady state:

$$\pi = (1-Q)[\pi^2 R_E Z_E + \pi(1-\pi)R_E Z_H + \pi(1-\pi)Z_E R_H + (1-\pi)^2 R_H Z_H] + Q\pi R_E Z_E + Q(1-\pi)R_H Z_H \quad (8)$$

Taking the first-order condition of the function with respect to π:

$$\frac{\partial D}{\partial \pi} = +(1-Q)[2\pi R_E Z_E + (1-\pi)R_E Z_H - \pi(R_E Z_H) + (1-\pi)Z_E R_H - \pi Z_E R_H + 2(\pi-1)R_H Z_H] - 1 + QR_E Z_E - QR_H Z_H = 0 \quad (9)$$

$$\frac{\partial D}{\partial \pi} = +(1-Q)[2\pi R_E Z_E - 2\pi R_E Z_H - 2\pi R_H Z_E + 2\pi R_H Z_H + R_E Z_H + R_H Z_E - 2R_H Z_H] - 1 + Q(R_E Z_E - R_H Z_H) = 0 \quad (10)$$

$$\frac{\partial D}{\partial \pi} = +(1-Q)[2\pi(R_E Z_E - R_E Z_H - R_H Z_E + R_H Z_H) + R_E Z_H + R_H Z_E - 2R_H Z_H] - 1 + Q(R_E Z_E - R_H Z_H) = 0 \quad (11)$$

$$\pi = \frac{(Q-1)(R_E Z_H + R_H Z_E - 2R_H Z_H) - Q(R_E Z_E - R_H Z_H) + 1}{(1-Q)2(R_E Z_E - R_E Z_H - R_H Z_E + R_H Z_H)} \quad (12)$$

Since $1-Q>0$, $R_E > R_H$ and $Z_E > Z_H$:

$$\pi(1-Q)2(R_E Z_E - R_E Z_H - R_H Z_E + R_H Z_H) > 0 \quad (13)$$

Therefore,

$$(Q-1)(R_E Z_H + R_H Z_E - 2R_H Z_H) - Q(R_E Z_E - R_H Z_H) + 1 > 0 \quad (14)$$

The function showing the ratio of married men and women, who mutually instilling the awareness of protecting nature during in each other in the t+1 period is a decreasing function. The consciousness of protecting nature is transmitted between generations. Governments need to implement the necessary policies so that individuals who grow up in families where the awareness of nature conservation is not instilled can develop and instill this awareness in their marriages. While doing this, it should encourage individuals who grow up in families where the awareness of nature conservation is instilled, to instill the awareness of nature conservation in their marriages. Our findings show that, only with these policies, the share of families who are conscious of nature conservation can be increased in society. The Ottoman society's high importance on protecting of animal rights made the next generation sensitive about animal rights. The continuation of the tradition of manca making in the Eminönü district of Istanbul in the 20th century is the most important indicator of this situation. Thus, there was a high level of animal diversity and quantity in the Anatolian lands during the early years of the Republic of Turkey.

The principles of the institutions underlying the Islamic faith regarding the universe, natural environment and resources play an important role in shaping the phenomenon of social mentality by developing environmental awareness in Ottoman social life. In the Quran, people are commanded to fulfill their responsibilities in order to preserve the natural equilibrium in which everything is created. It is stated that waste should be avoided in benefiting from the blessings of nature. It is emphasized that people should give importance to both material and spiritual cleanliness (Sever, 2023; Aydın, 2022; Altı, 2020). The issue of nature protection includes clean water supply, environmental cleaning, prevalence of green areas and animal protection activities. In Ottoman social life, the ecosystem was evaluated as a whole and it was envisioned that all creatures in nature should live in harmony. Perhaps, one of the most important indicators of this

situation is that food was left in a high tower allocated to birds in the almshouse, which was built during the Sultan Ahmet Era, to provide aid to the poor. Foundations established to increase the level of social welfare in Ottoman social life provided significant benefits for nature protection (Mikhail, 2019; Tuzcuoğlu, 2018; Inal and Köse, 2019; Altınbaş, 2021; Yörük, 2016).

Living creatures are sensitive beings and can be highly affected by even the slightest change in factors. They require more than just material possessions. Because all living creatures are spiritual beings, they also need spiritual nourishment. These needs must be met. Otherwise they will become stressed and experience difficulties continuing their lives (Donaldson and Kymlicka, 2013; Pelluchon, 2023; Reichholf, 2022). This situation is also valid for animals. Even if the habitats of animals, including the geographical conditions, are suitable for meeting all their material needs, they will become stressed and have difficulty surviving if they aren't receiving attention from their caretakers (Behnke and Claußen, 2001; Fogle, 1992; Mann, 2020). This scientific rule proves the compassion based approach of the Ottomans towards animals. Baygın and Onur (2021) state that Anatolian lands have demonstrated their importance with their climate and underground – aboveground riches throughout history. However if the Ottomans hadn't treated animals with a high level of compassion due to their Islamic belief, such a variety of animal species would not have existed in Anatolia. Furthermore, when considered from the perspective of animals that have economic value, treating animals with compassion is, a rational strategy. Prohibitions on leaving animals unattended on pastures are also important points to consider in this context (BOA, 1329).

4.3. Analysis of the Crime of Harming Animals

It is assumed that all individuals in society are defined as $N = \{1, 2, \ldots . n\}$The distribution of harm to animals in the society is defined by the vector x in the situation $(x \in R^{+})$. It is known that the maximum level of harm given to animals in the society is z>0The set of people who harm animals in the society is formalized as $Q = \{h \in N / x_h < z\}$The damage caused by those who harm animals in the society in each period is shown by the y vector. This vector can be defined as a subvector of the distribution of harm to animals: $x = (y, x_{-y})$. The analyzed time period is T+1 long. Let t denote the time distance from today: t=0,1,2,...,T. There are levels of harm given to animals in each period examined as $h \in Q$...., by $y_h = y_h, y_h(1), y_h(2), y_h(3), \ldots y_h(\mathrm{T})$ being each of those who harm animals. This information can be summarized by a matrix:

$$Y = (y_1, y_2, \ldots, y_q) \in R_{+}^{q \times (T+1)} \quad (15)$$

The maximum level of harm given to animals (z) is a time-independent variable and represents the natural limit. Harming animals above this level is thought to exceed the tolerance limit of nature and completely disrupt the natural equilibrium. Therefore, exceeding this level is mathematically possible, but not in practice. The total social cost of harm to animals is calculated by adding up the individual harms inflicted on animals. There are three basic assumptions underlying the model. The first assumption state that those who harm animals shape their own utility functions

by the harm they cause in each period $u_h^t\big(y(t)\big) = u^t\big(y_h(t)\big)$. The second is about the cost of time $u^t\big(y_h(t)\big) = \delta^t u(y_h(t))$. Time cost is taken into account. The third assumption concerns the shapes of the utility functions. Utility functions are increasing and concave. The problem caused by the harm done to animals can be understood in terms of change, which is inversely proportional to the level of intervention or mitigation efforts. $u\big(y_h(t)\big) = \bar{ln}\big(\bar{y_h}(t)\big)$ The dimension of the Y matrix implicitly includes the length of the time period and the number of individuals harming animals. The natural limit of animal harm (z) represents the maximum level of harm inflicted on animals. Deviations from this level occur in each period $(y_h(t) - z_t)$. The greater these deviations, the higher the level of social welfare. These deviations are taken into account in calculating the geometric mean of animal harm across time. In the model, it is assumed that this geometric mean reaches a maximum level of 1. Furthermore, it is assumed that the relevant deviation levels in the model vary depending on the ratio of the time duration above the discount rate to the total time length $(\frac{\delta^t}{T})$. When evaluating the situation in terms of total damage it is obvious that the entire historical process must be taken into account $(\prod_{t=0}^{T})$. Geometric mean of deviations between levels of animal harm between periods:

$$\mu(y_h) = \prod_{t=0}^{T} max\left\{1, (y_h(t) - z_t)^{\frac{\delta^t}{T}}\right\} (16)$$

The natural level of damage to animals is a increasing function of the geometric mean of deviations between levels of animal harm between periods (equation 17 and 18 $(\frac{\delta^t}{T} > 0, (y_h(t) - z_t) < 0\ and\ \frac{\delta^t}{T} - 1 < 0\ are$ known)).

$$\frac{\partial(\mu(y_h))}{\partial z_t} = \prod_{t=0}^{T} max\left\{0, (y_h(t) - z_t)^{\frac{\delta^t}{T}-1}(-1)\ \frac{\delta^t}{T}\right\} (17)$$

And

$$\frac{\partial^2(\mu(y_h))}{\partial^2 z} = \prod_{t=0}^{T} max\left\{0, \frac{\delta^t}{T}\left(\frac{\delta^t}{T} - 1\right)(y_h(t) - z_t)^{\frac{\delta^t}{T}-2}\right\} (18)$$

The level of damage to animals per period is a decreasing function of the geometric mean of deviations between levels of animal harm between periods (equation 19 and 20 $(\frac{\delta^t}{T} > 0, (y_h(t) - z_t) < 0\ and\ \frac{\delta^t}{T} - 1 < 0\ are$ known)).

$$\frac{\partial(\mu(y_h))}{\partial y_h} = \prod_{t=0}^{T} max\left\{1, \frac{\delta^t}{T}(y_h(t) - z_t)^{\frac{\delta^t}{T}-1}\right\} (19)$$

And

$$\frac{\partial^2(\mu(y_h))}{\partial^2 y_h} = \prod_{t=0}^{T} max\left\{0, \frac{\delta^t}{T}\left(\frac{\delta^t}{T} - 1\right)(y_h(t) - z_t)^{\frac{\delta^t}{T}-2}\right\} (20)$$

When the natural logarithm of both sides of equation (16) is taken and the level of harm to animals $(y_h(t)$ is tried to be calculated in unit context, it is understood that the effects of individual damages can vary by the value of multiplication the deviations from the natural level of harm to animals in each period with the discount rate of each period $(\Sigma_{t=0}^{T}\ max\{0, \delta^t(y_h(t) - z_t)\})$. The effect of individual damages:

$$d_h(P) = \Sigma_{t=0}^{T}\ max\{0, \delta^t(y_h(t) - z_t)\} (21)$$

The damage caused by those who harm animals is equal to the geometric mean of their deviations over time multiplied by the discount rate of $(\frac{T}{\delta^t})$ degrees. When equality (16) is included in equality (21):

$$d_h(P) = (\mu(y_h))^{\frac{T}{\delta^t}}\delta^t (22)$$

The level of natural damage to animals is a increasing and inflection forming for avarege The effect of individual damages (equation 23 and 24):

$$\frac{\partial d_h(P)}{\partial z_t} = -\delta^t\ (23)$$

And

$$\frac{\partial^2 d_h(P)}{\partial^2 z_t} = 0\ (24)$$

The level of damage to animals per period is a decreasing and inflection forming for avarege the effect of individual damages (equation 25 and 26):

$$\frac{\partial d_h(P)}{\partial {y_h}^{(t)}} = \delta^t = \frac{\partial(\mu(y_h))}{\partial y_h} T\mu(y_h)^{\frac{T}{\delta^t}-1}\ (25)$$

And

$$\frac{\partial^2 d_h(P)}{\partial^2 {y_h}^{(t)}} = \frac{\partial(\mu(y_h))}{\partial y_h} T\left(\frac{T}{\delta^t} - 1\right)\mu(y_h)^{\frac{T}{\delta^t}-2} = 0\ (26)$$

The average total social welfare loss resulting from animal harm is calculated based on two variables: the total time period (T) and the subpopulation of actors who harm animals $(h \in Q)$. The average

value of the social welfare loss caused by harming animals is defined as the welfare cost of harming animals:

$$C(P) = \frac{1}{nT}\Sigma_{h\in Q}\delta_t(\mu(y_h))^{\frac{T}{\delta t}} = \frac{q}{nT}\delta_t(\mu(y_h))^{\frac{T}{\delta t}} (27)$$

The level of damage to animals is per period (equation 28 and 29):

$$\frac{\partial C(P)}{\partial y_h} = \frac{q}{n}\mu(y_h)^{\frac{T}{\delta t}-1} (28)$$

So:

$$\frac{\partial^2 C(P)}{\partial^2 y_h} = (\frac{T}{\delta t}-1)\frac{q}{n}\mu(y_h)^{\frac{T}{\delta t}-2} (29)$$

An assumption $\varepsilon = 1$ is made to effectively analyze the intensity and severity of harming animals using the Atkinson (1970) Inequality Index. This index is accepted as the value obtained by subtracting the ratio from (1) the ratio of the geometric mean to the arithmetic mean of the deviations from the natural level of the harm done by those who harm animals:

$$A_1(d) = 1 - \frac{\mu(P)}{\mu^*(P)} (30)$$

The variable $\mu(P)$ in equation (30) is the same as the variable $\mu(y_h)$in equation (27). Therefore, the equation (30) can easily be placed inside the equation (27):

$$C(P) = \frac{q}{nT}\delta_t((1 - A_1(P))(\mu(P)))^{\frac{T}{\delta t}} (31)$$

The welfare costs of harming animals are an increasing function of each of its components. Aggravated penalties have a significant impact on the effectiveness of animal protection policies. It is assumed that the population is divided into *G* subpopulations ($g = 1,2, \dots, G$). In this case the group of individuals who harm animals is:

$$Q = U_{g=1}^{G} Q_g (32)$$

And:

$$q = q(g) (33)$$

If equation (32) and (27) are taken into account the following result is obtained:

$$C^g(P) = \frac{q(g)}{nT}\delta_t(\mu(P(g)))^{\frac{T}{\delta t}} (34)$$

Because of :$C(P) = \Sigma_{g=1}^{G} C^{g}(P)$:

$$C(P) = \frac{q}{nT}\delta_t \Sigma_{g=1}^{G} \frac{q(g)}{q}\delta_t(\mu(P(g)))^{\frac{T}{\delta t}} \quad (35)$$

The most important factor that determines the level of animal protection in a society is the social mentality. The impact of the Ottoman social mentality on attitudes and behaviors towards the protection of animals is shaped by Islamic belief and traditions-customs. If this situation needs to be examined in the framework of the Constitutional Economics Approach, it is understood that the effectiveness of the institutions that become evident on the basis of the Islamic belief in this structure and process is decisive. The creation and implementation of state policies for the protection of animals is also an important indicator of institutional effectiveness. Establishing legal rules for the protection of animals and punishing those who harm animals at an optimal level to achieve this goal, are critical issues in terms of ensuring the effectiveness of law discipline. As a matter of fact, the source of law rules derives from the history, philosophical perception and religious, political, economic and sociological structures of a country. Therefore, all the demands should be taken into account as much as possible in the formation process of legal rules (Berának and Titl, 2024; Billot and Çu, 2022; Sucu, 2024). Cowan (1948) defines the discipline of law as a technique that enables the cooperation of sciences for society and says that the discipline of law is situated among the sciences that cover its field of study more broadly. The effectiveness of can be achieved, as Cairns (1941) states, by protecting its relations with other disciplines in this framework and by benefiting from the principles, theories and rules of other sciences.

Posner (1998), who defines the discipline of law as an internal element of society that shapes social life, emphasizes that institutions of law should be examined within the context of social reality. Two basic points should be taken into account when evaluating the institutional economic effectiveness of the law discipline. The first law discipline is not only influenced by other disciplines with which it interacts, but it can also affect them. Secondly, any element in the field of law develops as a subsystem within it. The important point is that the elements that make up the discipline of law are in harmony with each other and maintain their consistency throughout the historical development process. In this context, examining the interaction between the disciplines of politics, economics, and law is a cornerstone. The importance of studies in this field of interaction remains on the international agenda for a long time. Thanks to their contributions in this field, Nobel Prizes in Economics were given to Ronald Coase (transaction costs and property rights) in 1991, to Douglas C. North (institutions and their impact on economic activity) in 1993, and to both Oliver E. Williamson (transaction costs, governance and organization theory) and Elinor Ostrom (field of common property) in 2009. Public Choice Theory and Economic Analysis of Law, as a reflection of this approach, have developed in this framework. Public Choice Theory examines methodological individualism, homo-economicus, and political exchange assumptions, by Public Choice Theory, similar to the functioning of the internal dynamics of the market. At this point, the interaction between political parties and voters is analyzed in the

framework of the principal – agent relationship. Voters try to maximize benefits in return for the votes they provide to political parties. Political parties, exhibiting homo-economicus behaviors, care about individual benefit maximization rather than maximizing social welfare. This structure and process, lead to the formation of institutional traps (Ayele et al., 2024; Klundt, 2024; Skarbek, 2024).

The Ottomans lived with a sense of justice based on the protection of the rights of all parts of the ecosystem. As Özcoşar (2018) stated, it is possible to see this, in all the oral and written cultural historical elements inherited from the Ottomans. Çiftçi (2023) states that the tribes played an important role in Ottoman social life, mining and army logistics with the high number of camels they owned. The importance given to animals and plants was, of course, at the highest level. The importance the Ottomans placed on birds is an issue that needs to be evaluated in this context. It was forbidden to hunt birds during their breeding season, even though they were otherwise allowed to be hunted during their breeding season. Those who didn't comply with this ban were given a monetary fine; those who didn't pay it were punished with imprisonment. The hunting of birds that were beneficial to agriculture by eating insects, and had no nutritional value, was forbidden (Erler, 2021; Emek, 2025). In a letter, the Austrian ambassador Busbecq wrote on 1 June 1553, he provides an example of a historical event regarding the punishment given to those who harm animals. This issue is about the cruelty of a Venetian jeweler, who was interested in birds. The Venetian jeweler hung, by stretching its wings, a bird with a strange beak at the entrance of his shop. The bird was holding garbage in its beak, which left its mouth open. Those passing by the shop initially thought the bird was dead. After a while, they understood that the bird was alive. They immediately complain to the kadı about a cruel jeweler because of torturing the bird. As a result of the intervention of the Venetian ambassador, the jeweler was saved from being punished (Busbecq, 1881).

Camels have great importance in Ottoman social life. Due to the conditions of the era, camels were widely used for transportation. As Gölcü and Yerlikaya (2016) also stated, camels were used in the Ottoman army during the First World War. Injustice against camels should also be evaluated. Polat (2024), who showed the document dated 30 October 1568 as evidence, understood that injustice was done to camels during the Ottoman Era by overloading them. The Ottomans gave great importance to the protection of animals. To prevent the crime of overloading the camels, the case mentioned by Polat (2024) was brought to the Divan, where important issues of the state were discussed and necessary decisions were made.

The findings of the game theoretical models underlying this study show that the compassion demonstrated by the Ottomans towards animals has been effective in the existence of a high level of animal diversity in Anatolian lands. The main determinant of benefiting from nature is the level of nature protection. The findings of the first model demonstrate this fact. The most important factor determining the approach of Ottomans to animals was Islamic beliefs. The development of research on Islamic belief during the Ottoman period is one of the most important factors supporting this situation. The historical document of (Addition 1) in the Ottoman Archives of

the Prime Ministry contains the statement of Prophet of Islâm that pigeons should be brung up in homes to protect children from jinn. The religion of Islâm does not allow harming animals in any way. Influenced by this belief the Ottomans tried to protect nature in the most effective way. As the findings emphasize, the protection of nature played an important role in the high level of animal diversity in Anatolian lands. In the second model, the probability of nature conservation awareness being transferred between generations is calculated. The tradition of creating bird sanctuaries in palaces and summer palaces in the Ottoman Empire is an important aspect to be evaluated in this context (Addition 2, Addition 3, Addition 5). Similarly the policies regarding the protection of endangered animal species are also cornerstones (Addition 4, Addition 6). These attitudes and behaviors of Ottomans regarding the protection of nature show that the awareness of nature protection has likely been passed down from generation to generation. The findings of the third model indicate that as the level of harm to animals increases the avarage social welfare loss resulting from this situation also increases. The importance of laws regarding the protection of animals becomes evident in this structure and process. The ecosystem is a mechanism where each part has a separate value and therefore when any part is damaged it is distrupted. Siskin and sparrow birds affect equilibrium's sustainability by eating insects that harm agricultural production. Hunting these birds which are effective in increasing biodiversity causes the natural equilibrium to be distrupted. As Koç (2006) stated, the Ottomans gave great importance to the protection of these birds. The historical document containing the decision of Dahiliye Nezareti, the Ministry of Internal Affairs of the Ottoman Empire, expressing certainty regarding the hunting of birds such as siskins and sparrows in the Ottoman Empire is an important document highlighting the importance that the Ottomans gave to the protection of nature (Addition 7).

5. Discussion and Results

The main aim of this study is to examine the interaction between humans and nature, on the basis of animal protection. This study aims to investigate the effects of the institutions that shaped the Ottoman approach to animals on the high number of animal species living in Anatolian lands. Game theory tools are used for these objectives. There are three game-theoretic models that form the basis of this study. The first model aims to analyze the interaction between nature and humans through "the Bargaining Model Under the Infinite Horizon. The findings of this model reveal the boundary area that expresses the sustainability level of nature. The second model analyzes the effects of the intergenerational transfer of awareness about nature protection. The third model is designed to discuss the effects on the protection of animals of the effectiveness of the punishments applied to those who harm animals. In addition, historical documents supporting the findings are presented in the study. The first model provides evidence that as the level of protection of natire of people increases so too does their ability to benefit from blessings of nature. European travellers note that the Ottomans placed great importance on protecting nature. The basis of this mechanism lies in the importance placed on nature protection in Islamic law. One of the most significiant benefits nature provided to the Ottomans was the advancements in the healthcare

sector brought about by herbal treatment methods. From this perspective, it becomes clear that this study has a broad and growing scope.

The findings of the first model suggest that, as the level of protection nature increases, the ability of humans to benefit from blessings of nature will also increase. The second model analyzes the effects of the intergenerational transmission of nature conservation awareness. The third model demonstrates the impact of the level of punishment imposed on those who harm nature on its protection. In this analysis, the evaluation of the effects of effective implementation of environmental protection policies is paramount. Public Choice Theory and, as a reflection of it, the Economic Analysis of Law examine the interaction between voters and political parties on the basis of homo-economicus behaviors. These behaviors also occur based on game theory, which is the basic method of this study. The most important aspect of this mechanism is the assumption that economic agents exhibit only rational behavior. Accordingly, political parties compete for votes, especially around the election time. During these periods, some governments that approve projects that violate environmental protection may act in ways that disrupt oversight of these projects. Corruption can prevent environmental regulation policies from being effectively implemented and can lead to the plundering of natural resources. Therefore, corruption is an important problem that leads to increased environmental pollution. Transparent and strong management accountability mechanisms play an important role in reducing environmental degradation. Such governments prioritize their personal interests in approving and supervising projects that are detrimental to the environment. Restricting public access to information about environmental issues can make environmental protection difficult. In this structural process, firms may avoid their environmental obligations. Natural resources may be exploited illegally and uncontrollably. Awarding contracts to select firms through opaque processes can lead to accelerated deforestation and illegal fishing. This system can lead to a decline in biodiversity, the destruction of ecosystems, and jeopardize future generations' access to these resources (Arin et al., 2025; Bosco et al., 2025; Dai, 2025). As Yasa et al. (2025) stated, in the presence of institutional poverty traps, voters receive elements from political parties that will support them in maximizing utility functions in exchange for votes. The profits gained by projects that cause environmental destruction are significant. Elements of political change are also the most important factors that need to be evaluated in this framework. Political exchange is in the form of votes-: temporary profits derived from the degradation of nature (Castillo-Figueroa, 2025; Olgun, 2025; Aydın and Akyol, 2025).

The two most important factors in the protection of nature in the Ottoman Empire were the Islamic belief and traditions. The approach of Ottomans to animals attracted the attention of European tourists, especially, and became the subject of travel books. However, although some problems such as "Hayırsız Ada" realized in the last period of the Ottoman Empire, when the conditions of the period are taken into consideration, it is understood that the Ottoman Empire was one of the most important states that gave importance to protection of animal rights. This situation was effective in the livestock sector, providing significant benefits to the development of the Ottoman Economy. The most important factor that provided the richness of the Ottoman

food culture, was wide variety of spices in meals. Thanks to the practices of the Ottomans in protecting and developing plants, various spices could be cultivated. Similarly, the most important reason why herbal treatment methods could develop at a high level in the Ottoman Empire is that they improved in this regard due to the great importance given to benefiting from nature. The protection and development of nature are core objectives in this structure (Öztürk, 2024; Lokmacı and Koçyiğit, 2024; Yerasimos, 2018).

The Ottomans gave great importance to the development of scientific activities. They gave priority to the development of applied scientific activities aimed at the protection and development of nature. They supported institutions and organizations that organize international scientific activities. The letters of appreciation given to the Ottomans have great importance in this context, thanks to these activities. The attitudes and behaviors of the Ottomans regarding the protection of nature provided significant benefits, especially in the Anatolian lands, by maximizing the benefits of nature. The belief formed on the basis of the Islamic religion and traditions, which shaped the approach of Ottomans to animals, has had significant benefits, resulting in the high number of animal species living in Anatolian lands. The number of animal species living in Anatolian lands is on average 1.5 times higher than the number of animal species living in Europe. In addition, the fact that Anatolia is one of the most used bridges for intercontinental bird migrations is an important element that should be evaluated in this context (Bilirli, 2020; Kaplan, 2023; Türkmen, 2024).

This study is interdisciplinary. At a high level, this study benefits from the disciplines of mathematics (game theory), history, geography, and public economics. An evaluation is conducted in the framework of the Constitutional Economics approach. In fact, the analysis is carried out based on the assumptions of Public Choice Theory, namely political exchange, methodological individualism, and homo-economicus.

References

Açıkel, A. (2023). Environmental and Sewage Network Cleaning in Tokat before Establishment of the Municipal Organization. *International Journal of History Studies, 15*(3): 401-418.

Akbulut, U. (2023). State and Society in the Face of Epidemics in the First Half of the 19th Century. *Erzurum Technical University the Journal of Social Science Institute, 16*: 22-40.

Akgündüz, A. & Öztürk, S. (2011). *Ottoman History Mispetceptions and Truths.* İstanbul: Kitapyurdu Yayıncılık

Aktürkoğlu, M. B. (2022). Cleaning Methods in the Ottoman Community of the XIX Century: Bibliople Arekel and Sadi B. Halid's Stain Booklet Examples. *The Journal of Social Sciences of Muş Alparslan University Anemon,10*(2): 741-751.

Altan, B. (2019). The Cholera Outbreak at the End of 19th Century Cizre and Its Devastating Impacts. *Mukaddime, 10*(1): 37-52.

Altı, A. (2020). An Institution for the Ferocious and Wildlife Animals in the Ottoman State. Lionhome. *Kare, 10*: 120 – 139.

Altınbaş, M. (2021). Regulations and Practices on Environmental Law in the Ottoman State. *International Social Sciences Studies Journal, 7*(89): 4672-4679.

Arin, K. P., Devereux, K., Methorst, J. & Thum, M. (2025). Flooding the Vote: Heterogeneous Voting Responses to a Natural Disaster in Germany. *European Journal of Political Economy, 89*: 102694

Aydın, Y. A. (2024). Forest, Bandits and State: Some Measures Taken Against the Use of Forests as Illegal Activity Areas in the Ottoman Empire (16th – 18th Centuries). *Turkish Journal of History, 84*: 67-77.

Aydın, M. (2022). The Liability of the Animal Owner in the Classical Age of Ottoman Law. *İnönü University Law Review, 13*(2): 420-432.

Aydın, Y. & Akyol, A. (2025). A New Policy Tool for Conserving Biodiversity: Other Effective Area – Based Conservation Measures. *Turkish Journal of Forestry, 26* (2): 182-189.

Atkinson, A. B. (1970). On The Measurement of Inequality, *Journal of Economic Theory, 2(3),* 244-263.

Ayele, Y., Edjigu, H. & Oostendorp, R. H. (2024). The Differential lmpact of Legal Origins on Firm Productivity. *Journal of Law and Economics, 67*(3): 611-638.

Aykanat, M. (2024). Stray Dogs in Ottoman Law and Practice. *Ombudsman Academic, (20)*, 47-80.

Baygın, O. & Onur, T. (2021). Anatolian Psychedelia. *Klaros Publisher*.

Behnke H. & Claußen, G. (2001). Fasan und Rebhuhn-Biologie, Hege, Aufzucht, Kosmos Verlags-GmbH.

Beránek, B. & Titl, V. (2024). The Cost of Favoritism in Public Procumerent. *Journal of Law and Economics, 67*(2): 445-477.

Biella, M., Henning, M.& Oswald, L. (2025). Investigating the Social Boundaries of Fairness by Modelling Ultimatom Game Responders' Decisions with Multinomial Processing Tree Models. *Games, 16*(1): 1-21.

Bilirli, T. (2020). Timber Procurement from Viranşehir Sanjak for Ottoman Naval Ships. Tokat Gaziosmanpaşa University. *The Journal of Social Science Institute, 15*(2): 421 – 437.

Billot, A. & Çu, X. (2022). Deliberative Democracy and Utilitarianism. Social Choice and Welfare, 63(3-4): 603-617.

Bingöl, Ş. (2021). Modern Municipality Work in Muş During the Ottoman Period. *The Journal of Social Sciences of Muş Alparslan University Anemon, 9*(1): 111-127.

Bosco, D., Colombo, L. & Femminis, G. (2025). Conflict, Information and Regime – Change. *European Journal of Political Economy, 89*: 102681.

Breuning, H. J. V. B. (2010). *Relation über seine sendung nach England im Jahr* 1595. New York: Nabu Press.

Busbecq, O. G. (1881). *The Life and Letters of Ogier Ghiselin de Busbecq*. London: C. Kegan Poul & Co.

Cairns, H. (1941). *The Theory of Legal Science.* Chapel Hill: University of North Carolina Press

Castillo-Figueroa, D. (2025). The Effect of Forest Microenvironment on Litter Decomposition in the Andean Tropical Mountains. *Journal Forest Research*, 36,102.

Choi, J. H. & Han, K. (2023) Delegation of information acquisition, information asymmetry, and outside option, *International Journal of Game Theory, Springer, Game Theory Society*, *52(3),* 833-860.

Cowan, T. A. (1948). Relation of Law to Experimental Social Science. *University of Pennsylvania Law Review, 96*(4): 484-502.

Çetin, O. (2005). Ecofeminism: The Relationship Between Women Nature and Patriarchy. *Socioeconomics, 1(1)*. 61-76.

Çiftçi, E. (2023). Camel, Tribe and the State: The Role of Tribal Camels in the Ottoman Mining and Army Logistic. Iğdır University. *The Journal of Social Science Institute, 32*: 148-163.

Çağman, E. (2017). Health Tourism in Ottoman Period: Sample of Kepekler Thermal Springs. *The Journal of Yalova Social Sciences, 8*(14): 87-104.

Dai, D. (2025). Can the Middle Class Benefit from more Conservative Redistribution?. *European Journal of Political Economy, 89*, 102700.

Donaldson, S & Kymlicka, W. (2013). Zoopolis:A Political Theory of Animal Rights. Oxford University Press.

Emek, F. (2025). Animal Culling as a Method of Agricultural Control from Ottoman Empire to Republic of Türkiye (1850-1938): Birds, Field Mice and Wild Boars. *Studies in Ottoman Science, 26*(1): 84-106.

Erler, M. Y. (2021). Birds of Prey on the Central Black Sea of Ottoman Realm. *Journal of Ottoman Legacy Studies, 8*(22): 469-493.

Fogle, B. (1992). The Dog' s Mind: Understanding Your Dog' s Behavior. Howell Books.

Gkekas, A., Apostolidou, A., Vernadou, A. & Kehagias, A. (2025). Learning Optimal Strategies in a Duel Game. *Games, 16*(1): 1-16.

Gölcü, B. M. & Yerlikaya, N. (2016). Camels in the Ottoman Army and Regulations Related to the Ottoman Camel Corps During World War I. *The Journal of International Social Research, 9*(47): 269-278.

Gürler, A. M., Osmanoğlu, Ş. (2009), Historical Development of the Animal Protection Law in Turkey, *Journal of Kafkas University Faculty of Veterinary Medicine, 15*(3): 325-330.

Gündem, C. Y. (2024). Earliest Mule Remains from Early Bronze Age Central Anatolia. *Animals, 14*(10): 1397.

Hawkins, R., Ferreira, G. & Williams, J. (2019). The Development and Evaluation of 'Farm Animal Welfare': An Educational Computer Game for Children, *Animals, 9(3)*, 91.

Inal, O. & Köse, Y. (2019). *Seeds of Power: Explorations in Ottoman Environmental History*. Cambridgeshire: The White Horse Press.

Johnson, L. R. (2017). Applying Game Theory to One Health: Modelling Veterinary Healthcare Delivery. *International Animal Health Journal, 3*(4): 16-21.

Kaplan, B. (2023). Kırklareli and Its Surroundings in Evliya Çelebi's Seyahatname. *Çukurova University The Journal of Social Sciences Institute, 32*(2): 729-744.

Küçükuğurlu, M. (2023). Tophaneli Hacı Mehmet Ağa Foundation from the Ottoman Empire to the Turkish Republic. *Erzurum Technical University the Journal of Social Science Institute, 16:* 94-119.

Klundt, M. (2024). Sozialstaat in Gefahr. *Sozial Extra, 48*(2): 118-122.

Koç, B. (2006). Various Conceptions on the "Hunting Prohibition and Its Limitations" as the Background of the Environment – Conscious in Juridical Texts after the Tanzimat. *Journal of the Center for Ottoman Studies, 19*(19): 271-281.

Kolay, E. (2023). The First Example of Ottoman Municipal Buildings: Sixth Department of the Municipality Building. *Journal of Palmette, 3:* 28-52.

Kurt, B. (2021). The Ottoman State between Urban Space and Environment: Preserving the Drinking Water of İstanbul. *Belleten, 85*(304): 933-966.

Lavelle, K., Fouad, K. & Illes, J. (2024). Stepwise Imperatives for Improving the Protection of Animals in Research and Education in Canada. *MDPI Animals, 14:* 1-9.

Li, C. (2024). Protecting Endangered Animal Species. *MDPI Animals,14*(18): 1-4.

Lokmacı, S. & Koçyiğit, M. (2024). Individual and Community Health in Ottoman Medicine: İnvestigation of Daily Life Practices. *Academic Journal of History and Idea,11*(5): 3506-3525.

Lubenau, R. (1995). *Beschreibung der reisen des Reinhold Lubenau*. Frankfurt: Johann Wolfgang Goethe University.

Mann, S. (2020). Easy Peasy Doggy Squeezy: Even more of Your Dog Training Dilemmas Solved. Blink Publishing.

Montagu, L. M. W. (1994). *Turkish Embassy Letters*. Chicago: Virago Press

Mehak, A., Mohsin, M., Shafqat, M.M. & Li, M.C. (2025). Prioritizing Risks in Pakistan's Fisheries Sector: A Strategic Analysis Utilizing Fuzzy AHP and IPA Methodologies. *Journal of Animal & Plant Sciences, 35*(1): 106-119.

Metcalfe, D. (2008). The Protest Game: Animal Rights Protests and the Life Sciences lndustry. *Negotiation Journal, 24*(2): 125-143.

Mikhail, A. (2019). *Under Osman's Tree: The Ottoman Empire, Egypt and Environmental History.* Chicago and London: Chicago University Press

Nasıroğlu, M. (2012). Mardin from the Eyes of Western Travelers in the New Age. *Batman University Journal of Life Sciences, 1*(1): 827-836.

Obuz, M. (2022). Personel Cleaning and Care in Payitaht Istanbul in the XVI. and XVII. Centuries from the Eyes of Western Travelers. *Van Yüzüncü Yıl University the Journal of Social Sciences Institute, 55:* 118-127.

Olivier, G. A. (2016). *Travels in the Ottoman Empire, Egypt and Persia, Undertaken by Order of the Government of France, During the First Six Years of the Republic.* Hungerford, Berkshire, England: Legare Street Press.

Olgun, Ç. (2025). The Effect of Ammonium Chloride Usage on the Recycling of Fiberboards in the Hydrothermal Hydrolysis Method. *Turkish Journal of Forestry, 26*(2): 175-181.

Onaran, B. T. (2022). Codification of Honor and Gender in the 1858 Ottoman Penal Code. *Mediterranean Journal of Gender and Women's Studies, 5*(2): 209-239.

Ortaylı, İ. (2024). *The Empire 's Longest Century*. İstanbul: Kronik Kitap.

Ougolnitsky, G. & Korolev, A. (2025). Differential Games of Cournot Oligopoly with Consideration of Pollution, Network Structure and Continuous Updating. *Games, 16*(1): 1-22.

Özcoşar, İ. (2018). City and Administration: Administration in Ottoman Mardin before Tazminat. *Mukaddime, 9*(1): 1-21.

Öztürk, D. N. (2024). A Concise Treatise on Ottoman Culinary Culture. *The Journal of Turkish Culture Study, 52*: 381-408.

Özyaşar, Y. K. & Nacar, C. (2024). *Anatolian Livestock Trade in the Late Ottoman Empire*. Leiden: Leiden University Press.

Pelluchon, C. (2023). Manifest für die Tiere. C.H. Beck Publisher.

Polat, M. (2024). Uses of Camels in the Ottoman Empire According to Achive Documents (6th – 18th Centuries). The Journal of International Language, Literature, *Culture, History, Art and Education Research, 17*: 274-284.

Posner, R. A. (1998). *Economic Analysis of Law*. Waltham.: Aspen Law & Bussiness

Prime Ministry Ottoman Archives. (BOA). (1262). Fund Code: A.MKT. Document Number: 49, 22.

Prime Ministry Ottoman Archives, (BOA). (1282). Fund Code: A.MKT.MHM. Document Number: 17, 347.

Prime Ministry Ottoman Archives, (BOA). (1311). Fund Code: A.MKT.MHM. Document Number: 15, 727.

Prime Ministry Ottoman Archives, (BOA). (1296). Fund Code: Y..PRK.HH.. Document Number: 6-7.

Prime Ministry Ottoman Archives, (BOA). (1286). Fund Code: HH.d… Document Number: 910, 22206.

Prime Ministry Ottoman Archives, (BOA). (1297). Fund Code: DA.MKT. Document Number: 95, 1330.

Prime Ministry Ottoman Archives, (BOA). (1309). Fund Code: DH.MKT. Document Number: 33, 1869.

Prime Ministry Ottoman Archives, (BOA). (1899). Fund Code: HR.SFR.3. Document Number: 50, 476.

Prime Ministry Ottoman Archives, (BOA). (1275). Fund Code: HR.MKT. Document Number: 60, 294.

Prime Ministry Ottoman Archives, (BOA). (1918). Fund Code: HR.TO. Document Number: 16, 548.

Prime Ministry Ottoman Archives, (BOA). (1332). Fund Code: A.DVN.MKL. Document Number: 60, 59.

Prime Ministry Ottoman Archives, (BOA). (1336). Fund Code: DH.UMVM. Document Number: 61, 75.

Prime Ministry Ottoman Archives, (BOA). (1309). Fund Code: Y.PRK.BŞK. Document Number: 122, 23.

Prime Ministry Ottoman Archives, (BOA). (1317). Fund Code: DH.MKT. Document Number: 17, 2234.

Prime Ministry Ottoman Archives, (BOA). (1900). Fund Code: MV. Document Number: 98-124.

Prime Ministry Ottoman Archives, (BOA). (1310). Fund Code: A.MKT.MHM. Document Number: 1, 727.

Prime Ministry Ottoman Archives, (BOA). (1322). Fund Code: DH.MKT. Document Number: 910, 2.

Prime Ministry Ottoman Archives. (BOA). (1322/1904). Fund Code: İ..HUSHH.d… Document Number: 123-21.

Prime Ministry Ottoman Archives, (BOA). (1326). Fund Code: Y.PRK.SH. Document Number: 58, 7.

Prime Ministry Ottoman Archives, (BOA). (1329). Fund Code: DH. HMŞ. Document Number: 19, 74.

Prime Ministry Ottoman Archives, (BOA). (1859). Fund Code: HR.TO. Document Number: 48, 452.

Reichholf, J. H. (2022). Stadt, Land, Fuchs: Das Leben der Heimischen Säugetiere. Aufbau.

Rubinstein, A. (1982). Perfect Equilibrium in a Bargaining Model. *Econometrica, 50(1)*, 97-109.

Sever, D. D. (2023). Captive Wild Animals as Visual Commodities in the Ottoman Empire: A Historical Environment. *Middle Eastern Studies, 60*(3): 368 – 384.

Siddiq, A. B. & Şanlı, S. (2020). Animals and Pastoral Groups in the Mountainous Ömerli District of Southeast Anatolia. *Anthrozoös A Multidisciplinary Journal of the lnteractions between People and Other Animals, 33*(2): 153-173.

Skarbek, D. (2024). The Political Economy of Criminal Governance. *Public Choice, 200*: 1-24.

Sucu, M. B. (2024). New Institutional Economics. *Bulletin of Economic Theory and Analysis, 9*(3), 1011-1048.

Tamgörgü, A. B. (2020). Garbage as a Problem in Nineteenth Century Ottoman İstanbul. (Unpublished Master Thesis) Ege University Social Sciences Institute.

Tamtam, H. K. E. (2022). A Semantic Overview of the Toponymy of Nusaybin. *Mukaddime, 13*(1): 170-191.

Thévenot, J. – D. (2018). *Voyages de Mr. Thévenot en Europe, Asie et Afrique*. Manchester: Wentworth Press Publisher

Topuzlu, C. (2002). *My 80 Years of Memories in the Periods of Independence, Constitutional Monarchy and Republic*. İstanbul: Topuzlu Publisher.

Tuzcuoğlu, R. (2018). *Environment and Urbanism in the Ottoman Empire*. İstanbul: Republic of Turkey Ministry of Environment.

Türkmen, Ö. S. (2024). The Relationship between Waqf and the Environment in Amasya During the Ottoman Period. *Amasya University The Journal of Social Sciences*, *9*(15): 58-91.

Vadas, A. & Baráth, Z. (2024). Impacts of Pre – Modern War on Forests: The Case of the Hungarian – Ottoman Military Frontier (ca.1521-1690). *Trees, Forests and People, 15*: 1-8.

Walsh, R. (2021). *Constantinople and the Scenery of the Seven Churches of Asia Minor First and Second Series*. Caroline: Createspace Independent Publishing Platform.

Weir, S. A., McDevitt, L., Andrews, C.P. & Kessler, S. E. (2025). The Creation of a Systematic Framework to Assess Dog Laws and Their Relationship to Societal Changes in the United Kingdom. *MDPI Animals, 15*(5): 1-29.

Wratislaw, B. W. (2022). *Adventures of Baron Wenceslas Wratislaw*. Hungerford, Berkshire: Legare Street Press.

Yardımcı, M. E., Gümüş, Ü. & Yasa, B. D. (2023). The Evaluation of the Sustainability Level of the Tax Farming System in the Framework of a Repeated Game Theoretical Model. *KMU Journal Social and Economic Research, 25*(45): 727-741.

Yasa, B. D., Gümüş, Ü.& Yardımcı, M. E. (2025). Evaluation of Development Strategy by Foreign Aid in Poor Countries. *Journal of Öneri, 20*(64),379-410.

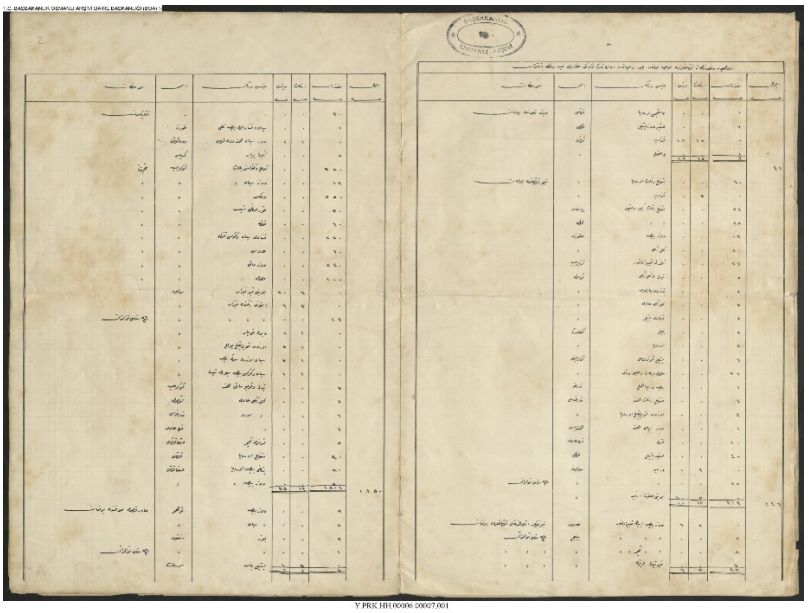
Yerasimos, M. (2018). *500 Years of Ottoman Cuisine*. İstanbul: Boyut Publishing.

Yeşil, M. (2016). Historical Development of the Changes in Approaches to Nature Conservation in Turkey and in the World. *Turkish Journal of Agriculture – Food Science and Technology, 4*(10): 867-876.

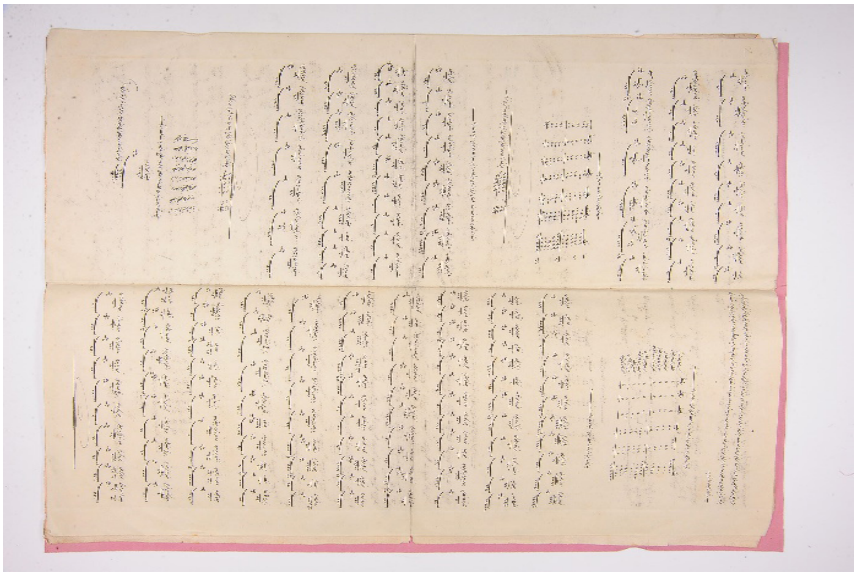
Yörük, D. (2016). Foundations and Associations for the Development of Environmental Understanding of Turkish Society from Ottoman Empire to the Present Day. *Journal Of Studıes In Turkology, 40:* 361-372.

Addition 1: Document regarding bringing up pigeons in in homes to protect children from jinn. (BOA). (1255/1840). Fund Code: TS.MA.e . Document Number: 42-62.

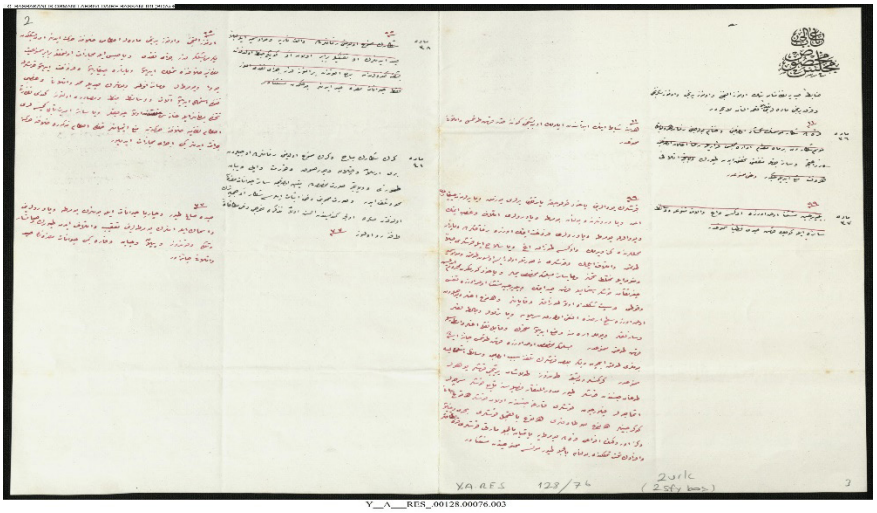
Addition 2: The book in which the amount of birds and other animals in the bird quarters of palaces and pavilions is recorded. Prime Ministry Ottoman Archives, (BOA). (1296/1879). Fund Code: Y..PRK.HH.. Document Number: 6-7.



Addition 3: Summary accounting book containing the expenses of the rebuilt bird buildings in Dolmabahçe Palace. Prime Ministry Ottoman Archives, (BOA). (1286/1869). Fund Code: HH.d… Document Number: 910, 22206.

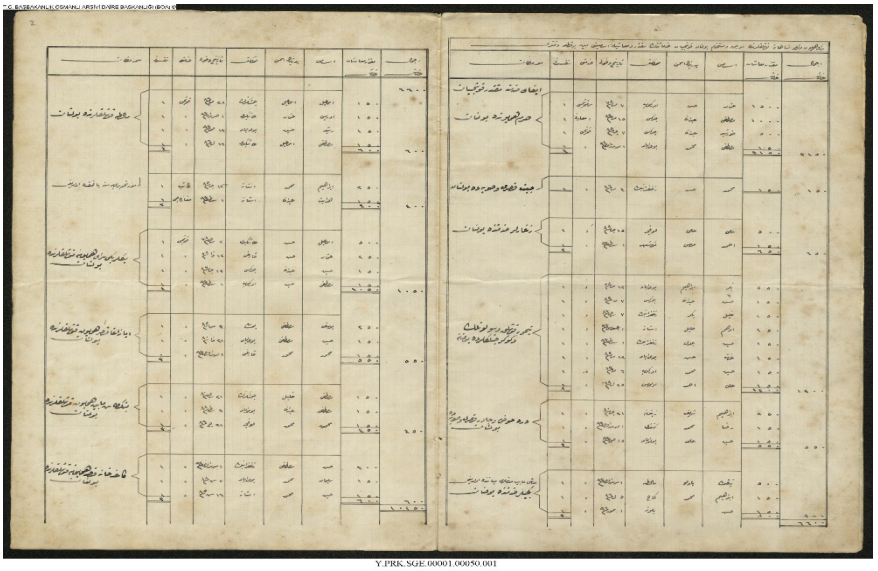


Addition 4: Adoption of the law prepared in Germany on the conservation of birds. Prime Ministry Ottoman Archives, Prime Ministry Ottoman Archives (BOA). (1322/1904). Fund Code: Y..A...RES. Document Number: 128-76.



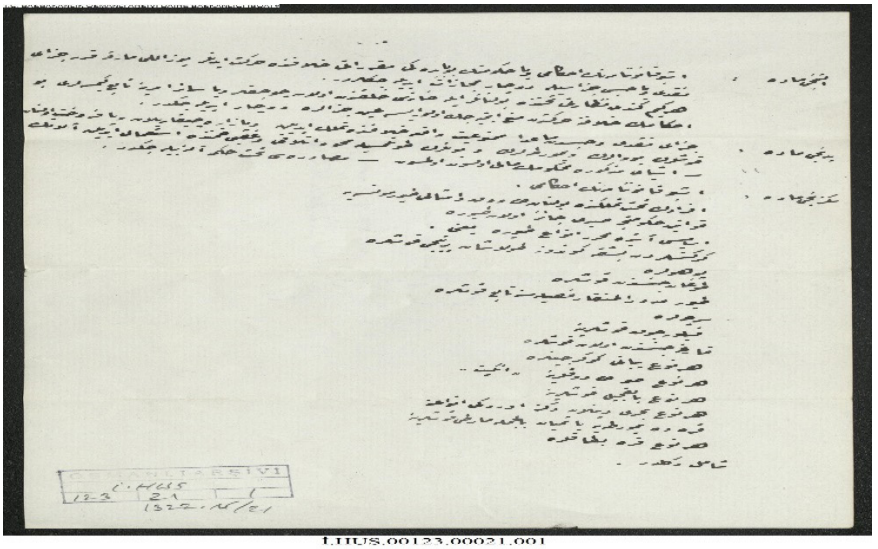
Y__A___RES_.00128.00076.003

Addition 5: Notification of the names and assets of the birdman janitors working in the palace and pavilion birdhouses and their salaries.. Prime Ministry Ottoman Archives (BOA). (1297/1880). Fund Code: Y..PRK.SGE. Document Number: 1-50.



Y.PRK.SGE.00001.00050.001

Addition 6: The regulation to be written about the conservation of birds. Prime Ministry Ottoman Archives. (BOA). (1322/1904). Fund Code: İ..HUSHH.d… Document Number: 123-21.



İ.HUŞ.00123.00021.001

Addition 7: The Document Showing the Importance the Ottomans Gave to the Protection of Birds Such as Siskins and Sparrows. Prime Ministry Ottoman Archives, (BOA). (1322/1904). Fund Code: DH.MKT. Document Number: 910, 2.